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Post-Soviet science: Difficulties in the transformation of the R&D systems in Russia and Ukraine

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ABSTRACT

In the late 1980s, the Soviet Union was among the foremost leaders of world science, thanks in large part to its heavy involvement in military programmes. The USSR developed a large research infrastructure but it lacked effective mechanisms for the commercialization of research results. The main aim of the transformation of R&D systems in the post-Soviet states in the 1990s and early 2000s was the re-orientation of scientific activities away from military and towards civilian goals. Analysis of statistical data at the macro-level suggests that this attempt was not particularly successful. Indeed, most newly independent states could not even preserve a ‘critical mass’ of scientific activities in order to remain among the list of significant producers of research results. In the post-Soviet countries (and in this paper we focus on Russia and Ukraine as the largest states of the region), inputs from the R&D system have failed to generate wealth-creating outputs because of a systemic inability to use the resources for generating commercially viable results effectively. All post-Soviet countries, including Russia and Ukraine, urgently need not only a major transformation within the R&D system, but also important changes in the wider ‘environment’. It is important to stress that, in recent years, changes in R&D have been determined not only by the general economic situation itself but also by the general policy of the post-Soviet states. While Russia has expressed ambitions to regain its former influence as a great power and to use S&T to achieve this goal, Ukraine has no clearly determined objectives for the development of its national science system. However, both countries face certain common problems. The development of relevant institutes and the stimulation of demand for R&D results from the side of industry, broader involvement in the international division of scientific work, and the introduction of adequate legal protection for intellectual property rights are all of critical importance for S&T institutes and other research organizations in Russia and Ukraine. This paper shows that the reforms in the R&D sector have been relatively modest and rather unsystematic over the last one and a half decades. The key challenges, which relate to the inertia and the negative aspects of the previous period (for example, a extremely low level of replacement of aging manpower, largely outdated scientific equipment in research laboratories, and institutional mechanisms that are not relevant to the market economy), pose serious problems for the transformation of the R&D systems in both countries, despite new possibilities and a willingness to increase financial support for R&D.

1. Introduction

Post-Soviet countries are going through a difficult period of reform, which differs substantially from that pursued by their Western neighbours. This article compares and evaluates key features of the post-Soviet R&D systems in the largest countries of the region – Russia and Ukraine – along with the main problems they face and their attempts to achieve successful development. Our particular concern is the implications of S&T policy for the transformation of the traditional structures that dominate these systems. We attempt to focus on the output indicators of the R&D system, although it is not possible to consider them separately from the resource indicators, as they determine, to the great extent, the parameters of the scientific output. We also discuss the changing role of S&T in Russian and Ukrainian societies and possible scenarios for the further development of science in the two countries.

In many cases, science policy has ossified the old disciplinary profile in these countries. The ‘path dependency’ in the science system, generated at some point in the past, has not been properly modified. Physics, chemistry and some technology-related disciplines continue to dominate the science landscape. While financial support is of considerable concern, the aging of the research community and the obsolescence of their research equipment poses serious threats for the future of R&D systems in the countries of the former Soviet Union. The great majority of researchers in the main post-Soviet countries are of a ‘mature’ age, and opportunities

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for recruiting young scientists are very limited. This also applies to the aging of research equipment. The obsolescence of the tools of research is particularly evident in the natural and life sciences and in certain engineering areas. These conclusions are based on official statistics, on a review of the literature (much of it in Russian or Ukrainian), and on our own research, which was conducted in 2005–2006 with the assistance of the Science and Technological Centre of Ukraine.

The problems of the S&T in Russia and Ukraine developed over many years and have now reached such proportions that neither quick nor relatively cheap solutions are feasible. The challenge to government policy in the S&T area is how to mould the remaining national research capabilities into a pattern that will contribute more effectively to the processes of economic recovery. For the time being, however, many of the remaining R&D 'assets' are perhaps more of a liability.

This article is organized as follows. Section 2 briefly outlines some key features of the Soviet research system that are important for understanding its further transformation. Section 3 provides an overview of the trends in a number of important R&D indicators of the main post-Soviet states – Russia and Ukraine – with the focus being on a comparative analysis of their dynamics. We conclude that, despite initial similarities, there is evidence of substantial differences in the approaches to the transformation of the R&D sectors in both countries. Section 4 deals with the changes within the scientific community and the problem of emigration from the post-Soviet states. Changes within the scientific communities have led to the creation of the group of successful scholars and institutes, which could form the basis of the new research system. Another key conclusion from this section is that the scientific emigration in the post-Soviet states is a complex phenomenon, which has not been reflected adequately in official statistics. Finally, Section 5 puts forward a number of conclusions and recommendations on ways to solve some of the existing problems and to meet new challenges that post-Soviet R&D systems will face in the near future.

2. Key features of the Soviet R&D system

The Soviet R&D system was responsible for major achievements in the past. It is difficult to overestimate the significance of S&T for the Soviet political and economic system in the period starting in the 1930s. In conditions of relative isolation from other developed countries, science and technology (S&T) were among the key factors that helped Soviet leaders keep pace with the Western world. Indeed, scientists were among the most highly privileged members of Soviet society, as they were not under severe ideological pressure from the Communist leaders (in particular, in certain natural sciences such as physics and engineering) and their salaries were substantially higher than those in industry in the period from the 1930s to the 1960s (Kelle et al., 1995). The significance of S&T for the Soviet political and economic system was especially crucial in the period after the Second World War. It is also important to note that Soviet society could provide very few possibilities of a successful future career for young talented people, particularly those who wanted to avoid ideological pressure from the Communist regime. Entrepreneurship was banned, while social sciences or arts required a high level of loyalty to the dominant ideology. Specialists in natural and technical sciences had a higher degree of freedom in the selection of topics for their research. This influenced the general atmosphere in many research institutes. That is why some prominent Soviet dissidents, including Academician Andrei Sakharov, came from the research community.

