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Science and technology in Russia: Collapse or new dynamics?

The Russian Laboratory

The development of science and technology in Soviet Union and now in Russia offers an interesting and even unique example of the interconnections in the development of science, technology and society especially as concerns the societal preconditions of the institutionalization of science. In the current Russian transition though, we should more specifically speak about the deinstitutionalization and potential reinstitutionalization of science.

Present day Russia is actually a huge "laboratory" for sociology and science studies. In laboratory studies of science it has been often stated that laboratory is actually a mess. In the Russian case we may speak of an overall turmoil where everything is connected to everything, even if some things seem to change very rapidly or even daily – e.g. political power relations – while some other things show much more inertia – e.g. cultural and institutional factors and, unfortunately, innovations in industrial practice. This complex interrelatedness of the different aspects of Russian transition, its systemic nature, necessitates a complex approach also in the study of science and technology. As concerns for instance Russian academic science in the current situation, it is no more as powerful and self-regulating an institution as it used to be, but greatly affected by external social, political and economic forces which are defining its future fate and potential functions. It is obvious that Russian science already has lost some of its previous functions while the new and compensating ones are still to emerge.

Bearing these societal connections in mind, this article has a general and discussive orientation[1]. Instead of limiting itself to academic science or some parts of it, the problems of the whole R&D system in Russia will be discussed in a broader societal and economic context which at the moment looks especially relevant.

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The Socio-economic Transition

In spite of more or less universal endeavours and increasing international cooperation, national R&D systems are basically children of their own society. They are still primarily subordinate and highly dependent on the national economic, political and social forces and demands. The global fatherland (Morin, 1993) as a subject of science is still very weak, even though it will necessarily become stronger and more active in the future. In the Russian case the national societal character, if not closure, of the R&D system is emphasized most and therefore it seems appropriate to start from the basics, i.e. from the socio-economic situation and its transition in Russia.

Pjotr Schedrovitsky (1994) has described the current situation in Russia as an overall systemic crisis of societal transition which means that effective subjects or agents of social transformation that really could influence and control the development are still missing. So far he has found only three types of effective agents or micro-entities which have some capacity of effective functioning:

1) middle-sized cities in case they have sufficient resources of their own,
2) some of the so called post-soviet transnational corporations, or fiscal-industrial groups, which have multiple functions and abundant resources, and
3) small new firms with active qualified staff able to develop new activities. These micro-agents still have a marginal impact on the development of society as a whole.

On the macro level the systemic transitions are advancing much slower. According to Schedrovitsky the major changes were started by the ideological transition in 1991 and were then followed by transitional changes in the political system. The next step ought to be the build-up of a modern legislative and administrative infrastructure and only then, if things go well for some three-four years, could a real reform of the national economy begin. Improvements in the living-standard and everyday life of the great majority of people would hopefully follow then. Concomitantly the new social demand for science and technology will depend on this slow transition process and on the future perspectives of political stabilization and socio-economic reconstruction. A major turn should not be expected to take place too soon.

The systemic scheme of Schedrovitsky looks quite logical and well argued. It is understandable that the Russian economy, which now develops as "wildly" as once upon a time in America, needs new institutional infrastructure – legal, economic policy, financing, taxation, etc. – which cannot be created from scratch. In Western countries this institutional and cultural infrastructure has taken centuries to develop (see Gerner and Hedlund, 1994). As indicated by a recent study (Kharkhordin, 1994), the cultural transformation of introducing the individualistic "spirit of capitalism" in Russia has already been started by some groups of economic actors.

On the other hand it is obvious that time is getting short in order to stop the decline in the economy, especially as concerns the main traditional areas of Russia's industrial potential. The economic reforms of liberalization and privatization have so far effected mainly some sectors of trade and commerce while their influence on the main industries has remained very limited, except the decline in output.

Vladimir Pastuhov (1994) has interestingly analyzed the economic development in terms of the formation of different capital groups in Russia. He concludes that the two new capital groups – the international capital and the speculative commercial capital – that have profited most from the economic crisis are quite satisfied with the status quo and have little interest in the long-term stabilization and development of Russian economy. Their interest in utilizing Russian R&D is limited and short-term as well. This is indicated for instance by the unofficial (and uncheckable) estimates that from 40 to 150 billion USD of "privatized" money have been transferred to foreign banks and not invested to revive the Russian economy. The third

capital group, the old national capital, consists of national industries such as resource, material and machinery industries which constituted the main bulk of former Soviet economy. This national capital would have a real long-term interest in the development of economy and its R&D potential. Unfortunately, the national capital group has suffered the largest losses during the transition (both on the civil and military side) and therefore is out of funds (in fact, in debt) and unable to renovate its activities.

