Working Paper

BASIC RESEARCH IN RUSSIA: HUMAN RESOURCES AND FUNDING

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WP-94-060
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Foreword

The major goal of the project "Research and Development Management in Russia's Transition to a Market Economy". is to advance the understanding of R&D management and to translate this understanding into practical advice to Russian policy-makers. The project is organized as a series of case studies and seminars and is aimed at bringing together Russian policy-makers and scholars with Western experts to exchange their views and research results in the field, and to promote further contacts and research collaboration among them.

Until now, five workshops on various aspects of R&D management have been held, and the first volume of papers presented at these meetings has been published (Serguei Glaziev and Christoph Schneider (eds.), *Research and Development Management in the Transition to a Market Economy*, IIASA collaborative paper CP-93-1, March 1993). Preparations for the second volume are currently underway and participants of the project have their studies in various stages of completion. This study by Dr. Leonid Gokhberg is circulated as an IIASA working paper to enable the author to broadly discuss his results with other project participants.

Contents

BASIC RESEARCH IN RUSSIA: HUMAN RESOURCES AND FUNDING

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1 Introduction

This paper describes the current status and recent trends of basic research in Russia, measured in resource terms.

The extensive growth in the numbers of R&D institutions, researchers and investment until the late 1970s provided the creation of an extremely large R&D base which was greater in scale than most of the industrially developed countries. It firstly concerns substantial highly-qualified human resources which made Russia famous for considerable achievements in basic research and military-oriented technologies.

The transition to a market economy has a strong influence on the resources of R&D in Russia. Changes in the objectives of economic, social, and political progress reflect in transforming the institutional structure of the economy, the fast growth of the private sector, the conversion of military industries, and the gradual integration of Russia into the world economy.

These processes take place in conditions of economic recession, rapid inflation, a growing deficit of the state budget, a worsening social situation, and political instability. Further progress of basic research in such a critical economic situation faces significant difficulties which should be observed in order to formulate an appropriate policy in this area.

The author is grateful to the Economic Transition and Integration (ETI) Project at IIASA for providing technical support.

2 Peculiarities of Basic Research Organization

Basic research in Russia is notable for specific features of institutional structure and organization that greatly influence its transformation in the transition period.

2.1 Traditionally, strong specialization of different parts of the national R&D system on different types of activity exist. Basic research has been concentrated in the

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academic sector (nearly two-thirds of the respective total), in a very limited number of R&D institutes mostly serving military industries and working independently of industrial enterprises, as well as in some elite higher education institutes.

The academic sector,[1] being the principal performer of basic research in Russia, consists of the Russian Academy of Sciences (RAS) and branch academies (agriculture, medical sciences, education). Contrary to the majority of scientific academies in the West, the RAS and the branch academies have been established, historically, as the bodies administering the network of R&D institutes separated from industry and higher education. At the beginning of 1993, the academic sector included 729 research institutes.

Formally, the highest body of the RAS is the General Assembly members—academicians. Academicians, being mainly directors of the major Academy institutes, the most prominent military research units and universities, are representatives of the political and social elite of Russia. The status of an academician is extremely prestigious and includes some top-level government officers, ministers, and members of parliament. They form a network for the Academy's influence on political decision-making. The competition for the elections of Academy members is still very high: in 1994 there were 1097 applicants for 122 vacancies.

The RAS, like other branch ministries, existed under the centralized planning system with the following hierarchical structure: the Presidium on top, sectoral and regional departments in the middle, and research institutes at the bottom (see Figure 1). The Presidium is elected by the RAS General Assembly and is responsible for the operative management of the Academy. In the past, it was in charge of allocating funds and material resources to the institutes, as well as approving their research plans. The institutional structure mentioned is maintained by the Academy leaders endeavoring to keep administrative levers of control of research institutes' activities. Currently, when the Academy institutes are financed mainly from the Republican budget or through the state S&T programs both of which are under the responsibility of the Ministry of Science and Technological Policy of Russia, the role of the Presidium in administering research units is declining. In this situation it is evident, that pretensions of the Presidium do not correspond with the objectives of the Academy institutes, particularly the largest ones, and, in fact, the opposition of some institutes' heads to the Presidium is strengthening.

Basic research in many important fields (nuclear and high-energy physics, mechanics, space exploration, new materials, computer sciences, electronics, etc.) has been developed as an integral part of military-oriented research. These kinds of strategic, i.e., oriented, basic research are being performed in some institutes of the RAS as well as in the specialized research units of extraordinary large institutions of military and atomic industries.

As a whole, basic research exists within the framework of tough administrative subordination of research-performing units. This leads to strong group interests and inertia of activity.

[1]It is necessary to distinguish the academic R&D sector in the Russian meaning from the traditional Western concept of academic R&D performed in universities.