It is difficult to agree entirely with the broad conclusion of some authors (e.g. Radosevic, 1999) that in the Soviet Union the links between enterprises and R&D institutions were weak. While this conclusion is certainly true for the purely civilian part of the economy, in the military-oriented industries, which constituted a large part of the Soviet economy, enterprises and R&D institutes were integral parts of the organizations of higher level ministries, which coordinated all stages of innovation activities. The absence of *market-based* relations between research institutes and the enterprises does not necessarily imply the absence of strong relations. Thanks to the centralized planning system, these institutes and enterprises received the best resources that the country could provide, and they were closely integrated into production chains (Saltykov, 1990). Soviet leaders attempted to integrate their S&T policies with industrial and broader economic policies. The prime impetus for better coordination came from efforts to direct S&T more effectively to military and economic needs through the mechanisms of centralized planning. Market incentives played almost no role. However, the planning system itself could not guarantee the effective distribution of resources and utilization of R&D results. Indeed, it is worth noting that, to a great extent, the R&D system was controlled by agents for whom permanent expansion was in their best interests, so this arguably led to an over-developed R&D system.

At the same time, the involvement of Soviet researchers in the processes of world S&T development was limited, as key indicators of scientific and innovation activities show. In the late 1980s, a group of American specialists attempted to estimate the Soviet R&D potential, ranking it second only to the United States (AAAS, 2001). At the same time, these experts stressed the relatively low productivity of the Soviet research system (in terms of conventional indicators) and its weak links with universities. Hence, in 1985, the Soviet Union had 35.6% of the world total of researchers, but the Soviet research system generated substantially fewer patents than American one and in terms of the number of internationally recognized scientific publications, the Soviet Union was lagging well behind the leading Western nations. The world share of such publications by Soviet authors was much lower than the corresponding share of scientists, and the number of students in universities and higher education institutes was almost three times smaller than in the United States.

In a highly centralized planning system, there was little need for mechanisms for IPR protection. The state exerted control over almost all R&D results and their utilization. Due to artificial restrictions on contacts with the colleagues from abroad, Soviet specialists had to 'reinvent' a lot of things that were available to Western scientists. The planning system could not react satisfactorily to new challenges and could not redistribute resources effectively to new areas of S&T. As a result, the USSR started to lag behind in some key and fast-growing disciplines, such as electronics and biotechnology, while its position in mathematics, physics and new materials remained relatively strong up to the late 1980s and even the beginning of the 1990s. Moreover, the system of regulation of scientific activities and the corresponding rewards were quite different from those that existed in Western countries. All this left Soviet scientists largely unprepared for the fundamental changes in the economic and social spheres that took place in the early 1990s.

3. Trajectories of R&D in the post-Soviet states

3.1. Common features and differences in the development of the R&D sector in post-Soviet states

The inability of the Soviet economic system to meet major new challenges in a rapidly changing world fundamentally undermined political stability and, in the end, this led to the collapse of the Soviet Union in 1991. The dynamics of the main R&D indicators show a number of common features at the beginning of the transition period, but later on the trajectories of S&T development in the newly formed countries were determined by rather different social, political and economic factors.

All post-Soviet states inherited substantial number of researchers and R&D institutions. Even the Central Asian and Trans-Caucasian republics had relatively high shares of R&D personnel per 1000 of labour force (GKNT, 1990). However, during the period of transformation, the post-Soviet states experienced significant reductions in their R&D systems in terms of both expenditure and personnel. The impact of domestic S&T on industry was much lower than it had been in Soviet times, and lower than it might have been, bearing in mind the number of trained specialists.

For the first 10–12 years, post-Soviet S&T was characterised by a sometimes explicit and sometimes implicit policy of gradualism in R&D restructuring. There was initially a strategy of 'saving science' in the years after 1990. The national R&D systems were overly large and over-manned, and in all cases it proved very difficult to restructure them. However, now after more than 15 years of transition, it is clear that science and technology play different roles in the various post-Soviet states. The current state of the Russian and Ukrainian R&D systems share certain common features with the early stages of transformation in Poland, Hungary and some other Eastern European countries (Dyker, 2004), while the development of the R&D systems of the Central Asian and Trans-Caucasian states have followed different trajectories. As the statistical data show research institutes and individual scientists in Russia and Ukraine have been partially re-oriented to foreign customers but they are also trying to co-operate with companies from traditional sectors (such as metallurgy, oil and gas) and with the remaining manufacturing enterprises (in particular, aviation, space and military-oriented companies in Russia), which have the financial resources needed to pay for R&D results. At the same time, governments in the Central Asian and Trans-Caucasian states rely predominantly on the mining sector and foreign companies, which utilize their own technologies. Manufacturing industries have almost disappeared as major customers for R&D results, while the ties with traditional partners in the European parts of the former Soviet Union have weakened.

The main idea of the transformation of scientific systems in the post-Soviet states was that of 'creative destruction' and of the re-orientation of scientific activities from military to civilian goals. In fact, most newly independent states were unable to preserve a 'critical mass' of scientific activities in order to remain among the main producers of research results. In many post-Soviet countries, inputs from the R&D system have failed to generate wealth-creating outputs because of an apparent systemic inability to use resources effectively (Kitova, 1994; Varshavsky and Varshavsky, 1995). In addition, many Russian-speaking specialists left these countries for political or cultural reasons. Thus, in the Central Asian states, Russian-speaking specialists had previously formed the core of the republics' R&D manpower, and their outflow created problems not only in R&D institutions, but even in the servicing of relatively complex equipment, such as hydroelectric stations. The resources devoted to R&D in the post-Soviet countries (except for Russia and Ukraine, to some extent) have not been sufficient for effective scientific and technological development (Yaremenko, 1998). The expenditure on R&D as a percentage of GDP was lower than 0.4% in most of the countries, except in the case of Russia, Ukraine and Belarus. The trends in R&D expenditure in the post-Soviet states are shown in Table 1.

