Science and technology in Russia: problems and prospects

Simanovsky, Stanislav

Bundesinstitut für ostwissenschaftliche und internationale Studien, Lindenbornstr. 22, D-50823 Köln,
Telefon 0221/5747-0, Telefax 0221/5747-110; Internet-Adresse: http://www.uni-koeln.de/extern/biost

ISSN 0435-7183

Inhalt

27. April 1998

Der Verfasser war bis 1997 Leiter des Forschungszentrums für internationale Strukturvergleiche am Institut für internationale wirtschaftliche und politische Studien (IMĖPI) in Moskau und lebt heute als freier Wissenschaftler in Deutschland.

Redaktion: Hans-Henning Schröder

Stanislav Simanovsky

Science and Technology in Russia

Problems and Prospects

Bericht des BIOst Nr. 18/1998

Kurzfassung

Vorbemerkung

Der vorliegende Bericht gibt einen Überblick über die Entwicklung der russischen Wissenschaft in den letzten Jahren. Er zeigt die Probleme, die in allen Bereichen des Forschungs- und Entwicklungsprozesses auftreten, und untersucht die Ursachen für die krisenhafte Situation. Darüber hinaus erörtert er, welche Auswege sich eröffnen, die es erlauben, daß Wissenschaft in Rußland wieder den angemessenen Platz in der Gesellschaft einnimmt und eine aktive Rolle beim Übergang zu Demokratie und Marktwirtschaft spielt.

Der Bericht basiert auf statistischen und faktologischen Materialien, die Parlament und Regierung veröffentlicht haben. Darüber hinaus stützt er sich auf offizielle Dokumente, statistische Jahrbücher, Informationen des russischen Ministeriums für Wissenschaft und Technologie und der Akademie der Wissenschaften sowie auf Publikationen in Fachzeitschriften und der allgemeinen Presse.

Ergebnisse

1. In der UdSSR war Wissenschaft integraler Bestandteil der Planwirtschaft. Das wirkte sich nachhaltig auf ihre Strukturen aus. Zum einen war Forschung und Entwicklung in der Sowjetunion deutlich auf militärische Bedürfnisse orientiert. Es gab kein "spin off" und keine Konversion. Zwischen Rüstungsforschung und Forschung im zivilen Sektor bestanden erhebliche Unterschiede, was Finanzierung, intellektuelles Potential (Qualität des Personals), materielle Basis und Forschungsergebnisse anging. Das führte auch zu einer relativen Isolation der sowjetischen Wissenschaft von der internationalen Entwicklung.

2. In der Endphase der UdSSR wirkten sich die Wirtschaftsreformen, die während Gorbačevs Perestrojka begonnen hatten und dann nach dem Zerfall der Sowjetunion eine neue Qualität erlangten, nachhaltig auf die Lage der Wissenschaft aus. In dieser Zeit wurde der Wissenschaftssektor von der politischen Führung vollkommen vernachlässigt. Die Krise der russischen Wissenschaft ist aber nicht allein als Folge der administrativen Kommandowirtschaft entstanden, sie ist vor allem auch ein Symptom der tiefen sozioökonomischen und politischen Krise, die alle Seiten des Lebens in Rußland erfaßt.

3. Seit Beginn der 90er Jahre sind alle Elemente des russischen wissenschaftlichen und technologischen Potentials schwer geschädigt worden. Das wird am deutlichsten bei der Finanzierungsfrage, von der Reichweite, Umfang und Struktur der wissenschaftlicher Arbeit abhängen. Tatsächlich gibt es kein einziges Gebiet in der russischen FuE-Sphäre, das von der gegenwärtigen Finanzierungspolitik nicht betroffen ist. Die Situation wird u.a. dadurch schwieriger, daß mit den Steuern, den Preisen und Tarifen für kommunale Dienstleistungen, Elektrizität, Kommunikation, Verlagswesen, auch Mieten steil nach oben gehen. Faßt man dies zusammen, so liegt das tatsächliche Niveau der Wissenschaftsfinanzierung bei 6-7% (Abalkin) bzw. 3-5% (Fortov) des früheren Wertes.

4. Die deutliche Kürzung der Wissenschaftsfinanzierung durch den Staat wirkte sich auf die innere Ausgabenstruktur des Wissenschaftssektors negativ aus – insbesondere auf die Gehälter der Mitarbeiter. Obwohl heute Personalkosten den Löwenanteil der laufenden Kosten im Wissenschaftsbetrieb ausmachen (etwa 43-45%), liegt das Gehaltsniveau weit unter dem vieler anderer Wirtschaftssektoren.

5. Diese Entwicklung führte zu einer substantiellen Reduktion des Forschungspotentials, das Rußland zur Verfügung steht. Während 1992 – nach dem Zerfall der UdSSR – die Zahl aller in Wissenschaft und damit verbundenen Bereichen Beschäftigten etwa 5 Mio. betrug (davon fast 3,2 Mio. in Rußland), waren es Anfang 1995 nur noch 1,1247 Mio. Die Zahl der Wissenschaftler selbst ist von ca. 2,1 Mio. (gesamte UdSSR 1992) auf 643,3 Tausend (Rußland 1995) gesunken. D.h. in drei Jahren ist die personelle Komponente des Wissenschaftsbereich auf ein Drittel reduziert worden.

6. Der Abfluß von Fachleuten aus der FuE-Sphäre wirkte sich auf das Netzwerk von Forschungs- und Entwicklungsorganisationen aus, die angesichts der anhaltenden Finanzkrise von wenigen Ausnahmen abgesehen nicht in der Lage waren, sich an die Marktbedingungen zu adaptieren und ein neues Profil zu gewinnen. Viele Einrichtungen wurden liquidiert, die Forschungsteams aufgelöst. Im Ergebnis verschwanden viele Forschungszentren und wissenschaftliche Hochschulen von Weltruf von der Bildfläche. Andere große FuE-Einrichtungen wurden in kleinere und mittlere Organisationen umgegliedert und umbenannt, um wenigstens die Arbeitsplätze für das Personal zu retten.

7. All das mußte sich auf die Effizienz der intellektuellen Arbeit in der russischen Wissenschaft auswirken und ihr internationales Prestige beschädigen. Während Mitte der sechziger Jahre der durchschnittliche Zitatindex sowjetischer Wissenschaftler etwa 30% unter dem der amerikanischen lag, vervielfachte sich der Abstand zu den USA bis Mitte der 90er nahezu auf das Vierzehnfache. Während die UdSSR in den frühen 80er Jahren gegenüber Japan und den USA bei der jährlichen Anmeldung von Erfindungen weit vorne lag, ist jetzt der Umfang nationaler Patentanmeldungen auf ein Bruchteil gesunken, von internationalen Patenten gar nicht zu sprechen, deren Zahl heute dem eines mittleren amerikanischen Industrieunternehmens entspricht.

8. Eine weitere Konsequenz war die Abwanderung von Wissenschaftlern, die teilweise im Ausland bessere Bedingungen für Entwicklung ihrer Kreativität, für wissenschaftliche Ar-

beit und Familienleben suchen. Entgegen der ursprünglichen Erwartung, die davon ausging, daß 200-250.000 Angehörige der intellektuellen Elite abwandern könnten, haben sich allerdings tatsächlich nur 75.000 Wissenschaftler und Ingenieure entschieden, ihren Aufenthaltsort auf Dauer ins Ausland zu verlegen. 1992 emigrierten 4.572, 1993 – 5.976, 1994 – 5.171 Personen, 1995 – etwa 5.000. In den letzten Jahren ist der Umfang der Emigration allmählich gesunken, etwa auf 3.000 pro Jahr 1996 und 1997. Für 1998 werden noch geringere Zahlen prognostiziert.

9. Eine wichtigere Rolle als die Abwanderung ins Ausland spielt der interne *brain drain*, d.h. der Exodus von Forschern und Fachleuten aus dem Wissenschaftsbereich in die Verwaltung und das Geschäftsleben. Dieser Prozeß ist ein Reflex der gegenwärtigen schwierigen Situation in der russischen Wissenschaftssphäre. Niedrige Gehälter und Arbeitslosigkeit zwingen einen beträchtlichen Teil des Personals, den Beruf zu wechseln und ihr Glück in anderen Bereichen zu suchen.

10. Gewiß wurde in der Untersuchungsperiode auch einiges getan, um die russische Wissenschaft zu bewahren, sie an die Wirtschaftsreformen zu adaptieren und ihnen im neuen, härteren sozioökonomischen Umfeld einen Platz zuzuweisen. Es wurden in administrativem und legislativem Rahmen verschiedene Versuche unternommen, die Wissenschaftssphäre abzusichern, das Finanzierungssystem gegen voluntaristische Einschnitte zu schützen, die perspektivreichsten Forschungszweige zu bewahren, das qualifizierteste Personal zu halten. Zu solchen Maßnahmen zählen gesetzliche Regelungen, die Mittel für herausragende Forscher und für talentierte Nachwuchswissenschaftler bereitstellen, Gehaltszuschläge für akademische Grade, Stipendien für begabte Studenten und Doktoranden, sowie die Anhebung des Mindestlohns im Bereich der Akademie und die Einführung eines Inflationsausgleiches.

Introduction

Presiding over a meeting of the Russian Federation Security Council at the end of November, 1997, President Boris Yeltsin for the first time openly referred to the present poor state of Russian science and expressed his dissatisfaction with the efforts of federal ministries and other government bodies to reform the R&D sphere. "This will have dangerous consequences, both economic and political", he said.[1] On 8 January, 1998, the Russian government approved the "Concept for Reforming Russian Science for the Period 1997-2000". It stipulates concrete measures to be taken in the immediate future to preserve the R&D sphere and to bring it out of its present crisis. In contrast to science in the industrially developed states facing the technological challenges of the twenty-first century, science in Russia does not currently have a major role to play in the acceleration of socio-economic progress.

The present paper attempts to provide a comprehensive survey of what is currently going on in Russian science. It looks at the underlying reasons for the present crisis, which affects every component of the national R&D potential, and examines possible ways of remedying the situation so as to restore Russian science to its proper place in society and enable it to play an active part in bringing about further democratic transformation and in facilitating the transition to a market economy.

The article begins by examining the roots of the current grave situation in Russian science, which lie both in the command-and -control system of economic management used in the former Soviet Union and in the way Russia has chosen to implement economic reforms more recently.

The reform of the R&D sphere in Russia is taking place during a very difficult initial stage in the transition to a market economy. Science is one of the sectors for which the transition has been most destructive. Thus, allocations for science from the state budget were reduced by a factor of six over the period 1991-1996. Their share of the gross domestic product (GDP) dropped from 2.0% in 1990 to 0.53% in 1996. The average monthly salary of Russian scientists and specialists has decreased roughly three-fold in real terms and is now only 60% of the average salary in Russia and about 20-25 times lower than that of scientists in the USA and Western Europe. The number of people employed in the R&D sphere has more than halved and is now close to the "critical mass" of the national research potential below which the country's technological security and economic sovereignty are threatened. This is aggravated by the fact that the influx of young people into the R&D sphere has decreased considerably. The number of persons with academic degrees of candidates of science dropped by a factor of 2.5 between 1991 and 1996 and the number of doctors of science by a factor of 2.3, which points to a decline in the level of professional qualifications in the R&D sphere. This has had a detrimental effect both on scientific output and on the prestige of Russian science both at home and abroad.