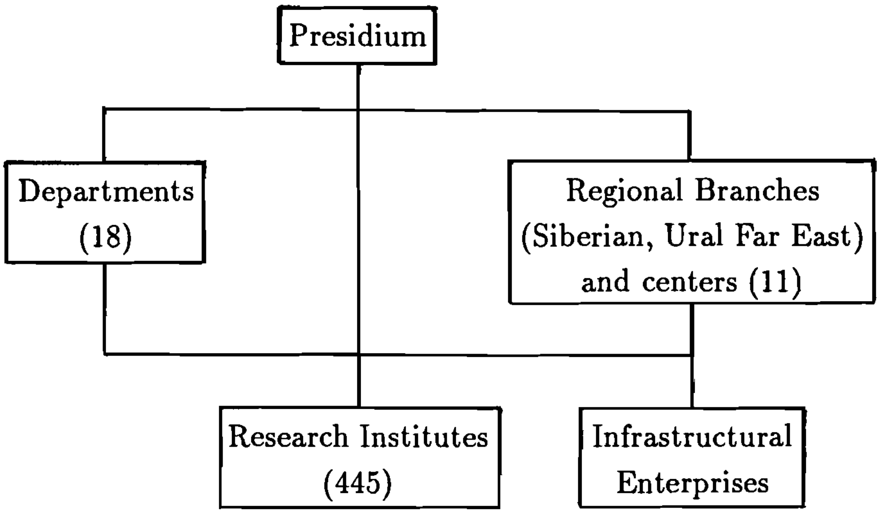

Figure 1: Institutional Structure of the RAS

2.2 For decades, the expansion of basic research in the former Soviet Union has been considered from the viewpoint of both political prestige and sustaining the military potential of the nation. It has been supported by a large-scale system of state actions implemented in various forms: direct budget funding, centralized supplies with imported research equipment, construction of modern buildings for the most prestigious institutes, currency appropriations intended for missions abroad and purchases of scientific literature, legally approved privileges in salaries and even in the duration of holidays. The Academy owns a network of libraries, a publishing house, a book-selling company and 193 scientific magazines. A ramified social infrastructure has been established in the RAS for providing its employees with housing, medical and childcare services, foodstuffs and consumer goods, whereas researchers in other sectors were deprived of such incentives.

This has created a very high prestige of employment in the RAS versus that in the industrial R&D institutes and higher education sector, and served as an attractive factor for involving skilled personnel in academy research. Recognized research schools were created in many fields of science and technology. Simultaneously though, the mentality of a "spoiled" academic researcher arose, and many people in the Academy nowadays cannot adapt themselves to current changes and modern requirements while, along with qualification, dynamism is necessary for individuals.

2.3 Regional distribution of basic research has tended to be concentrated in the developed regions with intensive economic activity, especially in the largest cities. This is true both for the former USSR and for Russia and determines the scale of basic research potential of the former Soviet countries and regions of Russia. Thus, almost three-fourths of the total basic research in the former USSR was performed in Russia. Russia's contribution (75.1%) was seven-times higher than that of the Ukraine (10.8%) which ranked second in this share; the gap was even greater in other countries.

Russia's basic research in many fields used to be the source of progress in science and technology in other newly independent states, the disintegration of the Soviet Union threatened their further development. At the same time, some advanced institutions and unique facilities of All-Union importance (like the Crimean and Armenian observatories) are located outside the Russian Federation. Russian scientists lost access to some 30% of information funds which now belong to other republics. It is reasonable and mutually beneficial to maintain long-term cooperation between Russia and the former USSR countries in basic research.

In Russia the Central Economic Region accounts for about half of the total value of basic research, with Moscow contributing 42% of the national total. West Siberia (13.3%) and the North West (7.4%) regions take second and third places, by their percentages of the basic research total, because major centers of the Academy of Sciences—its Siberian Branch (Novosibirsk et al.) and St. Petersburg Center respectively—are located there.

The uneven geographical distribution of basic research and the differences in economic regions in terms of scientific capacity by size and specialization have been influenced by political reasons and historical traditions and it is impossible to overestimate the value of those factors. The network of academic research institutions and leading higher education establishments in the former USSR is concentrated mostly in the largest cities—capitals of the former union and autonomous national republics, centers of the administrative regions. It was connected to their administrative functions, concentration of central and local governmental bodies, as well as to the better standard of living in the largest cities. Historically, the first institutions of the Academy and universities were established, for example, in Moscow, St. Petersburg, Kazan, Vilnius, Kharkov, Kiev, Lvov, etc. The major centres of scientific and technological information, libraries, and archives are also sited in the largest cities.

Besides, the very limited opportunities for allocating new institutions and expanding those already in existence in the largest cities influenced the formation of the so-called science cities at the periphery of the agglomerations. Thus, the Moscow Region is famous for the centers of academic research in biology (Puschino), physics (Troitsk), nuclear energy (Dubna, Protvino), chemistry (Noginsk), agriculture (Nemchinovka), etc. Many monofunctional science cities oriented to nuclear and military research (like Arzamas, Obninsk, etc.) have also provided outstanding contributions to the advancement of basic knowledge.

The former USSR Academy of Sciences was organized as a highly centralized administrative body, while republican academies and regional branches (Siberian, Ural, Far Eastern) existed as affiliations for solving local economic and social problems and serving for political prestige of republics and regions. In order to rapidly create a stock of researchers for the national republics special actions were undertaken including quotas for them to enter universities without competition and lower requirements for dissertations.