It is important to stress that the decline in funding for R&D was more substantial than the decline in the number of researchers and engineers in almost all post-Soviet states during the most difficult period in the early 1990s (Yurevich, 2004). In contrast, in some Eastern European countries, the decline in R&D manpower was greater (Balazs et al., 1995; Meske et al., 1998). Instead of reducing the number of employees, R&D organisations reduced their material costs to a minimum but tried to save their human capital. This step cannot be explained in terms of an apparent intention to preserve the best and the most experienced researchers. Scientific organisations in almost all post-Soviet countries have had to pay considerable social benefits to staff that are dismissed. In fact, in many countries the system of financing S&T organisations in proportion to the number of employees has still been in operation. Consequently, if the directors of research institutes were to have fewer employees, they would receive less income from the state budget. The problem is that some branch (or sector) ministries have had no money for the support of subordinate organisations, and the budget allocations have been in sharp decline. This has led to a substantial outflow of the most energetic people of working age to other sectors of the economy, while the attractiveness of scientific work has become lower than that in some industries and in the service sector, especially in banking and insurance.

However, the positions of the more 'western' post-Soviet states are still relatively high in educational and research terms, at least if you compare them with newly industrialized or developing countries. Trends in the number of researchers in post-Soviet states are presented in Table 2.

In recent years, the decline in the number of researchers has been halted in some countries, and it is slowing down in others. However, this stabilization is not sustainable; as we shall show in the next section, the 'demographic crisis' in post-Soviet science is very serious and it cannot be easily overcome.

Table 3 contains data on scientific publications in the post-Soviet states and in certain Eastern European countries over the period 1995–2000.

Table 1
Expenditures on R&D as a percentage of GDP (GERD) in the post-Soviet countries, 1990–2004.

Country	1990	1991	1995	2000	2002	2004
Azerbaijan	1.01	0.75	0.31	0.35	0.3	0.2
Armenia	2.54	1.09	0.08	0.26	0.3	0.3
Belarus	2.27	1.43	0.95	0.81	0.7	0.7
Georgia	1.20	1.10	0.11	0.19	0.2	0.01
Kazakhstan	0.74	0.56	0.27	0.17	0.3	0.3
Kyrgyzstan	0.73	0.33	0.26	0.13	0.2	0.2
Moldova	1.57	1.03	0.75	0.58	0.5	0.4
Russia	2.98	1.89	0.81	1.28	1.4	1.9
Tajikistan	0.73	0.44	0.11	0.07	0.05	0.06
Turkmenistan	0.65	0.48	0.26	–	–	–
Uzbekistan	1.22	1.16	0.39	–	–	–
Ukraine	2.33	1.81	1.34	1.14	1.1	1.2

Source: Statistical Bulletin of NIS №. 17 (368), 2005, pp. 9–22 and the Belorussian Economic Journal, 2003, №. 4, p. 137.

Table 2
Dynamics of number of specialists involved in R&D in post-Soviet states in 1995–2004 (level of 1991 = 100%).

Country	1995	2000	2002	2004
Azerbaijan	79.9	70.7	72	81.1
Armenia	39	29.1	31.4	30.2
Belarus	45.4	37.6	34.7	32.4
Georgia	75.9	44.6	53	63.1
Kazakhstan	65.2	37	38.8	43.4
Kyrgyzstan	63.2	40.4	40.4	40.4
Moldova	45	31.8	24.8	24.0
Russia	57.5	46.4	45.3	43.6
Tajikistan	40.9	56.8	56.8	40.9
Turkmenistan	70.2	38.6	–	–
Uzbekistan	40.9	37	–	–
Ukraine	60.9	40.9	36.4	36.2

Source: Calculated on the basis of data from the Statistical Bulletin of NIS №. 17 (368), 2005, pp. 9–22.

Table 3
Scientific publications in the Former Soviet Union and Eastern European countries in 1996–2000.

Rating of the country in the world	Country	The share in world publications (%)	Total number of publications	The share of cited publications (%)	Impact - factor
8	Russia	3.52	125,530	37.75	1.58
31	Ukraine	0.52	18,441	35.13	1.23
45	Belarus	0.15	5,425	33.88	1.27
57	Estonia	0.07	2,525	55.29	2.97
63	Lithuania	0.05	1,929	49.66	2.41
68	Uzbekistan	0.05	1,671	27.77	0.77
69	Latvia	0.04	1,592	46.23	2.21
73	Armenia	0.04	1,323	39.68	1.65
80	Georgia	0.03	1,034	40.14	1.70
81	Kazakhstan	0.02	888	27.48	0.81
82	Moldova	0.02	870	38.85	1.27
87	Azerbaijan	0.02	777	20.34	0.60
128	Tadjikistan	0.01	183	21.32	0.54
135	Kirgizia	0	145	26.21	0.89
157	Turkmenia	0	49	28.59	0.71
20	Poland	1.14	40,540	51.59	2.27
30	Czech Rep.	0.53	18,944	51.62	2.32
34	Hungary	0.49	17,448	54.24	2.76
39	Slovakia	0.27	9,667	44.92	1.88
41	Romania	0.21	7,651	43.39	1.53
43	Bulgaria	0.2	7,175	49.52	1.83
46	Slovenia	0.15	5,211	47.94	2.07
47	Croatia	0.14	4,894	47.22	1.76
49	Yugoslavia	0.12	4,389	42.76	1.35

Source: Compiled from Marshakova-Shaikevich I., 2002. The Contribution of Russian in Development of the World Science: Bibliometric evaluation. Otechestvennie Zapiski. №. 7, pp. 314–345 and http://www.nsf.gov/statistics/seind06/.