---

[1] Carl Levitin, "Yeltsin Voices Concern over 'Brain-Drain'", *Nature*, vol. 390, 4 December, 1997, p. 434.

Dissatisfied with the working conditions and low living standards in Russia, many scientists and specialists have either emigrated permanently or gone to work abroad temporarily. Since 1990 about 70,000 researchers have left the country and now the annual rate of this "brain-drain" process is about 2,000 persons. In addition, many scientists and engineers have left the R&D sphere and gone to work in other areas not associated with science – in the business and administrative sectors, for instance. The proportion of people employed in R&D fell between 1990 and 1996 by a factor of about 1.7. All this has had a negative effect on innovation, on the rates at which basic production assets are renewed, on the structure of Russian exports and on labour productivity in general.

The international community is well aware of the worsening situation in Russian science and has been providing assistance since the beginning of the 1990s. Now the average annual volume of financial support provided via various intergovernmental programmes (such as TACIS) and public and private foundations is about US-$ 1.2-1.3 billion, which is equivalent to nearly half the RF budget for R&D. This assistance has thus provided a life-line to Russian science under the severe conditions of the transition period.

During recent years a number of measures have been taken in Russia designed to make better use of existing sources of funding for the R&D sphere and to find new ones. These have included the creation of an appropriate legal, institutional and economic framework, aimed at attracting greater domestic and foreign investment in science, particularly from the private sector. But these measures (including the recently adopted Concept for Reforming Russian Science for the Period 1997-2000), however goal-directed and timely they maybe, are of a rather interim, fragmentary nature, aimed at eliminating the current bottlenecks in Russian science rather than at charting a long-term strategy for the development of the R&D sphere and its integration in Russian society.

A change in the paradigm of socio-economic development in Russia is needed that would be based on an intensive and efficient use of intellectual resources and of scientific and technological innovation, rather than merely on monetarist and fiscal considerations and on the extensive exploitation of natural resources. Such a change could bring about a better understanding of the role of science among the public at large, the elaboration of a proper strategy for Russia's socio-economic development based on scientific and technological progress and the creation of a favourable psychological, social and investment climate for and in the R&D sphere. Russian science would then be able to regain its lost status in the national economy and world-wide and forge global links.

1. The Background to the Present Crisis in Russian Science

As the twenty-first century approaches it is clear that the future progress of socio-economic transformation in Russia and her place in international economic and political relations will largely be defined, by the level of her scientific and technological development – i.e., by her ability to produce and efficiently use her own and imported advanced technology and to participate in international technological markets. To accomplish these objectives, the country must preserve its scientific and technological potential, which, unlike its vast natural resources, is a (indeed the only) renewable component of the nation's strategic wealth (according to current available estimates, Russia's intellectual property now amounts to US-$ 400 billion, or seven times her annual national budget[2]). What is needed is a reliable system of well-balanced and interlocking political, legal, institutional, economic and social mechanisms that would ensure the preservation and renewal of national science and technology.

This task is especially urgent in view of the currently observable negative trends in Russian science and technology, which, if they prevail, could have a detrimental effect not only on science itself but on the entire course of democratic reforms in Russia.

These trends stem both from the legacy of the command-and-control economic system of the former Soviet Union and from the current severe economic situation.

Science in the former USSR was an integral part of the national economy and, as such, it had a number of particular characteristics. First of all, the Soviet R&D sphere was strongly oriented towards the military. Even by the end of the 1980s, military spending still accounted for about 75% of the federal science budget.[3] As a result much of Soviet science was shrouded in secrecy and many of its most outstanding achievements were never made available to the public. There was no "spin-off" or conversion process, so that there was a great difference in terms of financial support, intellectual potential (quality of personnel), material base and results between scientific research and production in the military-industrial complex (MIC) and that in the civilian sectors of the economy.

Second, the generally closed nature of Soviet society and the ideological doctrine of "peaceful coexistence" with the West (in fact a euphemism for military and political confrontation) meant that Soviet science was rather isolated from the world scientific community. Cut off from their colleagues abroad Soviet scientists tended to operate according to the principle of self-sufficiency and to carry out their own research in virtually all areas of international science. Resources were thus spread over an enormous range of fields, a factor which determined the scale, scope and structure of Soviet science.

The third factor that strongly influenced the effectiveness of Soviet science was its vertical or "branch" subordination. Every research organisation was affiliated to the USSR Academy of Sciences or to some other ministry or agency. The latter tightly controlled its research plans, resources, staff, and relations inside and outside the country. This "departmental" approach to the management of Soviet science led to unnecessary duplication of research, and owing to its inflexibility, hindered the efficient allocation and use of financial, material and human resources. It also became an obstacle to productive interaction and communication between scientists and specialists from different research organisations and stood in the way of links between the R&D sphere and education so that, unlike in the West, links between universities and industry were insignificant.

---

2 *Poisk*, No. 49, 29 November-5 December, 1997, p. 1.

3 Boris G. Saltykov, "The Reform of Russian Science", *Nature*, vol. 388, 3 July, 1997, p. 16.

Research priorities and hence the proportion of spending on R&D were determined by the role and "weight" of a respective ministry or agency in the MIC and the personal standing of its "boss" in the Soviet establishment, rather than by the actual needs of particular fields of science and production or by global scientific and technological trends.

An important feature of Soviet science that distinguished it from science in the industrially developed economies of the West was that it was totally state owned. Everything that occurred in the R&D sphere was under the tight control of the state. Even the results of intellectual activity became the property of the state, via a specially invented system of protection of intellectual property.

However, it would be unfair to focus only on the negative aspects of the Soviet system of organisation and management of science. The system had its own logic and structure and was designed to match the principles and needs of the command-and-control economy. It allowed the short-term concentration of enormous capital and intellectual resources in selected areas of science and technology and thus enabled the Soviet Union to obtain impressive achievements in basic and applied research as well as in military-oriented industrial technology that were on a par with international standards.

The former command-and-control system of management of the R&D sphere thus had a dual effect on national science. On the one hand, a well-developed network of research organisations and highly renowned scientific schools and research centres was formed, scientists gained a relatively high level of public recognition and prestige and in many areas Soviet science ranked high in world league tables. On the other hand, its adherence to communist ideology, its military and technocratic character, its lack of openness and its unjustified restriction of intellectual property rights resulted in serious distortions of R&D potential and limited its benefits for the national economy.

The reforms of the late 1980s and early 1990s clearly demonstrated the disadvantages and drawbacks of the way Soviet/Russian science was organised and, at the same time, relegated its problems to a position of secondary importance against the background of general economic deterioration and the worsening social and political situation. Those in charge of the R&D sphere, the scientific community and the public at large all appeared to be insufficiently prepared for the adaptation of science to the requirements of a market economy – in other words, for systematic reforms that would preserve its most efficient, valuable and productive elements.

The situation in the R&D sphere at that time was additionally aggravated by three external factors, each of which had far-reaching consequences. The first was the collapse of the "world socialist system" and the dissolution of the Council for Mutual Economic Assistance (COMECON) in 1991. The immediate result of this was the abrupt curtailment of scientific and technological co-operation within COMECON. The "Comprehensive Programme for Scientific and Technological Progress until the Year 2000" as well as all other R&D programmes and projects were stopped and research and production links with the ex-socialist countries of Central and Eastern Europe were severed. Scientific equipment and instruments became idle or inaccessible and numerous national and international research teams and individual specialists inside and outside the USSR were faced with unemployment. This brought about not only the destruction of science within the USSR but also the break-up of what had previously been a single scientific and technological area and the destruction of Russia's largest external market for technology, which at that time accounted for about 20-25% of world technological exchanges.[4]

The second factor that dealt a sudden and instantaneous blow to Soviet science was the break-up of the Soviet Union. Thousands of researchers and specialists found themselves in the "near abroad" overnight as nationals and residents of newly formed foreign states. This dramatic turn of events destroyed the integrity of the R&D complex and caused great structural disequilibrium in it. Nearly one-third of what had formerly been common Soviet scientific and technological potential was removed from Russia without any prior warning. As a result, Russia was partly, or in some cases fully, deprived of the means of carrying out research in many areas of science and technology.

For example, in the electrical engineering industry, the research centres for electrical transformers and small electrical machines are in Ukraine and Lithuania. In chemical and petroleum engineering, nineteen research institutes and design offices remained outside Russia. In the machine-tool industry twenty research centres are now "abroad". In biology and mechanical engineering only 50-60% of the research potential of the former USSR was left in Russia. A similar or even worse situation exists in other areas of science and technology. Whole fields of research have ceased to exist in vitally important spheres of the Russian economy. Examples of disciplines that Russia has lost completely are soil protection from water and wind erosion, ecological aspects of water and land amelioration and the restoration of soil fertility. Also lost are a considerable number of research organisations that specialised in such problems as pollutants and their effect on soil (of twelve organisations only two are left in Russia); selection and seed-breeding of farm crops (only 71 of 137 research organisations remained in Russia and – nearly half of the previous research base is lost); in welding (40 out of 105 scientific organisations are lost, including the world-famous Paton Welding Institute in Kiev, i.e. about 40% of the research potential of the industry).

As a result of the break-up of the former Soviet Union, Russia was deprived of all sixteen deep-sea research vessels and the service ships that supported them. This casts doubt on the future of Russian deep-sea studies and of jobs involving the exploration of deposits of gas and oil in the Russian North and Far East, to say nothing of research jobs involving the study of the world's oceans.[5]

This factor has had disastrous consequences, both quantitative and qualitative. First, a further and more substantial shrinkage of the single technological area has placed Russian science under conditions of even greater isolation. Second, in addition to the losses in the quantity

---

[4] S. Simanovsky, M. Strepetova and Y. Naido, *Brain Drain from Russia*, Nova Science Publishers, N.Y., 1996, p. 38.

[5] Y. Naido and S. Simanovsky, *Problems of Russia's Technological Security*, Scientific report, Institute for International Economic and Political Studies, Moscow, 1995, pp. 6-7.

and quality of the R&D potential of the former USSR, big structural deformations have occurred in the portion inherited by Russia, which owing to the loss of scientific schools and even whole disciplines and fields of knowledge, now has major gaps. In some cases it will be impossible to compensate for these losses in the foreseeable future, since the establishment of even a small efficient team takes between five and ten years, while the re-creation of the lost R&D organisations would require decades.

According to some estimates, Russian science can now meet only 44% of the needs of the national economy, while its capacity for developing and adopting new technologies and equipment has fallen by 60-70%.[6] This means that some sectors of the economy will increasingly lag behind the industrially developed nations, thus incurring losses in productivity, efficiency and competitiveness in world markets and leading to certain kinds of technological and financial dependence on foreign countries.

Finally, the factor that had the most serious influence on the situation in Russian science was the economic reforms that were initiated during Gorbachev's *perestroika* and that continued after the break-up of the Soviet Union. These had the effect of more or less removing Russian science from the political agenda. The crisis in Russian science has been caused not only by the above-mentioned "legacy" of the former command-and-control administrative system of the collapsed Soviet Union, but is also a product of the profound socio-economic and political crisis that has gripped practically all aspects of life in Russia. An analysis of what is really a global phenomenon is beyond the scope of this study. Nevertheless, it is expedient and logical to give a brief general description of the environment in which Russian science now has to exist.