Until now, R&D capacities of the newly developing regions (North, East-Siberian, Far East) are mainly represented by the academic institutions. This predetermines the fact that the shares of such regions in the basic research total are somewhat higher than those in the national R&D total. Along with this, the major part of research efforts in the considered regions is devoted to environmental sciences (geology, oceanology, meteorology, forestry, etc.) which, for example, account for more than two-thirds of the total of R&D efforts in the North and Far East economic regions expressed in R&D personnel and expenditure terms. These researches, as a rule, head special expensive facilities and equipment and are strongly dependent on budget support.

2.4 Basic research in the former USSR has been developed under heavy pressure of ideological and political dogmas.

It concerns the strong political influence on setting priorities in basic research according, first of all, to military objectives, while biology and medical sciences, cybernetics, social sciences and humanities were pressed by ideological limitations and the lack of resources.

The autarchy policy in the economy and S&T sphere was also significant for basic research trends in this country. Following the traditions of the forced economic isolation of the USSR before World War II and negligible international cooperation during the "cold war", the new political era has led to a gap from world science. In some fields domestic objectives of scientific programs repeated those set abroad. It caused ineffective resource spending instead of gaining from the collaboration in international efforts and, at least, a gradual lagging behind the international scientific community. Thus, in spite of the prominent achievements in space research, nuclear physics, etc., the contribution of the former USSR to world S&T literature decreased in 1981–1991 from 8.0% to 6.7%, e.g., in mathematics from 7.6% to 4.4%, in engineering and technology from 7.6% to 5.6%, in earth and space sciences from 10.0% to 5.5%, in physics from 16.8% to 13.0%, and in chemistry from 16.7% to 12.4%. Only biomedical research was marked by a slight increase in this share: from 5.7% to 6.9% (National Science Board, 1993, p. 424).

All these factors resulted in the heavy inertia in the basic research organization and the desire to maintain obsolete institutional structures. This hampers timely reactions to the changes in the environment and urgent structural transformations.

3 Human Resources of Basic Research

The complicated financial position of the majority of research institutions, decreasing R&D expenditure, fall in the prestige of R&D jobs, and low salaries in this sector influenced the declining employment in R&D. The number of R&D personnel[2] in 1989–1992 fell from 2.2 to 1.5 million or by almost 31%, compared to 5.2% for total employment and 12.7% in industry.

[2]Here and following, R&D personnel is defined as full-time personnel engaged in R&D or in direct R&D services. It is measured in head-counts whereas full-time equivalents are still unused in Russia.

Table 1: R&D Personnel of the Russian Academy of Sciences (in thousands)

	1989	1990	1991	1992
Total R&D Personnel	152.5	137.7	134.7	128.5
Researchers	83.8	78.5	80.0	77.6
Of those holders of advanced degrees	31.6	33.5	34.7	35.4
Technicians	9.7	8.9	8.5	7.6
Support staff	59.0	50.3	46.2	43.3

The Russian Academy of Sciences is less affected by the large-scale reduction of personnel compared to other sectors of R&D. R&D personnel at the RAS decreased by only 15.7% in 1989–1992; at the beginning of 1993 it numbered 128.5 thousand (Table 1).

The reduction especially concerned support staff. This can be explained by the urge to reduce overhead expenditures and a deterioration in the quality of R&D equipment. Technicians and support staff have become convenient categories of personnel to be laid off in order to preserve the stock of researchers. Not surprisingly, a deterioration in labor conditions of researchers and a reduction in their effectiveness have taken place.

The real potential of the academy sector manifests itself not only in numbers but also in the notably high level of qualification of its personnel. Against the general background of reduced R&D employment, the situation of highly-qualified researchers looks different. Thus, the number of doctoral researchers at the RAS grew by 12% in 1989–1992. The uneven decreases in the categories of R&D personnel and the absolute growth in the numbers of doctoral researchers have led to an increase in the share of highly-qualified personnel: 45.6% of researchers hold advanced degrees. The largest numbers of academic researchers are in physics and mathematics (21.5%), engineering (16.4%), biology (14.8%), chemistry (9.7%) and agriculture (9.4%), while shares in other fields of science do not exceed 1–7%.

This relatively favorable picture is a result of the Academy's policy of preserving human resources for basic research. It seems that the major portion of the scientists do not intend to leave the Academy because they consider research as their life's work and have already achieved some scientific results. According to the Center for Science Research and Statistics (CSRS) sample surveys, almost 85% of the academic researchers planned to continue their career at the Academy and only 2% of the respondents would undoubtedly leave. 44% of the researchers were not interested in any other careers, 23% were absolutely confident of the successful perspectives of their institutes and considered current difficulties as temporary. Only 10% of the respondents were unwilling to change jobs at pre-retirement age, and 8% continued to work at the Academy because of the difficulty of finding another job.

Employment at the Academy is also attractive for researchers because of the opportunity to combine their primary job with secondary employment in business companies. Analysis of the data of the CSRS sample surveys demonstrates the growth in shares of academic researchers partly employed in private firms: from some 35% in 1992 to 45% in 1993. Among administrators and senior researchers this was a little higher. 24% of the academy researchers who responded also worked as university teachers and 11% worked in industrial R&D institutes.