It is clear that most of the internationally accepted indicators of scientific productivity were lower in the former Soviet Union than in neighbouring Central and Eastern European countries during this period. This is further evidence of the lower level of internationalization of science in these countries. On the other hand, some of the comparative indicators of publication activity are not so bad (see Table 4). The difference between Russia, Ukraine and Eastern European countries is not substantial, if the number of publications per unit of GDP is taken into account.

Unfortunately, detailed information on publications for all post-Soviet states is not available. We will focus more on Russia and Ukraine in the remaining part of the paper because these two countries comprise about 80% of the S&T potential of the post-Soviet states. Some parameters of their R&D systems are comparable with those of mid-sized countries. At the beginning of the period of social and economic crisis in 1990–1991, according to various estimates, Russian expenditure on R&D was comparable to that in France and UK, while at the end of 1990s the country was behind not only the large European countries, but also Canada, India, South Korea and China (Trofimova, 2000). The Ukrainian S&T potential was at a level of around 16–18% of the Russian one.

Table 4
Some relative indicators of publication activities in Russia, Ukraine and some countries of Eastern Europe, 1995–2000.

Country	Number of publications per 1000 inhabitants	Number of publications per 1 mln. USD of GDP
Ukraine	0.38	0.24
Slovenia	1.85	0.18
Hungary	1.49	0.20
Slovakia	1.43	0.27
Czech Rep.	1.32	0.14
Estonia	1.27	0.19
Bulgaria	0.91	0.24
Croatia	0.91	0.23
Poland	0.88	0.13
Russia	0.84	0.18

Source: Calculated by the author on the base of http://www.nsf.gov/statistics/seind06/ and Science and Innovation in Ukraine. Yearbook, 2005. State Committee of Statistics of Ukraine, 2006.

Recent data on scientific publications in Russia and Ukraine demonstrate the growing gap between them and Eastern European nations. For Russia, the number of such publications dropped from 18,300 in 2000 to slightly more than 15,800 per year in 2001–2003 (MES, 2007, p. 216). The Russian share of world scientific publications declined from 3.81% in 1994 to 2.26% in 2003. For Ukraine, the number of publications was more or less stable at approximately 2500 over the period 2001–2005, as the US National Science Foundation data shows. (The Ukrainian State Committee of Statistics unfortunately stopped collecting and publishing these data in 2000.) The relatively low scientific productivity in Russia and Ukraine can be explained by two key factors. The first is the decline of R&D financing in the 1990s and the start of the following decade, when almost all research budgets were spent on wages and on bills for utilities. As a result, the share devoted to modern research equipment has shrunk to a small fraction in many research institutes (Dynkin and Ivanova, 2005; Popovich, 2005). Between 1998 and 2005 the value of capital assets in the R&D sector declined by more than 50% (in constant prices) in Russia (MES, 2007, p. 92), and by more than 60% in Ukraine[1]. Almost half of all equipment could be written off the balances of research institutes according to existing rules but there is no adequate replacement for this equipment. Some institutes have had to stop the regular scientific experiments needed for undertaking research programs. For example, the only experimental reactor in the Ukrainian Institute for Nuclear Physics was closed in the first half of 1990s, thanks to a lack of funds to cover the electricity bills. Since this time, Ukrainian nuclear physicists have had very few opportunities to test their theoretical results. There was a similar situation in other natural science institutes. This means that scientists from the former Soviet Union have had limited opportunities to obtain important new empirical results during the period of crisis. Sometimes, it has been possible to work in Western countries but in these cases the resulting publications have usually been credited to foreign research centres (Mindeli and

[1] Ukrainian statistics do not usually use constant prices. That is why the corresponding figure has been calculated on the basis of the GDP deflator for 1995–2005.

Pipya, 2004). The second reason is related to the huge outflow of researchers to other sectors of the national economy and to emigration, especially in 1990s, an issue that will be discussed in the next section of the paper.

Trends in the R&D indicators for Russia and Ukraine were similar in the 1990s and the early part of the following decade, although in recent years Russia has announced changes aimed at the restoration of its position in the world, including more energetic support for the R&D sector. The level of R&D financing and capital assets have shown a strong tendency to grow in Russia (in constant prices) over the period 2002–2006, although the level of financing is still much lower than it was in 1990.[2] In Ukraine, the growth in expenditure on research and development has not been as strong, due in part to a decline in industrial R&D in 2006, which could not be fully compensated by the growth in budget appropriations.

It is evident that the growth of R&D expenses in itself could not solve all the institutional problems that exist in both countries. Despite official support for 'national science', the R&D sector is not a focal point of economic policy in either Russia or Ukraine. Different laws are not properly co-ordinated as they are prepared by different interest groups. The most vivid examples are related to the almost permanent conflict between the Ministries of Finances and the Ministries that are responsible for S&T. For instance, in Ukraine, thanks to the superiority of the Budget law over all other laws, the Ministry of Finance tends to blocks all initiatives aimed at the support of R&D and of innovation activities. The main reason for this blockade is the hypothetical possibility of a decline in state income. Calculations of the likely indirect benefits (in the form of new jobs, growth of exports and so on) are not taken into account.

3.2. *Crisis at the research institute level in industry: slow adjustment to new realities*