The major problems of conversion are also related to this basic situation. Conversion from military to civil products in Russia as a rule means a shift from the rich international market or preferential domestic market (state orders) to poor domestic consumer markets. The military-industrial firms used to have a monopoly position and that is why they are rarely competitive in civil production, especially if they have to compete with foreign high-tech products.

The overall situation in the Russian economy is very critical and controversial. The economy needs time to create new economic and industrial policies and institutional preconditions for a market economy, or more properly perhaps, a Russian type of mixed economy. On the other hand it is politically and economically impossible to wait for too long and let the traditional industrial potential collapse. This latter alternative would have unpredicted consequences for Russian society; even the well known tolerance of the Russian people would hardly be enough to stand it. The price for anticipated economic reforms would become too high and Russia would possibly return to a centralized control of the economy and society, but now on a considerably lower economic level than before perestroika. For science, except perhaps military R&D, this would be the worst scenario of all. The new closure of society would probably mean deeper stagnation and new international isolation of science, on the one hand, and massive emigration of R&D experts, on the other.

To prevent this scenario of further decline and collapse of national industries from coming true, it is possible that new steps in economic and industrial policy will be taken that may change the liberalization policies of the past years. These steps may well be in line with an interesting report and recommendations of Japanese specialists from MITI (Ministry of international trade and industry; Ota et al., 1993; see also Kharkhordin, 1994).

In analyzing the Russian economical situation Ota et al. (1993) conclude that it is very similar to the one that prevailed in Japan in 1945–49, a post-military regime period characterized by production decline, high inflation and international isolation. The Japanese analysts suggest strong industrial policy measures which are in stark contrast with the macroeconomic monetary and fiscal policies recommended by Western experts, which clearly have failed (cf. Gerner & Hedlund, 1994). The MITI report emphasizes the need to create an emergency program for Russian-style industrial policy in order to stop the decline and save the basic industries. Priorities should be set from the bottom up beginning from the resource industries (oil, coal) and then proceeding to material (steel) and machinery industries which again would support the resource industries. This policy could gradually create a steady basis for the other more diversified industries and also for export, which is essential in order to acquire new technology from abroad. Also the huge industrial monopolies should be carefully split up in order to create necessary competition and business management practices inside the country. This could gradually create new real demand for industrial R&D. Between lines the report also suggests that in order to carry out preferential industrial policy the government should assume a more active role in steering the economy.

The suggested policy scheme looks symphatetic as it emphasizes the basic potential strengths of the economy and shows a feasible and not-too-distant way up from the present "wild" situation in the Russian economy. It outlines a possibility to cut the vicious circle in the economy, which is equally vicious for the development of science and

technology. The alternative scenario (as far we can judge) would thus be a combination of gradual, but necessarily quite slow, introduction of the institutional and practical elements of modern market economy, on the one hand, and more controlled emergency measures to save and to renovate the key industries, on the other. In post-war Japan the basic economic crisis was over in 4 years and the new national policy produced a technological miracle in thirty years. To be sure, Russia is not Japan. It has little previous market experience except from very distant pre-revolutionary times and from the more recent black market activities. Russia has created its own model, with specific economic, state and R&D structures that have grown during the socialist era in isolation from the international economy. Following the Japanese model may be psychologically controversial as well, as it implies in a certain sense the recognition of a time lag of half a century.

The Utopia of Science-based Progress

The communist utopia of the Bolsheviks, which from the very beginning emphasized economic and social progress in the name of science and technology, was actually rather successful for a long time. It lasted until the 1960s, and maintained the idea that the Soviet Union and later other socialist countries could develop in (relative) isolation from the world economy and compete with the developed capitalist countries on the basis of their own socialist science and technology. Still during the first wave of scientific and technological revolution in the 1950–60s (as Nesvetailov, 1990, calls the era of nuclear energy, quantum electrics and space technology), the Soviet science and technology still could show their strength and innovative capacity, even though mainly in the military sphere. During the 1970s and 1980s this innovative capacity (e.g. as measured by new inventions and state prizes on S&T; Nesvetailov, 1990) gradually weakened, in spite of extensive investments and continued growth in the sphere of R&D. As the second wave of STR – characterized by such predominantly civil fields as microelectronics and biotechnology – then began at the turn of 1970s and 1980s, the Soviet science and technology system was no more able to meet the challenge and its hidden stagnation became gradually evident.