This factor, to some extent, is an explanation of reliable statistics of employment in the Academy. In order to overcome the deterioration of research units, the heads sometimes allow long-term unpaid vacations for staff members or transfer them to part-time jobs. This gives researchers an opportunity to keep their nominal employment while working somewhere else. However, it has a negative influence on the volume and the quality of Academy research. Evidently, it is especially difficult to combine employment in basic research with any commercial activity, that is why this type of research is threatened to a larger extent.

In the absence of strategic regulations aimed at urgent structural changes, the reduction of R&D personnel and the formation of S&T labor market are occurring spontaneously. The decrease in the RAS R&D staff has mostly concerned those engaged in research in economics (by 17.9% in 1991–1992), world economy and international relations (14.9%), and philosophy and law (14.8%). At the same time, employment in mathematical research institutes grew by 2.3%. In nuclear physics it decreased only by 0.1%.

Most of the RAS researchers who left did so voluntarily (85.8% of the total). 7.6% retired and only 6.6% were laid off because of direct staff reduction.

In this connection, the increasing outflow of especially highly qualified scientists and engineers to the business sector (internal "brain drain") should be mentioned. The widening opportunities for business and the revival of private property make entrepreneurship increasingly more attractive for qualified and enterprising people.

Higher revenues in the business sector are also a very important reason for the outflow from R&D. 90% of the researchers leaving the Academy mentioned this factor as a crucial one for their motivation.

In 1988 new management mechanisms in most R&D salary levels was introduced. At the beginning of 1989, for the first time in many years, the average monthly salary in R&D rose above that in industry. From this moment, R&D wages slowed down in comparison to the wages in the economy as a whole and in its leading sectors.

In 1992 this trend began to threaten R&D itself. If in 1990 the average monthly salary in the sector "Science and Scientific Services" was still 118.6% of that for the economy as a whole, and 113.2% of that in industry, in 1992, it decreased to 70.9% and 59.9%, respectively. In 1993 it already declined to 64.8% and 60.1%.

Since 1990, the Academy has lost its leadership in wages among other R&D sectors to enterprises and industrial R&D institutes, as a result, primarily, of an accelerated contract price growth for R&D projects in sectors with high shares of applied research and development (and not basic research which is financed from the budget). In 1992, wages in the academy sector were only near 82.7% of those in the R&D units of industrial enterprises.

With respect to wages in different fields of science, the sample survey of the CSRS showed that the highest level was in the geological and mineralogical sciences (80% higher than the average). In physics and mathematics, and engineering salaries of researchers were only 5.3% and 1.2% respectively higher than average, they were lowest in geography, humanities and agricultural sciences at 70% of the average.

In terms of salaries, researchers have suffered to a larger extent than other groups of the employed population. Table 2 is an illustration of the gradual worsening of researchers' well-being.

Due to the lack of an effective mechanism for social protection, galloping inflation, and the deteriorating consumer market situation means that wages can barely retain personnel in R&D institutions. By the beginning of 1993, wages in joint ventures were 2.5 times higher and in private firms 1.8 times higher than the average attained in R&D. According to the sociological survey, 34% of the RAS researchers who intended to leave the Academy indicated their desire to move to business companies. Many top-level managers of large business enterprises (banks, industrial groups, joint ventures, etc.), as a rule, have doctoral degrees. Under these conditions the government should appreciate and support individuals to continue work in basic research. Since 1994 state scientific fellowships have been established for prominent Russian scientists having outstanding research achievements, as well as for talented young researchers or post-graduate students. The fellowships are awarded for three years by the RAS Presidium.

The decisive role in the negative trends in human resources of basic research also belongs to the sharp reductions in the inflow of young qualified researchers. This is connected both to the reduction of S&T training and the decreasing interest of graduates in R&D careers.

Thus, the overall number of higher education entrants decreased in 1985–1992 by 18%. Respectively, the number of higher education graduates fell by 10.8%. The share of higher education graduates intending to work as researchers was 6% in 1976–1980, whereas in

Table 2: Average Monthly Salaries in the "Science and Scientific Services" Sector and Living Standard Indicators (rubles)

	1991	1992	1993
Average monthly salary in the "Science and Scientific Services" sector	558.0	4108.5	38051.5
Average monthly money income per capita of the population	465.4	3509.9	43969.0
Subsistence minimum per capita	200.0	*5700.0	*42800.0

* Data for December.

Source: Center for Science Research and Statistics, State Committee on Statistics of the Russian Federation.

1986–1990 it fell to 2%. In 1992 only 1.1 thousand graduates of higher education institutes started work at the RAS compared to 3.3 thousand in 1989.

The last two decades in general were characterized by an absolute decrease in the number of post-graduate students. During 1970–1990 it decreased by 7.3% in the former USSR. In Russia in 1986–1992 it declined by 22.2%, while the educational potential of post-graduate training as a whole is not utilized successfully. This is reflected in the fact that only about 20% of post-graduate students annually finished their candidate dissertations in 1990–1992. In the RAS institutes this share accounted for 13.5% in 1992.

The data of the CSRS sample survey of post-graduate students at major universities and engineering higher education institutes show that only 8.8% intended to work at the RAS institutes after completing their education, whereas 54.2% planned to join business companies.