For a number of years Russia's economy has been in a deep recession. The drop in output, significant inflation and unemployment, investment paralysis, the crisis of non-payment, the permanent delay in paying wages and salaries, the severing of production links and the return to a system of barter between the enterprises and regions of the country – all these and many other negative phenomena have become normal everyday features of the Russian economy that have brought about a swift decline in living standards and in the quality of life of the population.

Since it has no idea (in the form of an appropriate theory, concept or a model) of what kind of a society should replace the communist one in Russia, the country's leadership regards science not as an engine of reform or as a source of intensive socio-economic development but rather as another "black hole", just like the defence sector, from which "extra" money can be drawn to cover the budget deficit, finance current economic needs or eliminate "bottlenecks". The chosen paradigm of economic management is based on monetarist, fiscal approaches and the commercialisation of natural resources rather than on the consistent promotion of science, technology and innovation.

---

6 Naido and Simanovsky, *op. cit*., p. 7.

This approach has been taken on board by the public at large, so that Russian society, with rare (but fortunately growing) exceptions, has not yet fully understood the gravity of the current situation regarding science and technology. The categories and stereotypes of the past still prevail in the public consciousness with respect to the role and significance of science and technology and the place of intellectuals in the socio-economic progress of the nation. This explains, to a great extent, the current failure in the higher echelons of power (parliament and government) to appreciate the importance of the R&D factor) and the delay in adopting adequate measures to maintain and develop Russia's scientific and technological potential.

This may be illustrated by the fact that of the nearly twenty anti-crisis programmes that were publicly announced during the period 1992-1995, none included any measures designed to ensure the survival or development of the Russian R&D sphere. At the same time, the Russian Academy of Sciences and the RF Ministry of Science and Technological Policy (the ministry's name at that time) by and large stood by passively and, apart from some piecemeal measures, did not really take any systematic practical steps to maintain national R&D potential or to alert the government's attention to the problems of Russian science and technology.

As a result, the most important strategic resource for overcoming the current socio-economic crisis, for bringing about the success of market reforms and for reinforcing the international position of the Russian Federation still remains untapped either by the state or by commercial structures, thus allowing the perpetuation of negative trends in science and technology.

By contrast, US President Bill Clinton has declared scientific and technological policy one of the top priorities of his administration, clearly understanding that it is impossible to retain the leading position of the USA in international political and economic relations without keeping up US leadership in world science and technology. One of his conceptual presentations on this subject is entitled "Technology for America's Economic Growth, A New Direction to Build Economic Strength".[7] In his address to the US Congress in February 1997 he also pointed out: "In order to be prepared for the twenty-first century, we must put the powerful forces of science and technology to the service of all Americans."[8]

This approach shows a clear understanding of the fact that on the eve of the third millennium it is above all scientific and technological potential that determines any country's ability to solve its economic problems and ensure its competitiveness in external markets and its position in the global economy. Stable economic growth in industrially developed countries depends primarily on efficient use of scientific knowledge and expertise. According to the estimates of some experts, factors associated with innovation account for up to 60% of the "sources of economic growth" in the leading Western states, thus reflecting their efforts to promote science and technology with the help of a properly formulated and consistently followed national policy in this area.

---

7 22 February, 1993, Washington, D.C.

8 *Nezavisimaya gazeta*, 19 February, 1997, p. 6.

"However, the lack of a state science policy in Russia", – writes Sergei Rogov, director of the Institute for USA and Canada Studies at the Russian Academy of Sciences, – "has left science in a position of being unclaimed".[9] This means that the results obtained in the R&D sphere remain unused, since neither the state nor the private sector are interested in their application in the national economy. Such a situation has brought about serious problems in innovation policy i.e., a reduction in the application of the most up-to-date achievements of both national and foreign science and technology. The scale of innovative activity has shrunk, the rate of renewal of the material and technical base of production has slowed down and the quality and competitiveness of manufactured products has declined. "The present leaders of Russia", – notes Dr. Chem. Sci Vladimir Torchilin, a Lenin Prize winner who is now a professor at Harvard Medical School, – are completely ignoring the fact that without science the country will lose its technological base tomorrow and then its own manufacturing."[10]

Similar concern about the plight in which Russian science finds itself as a result of neglect on the part of the Russian leadership has been expressed by many representatives of the academic community, business circles and public organisations. Following a live debate the State Duma (lower house of the Federal Assembly – the Russian parliament) adopted an Ordinance "On the Crisis Situation in Russian Science" (25 March, 1994, No. 77 1, GD, Moscow) in which the state of national R&D was for the first time officially characterised as "close to a catastrophe".

Statistical and factual illustration of the scale, depth, character and consequences of this catastrophic situation in Russian science and technology is given in the following chapter.

2. The Crisis in Facts and Figures

2.1 Funding

Since the beginning of the 1990s virtually all components of Russia's scientific and technological potential have been in a deep crisis. This is reflected most clearly in the funding of the R&D sphere, for it is this that determines the scope, scale and structure of all the other components, such as personnel, material base and international scientific activities.

Changes in expenditure on R&D in Russia are illustrated by the following data:

Table 2.1: R&D Expenditure 1990-1995 (in millions of rubles)

	1990	1991	1992	1993	1994	1995
In current prices	13,077.8	19,991.3	140,590.7	1,317,199.5	5,146,102.0	12,149,458.6
In constant prices of 1989	10,898.2	7,290.2	3,224.5	3,055.0	2,929.9	2,445.7

[9] Sergei Rogov, "Science – Always a Burden for the State", *Nezavisimaya gazeta*, 19 February, 1997, p. 6.

[10] Vladimir Torchilin, "Clever Men Are Good, but It Is Better without Them" –, *Nezavisimaya gazeta – Nauka*, 6 February, 1998, p. 9.

Source: *Russian Science in Figures 1996*, Centre for Science Research and Statistics (CSRS), RF State Committee for Science and Technology, Russian Academy of Sciences, 1996, p. 38.

Table 2.2: *R&D Expenditure (as a percentage of 1990)*

	1990	1991	1992	1993	1994	1995
	100	66.9	29.6	28.0	26.9	22.4

Source: *Ibid.*

Table 2.3: *R&D Expenditure (as a percentage of GDP)*

	1990	1991	1992	1993	1994	1995
	2.03	1.43	0.74	0.77	0.84	0.73

Source: *Ibid.*

These official figures, available from the CSRS, seem to be overstated, since they are based on targets that in reality were never fully met. A number of people have provided alternative data that reflect more closely the allocations actually received by the R&D sphere. For example, Russian Minister of Science and Technology Academician Vladimir Fortov points out: "Previously we, like all industrially developed countries of the world, spent 2.5-3% of GDP on science, but now this share has fallen to the humiliatingly low level of only 0.4-0.5%. As regards this index, we are on a par with the least developed countries of the world. Even Pakistan, Turkey and Bulgaria spend more money on science than we do."[11]

The table below gives some alternative data showing, for example, R&D expenditures as a percentage of GDP:

	1991	1992	1993	1994	1995	1996 (estimate)
	1.03	0.57	0.52	0.47	0.41	0.53

Source: *Herald of the Russian Academy of Sciences*, vol. 66, No. 2, 1996, p. 122.

These figures place Russia on a par with such countries as Argentina (0.30%), Romania (0.45%) and Bulgaria (0.50%).[12]

According to yet another source, in 1996 R&D expenditure in Russia was only 0.59% of GDP, whereas in Japan and Israel it was 3.1, in Germany and Sweden, 2.8%, and in the USA, 2.7%. In US-$ per capita the pattern was as follows: Japan – 579, Sweden – 482, USA – 611, France – 439, Great Britain – 325, and Russia – 43.[13]

---

[11] A. Vaganov, "Expenditure on Science – A Guarantee against Mistakes", *Nezavisimaya gazeta*, 24 September, 1996, p. 6.

[12] *Herald of the Russian Academy of Sciences*, vol. 66, No. 2, 1996, p. 122.

[13] *Ekonomika i zhizn'*, No. 51, December, 1997, p. 27.

The absolute figures for R&D allocations in Russia during recent years (1996 – 11.6 trillion rubles or US-$ 2.4 billion,[14] 1997 – 12.54 trillion rubles or US-$ 2.32 billion, 1998 – 13.5 billion (denominated) rubles.[15] or US-$ 2.25 billion) show that the present level of financing for Russian science matches that of a major international concern such as Acea Brown Bovery, whose R&D budget in 1995 was US-$ 2.627 billion.[16]

It should be reiterated that the above figures for R&D spending are official target figures and that in practice the R&D sphere has not actually received this amount of money. As Russian Science Minister Fortov said, "in 1996 as little as a third of the science budget actually got paid out. This year (1997) it looks set to be about 60% thanks partly to the notorious '*sekvestr*', whereby the government revises its original promises part-way through the financial year to make it look as if it is paying a bigger percentage than it actually is. In 1998 it will be 100%."[17] But the scientific community of Russia does not believe such promises. In 1996 the government's debt to Russian science was 4.7 trillion rubles. The amount owed in salaries alone was 1.7 trillion. rubles.[18] which by October, 1997 had grown to 2.4 trillion. rubles. (US-$ 400 million).[19]

It should be noted that the crisis in R&D funding has affected many areas of Russian science and technology that used to be of key importance to the national economy. This applies above all to the MIC. As mentioned above, a considerable portion of scientific research in the Soviet Union took place within the MIC. Traditionally, research and manufacturing of such things as TV and radio sets, tape recorders, refrigerators, washing machines, etc. was carried out by the MIC and in some cases accounted for their entire output in the former Soviet Union. In 1991 up to 40% of the research for civilian applications in the USSR was carried out under the auspices of the MIC.[20] However, the policy of conversion and the resulting 80% reduction in state military orders has led to severe cuts in the R&D budget of the MIC – since 1991 it has fallen fifteen-fold.[21] Now R&D expenditure in many defence industries constitutes about 1-8% of total defence spending, despite the Russian president's instructions to keep it at about 12-15%. At the same time, the USA has increased the proportion of R&D spending to 22-23% of its total defence budget. It should be noted that spending on basic research as a proportion of the total defence R&D expenditure in Russia is now only 2.5-3%, while in the USA it is three or four times higher.[22]

---

14 *Finansovye izvestiya*, No. 24, 5 March, 1996, p. V.

15 *Nature*, vol. 389, 30 October, 1997, p. 900.

16 *Finansovye izvestiya*, No. 24, 5 March, 1996, p. V.

17 *The Economist*, 8 November, 1997, p. 23.

18 *Nezavisimaya gazeta*, 10 February, 1997, p. 6.

19 *Nature*, vol. 389, 30 October, 1997, p. 900.

20 Aleksei Shulunov, "Systemic Crisis", *Nezavisimoe voennoe obozrenie*, No. 2, 16-22 January, 1998, p. 4.

21 Vladimir Gavrilov, "The Military-Industrial Complex in the Russian Economy", in a collection of papers entitled *Conversion in Russia: Problems and Ways of Solution*, Moscow, Russian Academy of Sciences, 1996, p. 11.