What have these mainly economic considerations to do with the transition of Russian science and technology? The answer is that the specifics and problems of past Soviet and present Russian science have been closely connected with the development and problems of the economy, directly or indirectly. I believe that in the future this connection will be even more critical than before. The fate of the Russian science and technology system will greatly depend on the prospects of the Russian economy and its innovative capacity, which will mainly determine the future national demand for R&D. Actually, the concept of scientific and technological revolution (STR) is still most relevant in this respect. In the economically developed capitalist countries the interrelations and interdependences of science, technology and production have grown all the more stronger. This development is also reflected in the rather novel concept of "national innovations systems" (e.g. Lundvall, 1992) even though the concept is necessarily not valid any more. Actually, innovation systems are becoming more or less international or regional; e.g. in some sense it would be already possible to speak of a "European system of innovations", and perhaps some time in the future about a "global system of innovations".

It is quite paradoxical that when Soviet philosophers and politicians introduced the new key concept of STR in the early 1970s, the actual development of the economy gradually stagnated and started to diverge from this strategic ideal, while some capitalist countries like Japan proved to be very successful in implementing the main principles of this concept. To put the essense of STR briefly, science and technology have a strategic and in that sense a leading role in the

innovation system, but their usefulness is dependent on the developmental level of industrial and societal practices, which also determine the demand and resources for R&D. The balanced development of the different elements of innovation systems is thus crucial. Interestingly, in Japan, where the hard side of the science and technology sphere (i.e. material applications) has developed rapidly and successfully, more and more attention in science policy is currently given to "soft S&T" (Sub-Panel on Soft Science and Technology, 1992) which includes the human aspects and their interface to hard S&T.

The Russian society is facing quite opposite problems and threats, a potential and to some degree already factual build-down of the innovative elements of the economy and society. During the early 1990s the gross national product has decreased by 30–50 % (according to various estimates and depending on how to calculate the size of shadow economy). At the same time there have been parallel and even larger cuts in the funding of R&D. As a consequence, the overall status of science and the material position of scientists has weakened dramatically. On the other hand, the suddenly born crisis situation has created (by force) new dynamics and mobility in the scientific community. By the way, it looks that Marx was quite right in emphasizing the decisive role of the economy and its productivity for the development of the larger society.

The critical question, however, remains: how much of the best scientific potential will survive in the short and longer run in the turmoils of Russian economic and social transition, and how much and what parts of scientific and technological activities will become obsolete or a "useless decoration for society" as one academician from St Petersburg put it last year. It should be held in mind that to build-down societal institutions, especially scientific infrastructure, is much easier and quicker than to build them up again.

In the following I will have a somewhat closer look at the main specifics and problems of the Soviet/Russian R&D system, especially the academic one, and its transition from past to present, and to future.

On the Specifics of Soviet Science and Technology: or What Went Wrong?

The historically expansive development of science in different institutional forms and societal contexts has reflected the growing importance and legitimacy of scientific knowledge for various societal purposes and audiences. Science has invaded new social spheres and expanded its social influence and practical functions through technological applications. The main logic of the institutional development of science has been quite similar in different countries even though major national specifics still exist. In general, the center of scientific activities has shifted from academic (or university based) research through governmental (or sectoral) R&D to industrial (private) R&D. Japan represents the leading edge in this development with the share of over 80 % of private industrial R&D (see Nakayama, 1991). In Western countries the once independent academies of science have practically converged into the university based research systems.

The Soviet research system developed into directions quite different from the international main line and as such represents a unique case in the world. It should be reminded that before 1917 Russia still followed the European model. In addition to the independent Academy of Sciences, universities were also developing an active research orientation and Russian scientists were internationally mobile and visible (e.g. they won a relatively higher share of Nobel prizes per scientist than the US scientists).