The system of wages existing in R&D does not stimulate younger researchers. Those aged 30–34 years receive salaries at a level of 84% of the average, whereas researchers below 30 years of age have 73%. According to the CSRS estimation, researchers over 60 years of age are paid 50% higher than those in the 35–44 age group.

Both the reduction of the inflow and the growing outflow of young researchers have caused the ageing of R&D personnel. Almost half of those who left the RAS institutes in 1991–1992 were below the age of 40. At the beginning of 1993 only 42.3% of the RAS researchers were in this age group, while its share among doctors and candidates of science were 2.4% and 29.0%, respectively. 39.6% of the doctors of science at the RAS are of retirement age. The average age of the RAS full members ranges from 63 (economists) to 72 (researchers in the field of international relations). Even in the most dynamic fields of S&T, like nuclear physics, informatics, biology, the average age is 68–69.

Personnel engaged in basic research as one of the advanced parts of R&D employment feel the influence of the international migration of scientists and engineers and other kinds of external "brain drain".

Russia has become more open for international economic and S&T cooperation. Participation of Russian scientists and engineers in international S&T projects, the creation of foreign-related companies, their subsidiaries and joint ventures in Russia mean the actual entrance of this country into the international S&T labor force market.

On the other hand, the dissatisfaction of scientists and engineers with the social and political situation in the country, its welfare standards, existing low opportunities for implementating their research ideas make them look for a job or grant abroad. This often results in international migration for a temporary job or for continuing education and, finally, in emigration as well.

A recent special study of the emigration of researchers conducted by the CSRS using the data of the Ministry of the Interior of the Russian Federation made a statistical evaluation of the numbers of R&D personnel who have emigrated (Table 3).

Table 3: Number of R&D Personnel who Emigrated from Russia (in thousands)

1980	1989	1990	1991	1992	1993
0.14	0.95	2.1	1.8	2.1	2.3

This analysis seems to indicate that the process of the "brain drain" has not yet serious dimensions. The main part of the emigrant flow, as previously stated, is driven by ethnic factors; the labor market still plays a less significant role.

According to the CSRS survey of employment in the RAS institutes, 508 researchers left the RAS institutes in order to emigrate in 1991–1992. This represents some 0.8% of the total number of the RAS researchers. 13.2% of the emigrants were employed in general physics and astronomy, and 11.6% in biochemistry, biophysics and chemistry of physiologically active compounds. Most of the emigrants had a candidate degree (55.9%) or doctor of science (16.2%). Half of the researchers who emigrated were under 40 years old. Israel and the United States dominate among the receiving countries: 42.1% and 38.6%, respectively, of the total number of emigrants (Nekipelova et al, 1994, p. 32–33).

Furthermore, jobs in R&D abroad on contract are gaining growing importance. This concerns the most highly skilled and competitive specialists, often those with recognized scientific achievements. In the cases of those specialists not returning, this form of "brain drain", even if insufficient in scale, may have qualitative effects and represent a problem for the development of science and technology in Russia.

Thus, besides emigrants, 1701 researchers of the RAS were working on long-term missions (lasting over half a year) or under contracts abroad. 81.5% had scientific degrees and 60% were under 40 years old.

It is interesting to rank fields of science according to the share of researchers working abroad in respective totals at the RAS. Mathematics leads (12.1%) followed by biochemistry and biophysics (9.2%), then nuclear physics (4.9%) and general physics and astronomy (4.1%). A significant share of these researchers work in the United States (38.2%) followed by Germany (16.2%), France (8.9%), the United Kingdom (5.7%), Canada (5.2%) and Japan (4.1%).

4 Basic Research Funding

Problems of basic research funding should be examined in the context of the further decline of the role of R&D in the national priorities expressed in decreasing indicators of R&D expenditure.

R&D expenditure reached some 140.6 billion rubles in 1992 (Table 4). In Russia the annual growth of R&D expenditure calculated at current prices (12.8% in 1989–1991) was slightly ahead of that of the former USSR (11.7%) but insufficient to compensate for accelerating inflation. Measured in constant 1989 prices R&D expenditure in 1992 accounted only for 27.6% of that in 1990.

Table 4: R&D Expenditure*

	1990	1991	1992
Total R&D expenditure:			
million current rubles	13077.7	19990.7	140590.8
million 1989 rubles	11702.6	8735.3	3233.3
As a percentage of GDP	2.03	1.54	0.78

* Calculated in line with OECD standards.

The growth in R&D expenditure lagged behind the trends of main macroeconomic indicators. The share of the R&D expenditure in GDP declined from 2.03% to 0.78% in 1990–1992. Compared with the OECD data for this indicator, Russia falls to a level less than the median, into the group of countries with low R&D potential, such as Ireland, Spain, Portugal and Greece.

The value of basic research (exceeding expenditure by profit obtained by R&D institutions from this activity during the year) was some 19.8 billion rubles in 1992. Due to increasing short-term economic considerations, there are signs in all sectors of decreasing interest in long-term investments, such as R&D, and notably in basic research. Still keeping support of the Academy from budget funds taken together with the reduction of industry demand for applied research was the main reason of minor relative growth in basic research: its share increased from 8.8% to 10.9% of the national R&D total in 1990–1992. Nevertheless, Russia lags behind the leading industrial nations in terms of shares of basic research, which is 13% in the United Kingdom and Japan, 14% in the United States, 19% in West Germany, and 23% in France (National Science Board, 1991, p. 344).