22 Shulunov, *op. cit*.

Thus, it is quite clear that with a funding policy of this kind the defence arm of Russia's R&D is no longer in a position to satisfy the needs of the civilian sector of Russia's economy for many products. The lack of funds has also led to the loss of Russia's previously strong position in the world armaments market where many of the weapons it produces have become non-competitive.

This can be illustrated by numerous examples. The domestic electronics industry, for instance, where the R&D sector receives only 10-12% of the official government allocation is no longer in a position to provide the armed forces with the most up-to-date electronic equipment, thus weakening Russia's defence system, to say nothing of civilian industries, which now lag at least twenty years behind the West.[23] In 1995 about one million computers were sold in Russia, whereas in Germany the figure was nearly 4 million That year, Russia ranked sixth in Europe after The Netherlands in terms of computer sales. The pool of Russian computers now constitutes less than 1% of the total number of computers in the world and there is no indication that this share is likely to increase.[24]

Even in space research, which was formerly carried out mainly by the MIC, the situation leaves much to be desired. As regards the level of funding in this area, Russia is now on a par with India. The space station "MIR" has been used for twelve years, although it was actually designed for a service life of only five years. At least 50% of the funds needed to maintain it come from foreign investment. In 1996 Western investment in Russian space engineering amounted to US-$ 461 million, 60% of which was directed to areas of space research that have remained completely untapped by the national economy.[25] The low level of financing for space R&D has had a negative impact on the quality of space experiments, with constant hitches and failures in the operation and launching of space objects. Recent examples are the well-known problems experienced by international crews at the "MIR" space station, the failure to launch the Chinese satellite "Asiasat" using a Russian "Proton" missile and a similar incident with the Israeli communications satellite "Ofek", all of which have lowered the prestige of Russian space technology and resulted in commercial losses.[26]

Owing to insufficient funding – or in some cases no funding at all – especially in the Russian Academy of Sciences, a considerable portion of unique research equipment and instruments is no longer functioning, thus resulting in a discontinuation of or reduction in experimental research. The majority of research ships are now standing idle in sea ports and many scientific expeditions (including those under international auspices) cannot be undertaken. In 1994 five of the six seismological stations in the Far East region were closed, thus in effect putting out of action the early warning system for natural disasters, which are frequent in this part of the country. The earthquake at Neftegorsk, Sakhalin Island, in May, 1995 demonstrated the fool-

---

23 Gennadii Bocharov, "Computer versus Bast Shoe: Who Beats Whom?", *Izvestiya*, 18 February, 1997.

24 Sergei Leskov, "Americans Send Scientist to Russian Space Station", *Izvestiya*, 16 January, 1997.

25 Andrei Kolesov, "Russia Cannot Afford Mass-Scale Computerisation", *Finansovye izvestiya*, 1 October, 1996, No. 93, p. V.

26 Sergei Leskov, "Russian Rocket Stopped Chinese TV Transmission", *Izvestiya*, 27 December, 1997.

hardy nature of this decision. A similar situation exists with regard to forecasting high water and river flood tides.[27]

R&D expenditure for polar studies in the Arctic and Antarctic regions has been cut four-fold, an area in which Russia was a world leader until several years ago.[28] The substantial reduction in funds for R&D in pharmacology has deprived the Russian pharmaceutical industry of a significant portion of the domestic market, more than 60% of which is now controlled by foreign companies, thus making the population of Russia dependent on very expensive foreign medicines. The Russian optical industry also suffers from insufficient R&D funding, thus failing to meet the requirements of the domestic scientific instruments industry and the needs of the armed forces for high-quality optical equipment, which makes the country increasingly dependent on foreign-made optics.[29]

A grave situation has also emerged in the Russian aviation industry, where the budget for R&D has been reduced dramatically (forty-fold in constant prices) from 20 trillion rubles in 1991 to 500 billion. in 1997. Without the required funds no new models of civilian or military planes can be put to the service of the national economy--Russian aviation has suffered a significant loss in competitiveness not only on international but even on domestic passenger and cargo lines, the number of problems and accidents is growing and there has been a deterioration in safety standards. Despite the existence of a special so-called Presidential Programme for the development of civil aviation engineering, the money actually allocated for the R&D sector of this industry amounts to only 45-50% of that stipulated by the programme. "The domestic aviation complex is in a state of collapse, whereby research and development of new aircraft have virtually stopped."[30]

A similar state of affairs now exists in the Russian navy and merchant navy. The average "age" of ships is now about twenty years, four years more than the rated service life. A special programme for the renewal of the Russian fleet for 1993-1995 envisaged an allocation of 25.5 billion rubles for the R&D sector of the industry, but in reality the research institutes and design bureaus of the ship-building sector have not received any money at all.[31]

In 1996 a special programme called "National Technological Base" was adopted, which also acquired the status of a Presidential Programme. Its goal was to bring the most up-to-date high technologies to Russia by way of an extensive spin-off from the MIC to the civilian sectors of the national economy so as to close the technological gap of factor 2-5 between them. 2.5 trillion rubles were allocated for the programme for 1997. However, only 24 billion rubles were actually provided, i.e., less than 1%. "Consequently, the programme can be regarded as

27 Svetlana Galkina, "Rivers Will Soon Burst Their Banks", *Izvestiya*, 20 February, 1996.

28 Sergei Leskov, "American Pilots Evacuate Russian Antarctic Station 'Vostok'", *Izvestiya*, 26 January, 1996.

29 "Russian Optics Might Stop Working for National Security", *Finansovye izvestiya*, No. 104, 12 November, 1996, p. IV.

30 Ekaterina Titova, "New Law Allows Nationalisation of the Aviation Complex", *Finansovye izvestiya*, No. 95, 16 December, 1997, p. II.

31 Aleksandr Rubtsov, "Domestic Fleet Runs Ag?round", *Finansovye izvestiya*, No. 24, 5 March, 1996, p. II.

buried, since the discontinuation of work in science for one year means lagging three years behind the developed countries. By the end of this century, the gap between Russia and potential competitors in advanced technology will become catastrophic – ten and more years."[32]

Unfortunately, this sad list of examples illustrating the present catastrophic situation in R&D funding in Russia could be endless. There is virtually not a single area in Russia's R&D sphere that will not be affected by the present funding policy. The situation is also aggravated by rampant inflation and the introduction of taxes and tariffs for communal services, power, electricity, communications, information and publishing services, rents, etc. In view of these expenses, the actual drop in financing of the Russian R&D sphere ranges, according to various estimates, from factor 15-18 (Academician Leonid Abalkin)[33] to factor 20-30 (Academician Fortov)[34].

2.2 Salaries

The considerable reduction in state financing for science has also had a negative influence on the salaries of research personnel. Despite the fact that salaries make up the lion's share of the expenses of R&D organisations (now about 43-45%), salaries in scientific research have become much lower than those paid in many other sectors of the economy.

The trend towards a reduction in salaries in scientific research relative to the economy as a whole and to certain leading sectors began in 1990. In 1992 this trend had already reached threatening proportions. While in 1990 the average monthly salary in the sector "science and related services" was still 118.6% of the average monthly salary in the economy as a whole and 113.2% relative to industry, in 1991 it had fallen to 105.3% and 96.2% respectively. In 1992 this index was 70.9% and 59.9% respectively. In 1993 the average monthly salary in science was 64.8% relative to the economy as a whole and 60.1% relative to industry. In 1994-1995 salaries in science went up again slightly relative to the economy as a whole and relative to certain leading sectors (in 1995 – scientific salaries were 75% relative to the economy as a whole and 65% relative to industry),[35] but this increase was insignificant. Therefore, the general trend is towards a gradual fall in the salaries and wages of people working in the science sector.

This is illustrated by the following official data available from the CSRS.

Table 2.4: Average Monthly Salary in the Sector "Science and Related Services"

	1990	1991	1992	1993	1994	1995	1996
Monthly average salary, rubles.	351.9	515.0	3,859.0	39,645.0	171,720.0	365,833.0	724,310.0

[32] Yurii Novoselov, "In the 21st Century Russia Will Have No Technological Base", *Finansovye izvestiya*, No. 38, 27 May, 1997, p. XII.

[33] "Russia Loses Basis for Growth Renewal", *Finansovye izvestiya*, No. 11, 18 February, 1997, p. I.

[34] "Expenditure for Science – A Guarantee against Mistakes", *Nezavisimaya gazeta*, 24 September, 1996, p. 6.

[35] Tatyana Burtseva and Marina Motova, "Russian Scientists Are Consigned to the Periphery of Reforms", *Finansovye izvestiya*, No. 116, 26 December, 1996, p. VII.

Percentage of salaries in:							
the economy as a whole (= 100%)	118.6	94.0	64.4	67.6	77.9	77.4	81.9
industry (= 100%)	113.2	85.0	54.6	63.2	76.0	70.1	73.1
construction (= 100%)	93.6	74.1	47.9	50.8	60.6	61.5	60.9

Source: *Russian Science in Figures 1996*, CSRS, RF State Committee for Science and Technology, Russian Academy of Sciences, 1996, p. 52.

Taking into account the growing cost of living in Russia, these figures point to worsening living conditions for Russian scientists and specialists, who have to struggle to make ends meet. Still lower than the salaries in science are those in such sectors as education (85%) and the arts (78%).[36] All this illustrates the attitude of the present leadership to Russia's elite, i.e., those who shape and develop the intellectual potential of the nation and determine its contribution to global culture and science.

By contrast, salaries in the scientific sector in the USA are on average twice those in the national economy as a whole, while in absolute terms the salaries of American researchers defy comparison with those of their Russian colleagues, even though the cost of living in Russia now nearly equals that in the USA. According to some data, in 1995 the average monthly salary of a researcher in Russia was about US-$ 88, i.e. 50-60 times lower than that of his American counterpart.[37] Corresponding Member of the Russian Academy of Sciences and Director of the Institute of the History of Russia Andrei Sakharov points out that the salary of a professor or doctor of sciences is, following the salary increase granted to the Russian Academy of Sciences, about US-$ 200, while in Poland it is US-$ 300 , i.e., a third higher. By contrast, the salary of a professor of history in Western Europe, the USA or Canada is US-$ 4,000-5,000 US-$, i.e. 20-25 times higher.[38]

In 1997 the average salary in Russian science was about 700,000 rubles (US-$ 120) a month.[39] In 1998 it will be increased to US-$ 140-200, depending on rank. However, this will require a 10% reduction in staff.[40]

The capital intensity of labour of one researcher in Western countries in 1996 was as follows: USA – US-$ 189,400, France – US-$ 177,100, Germany – US-$ 158,400, Great Britain – US-$ 150,600, Japan – US-$ 148,500, i.e., 33-43 times higher than in Russia.[41] (Capital intensity in this context includes the salary of a researcher, the cost of equipment, materials and instruments for his work, information services, participation in international conferences, etc.).

---

36 Burtseva and Motova, *op. cit.*

37 Elena Galaeva, "Intellect without Potential?" *Ekonomika i zhizn'*, No. 51, December, 1997, p. 27.

38 Andrei Sakharov, "Drudgeries of Young Talents", *Nezavisimaya gazeta – Nauka*, No. 2, 6 February, 1998, p. 9.

39 *Nature*, vol. 388, 24 July, 1997, p. 315.

40 *Nature*, vol. 391, 15 January, 1998, p. 221.