The Soviet Union developed into a major political superpower, with strong and centralized state authorities. The idea of the strong state was visible already in the earlier history of Russia and it greatly influenced the status and functions of science. Science became a constitutive element of the state and political power already in the times of Peter

the Great. The high status of scientific eminence resulted largely from its political and symbolic functions. Prestigious science brought glory and might to the state and the Bolsheviks" utopia of scientific communism further strengthened this historical tradition. The historically high position of science is interestingly visible in the old architecture of St. Petersburg and to a lesser degree also in Moscow.

The main structural characteristics of the later Soviet R&T system were the following (figures depict the situation in 1990–92; OECD, 1994; Russian country report related to OECD study, 1993):

1) A strong, prestigious and independent Academy of Sciences that has had the main responsibility for basic research while having little connections to universities and other R&D institutions (589 research institutes and 11% of total R&D funding).
2) Weak university sector that was devoted to teaching and higher education and had little research activities (450 higher education institutions and 6 % of total funding).
3) A massive system of sectoral research organizations that was subordinated to numerous branch ministries with an orientation to industrial R&D, both civil and military (3574 research institutes and 78 % of total R&D funding).
4) A strong and prestigious complex of military R&D that was formally part of the sectoral research system (above) but at the same time strictly separated from the other sectors and located under the so called "nine" ministries; the biggest "dinosaurs" being the ministry of defense and the ministry of atomic energy. The complex included 70 closed and privileged cities and some 800 research institutes, 200 of which have been closed by now (the estimates of military spending vary between 43–70 % of total R&D funding).
5) Weak and non-developed research activities at the enterprise level (according to latest estimates some 400 enterprises have inhouse R&D activities which account for 5 % of the total funding).

At present, the whole S&T system is still practically funded by the state (89 % in 1990) and it is heavily concentrated in the central parts of the country (45 % of the potential is located in the Moscow region and 15 % in the Leningrad region). The overall picture is thus quite the opposite compared with Western countries and especially with Japan, where business enterprises dominate in R&D funding and S&T institutions are rather evenly scattered all over the country (e.g. the new regional science cities and parks). The typical research units in Russia are also much bigger (average size before cuts was 300 scientific workers) than in Western countries (average staff in US is ca. 100). The Soviet R&D system was developed according to a socialist "industrial organization" model, which explains its huge scale. It grew extensively when new sectors and research "plants" were established to solve new problems, especially under the numerous branch ministries.

The main weaknesses of the R&D system were also the same as in industry: it was internationally isolated and domestically departmentalized in monopolistic and more or less closed entities. Communication, cooperation and also competition between the various units was hindered by many factors such as administrative barriers, overemphasized care for secrecy, political (and philosophical!) control and the formalized division of labour which was guided by official research programs and plans. Coordination and integration of different scientific and technological fields was up to the higher authorities; as a researcher you did better just to stick to your own piece of the given problem and not worry about the bigger issues.

Attempts to solve the big strategic problems by establishing large scale science cities (*naukograd*) could not avoid facing similar problems. An example of an ambitious mega-project is provided by Academgoro-

dok, a famous Siberian science city, which was founded as early as 1957 and in 1990 had a population of 70,000 people (see Castells & Hall, 1994: 41–57). Despite the abundant resources and highly qualified scientists the city was not, however, able to fulfill the promises of promoting technological innovations and economic development in the region. The good, even avant-garde idea did not work in practice. In their evaluation of the city Castells and Hall conclude, that the main problems in Akademgorodok were related to the lack of dynamics in the science-industry complex. It did not succeed in solving the internal and external problems of communication and interaction between the scientific and industrial units. The administrative structures and the organizational logic of the Soviet economy "forbade the formation of a true complex of technologically-led production" (1994: 56).

In the 1980s, as the structural problems in science became more evident, the administrative piecemeal programming of scientific activities created a counter-reaction from the part of official science policy. The institutes and researchers were now criticized for concentrating on "small topics" (*melkotemye*) only and not being able to solve the big ones! In actual practice the programming and planning ideology itself had proved to be quite ineffective.

As concerns the really active researchers they used to have a double structure of research thematics, one officially planned for them and the other, unofficial, reflecting their own personal research interests. Thus there were actually more cognitive dynamics in research practice than the official structures and the plans would tell (see Lubrano, 1993). Within the hidden, unofficial structure of Soviet science several intensively discussing communities and important scientific schools were created. Famous examples of these "kitchen seminars" and "pub clubs" have been for instance the literary studies circle around Mikhail Bakhtin and the Moscow methodological school that was created by Georgi Schedrovitsky and others (Alexandrov, 1993). But the official structures dominated the hidden structures and were stronger in conflict situations.