In spite of the substantial transformation of the institutional structure of science, the government budget still remains the largest source of R&D funding (91.1% of the total current R&D expenditure in 1992) and almost the only one for basic research. The situation did not change even in 1993, i.e., the extremely centralized system of R&D funding is being maintained.

At the same time, the demand of the state for R&D has not been really formed yet, and, unfortunately, R&D spending is not considered as a high-priority objective of today's structural policy of the government. In 1991–1993, the R&D budget appropriations grew from 25.8 billion to 1232.8 billion rubles, but in 1991 prices, the 1993 budget allocations for R&D decreased by nearly two-thirds. For 1994, it is planned to keep them at the same level. The share of R&D in the total government budget of Russia is estimated for only 3.6% in 1993, whereas, for example, in the United States it reached 7.6% (National Science Foundation, 1993, p. 7).

In the structure of budget allocations intended for civil R&D and coordinated by the Ministry of Science and Technological Policy (MSTP) of the Russian Federation three main orientations may be emphasized (Table 5).

Table 5: Structure of Budget Appropriations on Civil R&D (%)*

	1991	1992	1993
Total	100	100	100
I. Program for maintaining Russia's R&D potential	79.9	58.7	57.3
II. Fund for Fundamental Research	2.0	3.0	2.1
III. Priority R&D objectives	18.1	39.8	40.6

* Details may not match the total because of rounding up.

1. R&D performed by R&D institutions of ministries and public agencies and integrated into the program for maintaining Russia's R&D potential (57.3% of the budget allocations for civil R&D).

   In 1991–1992, approximately one-quarter of these resources (or 16–17% of the total budget R&D appropriations) were intended to finance the institutes of the RAS and its regional branches. In 1993, a slowing in the growth rate of the Academy R&D budget was notable. As a result, the share of the RAS in the total budget R&D appropriations was reduced to 14%.

   Forming a new national science and technology policy the MSTP tries to strengthen a goal-oriented approach to budget R&D financing. This leads to a decrease in the funds intended for maintaining the R&D base while increasing those for priority programs. No wonder this policy meets with some resistance by R&D units' administrators.

2. Financing, by the Russian Fund for Fundamental Research, of basic research in the RAS, academies of medical and agricultural sciences, higher education institutes and R&D institutions.

   Initially, the resources of this Fund were planned to be some 3% of R&D budget financing (18.1 billion rubles in 1993), used as grants to finance basic research performed by small teams of researchers and individual scientists, the development of material and equipment bases of R&D institutions, the acquisition of scientific literature, fellowships, etc. The Fund is important for the support of research in specific fields (like theoretical mathematics, botany, zoology, linguistics, etc.) which, being outside federal S&T programs, are not provided with financing in the framework of R&D budget priorities.

   In 1994, the Fund already received 13.5 thousand applications. Now, the Fund pays more attention to financing individual grants for small teams (with no more than 10 researchers). This allows an increase in the number of grants of smaller sizes (on average, nearly 20 million rubles).

   The interest to obtain financing from the Fund for Fundamental Research is growing not only at the Academy, but also at universities and in industry. In 1993, the share of the RAS number of applications was some two-thirds and 65% of that of approved ones, whereas in 1994 it declined to 55% and 59%, respectively. The universities' percentages increased in 1993–1994 from 11% of applicants and 11% of grant recipients to 15% and 18%, respectively. Along with this, the participation of research institutes from the provinces is also growing.

According to a governmental statement, the allocations for the Fund will be increased to 4% of the total budget R&D appropriations.

3. Financing of federal S&T programs, intersectoral and industrial R&D in priority S&T areas, and also the participation of the Russian Federation in important international programs.

   In 1993, the allocations for these projects reached 360 billion rubles. As mentioned above, the continued growth in these funds and the shares of R&D in federal programs shows the strengthening of the goal-oriented approach in R&D budget financing and the efforts to concentrate limited financial resources on major objectives.

   A significant part of government S&T programs is devoted to basic research in high-energy and nuclear physics, high-temperature superconductivity, space exploration, genetics, biochemistry, chemical substances, exploration of the Arctic and Antarctic, etc.

   It should be mentioned that, in general, these programs coincide with those already established in the former USSR in 1989–1990. At the same time, the shares of the principal programs are now considerably small—approximately a tenth of what they were in 1989–1990. The dissipation of resources among particular programs does not provide a real growth of funds, especially when accelerating inflation is taken into account. Thus, the funding of research on superconductivity grew only 8.9 times at current prices during 1989–1993.

The worsening financial position of different sectors of Russian science influences the gradually growing concentration of basic research in the academy sector (Table 6). Its share in the basic research total increased from 62.4% to 66.4% in 1990–1992, i.e., it was 4.9 times higher than that in the total national R&D effort (13.6% in 1992).