41 Shulunov, *op.cit.*

Taking these capital intensity data as a basis for calculation, Academician Fortov, Russian minister of science and technology, said in a recent interview: "A crude option is possible: we just take the sum of money allocated for science today and say that for the normal development of science it is necessary to spend about US-$ 150,000 per researcher. But if we did that there would only be about 20,000-30,000 persons left in science. This would mean the immediate breakdown of science. So we have decided that this option does not suit us."[42]

Hence, it is quite clear that for political and socio-economic reasons the Russian leadership cannot now or in the foreseeable future bring the level of R&D financing, especially salaries, up to Western standards. Thus, Russian scientific personnel will continue to leave science for other sectors of the economy in search of better working and living conditions. (Especially attractive are those sectors where a high proportion of privatisation has taken place and salaries are 10-15 times higher than in the state sector.).

2.3 Personnel

As mentioned above the combined factors of the break-up of the former Soviet Union and the low level of funding for Russian R&D during the economic transformation have resulted in a substantial reduction in the amount of research potential that Russia is able to draw on.

Indeed, while by the end of the existence of the USSR (1992), the total number of people employed in "science and related services" was about 5 million (of whom nearly 3.2 million. were employed in Russia), including 2.1 million researchers, by the beginning of 1995 the figure had dropped to 1.124.7 million persons of whom 643,300 were researchers, in other words a reduction of two thirds in three years.[43]

By contrast, official science statistics give the following data:

Table 2.5: Annual Average Number of People Employed in the Sector "Science and Related Services" (in millions)

1991	1992	1993	1994	1995	1996
3.075	2.307	2.237	1.833	1.532.5	1.334.3

Source: Russian Science in Figures 1996, op. cit., p. 36.

Although these figures seem to be overstated, they nevertheless clearly show a decline in the number of personnel engaged in the R&D sphere of the Russian economy According to them, the total number of people employed in this sector fell between 1991 and 1996 by a factor of 2.3.

42 Andrei Vaganov and Vladimir Fortov: "Priorities Appear from the Possibilities of the State", *Nezavisimaya gazeta – Nauka*, No. 2, 6 February, 1998, p. 10.

43 Stanislav Simanovsky, "The Intellectual Redivision of the World", *Nezavisimaya gazeta*, 1 February, 1996, p. 4.

The proportion of researchers to the total number of the personnel engaged in research and development and the shifts in both categories are illustrated by the following data (which, though obtained from the same official source, differ from those given in Table 2.5 above).

Table 2.6: *Personnel Engaged in Research and Development (in millions)*

Year	Total	Researchers	Researchers (% of total number)
1990	1.943.4	0.992.6	51.1
1991	1.677.8	0.878.5	52.4
1992	1.532.6	0.804.0	52.5
1993	1.315.0	0.644.9	49.1
1994	1.106.3	0.525.3	47.5
1995	1.061.0	0.518.7	48.8

Source: *Russian Science in Figures 1996*, *op. cit.*, p. 24.

The data in this table show that the total number of personnel engaged in research and development fell 1.83 times between 1990 and1995 , while the number of researchers fell 1.91 times during the same period. In addition, while during the 1990-1992 period the reduction took place mainly at the cost of technicians and other auxiliary personnel, between 1993 and 1995 the reduction in the number of researchers employed in this sector was higher than that of other categories of personnel.

The reduction in personnel engaged in the R&D sphere as calculated per 10,000 persons employed in the national economy is illustrated by the following data.

Table 2.7: Number of Persons Engaged in Research and Development per 10,000 Employed in the Economy of Russia as a Whole

1990	1991	1992	1993	1994	1995
258	227	213	186	162	158

Source: *Ibid.*

These data show a reduction of factor 1.63 over the period 1990-1995 which indicates a steadily diminishing share of the R&D sector in Russia's national economy.

In the MIC this situation is especially dramatic. In 1992 alone more than 200,000 scientists and specialists left the defence complex. Between 1992 and1993 about one-third of highly-skilled researchers and engineers were forced to leave their jobs in the defence sector.[44] By the beginning of 1997 the staff of research institutes and design bureaus in the defence industry had fallen by 53-60% compared with 1991, thus resulting in the destruction of famous research schools and design-engineering centres and in a decline in the quality of the remaining R&D personnel – during this period nearly 40% of doctors and candidates of science left the R&D sector of Russia's MIC.[45]

---

[44] Stanislav Simanovsky, "The 'Brain Drain'. Is it Inevitable?" *Delovoi mir*, 18-24 July, 1994, p. 25.

[45] Shulunov, *op. cit.*

All this not only weakens the intellectual potential of the defence and other industries but creates a large number of social, economic and even political problems and increases unemployment in both proportional and absolute terms. A paradoxical situation now exists in Russia, especially in big cities such as Moscow and St. Petersburg, whereby the level of qualifications of the unemployed is higher than that of the employed. In Moscow in 1993-1994, for instance, more than 40% of the total number of unemployed were engineers and scientists.[46]

In the opinion of some Russian and foreign experts and analysts the trends indicated above are but a mere reflection of a normal process of stripping the R&D sector of the former Soviet Union of its excess labour force, freeing researchers and specialists from unproductive research, and reducing or eliminating altogether dead-end areas of science and technology in the course of an inevitable restructuring of science taking place against the background of a general economic reform.

A similar view has been voiced by foreign officials. At an international scientific conference in Moscow (September, 1993), for instance,[47] this opinion was presented in a report about science by the OECD and was later supported by Prof. A. Connaway (British Royal College of Science, Technology, and Medicine).[48] These and other foreign experts advise Russia to cut the staff engaged in R&D down to a total of 500,000-600,000 with the number of researchers not exceeding 300,000. They argue that the current lack of investment in science makes it necessary for the scientific sector to match its needs with the material and financial realities of the economy.

Although this line of reasoning sounds convincing, the question remains whether in reducing its scientific personnel by a factor of 1.5 or 2 from its present, already low level, Russia will still be able to meet the challenges of the twenty-first century, preserve its scientific and technological sovereignty and guarantee its economic security.

The continuing exodus of scientists and engineers to other sectors of the economy where their work is not directly related to their scientific training might be regarded as raising the intellectual level of these other sectors and making those employed in them more professional and efficient. In addition it might also be construed as ensuring that the R&D sphere is continuously replenishing its workforce with young graduates and postgraduates – i.e., a new generation of researchers and specialists in possession of the most up-to-date skills and knowledge.

2.4 Academic Standards

Unfortunately, however, this is not the case,. as is illustrated by the following data, showing the number of scientific degrees approved by the Higher Attestation Commission (HAC) – the only authority awarding scientific degrees and titles (candidate and doctor of sciences, dotsent and professor) formerly in the USSR and now in Russia.

---

46 Naido and Simanovsky, *op. cit.*, p. 12.

47 Scientific and Innovation Policies, The Russian Federation, OECD Evaluation Report, Centre for Co-operation with Countries of Transitional Economies, Paris, 1994, vol. 1.

48 *Finansovye izvestiya*, 2 February, 1995, p. VIII.

The data in Table 2.8 show a decrease of factor 2.4 between 1991 and1995 in the total number of persons obtaining scientific degrees, of factor 2.3 for the category of doctor of science and of factor 2.5 for the category of candidate of science

Table 2.8: *No. of Degrees Approved by the HAC*

	1991	1992	1993	1994	1995
Total	35,040	29,612	19,790	16,149	14,266
Doctors of science	6,326	5,491	4,111	3,185	2,743
Candidate of science	28,714	24,121	15,679	12,964	11,523

Source: Russian Science in Figures 1996, *op. cit.*, p. 21.

This is an alarming trend. It reflects a steady decline in the professional qualifications of Russia's R&D personnel, which threatens to jeopardise Russia's chances of meeting the growing requirements of scientific and technological progress in the coming century both nationally and internationally. One of the reasons for this is that younger people with the personnel and intellectual potential to make a career in science and to spend the most productive period of their life engaged in research and engineering no longer have the desire to do so. The particularly sharp decline in the number of people taking candidate's degrees shows that young Russians have lost interest in working in the R&D sphere. The main reasons for this are the low salaries, poor working and living conditions, the falling prestige of scientists and engineers in Russian society and the decline in the status of the scientific and creative intelligentsia.

This phenomenon is illustrated by the following data, which show changes in the total number of post-graduates and in the numbers of students enrolling in and completing post-graduate courses between 1990 and1995. One of the reasons for the decline in all three categories is that the number of Russian graduates is decreasing as well--from 406,800 persons in 1991 to 394,600 in 1995.[49]

Table 2.9: *Numbers of Post-graduate Students in Russia and Enrolment in and Completion of Post-graduate Courses*

	1990	1991	1992	1993	1994	1995
Total number of post-graduates	63,072	59,314	51,915	50,296	53,541	62,317
Enrolment in post-graduate courses	17,466	15,687	13,865	16,507	19,416	24,025
Completion of post-graduate courses	16,355	16,322	14,857	13,432	12,292	11,369

Source: pp. 19-20.

[49] *Russian Science in Figures 1996*, *op. cit.*, p. 16.

The reason for the apparent increase in the total number of post-graduates and in enrolments at post-graduate institutions in 1994-1995 is that many graduates signed up for post-graduate degrees that year in order to avoid being drafted into the army and sent to Chechnya and other "hot spots" in Russia and the other countries of the former Soviet Union. (A new law adopted in 1994 exempted post-graduates from military service.) Whereas the first two figures rise that year, the number of post-graduates completing their courses continues to decline. It should also be noted that the number of persons actually obtaining degrees during the period 1991-1995 was about 21-22% a year on average.[50]

According to some estimates, Russian scientific institutions need about 10,000-12,000 young researchers between the ages of twenty-two and twenty-five. One plan is to grant exemption from military service this year to young scientists graduating from the country's leading universities.[51]

2.5 Research Organisations

The exodus of scientists from the R&D sphere has also affected research and engineering organisations. The permanent shortage of funding, has made them unable, with a few exceptions, to develop a new profile or adapt themselves to market conditions. Many of them have been closed and their research teams dismissed. As a result, numerous research centres and scientific schools of world renown have ceased to exist as such. Other big R&D organisations, in an attempt to retain personnel, have split into several smaller organisations with new names. In order to cope with high prices and taxes for utilities and communal services, nearly all R&D institutions have begun leasing their premises and even whole buildings to commercial structures (e.g. banks and trade and tourist companies.) and have started co-operating with private business. Of a previous total of more than 4,500 R&D organisations in Russia, including 550 belonging to the Russian Academy of Sciences, 1,100 have been privatised since 1991.[52]

Changes in the system of R&D organisations in Russia are shown in the table below. It shows a decline in the total number of organisations carrying out research and development from 4,646 in 1990 to 4,059 in 1995, with the proportion of research institutes and similar organisations growing during the same period as a result of the above-mentioned job-saving measures. (In a bid to keep the personnel of industrial sciences from leaving the R&D sphere and to keep at least a bare minimum of scientific activity going, some R&D organisations have also re-formed into so-called "branch" public academies linked to various industrial scientific disciplines. These academies now number more than forty.)

[50] *Ibid*, p. 19.

[51] "Russia's Young Scientists Set to Escape the Draft", *Nature,* vol. 391, 22 January, 1998, pp. 318-319.

[52] "Science in Russia", *The Economist,* 8 November, 1997, p. 24.