To understand the key features of the crisis in the R&D system in Russia and Ukraine, it is important to note that it was not the Academy of Sciences nor the universities but the so-called branch institutes and design bureaux responsible for applied research and development that formed the bulk of Soviet R&D. These organizations were subordinate to the ministries and they were the key players in the Soviet research system. After the collapse of the USSR, these institutes and design bureaux suffered more than other types of R&D organizations, as their traditional customers had no money to pay for their products and services. Their share of the total number of R&D organizations and their share of the expenditure on research and development both dropped substantially (Todosyichuk, 2002). Dissolution of the so-called scientific and industrial complexes (nauchno-proizvodstvennyh ob'edineniy) led to a separation of research institutes and design bureaux, on the one hand, and production units, on the other. For the institutes and design bureaux, this meant that the relations with their traditional partners became more tenuous. The financial situation in these institutes and design bureaux deteriorated rapidly as a result of losing state contracts, especially for the so-called military–industrial complex (Schweitzer, 1995; Egorov, 1998), and because of the worsening general economic situation facing industrial enterprises.[3] The ministries tried to support their own institutes and design bureaux, but financial resources were scarce in comparison with the number of researchers. Having lost most of their industrial partners, the branch institutes and design bureaux sought to survive by securing funds from other sources. However, for a number of scientific institutions, especially in the Ukraine, ties with local industries were weak at that stage, resulting in the misuse of the existing S&T potential, while the majority of scientists could not find a suitable place in the transition process (Kohut, 2002). This situation was a result of the system, in which more than 90% of branch institutes and design bureaux were subordinate to the All-Union, not to local (republican) ministries, and consequently worked largely in isolation from the interests of local enterprises. The introduction of different currencies and custom regulations and the shrinking number of orders from traditional partners have created serious problems for branch institutes, which have had no substantial support from the state budget. These research organizations had no experience of working in external markets, and no institutional mechanisms for the proper protection of their IPR abroad.

The process of transition was also greatly influenced by attempts to preserve the existing number of employees while waiting for the resumption of large-scale direct state financing. This led to substantial imbalances between the nominal and actual activities of organizations. Many institutes had to shift to non-R&D activities. These now comprise more than half of their total activities (Golichenko, 2004; Yegorov et al., 2006). This was accompanied by a substantial decrease in the number of scientific publications produced by these institutes, as well as by a decline in the number of patent applications. The latter was connected not only with the relatively low level of research efforts, but also with high price of patenting, especially patenting abroad. For instance, the price of patenting in the USA or in the EU is roughly equal to the salary of a Russian or Ukrainian researcher for several years![4]

In fact, a very complicated situation existed with regard to patenting in Ukraine. After the collapse of the Soviet Union, Ukrainian scientific institutes and design bureaux did not receive patents, especially Western ones. It is important to note that the great majority of patents were inherited by Russian institutes and Ministries as the leading or the main institutes in particular sectors. Ukrainian institutes usually have no foreign patents at all. This is a tremendous liability when trying to negotiate with foreign companies and attempting to market high-tech products abroad. As a result of the economic crisis and the devaluation of assets, institutes and enterprises have usually lacked the funds needed to pay for patents and licenses.

It is also important to mention that design bureaux have suffered more than other industrial R&D organizations in the post-Soviet period. In fact, the number of branch institutes declined by more than 70% in Ukraine and by 50–60% in Russia, while the number of design bureaux fell by 70–90% in both countries in period from the 1990s to the first half of following decade.

Most of the employees who left their positions in the R&D sector in 1990s did so voluntarily. In other words, their departure was not the result of management decisions, nor the consequence of liquidation or restructuring of their organisations. This demonstrates, in particular, that the decline of R&D personnel in Russia and Ukraine in the 1990s was a spontaneous process that was not been properly regulated on the part of the state.

In the late 1990s, the governments of Russia and Ukraine created special state research centres (56 in Russia and 3 in Ukraine[5]), but financial support for these centres is at a very low level, while very limited interest has been shown by industry in the results obtained by domestic R&D institutes (Dezhina and Saltykov, 2004).

[2] The last full year of the existence of the Soviet Union.

[3] It is known that during the 1990s Russian GDP declined by more than 40%, while that for Ukraine fell by 60%.

[4] Official salaries of researchers in Ukraine and Russia were at the level of approximately 300–400 USD per month in the mid-2000s, taking into account the exchange rates of the Russian Rouble and the Ukrainian Hryvnia.

[5] In Ukraine, the centres were created in the form of 'technoparks'. At the end of 2004, there were 16 such technoparks in Ukraine but very few of them worked effectively, as the corresponding laws with regard to their activities were blocked by the Ministry of Finance and almost all financial incentives were abolished in early 2005.

The efficiency of the fiscal and financial means employed by the Ukrainian and Russian authorities to boost demand for R&D results among companies is far from satisfactory. There are insufficient incentives for economic agents to develop and patent new solutions. The existing system of tax relief, exemptions and subsidies is imperfect and is a source of much controversy. There is a lack of strong financial and organisational ties between units operating in the sphere of S&T, on the one hand, and industry on the other, as well as between these units themselves. A limited number of industrial enterprises and R&D units are now trying to change the situation.

In some cases, the collapse of the old branch structure of the Soviet-type economy led to the development of new links between research institutes and industrial companies, and especially to the development of direct links with foreign companies. At the same time, the changing boundaries between private and public sectors led to new, nationally specific systems of innovations.

One might expect that some applied research institutes and design bureaux might be transformed into relatively small research or production companies and science-based SMEs. However, their future depends heavily on the speed of economic transformation in key manufacturing industries. If Russian and Ukrainian manufacturing enterprises develop better access to international markets and strong ties with foreign partners, this will have an obvious and positive effect on industry-oriented R&D institutions. Without clear signals from industry in the form of new orders and, in some cases, without sufficient financial support, research institutes will be unable to retain their best staff or to update their technical base.

3.3. Growing role of the academies of sciences

In contrast to the branch institutes and design bureaux, the research institutes of the Academies of Sciences in Russia and Ukraine rely on the state budget as the main source of their financing. They receive approximately three quarters of their funds directly from the state. This level of financing does not guarantee effective development but at least it provides a basis for the survival of research institutes (Voronin, 2003). In recent years, the number of employees in the Academies has stabilized, while the number of research institutes has doubled. The share of the Academies of Sciences in the total expenditure on R&D and their share of the total number of employees in research sector have both increased in recent years.