This demonstrates the increasing role of the Academy for maintaining basic research potential. But for the Academy itself it is very complicated to keep the existing level of basic research. The recent trends in the structure of sources of R&D funding and objectives of financial resource spending have caused some changes in the character of the activities of research institutions. Thus, the increasing commercialization of academic research, its orientation to search for additional funding sources led to the growth of the of applied research share in the R&D total at the academy sector from 34.8% in 1990 to 39.3% in 1992, while that of basic research remains almost unchanged: 53.3% in 1992 versus 52.3% in 1990 (the remaining part of the Academy R&D, 7.3%, was devoted

Table 6: Percentage Distribution of the Basic Research Value by Sector of Performance

	1990	1991	1992
Total	100	100	100
Academy sector	62.4	64.6	66.4
Industrial R&D sector*	23.8	18.0	16.7
Higher education sector	12.9	17.0	16.8
Enterprise sector	0.9	0.4	0.1

* Research institutes, design bureaus, project and experimental organizations working independently of industrial enterprises. This sector traditionally also includes R&D units serving the government.

to development). In this case the institutes of the Far East and Ural branches of the RAS, where these shares achieved 84% and 73.2% respectively, are leading the academy R&D institutions. The academies of agricultural and medical sciences are oriented mostly towards applied research (the shares of basic research—22.5% and 31.4%, respectively).

Due to an unstable financial situation the Academy institutes are forced to perform projects which do not meet the objectives of their research. Thus, according to the CSRS survey data, in 60% of the surveyed research units some 10% of their research does not correspond to the profile of their activity, in 40% of all the cases this share is approximately 25%.

In the higher education sector there is a notable increase of basic research (both absolute and relative) which was connected with the decline of the demand for applied research and development. On average, basic research in universities and other higher education institutes accounted for 36.1% of the total value of R&D in 1992.

The disinterest of enterprises in financing long-term projects in the long run influenced the decreasing role of the industrial sector in performing basic research. The share of basic research in the R&D totals in the major industries is within the limits of 0.4–1.7%, but among them there are branches determining technological progress (chemistry, electrical machinery, instruments-making, etc.).

The decline in basic research efforts in industry is strictly connected with the conversion of military enterprises and research institutes which were recognized as significant contributors to its performance.

It is impossible not to notice the reduction of the share of R&D in total military expenditure. Thus, in 1989–1992 it decreased from 19.8% (USSR) to 10.6% (Russia). So, the R&D base suffered to a larger extent than military-oriented production. The chaotic and unplanned character of conversion threatens the further existence of many big research institutions of military industries and leads to the breakdown of links between R&D and industry.

Totally, budget appropriations on military R&D decreased by 21.4% in 1991, and by 16.5% in 1992. The share of civilian projects in the total R&D value performed by conversion R&D institutions was 32.6% in 1991. In 1992 it increased to 42% in the space industry, 46% in aircraft and 49% in the ammunition industry.

Nevertheless, growth in civilian R&D cannot compensate for the decline of military programs. Changes in the profile of military research units demand time and additional financing. Moreover, even budget appropriations on civil R&D projects were cut in 1992 by 38%. The savings in industrial R&D institutes usually start from the oriented basic researches, which are the first victim of the situation. The rate of its value decline is twice as high as that of the R&D total in military R&D institutions. Finally, even in this sector the share of basic research nowadays is less than 5% of the R&D efforts (CSRS, 1993).

The analysis of R&D spending by fields of science shows disproportions in the structure due to strong technocratic orientation (Table 7).

For many years, the main emphasis was on engineering which still accounts for some three-quarters of the total, while in the United States it does not exceed 50%. The gap is especially big in medicine (2% in Russia and some 10% in the United States) and in natural sciences (14.7% and 30% respectively). The natural sciences dominate the pattern of basic research in R&D institutions of Russia. Together with medical and agricultural sciences, they account for over 58% of all basic research.

Research is insufficiently oriented towards the solution of social and ecological problems, and the problems of human life. The shares in total R&D of medical and agricultural sciences and of informatics are very low, only 1–2%. In engineering the scale of pilot, future-oriented work is also very small. If the share of basic research reached some 33% in medical sciences, and in natural sciences even 40%, in engineering and informatics it does not exceed 5% and 10%, respectively. This does not provide the necessary background for developing prospective technologies.

Table 7: Percentage Distribution of R&D Expenditure by Field of Science*

	Research and Development	Basic Research	Applied Research	Development
Total	100	100	100	100
Natural sciences	14.7	49.8	19.7	5.5
Social sciences and humanities	3.1	7.1	4.1	2.0
Engineering	71.3	28.8	63.1	83.4
Agricultural sciences	1.8	3.0	3.0	1.1
Medical sciences	2.0	5.5	3.4	0.6
Information and information systems	1.0	0.9	1.3	0.9
Other	6.0	4.9	5.4	6.5

* Estimation on the basis of 1989 survey data.

The implementation of vital structural changes which are needed to prevent the further deterioration of the resource potential of basic research faces the influence of rapid inflation processes. In 1991–1992, along with the increases in material costs, salaries and labor-related costs (indexation and compensation payments, increased social security allocations, introduction of retirement tax) grew sharply. Depreciation rates for machinery and equipment were also raised. As a result, expressed in 1989 prices, the value of basic research in 1992 was only 0.43 billion rubles, or 20% of that in 1989. Sometimes the Academy institutes have no funds for current spending, as happened at the end of 1993, when some 10 institutes announced their desire to stop activities completely.