Table 2.10: Organisations Engaged in Research and Development

	1990	1991	1992	1993	1994	1995
Total	4,646	4,564	4,555	4,269	3,968	4,059
Research organisations	1,762	1,831	2,077	2,150	2,166	2,284
Design bureaus	937	930	865	709	545	548
Project and prospecting organisations	593	559	495	395	297	207
Industrial enterprises	449	400	340	299	276	325
Higher education institutes	453	450	446	456	424	408

Source: Russian Science in Figures, *op. cit.*, p. 8.

So-called industrial science takes place in design bureaus and factory laboratories where the results of applied research and development are translated into everyday practice to meet the current needs of industry, thus keeping it on a high technological level. Their number has fallen by a factor of 1.7 and 1.4 respectively. The slight growth in the number of R&D organisations at industrial enterprises might indicate a trend towards paying greater attention to innovation in the private sector of industry. However, a lack of statistics for more recent years makes this difficult to verify.

Of special concern is the steady reduction in the number of project and prospecting R&D organisations, which are concerned mainly with geological exploration and surveys (finding and evaluating deposits of natural resources). Their number fell by factor 2.9 between 1990 and 1995. The abrupt reduction in funding for geology and other related fields and, consequently, a significant reduction in the number of R&D organisations and experts in this field have caused a sharp decrease in the quantities of raw materials being explored – by factor twelve for gold and by factor five for petroleum and non-ferrous metals. In 1995, the increment of oil resources was only 65% of oil extraction and that of gas resources – only 36%.[53] This means that, if this trend continues, Russia will soon deplete her vast natural resources.

Especially critical is the situation in R&D organisations in the "naukogrady" or science cities –closed research and production settlements subordinated previously to the Ministry of Defence and the Ministry of Nuclear Energy. There are about seventy such cities with a total population of around 3 million people. (These include such well-known townships as "Arzamas-16", "Chelyabinsk-70" and the like). For many science cities the cuts in budgetary allocations have had disastrous consequences. Teams of researchers that took years to form have been broken up, unique research centres have disintegrated, expensive equipment breaks down for lack of proper maintenance, municipal services are in a shambles, and the supply and service routes of townships that used to be in a privileged position have been disrupted, with unemployment growing and the best personnel leaving. All this may cause social tension not only in the science cities themselves but also in the regions where they are situated. It is

[53] Rogov, *op. cit.*

quite possible that a big technological disaster like the Chernobyl catastrophe may occur again. An attempt has recently been made to improve the situation in science cities by way of a draft bill "On the Status of Science Cities in the Russian Federation" that has been submitted to the State Duma.[54]

The reduction in R&D organisations at educational institutions (so-called "university science") by a factor of 1.1 between 1990 and1995 reflects the difficulties currently being experienced by the higher education system in Russia, which also suffers from underfunding and an exodus of highly-qualified academic staff. It also shows that, despite official statements, university science still has not found its proper place in an integrated system of "science, education and industry". In the West university research laboratories take an active part in both basic and industrial research and in the innovation process in general. In Russia in 1995, for example, university science accounted for only 10.1% of the total volume of research performed in the country.[55]

The material and technical base of R&D organisations has also deteriorated substantially. The purchase of scientific instruments and equipment for research units has practically stopped, so the available stock of equipment, becomes obsolete very quickly. Thus, the proportion of instruments and machinery corresponding with world standards in R&D organisations of the Russian Academy of Sciences is only 26% and only 19% of the equipment can be considered new – i.e., it has not been used for longer than two years, while 55% of it is more than five years old.[56]

The information base of Russian science has also been reduced considerably owing to an unprecedented increase in subscription prices for the domestic general and specialist press, to a decrease in the number of scientific journals and other research periodicals and to a shortage of hard currency for the acquisition of foreign scientific literature, handbooks and periodicals.

Russian scientists' opportunities for international contacts have also become considerably more limited. Their participation in international programmes, projects and expeditions is restricted by a growing lack of money for trips abroad, a sharp increase in the prices of air and railroad tickets and in charges for international postal, telephone and telefax services, and by visa formalities.

2.6 Performance

All this was bound to affect the academic performance of Russian scientists and experts and to bring about a lowering of the prestige of Russian science in the international community. While in the mid-1960s the average number of citations of papers by Soviet scientists in world academic literature was only about 30% lower than that of the Americans, by the mid-

---

[54] Aleksandr Spiridonov, "Science Cities Require an Experiment", *Finansovye izvestiya*, 30 October, 1997, p. II.

[55] *Russian Science in Figures 1996*, *op. cit.*, p. 8.

[56] Naido and Simanovsky, *op. cit.*, p. 9.

1990s this gap had increased in favour of the USA by a factor of nearly fourteen.[57] While in the early 1980s the former USSR was ahead of the USA and Japan with respect to the annual registration of inventions, now the volume even of national patenting has dropped several times, to say nothing of Russia's foreign patenting, which has now dropped to below the level of a medium-sized American company. Russia's income from selling licenses on the world market has also dropped considerably and now constitutes less than 2% of US earnings from this source.[58]

More than 80% of inventions in Russia remain unclaimed by the national economy, i.e., they find no practical application. "It is very difficult to put them into practice in domestic industry, because in Russia there is no government innovation policy."[59]

As a result, the technological lag in Russian industry is growing. The average age of production machinery and equipment increased from 10.8 years in 1990 to 14.1 years in 1995; accordingly the share of equipment that is less than five years old dropped from 29.4% to 10.9%. Modernisation of the products of the machine-building industry has all but stopped. The share of new products in this industry has fallen from 6.4% to 2.6%.[60]

The commodity structure of Russian exports has also been impaired. It is now similar to that of such developing states as Zambia or Lesoto. Russia still earns money for reform and debt servicing by exporting mainly fuels and raw materials. In 1996 fuels accounted for 45% of Russia's total exports and metals for about 15%, while the share of machinery and equipment was slightly over 9%.

Only 10% of the finished goods produced by Russian industry meet international standards. They are therefore seriously uncompetitive. According to the assessment of the International Economic Forum in Davos, which annually determines the competitiveness of forty-eight leading countries on the basis of 378 criteria, in 1995 Russia came last in this group, lagging behind China (34th place), India (40th place), Mexico, Poland, Hungary and even Venezuela.[61]

The substantial underfunding of R&D activities in agriculture has meant that no new farming machinery or equipment has been developed or supplied to the agrarian sector. As regards the yield of farm crops, the lag in output between Russia and countries with a well-developed agricultural sector has grown even further. Russia has become a country that imports between one third and one half of its consumer agricultural products.

---

57 Simanovsky, Strepetova and Naido, *Brain-Drain from Russia*, *op. cit.*, p. 42.

58 Lev Makarevich, "The Authorities Do Not Control the Disintegration of Production", *Finansovye izvestiya,* No. 9, 11 February, 1997, p. II.

59 Valeriya Bulanova, High Technology Paves Way for Production, *Finansovye izvestiya,* No. 43, 17 June, 1997, p. II.

60 Rogov, *op. cit.*, p. 6.

61 Aleksei Portansky, "Export of Raw Materials Still Enables Financing of Russian Reforms", *Finansovye izvestiya,* No. 1, 14 January, 1997, p. VII.

It is quite obvious that the lack of a proper state policy on science and technology has brought about a deterioration in both quantitative and qualitative economic indicators, resulting in turn in a decline in labour productivity. If in 1990 it was three times below the US level, it is now more than five times lower.[62]

All of the above clearly shows that the scientific and technological factor in the development of the national economy has been and is still being severely underestimated by the Russian leadership. It has not found a proper place either in economic doctrine or in the socio-economic development of Russia. "Never before have knowledge, expertise and intellectual potential in the sphere of science and technology been so little valued by the authorities."[63]

2.7 Social Protest

Of course, Russia's scientific community could not remain indifferent to the developments in national science and technology. The first signs of a deterioration in the R&D sector emerged at the very beginning of the 1990s and prompted an immediate reaction. Numerous memoranda were filed with the Presidium of the USSR (later Russian) Academy of Sciences, with the Council of Ministers, with the State Committee (later Ministry) for Science and Technology, with the Supreme Soviet of the USSR and then of the Russian Federation, which was later replaced by the State Duma. Many articles published in the domestic and foreign press called attention to the plight of Russian science and to its importance during the transition to a market economy. But amid the heady atmosphere of the early period of reforms in Russia, turbulent political events relegated the problems of the R&D sector to the background and the alarm bells sounded by worried members scientific community went unheard and therefore unanswered.

As the symptoms of a crisis in science became more obvious (delays in payments of salaries, the closure of research institutes, staff dismissals and falling living standards), people working in the R&D sector got together to organise various forms of social protest. Some of these, such as strikes, street demonstrations and picketing continue to be used throughout the country even today. In July, 1995, in a rather unusual form of protest, three young meteorologists shut themselves in a cage with an orang-utan at Moscow Zoo and fixed a tag to the cage saying "Genus Homo Sapiens, Species Researcher". They demanded that this species be entered in the Red Book as an endangered species, thus implying the probable disappearance of scientists as a social category.

More dramatic was a twelve-day hunger strike by Academician Vladimir Strakhov, director of the Joint Institute of Earth Physics at the Russian Academy of Sciences in October, 1996. This event sparked off an unexpected mass protest by the scientific community in the form of trade-union meetings and demonstrations, which resulted in a special session of the RAS Presidium at which Academician Strakhov made a statement about the state of Russian science. This was later brought to the notice of Prime Minister Viktor Chernomyrdin.

---

62 Rogov, *op. cit.*

63 Makarevich, *op. cit.*

A tragic form of protest against the crisis situation in science took place on 31 October, 1996, when Academician Vladimir Nechai, director of the Federal Nuclear Centre "Chelyabinsk-70" (16,000 employees) committed suicide in desperation at the delay in salary payments both to the centre's employees and to the inhabitants of the city of Snezhinsk (46,000 persons) who were fully dependent on the centre.[64]

But the most widespread, "silent" form of social protest is the phenomenon known as the "brain-drain" or the mass-scale exodus of scientists, engineers and other intellectuals from R&D, education, and culture either abroad or to other spheres of activity not associated with their previous professional background.

3. The Brain-Drain

3.1 Emigration Abroad

The desire to emigrate has been growing among Russian intellectuals for quite a long time, but during the Soviet period emigration was officially allowed – under the pretext of "reunification of families" – only for certain ethnic groups (Jews, Greeks, Spaniards, and some other minorities). It assumed significant proportions in the late 1970s with the liberalisation of the rules for Jewish emigration and increased considerably again in the late 1980s and early 1990s reflecting the greater respect for human rights and freedoms that characterised the Gorbachev era . A Law on Immigration to and Emigration from the USSR was enacted in 1991, which considerably simplified the procedure for leaving, and introduced many new forms and channels (e.g. to Germany) of emigration.

While the emigration of ethnic minorities is motivated primarily by such factors as the restoration of national dignity, the wish to stop being treated as a second-class citizen, and the hope of a better future for oneself and one's family, labour migration – the exodus of scientists and specialists going to seek temporary work abroad – is motivated by the wish for better opportunities for creative self-expression and academic work and for better living conditions, i.e. mainly by socio-economic factors.