In the Academy a special problem was gradually created by the leadership, the academicians and directors of the institutes who were elected by non-scientific criteria. Meyen (1990 has called this dilemma "the vicious triangle" in which academic degrees, administrative positions and economic privileges were combined. A joke that was told by a government official some years ago also reflected the common awareness of this problem. "What is specific about the general meeting of the Academy of Sciences? It is the only forum where academicians and scientists meet each other!".

This inbreeding, bureaucratic closure and lack of real scientific competition and mobility in the research "industry" had a negative effect on the quality and originality of research in many fields. Even if several excellent scientific schools and collectives survived and still exist (e.g. in physics and mathematics; that is mainly in areas that are not socially sensitive), in general academic science became gradually more stagnated. It was unable to meet new challenges, define new priorities and flexibly change its orientation towards new emerging thematics (e.g. from the main fields of the first STR, physics and space research, to biotechnology and microelectronics). As Nesvetailov (1990) concludes, this was one of the main reason why the Soviet Union could not compete in the second wave of the scientific and technological revolution.

The same downward trend in the qualitative development of basic research is visible in the Nobel prize statistics: in 1975–85 Soviet scientists received only 1 out of 62 prizes. In addition, academic science was isolated from the technologically most advanced fields in the closed military R&D and thus could not utilize and diffuse its results. The massive quantitative growth of Soviet science still in the 1970s and 1980s could not compensate these basic structural weaknesses and the lack of dynamics and competion in academic science.

In addition to internal problems of stag-

nation, Russian academic science and the whole R&D system have suffered equally or even more from the external problems of knowledge diffusion and utilization especially in economy and industrial production. The past Soviet economy can be characterized as a monopolistic, non-competitive deficiency economy which has been based on secured orders from the state authorities. This created a "lazy" practice where enterprises and other social organizations had little need for quality competion or competition in general, and hence little demand for qualitative development and differentiation of new products. Innovations and new products just meant extra costs for state monopolistic enterprises; to continue the supply of the same old products was both the most profitable and the easiest way to function. Actually this has been the main concrete reason for the stagnation and the low quality and productivity in Russian civil economy . Even if there were orders from the industry for new technological innovations and products, their utilization was usually limited to the one enterprise or customer only. In military industries the situation was different; it was necessary to develop new technology due to severe international competition.

The processes of innovation and technology diffusion which are of vital importance for any capitalist economy, have been practically non-existent in the Soviet economy and other social practices. This has resulted in a dual technological gap: one between the military and civil technologies and the other in relation to developed capitalist economies, especially in the civilian sector. The whole Russian technology system is thus suffering from a major structural imbalance. The medium or meso level technologies are actually lacking between the extremes of military high-tech and civilian low-tech. This structural polarization is most harmful in the current transition toward market economy.

The noncompetitive industrial practice of the Soviet period also explains the extremely slow progress in the field of information technology and services, a strategic and key area for modern industrial and social development. Despite the slogans of advancing the scientific and technological revolution and information society, there was little actual need to develop and introduce new facilities and systems for transferring scientific, technological and managerial information. New kind of information or more effective information transfer was not necessary. In a noncompetitive situation the old ways of handling with administrative information were good enough.

These basic dilemmas affected directly and indirectly the development of the R&D system. Weak or non-existent pull from the social practice (except political demands and control) resulted in the weakening of science and its potential push to promote innovations and practical knowledge. Of course, this left more room for theorizing and "self-realization" which constitute important motivating factors in science. To be sure, self-realization produced some excellent results in Soviet science, but also a lot of abstract contemplation and speculative thinking (e.g. the non-realistic visions of the advantages of socialism in promoting scientific and technological revolution). Here we have an example of a strange "dialectics" between science and practice. But the major problem for Russia remains: how could this vicious dialectics be broken in order to launch a new innovative dialectics upwards? Is a deep and forceful crisis the only alternative to create a "new order out of chaos", to put it in Ilya Prigogine's words?

The Present Crisis

A painful transformation is currently under way in the Russian R&D system. The processes of deinstitutionalization (cf. Etzkowitz, 1992) still prevail over the potential prospects of reinstitutionalization. At the moment it is not yet possible to clearly see where the road is leading and what will be the final outcome. Much will depend on the economic transition which was discussed in the first section of this article. However, an interme-

diary summary and some speculations can be presented.