The lack of financing made it necessary to revise the distribution of current R&D expenditure at the RAS by the type of costs which was influenced notably by trends in wages and material costs, e.g., purchases of equipment (Table 8).

As mentioned above, the Academy's efforts to compensate for the sharp inflationary rise in the cost of living by increased wages were unsuccessful and have been made at the expense of other costs, notably material ones. In 1992, wages rose to 39.9% of current R&D expenditure at the RAS and, if social security fees are taken into account, 55.1% of the total.

The reduction in the shares of the material costs in current R&D expenditures which themselves are decreasing in absolute terms, is further aggravated by a rise in the prices for their principal components—small equipment, materials, fuel, electric energy, etc. In nominal terms, prices for some types of instruments and materials for R&D increased 30–50 times in 1990–1992, and prices for fuel and energy experienced maximum growth—80 times in 1992.

The lack of foreign currency and the fall of the exchange rate of the ruble reduced the import of research equipment and the acquisition of foreign scientific and technical literature to zero. The absence of necessary equipment and materials sometimes causes the termination of research projects.

The maintenance costs of buildings and premises rose substantially. According to a sample survey of the RAS institutes, in 1992 the volume of equipment supply decreased 10 times at constant prices, and by 25 times for chemical reagents and other materials (CSRS,

Table 8: Percentage Distribution of Current R&D Expenditure at the Russian Academy of Sciences by Type of Costs*

	1989	1992
Total	100	100
Wages	34.2	39.9
Social security fees	2.5	15.2
Equipment	23.3	6.5
Other costs	40.0	38.4

* For current expenditure financed from the budget. Estimated using the data of the RAS Presidium.

1993). Many advanced capital-intensive research institutions with expensive equipment and modern premises found themselves in a most difficult situation. The problems of financing the maintenance of unique experimental facilities and oceanographic research ships of the RAS are well-known.

Financial difficulties also caused a sharp reduction in the spending for R&D information support. According to the sample survey data, from the beginning of 1990 to April 1992, some academic institutes experienced, on average, an eight-fold reduction of the number of scientific journals received. Spending for information materials decreased 3 times at constant prices and 20 times for information networks services.

In 1989–1992 the purchases of research instruments declined from 23.3% to 6.5% of current spending and from 48.8% to 5.6% of capital R&D expenditure at the RAS. This hamperered the replacement of the huge stock of obsolete equipment (more than 11 years old) which, according to the 1989 survey data, accounts for nearly a quarter of its total value in the Academy sector. More than 30% of the Academy research equipment does not correspond to the world state-of-the-art level. Only an insignificant part of expensive R&D equipment—0.2% of the total stock—is above the best world technical standards. Given the decrease in the replacement of fixed assets, the qualitative characteristics of R&D equipment are worsening.

5 Conclusions

The analysis demonstrates that the resource potential of basic research in Russia is developing under the influence of unfavorable processes which may cause significant long-term detriment for the future of Russian science and technology. The transformation of the institutional structure of basic research and the revision of resource policy in this area are urgent. Basic research is to be considered as the high-priority objective of budget funding but, simultaneously, it is necessary to increase the involvement of the scientific community in the management of this sphere and distribution of resources, e.g., through really independent expertise of projects.

Thorough state support of basic research should include strengthening the Fund for Fundamental Research, the expansion of the system of grants, the introduction of tax incentives for private and foreign investments in basic research, purchasing of equipment, infrastructure services, etc. While transforming the Academy towards establishing associations of independent research teams, it is essential to avoid an administrative campaign of breaking-up academic institutes into smaller units. Specialized cooperative units for basic research involving academic researchers as well as those from military R&D institutes may be organized under the major universities. In order to maintain the basic research potential of industry it is useful to help the respective units become independent non-profit ones, e.g., in association with parent institutes.

International cooperation is also helpful and is supported both by the Russian government and the world community. The coordination of efforts, widening opportunities for

Russian scientists to participate in international projects, the establishment of cooperative research units of different institutional forms, and the creation of philanthropic funds are among the variety of possible actions.

Permanent statistical monitoring of basic research trends (including ad hoc surveys) should be introduced to provide the necessary information for policy-making.

Bibliography

CSRS (1993), Razvitie nauki v Rossii (Research and Development Outlook in Russia), (in Russian).

CSRS (1994), Science and Technology in Russia: 1993. L. Gokhberg and L. Mindeli (eds.).

National Science Board (1991), Science and Engineering Indicators—1991. Washington,

National Science Board (1993), Science and Engineering Indicators—1993. Washington.

National Science Foundation (1993), Federal R&D Funding by Budget Function, Fiscal Years 1992–94. Washington.

Nekipelova, Elena, Gokhberg, Leonid, and Mindeli, Levan (1994), Emigration of Scientists: Problems, Real Estimations. CSRS.

OECD (1993), Science, Technology and Innovation Policies. Federation of Russia. Background Report. Paris.