Although it had been predicted that some 200,000-250,000 representatives of Russia's intellectual elite would emigrate, the number of scientists and engineers who actually took up permanent residence abroad was about 75,000 , i.e. about 10% of those employed in the R&D sphere of Russia. In 1992 4,572 scientists and engineers emigrated, in 1993 – 5,976 (the year the Immigration and Emigration Law came into force), in 1994 – 5,171 persons and in 1995 – about 5,000.[65] In more recent years the volume of permanent emigration has gradually fallen, with about 3,000 persons a year emigrating in 1996 and 1997. Even lower figures are ex-

---

[64] Sergei Leskov, "Nuclear Scientist Driven to the Bullet", *Izvestiya,* 1 November, 1996, pp. 1-2.

[65] Stanislav Simanovsky, "The Intellectual Redivision of the World", *op. cit.*

pected for 1998- 2000.[66] The reason for this is that the pool of potential emigrants has been exhausted– "those who wanted to leave have already gone".

However, it is not the quantitative but the qualitative aspect that matters, since it is the most able and talented scientists in their most productive years who are leaving the country. While still in Russia these people frequently headed research teams, generated new creative ideas and commercial hi-tech projects which did not get off the ground in Russia but instead were realised abroad. In many cases the loss of such people is irreversible. For example, A. Zinberg, formerly a shift engineer at the Moscow home electronics repair plant and the author of more than 30 of 100 crucial inventions for producing high-resolution TV (the new generation of TV technology), emigrated to the USA. Russia thus lost the opportunity to develop its own high-tech equipment in this field and over time it will probably spend millions in hard currency to import it from abroad.[67]

A considerable portion of Russian scientists have gone abroad for temporary work, mainly on a contract basis. The scale of this exodus is substantially higher than the permanent emigration of intellectuals and constitutes an important component of the whole "brain-drain" process. According to some available estimates, in recent years some 8,000-10,000 scientists and engineers a year have gone to work abroad.[68] However, these numbers are likely to be reduced in the foreseeable future owing to worsening employment conditions in the West, the relative saturation of the intellectual labour market world-wide (except, perhaps, in Latin America and China – a promising area for labour migrants from Russia).

To date, about 4,000 of Russia's best researchers have taken up temporary work abroad; of these about 1,000 have long contracts and are hardly likely to return home. 20% of them are doctors of science. In total, Russian science has lost about 40% of its world-class professionals. These are the scholars without whom scientific schools are deprived of their international renown and the ability to make technological break-throughs.[69]

A more subtle form of "brain-drain" is the recruitment of Russian scientists and specialists by foreign companies located on Russian territory. These people, who earn much higher salaries than their colleagues at domestic enterprises, are in effect working not for the economy of Russia but in the interests of their foreign employers, which do not always coincide with Russia's interests; such people are thus partly or fully excluded from the national economy and "emigrate" without actually going abroad.

A rather widespread opinion is that the "brain-drain" is actually a kind of safety net for many representatives of the domestic intellectual elite and a means of preserving Russia's R&D

---

66 Oleg Ikonnikov, "The Wasted Brains" of Russian Scientists, *Nezavisimaya gazeta – Nauka,* No. 2, 6 February, 1998, p. 9.

67 Simanovsky, "The 'Brain Drain'. Is it Inevitable?", *op.cit.*

68 Marina Volkova, "The Export of Labour is Not Such a Profitable Business", *Nezavisimaya gazeta – Politekonomiya,* No. 1, 13 January, 1998, p. 5.

69 Marina Kalashnikova, "Russia Has Lost 40% of Its Best Brains", *Kommersant Daily,* 29 November, 1997, p. 11.

potential, since the results of the creative activity of former Russians will eventually return home via the internationalisation of science and technology. To find out whether this opinion is valid, the interests of all parties affected by the "brain-drain" process should be taken into consideration. These interests may be divided into four groups: the personal interests of the emigrants and migrants themselves who, as a rule, gain from changing their citizenship or place of residence; the national and state interests of the home country (donor country), which bears certain losses; the national interests of the host country which, as a rule, benefits from the influx of a highly-skilled workforce into its economy; and, finally, the interests of the world community, which does not lose anything but rather gains from such exchanges, since the contribution of an intellectual to global civilisation is higher the better the conditions are for his creative activity and home life.

Therefore, the only party to lose out in this process is the donor country. According to UNESCO, Russia's losses from the "brain-drain" amount to some US-$ 30 billion.[70] In view of this the donor country is to some extent justified in taking appropriate legal and economic measures to prevent possible damage or to minimise it, as well as in claiming a certain amount of compensation for the actual damage associated with the departure of researchers and specialists abroad either temporarily or permanently. This, however, necessitates the elaboration of organisational and legal measures on both national and international levels in order to reconcile the interests of all affected parties in the "brain-drain" process while respecting human rights and freedoms.

3.2 The Internal "Brain-Drain"

In addition to the scientists who have emigrated abroad, a much larger number, faced with low salaries and unemployment, have left the science sector for jobs in administration or in the private sector. This process is known as the internal “brain drain”.

This process has had the most detrimental effect on industrial science and manufacturing in general, where the exodus of skilled engineers and specialists has led to a lowering of professional competence, technological discipline and safety standards. As a result there has been an increase in the number of accidents, especially in the mining industry, in rail and air transport, and at industrial plants and power stations, which in many cases have produced ecological disasters. In 1996, for example, 1,030 technology-related accidents took place in Russia claiming 1,655 victims, while in 1997 the figure was 1,062 with more than 43,000 victims.[71]

No less alarming is a situation whereby underpaid or unemployed academics are paid by criminal gangs to manufacture drugs and to produce illicit alcoholic beverages, foodstuffs, pharmaceuticals and cosmetics. Recently, such "science-intensive" fields as the design and manufacture of arms, the production of ammunition and radioactive materials, and the hacking of bank computers and other information networks have been added to this list. The scale of such activities has yet to be fully realised in Russia.

---

[70] *Ibid*.

[71] "Russia is Threatened...", *Novoye izvestiya,* 25 December, 1997, p. 5.

The "brain-drain" process, both internal and external, raises the question of what is the minimum number of scientific personnel that Russia can afford to have under the present economic conditions in order to try to stave off the worst effects on its R&D potential.

To answer this question, we suggest a notion of a so-called "critical mass" of national intellectual potential (including its research and engineering components), below which a country is doomed to long-term cultural and creative backwardness, to marginalisation in international science and technology, to permanent dependence on foreign material, financial and intellectual resources and, ultimately, to the loss of its economic and political sovereignty.

The "critical mass" of researchers and engineers can generally be defined by such indicators as the proportion of R&D expenditure in the total GDP, since the size of the personnel component of R&D depends on the volume of funding for science and technology as a whole According to expert estimates, the destruction of the national R&D potential might occur when the portion of expenditure on R&D remains at or below 1% of GDP a year for 5-7 years. Only when the share of R&D expenditure reaches 1.5-2% of GDP can the economy be expected to benefit, with a 5-7 year time-lag.

The data in the previous section (Table 2.3) show that in recent years spending on R&D as a proportion of GDP has been consistently below 1%, thus clearly indicating a trend towards the irreversible destruction of Russia's national scientific and technological potential.

The notion of a "critical mass" of national intellectual potential is closely related to the technological security of a country. This can be defined as the minimum permissible level of scientific and technological development needed to permit the simple reproduction of technology and to allow the survival of the national economy using the country's own intellectual, financial and material resources. It must also be able to guarantee its defence sufficiency and its technological and economic invulnerability in the event of an unexpected or foreseeable change in internal and/or external political and economic conditions.

There are a number of both external and internal threats to the national technological security of Russia. At present, however, the threat of the destruction of the national R&D potential is becoming one of the most significant internal threats.

3.3 Russian Science and the International Community

The West has come to the rescue of Russian science – less out of charity than out of fear. The concern felt by the international community about the "brain-drain" from Russia's MIC, particularly from its nuclear sector, derives from the fear that nuclear and other technology for the manufacture of weapons of mass destruction may find their way to "hot spots" of ethnic and regional conflict or may fall into the hands of terrorists. There are about 8,000 Russian nuclear specialists potentially ready to emigrate because of difficult conditions at home. About 500 former Soviet nuclear specialists have been working abroad on various projects in nuclear engineering in such countries as Iran, Iraq, Libya, Algeria and North Korea.[72] In an interview with the newspaper *Le Figaro* during a visit to France in January, 1998, General Aleksandr. Lebed', former secretary of the RF Security Council, said that before 1990 the USSR had produced "mini" nuclear bombs of below 30 kg in weight. These bombs had subsequently disappeared together with the scientists and engineers who developed and produced them.[73] Since 1992 forty-two illegal attempts to take radioactive materials out of Russia have been recorded.[74] "Human proliferation" from the arms industries of Russia and Ukraine is becoming an important new irritant in US relations with those two countries and a growing threat to global security."[75]

As a response to this threat, the International Scientific and Technological Centre was opened in Moscow in March, 1994, by the RF, the European Union (EU), the USA and Japan, later joined by Sweden and Finland. The Centre renders financial support to 12,500 persons formerly employed in the Russian nuclear sector of the Soviet MIC. By the end of 1996, the funds allocated for the Centre's projects amounted to about 60 million ecus.[76]

The beginning of financial assistance to Soviet science dates back to 1989 when the TACIS (Technical Assistance to CIS countries) was formed after a "G7" summit in Paris. This organisation is now carrying out hundreds of technological projects in the countries of the former USSR. In 1992 in Brussels an International association for the promotion of partnership relations with scientists from the CIS countries (INTAS) was established. In 1993 the INTAS launched 509 projects of costing 21 million ecus. In June 1996, a special training course for radiation protection was initiated in Russia under INTAS auspices. The total budget of INTAS and the radiation protection programme in 1996 was 70 million ecus. The EU also supports some other programmes and projects in the former countries of the USSR. While 120 million ecus were allocated for assistance programmes in 1994, for the period 1995-1998 about 60 million ecus a year have been provided on average.[77]

The technological assistance (comprising the transfer of "know-how", professional training, consulting and co-operation in R&D) provided by the West ("G7" countries) for 1991-1996 constituted US-$ 6.5 billion, or 8.2% of the total international assistance given to the Russian Federation. This aid has been used to support the implementation of more than 4,800 projects on Russian territory.[78]

---

72 Stanislav Simanovsky, "Conversion in Russia: International Aspects", *Herald of the Russian Academy of Sciences*, Vol. 66, No. 6, p. 457.

73 Radio Liberty, 24 January, 1998.

74 *Izvestiya,* 12 May, 1996.

75 Gordon Adam, "Only Scientific Co-operation Can Modernise Industry", *Finansovye izvestiya,* No. 105, 14 November, 1996, p. VI.

76 Gordon Adam, "Only Scientific Co-operation Can Modernise Industry", *Finansovye izvestiya,* No. 105, 14 November, 1996, p. VI.

77 *Ibid*.

78 *Finansovye izvestiya,* No. 103, 5 November, 1996, p. VIII.