Russia has lost its geopolitical super-power functions, and the centralized state and political power structure has been broken down, even though the latter process may prove to be partly temporary. Accordingly, Russian science has lost its ideological, political and symbolic (prestige science) functions as a major state agent and now stands on a low priority level in public policies. Science has been pushed off the pedestal. It has fallen into a "vacuum" where it should find new functions to compensate for the losses and stop the downhill drop.

The new compensating functions may be gradually developed by showing practical utility in various areas of economic and technological activity, social technology included. The creation of new functions, however, is not easy in the interregnum of identity crisis and disorganization that penetrates the society. Positive steps forward will greatly depend on the emergence of new social subjects (cf. Schedrovitsky, 1994) – in the economy, government and civil society – that would be able to act effectively and control their activities in a purposeful way. The new effective demand for R&D will only grow in the wake of these activities, not before.

As concerns the current decline, the OECD team (1994) that examined the Russian science and technology policy situation last year has calculated that in 1992, which was the most difficult year for science, the overall R&D funding declined from 2.2 % to 1.0 % of GNP. The salaries have dropped to a level of only 70 % of the average salaries which is hardly enough for minimum subsistence. The total number of scientists and engineers was calculated to be a little less than 1 million in the beginning of 1990s. Last year some 700.000 remained which means that 280.000 people (almost 30 %) had already left the R&D institutions. Some studies estimate that among the remaining scientists, almost 50 % have a secondary job, which indicates a high level of hidden unemployment in research institutes. The OECD team, however, states that the R&D staff is still considerably oversized and will continue to drop to the level of some 300.000 scientists and engineers, i.e. only 30 % of the original number.

The brain drain abroad has so far remained rather limited. In 1991–92 some 5000 scientists left more or less permanently, and the total number of those staying for a longer period of time abroad is estimated to be about 20.000. There are hopes that part of the emigration will prove to be "swinging" (Fomin et al., 1993; Kugel, 1993), not permanent. An intensive interview study by Fomin et al. suggests that the threshold for emigrating is actually quite high both on the push and pull side. In particular, the military scientists rarely regard emigration as a realistic option. Interestingly, the cultural factors and problems of anticipated adaptation into a new research and social environment play a major role in scientists" considerations. It may be that the younger generations with better language and cultural skills will have less such social and psychological constraints. Anyway, in the long run the presently uncontrolled international opening of Russian science may prove to be one of the most important positive results of the present crisis.

The centrifugal forces from the "vacuum" of Russian science are so strong that the new science policy principle "survival of the best" of the scientific elite may not function as it is hoped. The best researchers are not fired, of course, but among those who leave voluntarily there are all categories of R&D personnel. In addition to many less qualified persons leaving, there are young active talents who prefer profitable business, and there are also older top level scientists who move abroad. The picture is thus mixed and controversial. In the future the scientific institutions will need to create new incentives and better overall working conditions to attract the best scientific talents. This concerns especially the younger generation in order to avoid the emerging generation gap in science to grow too wide. The same concerns the endeavours to tempt foreign researchers to visit to and to stay in Russia.

In 1991–93, when governmental support

to science collapsed, a kind of free market for science and technology products was created. Researchers started to actively market and sell their intellectual property and services to domestic and international customers through newspapers and other media. Later on this new activity has considerably decreased which may be due to several factors, such as the declining demand from the part of the business community, the continuing indeterminacy of intellectual property rights or the price/quality level of the services offered. This open and "wild" R&D market, which obviously does not have direct counterparts in other countries, can also be understood as a transitional phenomenon in a situation where the old research system suddenly lost its position and was replaced by the new slogans of market economy. As the new commercial structures did not exist yet the researchers had to try to create the markets by themselves. At that time, for instance, one pedagogical university in Siberia was actively developing a marketing strategy to sell its products, i.e. teachers and other pedagogical services.

It is obvious that the market oriented R&D, which so far has developed rather slowly and weakly, will gradually assume more institutional and in-house characteristics as the industrial and commercial demand for R&D increases in the future. The situation somehow resembles the well-known problem of "crossing the valley of death" while starting new business activities.