At the end of this section of the paper, it is mentioning that S&T in Russia and Ukraine are each developing in rather different political contexts. Russian authorities have announced ambitious goals to restore the country to the level of economic and political influence that the Soviet Union had in the past. The country is trying to become once again an active player in the international arena. This explains the special attention of the state authorities to the R&D sector and to various initiatives that have been launched in this sphere recently (Dezhina, 2007). The state expenditure on R&D in Russia is much higher than the expenditure of the private sector: the respective figures were 143 billion roubles (approximately 5.72 billion USD[6]) against 69 billion roubles (approximately 2.75 billion USD) in 2005. The share of the state in financing R&D grew from 54.8% in 2000 to 61.9% in 2005. The share of the private sector fell from 32.9% to 30.0% while that of foreign organisations dropped from 12.6% to 7.6% during the same period.[7] It is possible to predict that some S&T programs, such as well-known 'Nanotechnology Initiative of President Putin', worth more than 1 billion USD, will receive stable financing, based on revenues from gas and oil. Military-related R&D has already received substantial support but the state will exert a strong influence over R&D in other sectors (such as aviation and electronics) too. The Russian Academy of Sciences passed new statutory documents in 2007, which strengthen the role of the state in its activities.

In contrast, in Ukraine has no far-reaching geo-political plans. Despite the growth of the state financing of R&D, the share of the state in R&D was only 33.5% in 2005 while the share of foreign organisations was 24.3%.[8] This means that the level of internationalization of Ukrainian R&D and its orientation to the needs of non-state customers is substantially higher than in Russia. Expenditure on military-related R&D in Ukraine is far smaller, representing less than 7% of the state expenditure on research and development. This leads one to conclude that Ukrainian S&T will develop in the near future with far less state control than in Russia. Such a path will obviously not guarantee success, but it does open the way for following a more flexible strategy with the emphasis on private initiatives.

To sum up, the past one and a half decades of independent development have led to a substantial shrinking of R&D in the post-Soviet states, with the greatest losses being experienced by the technologically oriented institutes and design bureaux. On the other hand, the academies of sciences and their research institutes have largely preserved their status and a substantial proportion of their employees. However, the nature and pace of reforms in this sector have been insufficient to raise the efficiency of the research sector substantially, despite various new financial opportunities that have emerged in recent years, especially in Russia.

4. Changes within the scientific community and the problem of emigration

4.1. Growing differences within scientific communities

The transformation in the economy has led to major changes within the scientific community. If in the Soviet Union state-sponsored military-related research had absolute priority, in the 1990s and 2000s the situation has changed dramatically. Research institutes and individual scientists have had to find contracts for themselves in a competitive environment. Not all of them have been successful in conditions of shrinking opportunities. This has resulted in the emergence of differences among scientists in the post-Soviet states. Plusnin has studied the situation in academic institutes in the famous Russian scientific centre at Novosibirsk. He found that approximately 30–40% of scientists from academic institutes felt that they had only rather vague prospects in their institutes, and only about 25% were judged to be successful in terms of a combination of scientific and commercial activities. Plusnin also considered the attitudes of these scientists to the processes in the scientific communities, and he came to the conclusion that a substantial proportion of these people faced serious psychological barriers to effective work as a result of chronic stress and the negative emotions they had experienced in recent years. Deep dissatisfaction with the present situation was apparently widespread among the scientists of Novosibirsk at the time of this survey (Plusnin, 1999).

Similar conclusions were arrived at by Kugel on the basis of his research in St. Petersburg. According to his sociological survey, carried out in various academic institutes in the city, many scientists are dissatisfied with their present status. Moreover, there are no

[6] According to official exchange rate. Expenses, calculated in USD on a PPP basis are three to four times higher, depending of the year of consideration.

[7] MES (2007), pp. 64–77.

[8] Total expenses on R&D in Ukraine were at the level of 5.164 billion Hryvna or 1.023 billion dollars at the official exchange rate Kyiv, SCSU.

"rich" people among scientists; only 26.7% of respondents consider themselves to have an "average" level of income, while 46.7% think they belong to the group defined as "slightly better than poor", 20% to the "poor", and 6.7% see themselves as "beggars". More than 25% of scientists are not buying books in their scientific speciality because they have no funds for this purpose (Kugel, 1998). On the other hand, the situation in St. Petersburg was apparently slightly better than in the more remote Novosibirsk. Up to 50% of the Doctors of Sciences working in natural sciences and mathematics were receiving grants from the West, although the share of researchers in the humanities and the social sciences with western grants was much lower (only 18%).

Results for Moscow and certain other Russian regions show that more than 52% of researchers were not satisfied either with their working conditions or with the results of their work, while only 4.5% were completely satisfied(Kugel, 1998; Zubova, 1997). Negative assessments prevailed when such factors as the financing of research and the utilisation of instruments, equipment and machinery were considered. In addition, many researchers mentioned that they had lost a number of opportunities for scientific contacts and for publishing both within and outside Russia. Furthermore, the level of research supervision is decreasing and the opportunities for presenting and defending dissertations are declining. The project was mainly devoted to the study of values, and it is worth mentioning that the bulk of respondents proclaimed their loyalty to the traditional values of the scientific community, although the answers to some questions showed that the reality actually differs significantly from the ideal system. For instance, almost all researchers stressed their negative attitude towards plagiarism and faked results. At the same time, they often knew about particular examples of misbehaviour and had apparently done nothing to reveal these facts and to punish those responsible for them (Zubova, 1997). On the other hand, scientists often could not resist political pressure, as illustrated by the notorious case of the Vice-Speaker of the Russian Parliament, Vladimir Zhirinovsky, who received a doctorate degree by 'arranging' the publication of dozens of books in different social disciplines within a remarkably short period of time.[9]

In Ukraine, the scandal concerning the former Speaker of the Parliament, Volodimyr Litvin in 2005, who published a translated version of a paper by an American scholar in a leading national newspaper, had little apparent impact. Moreover, after parliamentary elections in 2006, in which Litvin failed to secure his place in Parliament,[10] he received a prestigious position as Vice-President of the National Academy of Sciences of Ukraine. Negative reactions from within the Ukrainian scientific community were evidently too weak to prevent this nomination.