Apart from this intergovernmental financial assistance to the Russian R&D sector, a considerable amount of money has been invested in the preservation and maintenance of Russian science by various public organisations and private foundations (such as Soros, Mac-Arthur, Fulbright, Mitterrand and many others), whose total contribution to the financial support of science in Russia now amounts to nearly US-$ 1 billion. Altogether, external assistance to Russia's R&D sphere can be estimated at US-$ 1.2-1.3 billion annually. This is a large amount of money and is comparable with the annual volume of governmental expenditure on science and technology (US-$ 2.2-2.5 billion). The onus is on Russia to use it as productively and efficiently as possible.

4. Current Reforms

Of course, it would be unfair to say that during the period in question nothing has been done at all to preserve Russian science, to adapt it to economic reforms and to give it a place in the new, tougher socio-economic environment.

Both legislative and administrative measures have been taken to consolidate the R&D sphere, to protect its funding from arbitrary cuts, to save the most promising areas of research and, hence, to retain the most qualified personnel. With a view to helping Russian science to survive, a package of legislative measures has been adopted whose purpose is to provide financial support to outstanding scholars and talented young researchers. Bonuses are paid for academic degrees, higher stipends have been awarded to the most talented students and postgraduates (1993) andthe minimum salary of the Russian Academy of Sciences has been raised and subsequently linked to inflation (1994).

State support of Russian science of a more general kind has been provided via such legislative acts and governmental ordinances as, for example, On State Support for the Development of Science and Technological Innovation (1995); the Presidential Decree on the Doctrine for the Development of Russian Science (1996); the Law on Science and State Scientific Policy, which set the minimum level of funding for the R&D sphere at 4% of the state budget (1996); and governmental ordinance No. 543 On Urgent Measures for Strengthening State Support of Science in the Russian Federation (1997).

A system whereby support is guaranteed for basic and applied research as well as for innovative activities was introduced via the establishment of state-funded foundations, such as the Russian Foundation for Basic Research, the Russian Foundation for the Humanities, and the Foundation for the Promotion of Small Enterprises in the R&D sphere (1992-1994); forty-one areas of "top priority" research were given the status of federal goal-oriented programmes and as such qualified for independent financing; sixty-one top-level R&D institutions were given the title of "state research centres" and received preferential financial and material support.

On the administrative level, a decree issued by President Yeltsin in 1995 established a special Council on Scientific and Technological Policy under his auspices and the same year an interdepartmental government commission on R&D policy headed by Prime Minister Chernomyrdin was established. The RF Ministry of Science and Technology has been reformed several times since 1990 and its minister was given the rank of first deputy prime minister until July, 1997, when this post was taken over by Vladimir Bulgak, former minister of communications.

Attempts have also been made to adapt the R&D sphere better to the principles of a market economy. This has included encouraging research institutions to find alternative sources of financing, the privatisation of about 1,100 R&D organisations since 1991, and a broadening of the scope for the commercialisation of research and information activities. Industrial and technological parks have been established with the aim of promoting the closer integration of science and industry and to make innovative activity more efficient. There are now more than thirty technoparks in the country, about fifty technological and business 'incubators' and eight technological innovation centres. These bring together research institutions, technological 'incubators' and the production facilities of industrial parks. An international network of research and production associations of this kind has been formed in Western Europe and will probably eventually include similar Russian organisations. There are now about 50,000 small enterprises operating in Russia's R&D sphere. This number is still small, though. In Germany, for example, there are about 200,000, and Bulgak estimates that Russia needs between 1 and 1.5 million of them."[79]

On 8 January, 1998, the RF Government enacted its "Concept for Reforming Russian Science for the Period 1997-2000" which comprises a set of immediate measures directed mainly at reorganising internal funding for the R&D sphere in order to make more productive and efficient use of it . The principal measures are as follows:

- compiling an inventory of all existing R&D organisations with a view to revealing areas of duplication in their work and uncovering organisations using their scientific status to engage in activities other than research while still receiving the tax breaks and other benefits accorded to a scientific organisation;
- providing new accreditation – i.e., making a complete list of scientific institutions all over the country to be approved by the government (10-15% of R&D institutions are expected to fail to prove their "scientific" status and will be either reorganised or disbanded);
- professional certification of the personnel of the accredited organisations to reveal and dismiss non-productive workers;
- financing R&D programmes and projects on a competitive basis (rather than simply allocating funds to institutes and researchers);
- the creation of "venture funds" for financing innovative activities;
- introducing a contract system of payment for employees of the R&D sphere to replace the salary system;

[79] Elizaveta Ponarina, "Accreditation – Not an Easy Task", *Poisk,* No. 49, 29 November – 5 December, 1997, p. 3.

- the closer integration of the R&D and education systems and the provision of incentives such as higher salaries, better living conditions and broader opportunities for an early scientific career in order to attract to talented young people into science;
- the creation of a better environment for encouraging private investment in science and innovation via appropriate legal and economic mechanisms.

All of these measures, however, appear to be tactical rather than strategic in character, aimed at the immediate or short-term elimination of "bottlenecks" in the R&D sphere. The concept lacks any kind of strategy for medium- or long-term scientific and technological development in Russia. It is also doubtful that even these emergency measures will obtain the full measure of promised financial support (13.5 billion denominated roubles for 1998) given Prime Minister Chernomyrdin's promise on 23 February 1998 (The Day of the Defenders of the Fatherland) to double army salaries and to provide all the families of military servicemen with housing by the year 2000 not to mention proposals to cut the 1998 state budget by 28 billion roubles.

The task which Russia faces is to change the paradigm of socio-economic development away from a monetarist approach and the extensive exploitation of natural resources to an intensive use of human capital, science and innovation. This is especially important in view of new global trends and processes, the character and speed of which may reshape the future pattern of the world and the economic and political positions of individual states, including Russia. One of the global processes currently taking place is the – intellectual redivision of the world. This means that countries are competing for possession (in addition to territories, capital and technology) of the last undivided world resource – the human intellect, i.e. for the creators and carriers of up-to-date knowledge and advanced technology. If Russia's leadership fails to appreciate the full implications of this process and does not act immediately to preserve and foster the national scientific and technological potential, the country risks being consigned to the technological backyard of the twenty-first century and being excluded from the mainstream of global socio-economic progress.

At present there is still hope that Russia will soon come to realise the necessity of formulating and implementing a proper state R&D policy that would speed up socio-economic transformation and help to make it a success and that would allow Russia to regain its position in international science and technology and integrate it more closely into world civilisation.

Stanislav Simanovsky

Science and Technology in Russia

Problems and Prospects

Bericht des BIOst Nr. 18/1998

Summary

Introductory Remarks

The following report provides a survey of what has happened in Russian science in recent years. It illustrates the problems that exist in all areas of the research and development process and examines the reasons for the state of crisis. It then discusses possible ways out of the crisis that would allow Russian science once again to assume its proper place in society and to play an active role in the transition to democracy and a market economy.

The report is based on statistical and factual information published by the Russian parliament and government as well as on official documents, statistical yearbooks and information provided by the Russian Ministry of Science and Technology and the Academy of Sciences. It also draws on articles published in specialist periodicals and in the press.

Findings

1. Science in the former USSR was an integral part of the national economy, a fact that had a far-reaching effect on the way it was structured. First of all, science in the Soviet Union was clearly oriented towards the needs of the military. There was no "spin off" or conversion process, so that in terms of funding, intellectual potential (quality of personnel), material base and research results, there was a great difference between R&D in the military sector and that in the civilian sector. This also resulted in the relative isolation of Soviet science from scientific developments in the rest of the world.

2. The economic reforms, which began under Gorbachev's *perestroika* and then entered a new phase following the break-up of the USSR, had a lasting impact on the situation in Soviet science. During this period, namely, the science sector was completely neglected by the political leadership. The crisis in Russian science is not, however, just a product of the legacy of the Soviet command-and-control administrative system but is above all a symptom of the profound socio-economic and political crisis that has engulfed practically all aspects of life in Russia.

3. Since the beginning of the 1990s all components of Russian scientific and economic potential have been severely damaged. This is reflected most clearly in the funding situation on which the scope, scale and structure of Russian R&D depends. Indeed, there is not a

single area of Russian R&D that has not been affected by the current policy for financing science. The situation is aggravated still further by the fact that taxes, prices and charges for communal services, power, communications, publishing and rents have risen steeply. If this is taken into account, then the real level of funding for science lies between 6-7% (Abalkin) and 3-5% (Fortov) of the previous level.

4. The considerable reduction in the volume of state funding for science has also had a negative impact on the internal funding structure of the science sector. Although personnel costs today make up the lion's share of the costs in any scientific institution (approx. 43-45%), salaries in science are now much lower than those in many other sectors of the economy.

5. This development has resulted in a substantial reduction in Russia's research potential. Whereas in 1992, following the break-up of the USSR, about 5 million people worked in science and other related areas (of whom almost 3.2 million were in Russia), at the beginning of 1995 the figure had fallen to 1.1247 million. The 2.1 million scientists (as opposed to support staff) working in the former USSR in 1992 had decreased to 643,300 in Russia by 1995. In other words the volume of personnel in the science sector was reduced to a third in the space of three years.

6. The exodus of specialists from the R&D sector has also had repercussions for Russia's network of research and development organisations. Owing to a continuing lack of funding, these have, with a few exceptions, been unable to adapt themselves to market conditions and develop a new profile. Many institutions have been closed down and their research teams disbanded. As a result, many research centres and scientific schools of world renown have ceased to exist. Other large R&D organisations have been broken up into smaller units and renamed in order at least to save the jobs of their staff.

7. All this was bound to have a detrimental effect on the academic performance of Russian scientists and to damage their prestige abroad. Whereas in the mid-1960s the average number of citations of papers by Soviet scientists was about 30% below that of their American counterparts, by the mid-1990s the gap had widened so much that it was now factor fourteen. In the early 1980s the USSR was far ahead of Japan and the USA in terms of the number of new inventions registered annually. Now the volume of national patents registered has fallen to a fraction of what it was then. Moreover, the number of foreign patents registered by Russia annually now equals that of a medium-sized American company.

8. A further consequence of the lack of funding is that many scientists are leaving the sector, some of them to go abroad in the hope of finding better conditions for creative work and better living conditions for their families. However, despite initial predictions that 200,000-250,000 members of the intellectual elite might emigrate, only about 75,000 scientists and engineers have decided to take up permanent residence abroad. In 1992, 4,572 scientists emigrated, in 1993 – 5,976, in 1994 – 5,171 and in 1995 – about 5,000. In recent

years the volume of emigration has gradually decreased to about 3,000 per year for 1996 and 1997. The number is expected to fall still further in 1998.

9. More important than emigration abroad is the internal "brain drain" – i.e., the exodus of researchers and specialists from the scientific sector into the administrative and business sectors. This process is a reflection of the currently difficult situation in the scientific sector where low salaries and unemployment are forcing a considerable proportion of personnel to change their profession and try their luck elsewhere.

10. Of course some efforts were made during the period in question to preserve Russian science, to adapt it to the conditions of a market economy and to give a place in the new, tougher socio-economic environment. Attempts were made to provide an administrative and legislative framework for securing the place of science and to protect the system of funding from arbitrary cuts, to preserve the most promising areas of research and to retain the most qualified personnel. These included legislative measures designed to provide funding for outstanding researchers and talented young scientists in the form of bonuses paid for academic degrees, stipends for the most talented students and post-graduates as well as an increase in the minimum salary paid by the academy of sciences and a linking of salaries to inflation.

Gelöscht