Meanwhile, large parts of the Russian scientific and technological potential lie "fallow". Many excellent scientists have not been able to find market demand for their knowledge and skills proper. To survive and to keep up hope of continuing their scientific activities, scientists are often forced to do things quite different from their professional activities. I have, for instance, heard of a potential Nobel candidate in laser physics, who is selling vegetables and other products in the street market. The critical and, from a personal point of view, often tragic question concerns, how long can a top level scientist preserve his/her qualifications if they are not properly used. If the valley of death is too wide and deep it may be impossible to survive as a scientist in the longer run. Especially in rapidly advancing hard science fields scientific knowledge and qualifications may get obsolete in a relatively short period of time.

In the transition period the dependence of Russian science on international support to compensate domestic losses has grown considerably. According to various estimates (Science, 1993; OECD, 1994) the promised support for the year 1993 amounted to 200–250 million USD, which would constitute ca. 20 % of total R&D funding. The share of the Soros Foundation (which is known for its generous and comprehensive funding policies, including also basic research) of the promised aid made 100 million USD, that is almost half of the total. The aid actually delivered, however, was much less: only 34 million USD of which the share of Soros was 20 million. The discrepancy between the promises and what is actually fulfilled is not the only problem, however.

The transfer of money entails many bureaucratic and practical problems: a lot of funding "disappears" in the mediating organs and only a part comes down to the researchers themselves. The European Union is also well-known for its massive bureaucratic regulations that are often criticized by the disappointed and disillusioned Russian researchers. In order to apply for money, researchers have to fill in innumerous forms and report their previous major scientific findings, still without any guarantee of getting funding for their projects. Some scientists have felt that a new colonial relationship is emerging, although there is no guarantee of the continuity of support. Instead of the originally proclaimed purpose, the system may turn into a means for the West to monitor Russian science and reap its profits.

The situation is rather similar when Western enterprises make contracts with top level R&D institutions paying relatively high wages by Russian standards, which however may constitute only one tenth of Western salaries. I have met a European scientist who has employed seven Russian research as-

sistants with his own "pocket money"! These kinds of one-sided contracts may help Russian scientists in the short-run but they do not create a durable basis for long term co-operation. They also create new tensions and contradictions inside the Russian research community, which however seems to be unavoidable.

One such new tension concerns scientific communication. Earlier in the Soviet era scientific communication and collaboration was bureaucratically restricted and regulated from above by official plans. At present scientific communication is facing new kinds of constraints, now related more to scarce communication resources and increasing competition within the scientific community.

Those researchers who are actively involved in foreign cooperation and/or are doing "scientific business", may not any more be willing to share their operative information and scientific results with colleagues in their domestic research community (Fomin et al., 1993). International cooperation and competition is also producing a new phenomenon of "information emigration" (Zulman, 1993), which means that scientific results are published only in high ranking international journals which, due to several reasons, are not available to other Russian colleagues. On the other hand, the Russian scientific journals have got into big trouble; their liberated prices have made holding a subscription impossible for many. An example of this is a social scientist from St. Petersburg who is responsible for his institute's publishing activity. Earlier he used to subscribe personally to 15 scientific journals, but last year he could hardly afford one.

The tension between the Mertonian norms of academic science (CUDOS) and the all the more dominating commercial norms of industrialized science (PLACE) that has been widely discussed in Western countries (e.g. Ziman, 1990) has suddenly and forcefully entered the Russian scientific communities. The well known question is thus legitimate: What PLACE will be left for CUDOS in Russian science?

Restructuration: Present and Future

The crisis and transition in Russian S&T system has so far meant, in the first place, defensive adaptation to resource cuts and to a lesser degree an active and effective restructuration of the system. There has been much more deconstruction than actual reconstruction in science. The previous institutional structures are still mainly preserved, and the sharply decreased governmental funding dominates as before. Non-governmental funding, which should be a strategic resource for future expansion and diversification of the R&D institutions has still a rather marginal, but not negligible importance. It consists of funding from international sources, from the business enterprise sector and from various non-governmental foundations. As concerns academic science, which has been mainly basic research oriented, it is clear that it will remain dependent on governmental funds and the potentially increasing foreign support. This notwithstanding the potential institutional changes that may effect the Academy's present position as an independent institution.

The Russian ministry of science and technological policy has recently (1992–93) proposed some new science policy guidelines and priorities which include the following:

1) the creation of some 30 national R&D centers in selected priority areas using competitive peer review mechanism,
2) strengthening the already existing National foundation for basic research and
3) supporting the development of universities towards more active research orientation. In future the national priority areas and their research centers should constitute the "nucleus" of governmentally funded R&D.