At the expense of a certain degree of simplification, it is possible to distinguish several groups that have emerged from the scientific community in recent years in the main post-Soviet states. To do this, one needs to look at the actual involvement of scientists in different types of activities to identify the primary characteristics of each group.

First, there are the scientist-entrepreneurs who have their small enterprises that operate in domestic and foreign markets. Usually, these scientists utilize the results of their research with the help of their 'parent' institutes by making use of equipment and space either free of charge or for a relatively low fee. The key problem with such enterprises is that their relations with the institutes, which, as a rule, are the state-owned organizations, are not transparent (Parmon, 1996). The need to share their income with the institute's authorities creates a dependence that makes them less effective and flexible.

The second group consists of old Soviet directors and top managers who usually have shares in these newly established private organisations, since the institutes permit the commercial use of scientific equipment and office space. In the Soviet Union, there was a direct correspondence between bureaucratic and administrative positions. This led to a system of values typical in bureaucratic organisations. Consequently, for directors of the institutes it was usually possible to be an Academician or at least a corresponding member of the Academy. Communist Party officials tried to obtain scientific degrees and even members of the Central CPSU Committee could receive the status of Academician. This old nomenklatura still controls the lion's shares of financial resources in the post-Soviet states, especially in Ukraine, where democratic traditions in science are especially weak. For instance, in Ukraine, three quarters of the state budget money devoted to R&D goes to the six state-sponsored academies. The largest of them, the National Academy of Sciences of Ukraine, receives almost 50% of the state research budget. The head of the National Academy of Sciences has held this position since 1962.

As an aside here, we should perhaps note a significant new phenomenon among scientific organisations in Russia and Ukraine—namely, the emergence of various 'branch' Academies under the control of the directors of branch institutes. This represents a response of 'marginal' elites from branch sectors trying to preserve some measure of control over the distribution of financial resources after the collapse of branch structures in industries. As mentioned above, these 'marginal' elites often participate in the redistribution of property in modern Russia and Ukraine by selling or leasing office space and equipment.

A third category of scientists consists of those who have western grants and who can therefore continue to pursue their scientific activities. This group – generally the most active researchers – comprises about 25–30% of all researchers (Dezhina, 2005). These people are those most capable of co-operating with their Western colleagues. It is interesting to note that the relative importance of foreign aid is now declining, especially in Russia (Mirskaya and Rabkin, 2004). The forms of co-operation have also changed, as scientists seem to prefer direct rather than intermediated contacts with their foreign partners. It is also important to stress that even technologically oriented grants from the S&T Centre of Ukraine (STCU),[11] as our survey shows, do not necessarily lead to the substantial creation of new intellectual products, protected by international standards. Only 12 units from the 207 units observed declared that they have patents originating from projects supported by the Centre (Yegorov and Chekhun, 2007).

A fourth group consists of those who are still formally associated with research institutes, but who are now working outside the scientific sphere. The number of such persons is in decline but a new phenomenon has emerged and developed in recent years—namely, that of multiple occupations held by scientists and university teachers. The number of specialists employed in more than one job has been growing steadily in 2000s in the main post-Soviet countries. For instance, in Ukraine in 2005, the number of persons involved in R&D as their secondary place of work (in a part-time job) was 68,000, a figure that is comparable with the total number of researchers (83,000) for whom R&D is the primary place

[9] Indeed, no less than 218 out of the 450 members of the State Duma boast advanced degrees, often based on dissertations produced in a very short time while the author simultaneously held a senior (and presumably demanding) post (Klussman, 2007).

[10] In the most recent elections in autumn 2007, he obtained a seat and a small fraction in a Parliament again.

[11] The Centre (Foundation) has been created by Western governments to support researchers, who worked in the interests of the Soviet military-industrial complex. A similar centre has been operating in Moscow since 1994.

of work.[12] The situation in Russia is broadly similar.[13] To a great extent, this is the result of low wages in the R&D sector. The low-income forces people to find additional jobs outside their 'main' institutes, though in many cases this does not lead to a growth in scientific productivity. Moreover, the large-scale incidence of double or even triple occupations creates problems with the statistics on scientific manpower. In Russia and Ukraine, the figures for full-time equivalents (FTEs) of the number of researchers are higher than the actual 'head count', something that is impossible according to the OECD *Frascati Manual*. The method involved in the FTE calculations needs to be corrected substantially in both countries in order to permit valid international comparisons.

4.2. Aging scientific manpower and obsolescence of research equipment

It is also important to note that the age structure of R&D manpower is deteriorating very rapidly. The average age of doctors of sciences in Ukraine and Russia is about 61 years, while the proportion of those who work in R&D as their primary sphere of activity and who have scientific degrees (candidate of sciences or doctors of sciences) is shrinking from year to year – currently, the figure is less than 30% in both countries. The long gestation period during which very few young scientists are being brought into the research system will be seriously detrimental to scientific progress in the longer term. Only recently has the situation started to change, especially in Russia, when the state has created new incentives (higher salaries, substantial growth in the financing of state research programs, different types of social support and so on) for young scientists. However, it is too soon to assess the impact of these measures.

The situation with regard to research equipment was particularly dire in the 1990s, with the rate of renewal being less than 2%. The situation has changed a little in recent years, but it is still difficult to find modern research equipment and instruments in Russian and Ukrainian institutes. Besides low salaries, this problem is usually mentioned as the second most important factor behind the emigration of qualified specialists (Onoprienko, 2003). The obsolescence of research equipment is particularly evident in natural and life sciences and in some engineering areas. The problem developed over many years and has now reached such proportions that neither quick nor inexpensive solutions are feasible. Because equipment is so expensive to replace, institutions seek ways to extend the life of their equipment, keeping what they have longer. Much of the older equipment is frequently in need of repair. Most of the research tools cannot compete with modern Western equipment. Thus, scientists from the post-Soviet states have very limited possibilities to obtain results that will be comparable with the results of their foreign colleagues. The outlook on research instrumentation in the main post-Soviet countries is not promising in the near term. It is clear that government action is required to arrest and reverse these changes in the research system, but resources are so limited that further decline seems inevitable (Yatskiv et al., 2002; IEPP, 2005).