It is not clear yet how these new policies would change the autonomous institutional position of the Academy (and the huge amount of fixed capital that it still owns in the form of real estate, equipment and land). In any case it seems that the Academy's position is weakening due to the new poli-

cies and the "erosion" of funds and personnel. But to speak about the death of the Academy would be overhasty. As one Russian official mentioned, "the Academy seems to have several lifes: even Stalin could not eliminate it!"

The biggest problem in implementing the new policy is that the suggested measures are not necessarily realistic in the present situation, as the ministry is out of funds. In the Academy of Sciences the case is presently often so that the institutes are making direct deals with extramural ministries and authorities in order to get extra funding.

If we may speculate a little as a conclusion, some of the future characteristics of the Russian R&D system would be:

1) considerably smaller size,
2) a mixture of the old system and new market based structures (with the governmental sector still dominating),
3) more practical and commercial orientation in R&D,
4) less basic science and humanities,
5) more international orientation and cooperation,
6) increasing regional differences in R&D potential, and
7) more dynamics and competition in the research community.

In addition, there are some general key issues that will be of special importance for the future development of R&D in Russia. These are 1) success in the economic transition, 2) the restructuration and taming of the "dinosaurs" of the military-industrial complex, 3) the shift from administrative-political allocation of R&D resources to substantial qualitative competition and 4) in business oriented R&D, the guarantee of legal rights (on patents, etc.) against the traditional political benefits, illegal economy and other vested interests.

Concluding Remarks

As described above major restructurations in the Russian R&D system are taking place. Their final outcome is not visible yet. One may anticipate, though, that the rather anarchic processes that have prevailed so far will bring forth more stability and order both in society and science. To survive, science should adapt to societal changes and assume new functions to compensate for the current functional deficit. This does not mean, however, that the bifurcation phase in society would be over yet.

It is evident that there are no easy or immediate solutions to the systemic and structural crises of Russian economy. It will take time to fill in the technology gaps between the defence and civilian fields as well as between the Russian and international developments. New technologies can be imported from abroad, of course, but they will remain small and isolated islands with little effect on the economy at large unless the whole industrial infrastructure starts to develop in a more dynamic and competitive way. To transform the whole society and its deep-rooted cultural practices from top to bottom will necessarily be a gradual, non-synchronic and contradictory process.

One might ask also to what degree an optimistic transition scenario is realistic at all. Perhaps it would be time to start to discuss the more pessimistic ones more openly and explicitly (cf. Eronen, 1994: 46–47). Is the option of an industrially developed high-tech country (of a Western type) realistic for the future of Russia? Or should we rather speak about a semi-developed country in transition which is struggling to preserve its industrial and scientific potential? Or would it be more adequate to speak about a Russian way and model with its own specific characteristics, problems and potential solutions? I believe that asking these strategic questions realisticly is an important starting point for the discussions on the future options of science and technology in Russia.

The developments in Russia have a socio-historically specific and even unique character. At the same time they exemplify more general societal dependencies and constraints in the development of science

and technology. From the point of view of science and technology studies some important, even if tentative, conclusions may be drawn.

The Russian case shows that the growth of science and technology is not an autonomous and deterministic process without socio-economic limits. The transition of scientific R&D from an expansive development to a steady state is not the only alternative scenario either (see Cozzens et al., 1990: 7–81); also radical downsizing may take place. The societal position and functions of science and technology are deeply embedded in the developments of the larger society and its demand and capacity to use scientific and technological knowledge. Thus there seems to prevail a certain balance or correspondence between the developmental potential of the R&D system and the society at large. Nesvetailov (1990) has characterized this interdependence with his thought provoking title "sick science in a sick society". Analogically this would mean that "a healthy science may live and prosper only in a healthy society". Perhaps the soft, normative questions of the health of science, technology and society should also be included in the future agenda of science and technology studies, in addition to the hard core questions of structural transformations.

NOTES

1. During the 1990s and earlier the author has participated in several seminars and meetings in Russia in the fields of sociology, economics and science studies. Part of the data (e.g. some concrete examples, observations, jokes, etc.) included in the article are based on public and personal discussions with Russian colleagues in these occasions, and therefore not documented in the references.

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