4.3. New features of scientific emigration

Emigration is another serious problem for the post-Soviet states. Losses from emigration are considerable in the Ukraine and Russia. A significant number of scientists emigrated from the post-Soviet countries during 1990s. The estimates are based on the assumption that 9–11% of all emigrants were former employees of the R&D sector, while about 1% of all emigrants were specialists with scientific degrees. Officially, about 5000–6000 scientists have emigrated from Russia and Ukraine in recent years. These figures may not, at first sight, appear to be very high. However, in some sectors the losses are particularly significant. As sociological surveys show, the proportion of specialists in mathematics, physics and biology among emigrants from research institutes has been extremely high. That means that for some specific areas the losses have been critical. In many cases, official statistics do not fully reflect the real processes taking place. Russia loses about the equivalent of approximately 300,000 USD with the emigration of each scientist (Yurevich and Tsapenko, 1998). Among emigrants from Russia, mathematicians and specialists in software dominate (52%), followed by biologists with 27% (Nekipelova and Ledneva, 2003).

However, it would be misleading to consider only 'pure' emigration here. There are other forms of migration of highly qualified specialists from key scientific institutions. A growing number of scientists use unofficial channels (that is to say, channels that are not under the control of the administrators of research institutes) to go to the West. They participate in training programmes, receive stipends from foundations, and so on, without even consulting with the heads of their institutions. Such behaviour could not have been imagined in the former Soviet Union. 'Shuttle visits' and part-time work in the West have become more common in the post-Soviet countries. Russian statisticians have even introduced special statistical forms to try to 'catch' this type of migration (Zaionchkovskaya, 2004). Unfortunately, the estimates of 'traditional' emigration and 'shuttle visits' of scientists are not available in recent Russian publications on R&D statistics. However, Ukrainian data can be used to provide some estimates for 'shuttle migration'. For instance, just in 2006 alone, approximately 4000 scientists worked abroad for more than 3 months (of whom almost 60% worked abroad for more than half a year), and about 400–500 persons had long-term research contracts in foreign countries. Yet the official figure for 'traditional' emigration that year was less than 100 scientists.

In broad terms, over the last 10 years 3 new trends have appeared in the pattern of emigration. First, emigration has become 'professional' rather than 'ethnic'. There is strong evidence of an outflow of specialists, irrespective of nationality, from Ukraine and Russia between 1995 and 2005. For the first time, Russians and Ukrainians began to receive permission to emigrate to developed countries under the classification of specialists, rather than as refugees or family members.

Second, the will to emigrate has apparently grown stronger among young scientists. Many young people have been trying to pass exams to enter Western universities or to receive long-term work contracts in the West. As a result, young specialists may leave their countries even before they officially start their scientific careers, thus making it difficult to reflect this phenomenon in the statistics on scientific emigration.

Third, there has been change in the direction of emigration, especially in the case of Ukraine. From the second half of the 1990s, a remarkable number of specialists left Ukraine for Russia—mainly from the military–industrial complex and the nuclear energy industry. To a great extent, this was because the differences in salary between specialists in Russia, particularly in the nuclear energy sector or in some military-oriented companies, and their Ukrainian counterparts were very substantial. The process of emigration to Russia was not primarily a result of ethnic problems. The introduction of the Ukrainian language, as the one and the only official state language in Ukraine, met with a somewhat negative reaction on the part of the Ukrainian research community. Traditionally, the bulk of scientific literature had been published in Russian, and dissertations and papers were also written in Russian.

[12] SCSU (2006).

[13] We do not have the latest figures for Russia, but the data from *Russian Science and Technology at Glance: 2003 Databook* (Moscow, TSISN, 2004) show the trends in Russia and Ukraine were similar at the beginning of 2000s. (More recent Russian databooks on R&D and innovations do not contain such data.)

However, it is important to stress that the problem of the internal relocation of educated personnel is more serious than the problem of emigration, since many more specialists left the R&D sector for other types of activities than emigrated from the country. Low wages and lack of demand for intellectual products have led to an outflow of hundred thousands of educated people to other sectors of the national economy, and primarily to private business. The diffusion of former researchers from R&D into other sectors could bring positive results at the present stage of the economic recovery. Unfortunately, the great majority of former scientists have undertaken relatively simple work that does not make use of the scientific qualifications that they possess. Thus, the process of relocation of former researchers into other sectors has been accompanied by the underutilization of their potential as professionals.

Another threat to the scientific community in both countries comes from hidden emigration. This type of emigration is based on a combination of formal maintenance of the workplace in a scientific institute or design bureau while pursuing other work that is not connected with R&D. There is ample evidence based on sociological surveys (Fortov, 2002; Krasnova, 2003), and from the author's interviews with directors of research institutes in Ukraine, that this is a widespread practice in modern Ukraine and Russia. Many specialists formally associated with R&D institutions or production enterprises spend the bulk of their time on outside activities, mainly in the retail trade or other services. Indirect confirmation of this fact is that in many institutes, employees officially have to come to the office no more than twice a week for a couple of hours. Workshops are rare, and there is no obligation to publish in internationally recognized journals and no responsibility to teach students. This situation is a result of a bureaucratic system of budgeting in state-owned institutions based on a 'head-count' of personnel. Thus, employees can receive relatively low salaries, without reference to their scientific achievements. At the same time, in many cases, the level of income that scientists receive from their primary (or official) place of work is not sufficient to support their families. Without formally breaking with the research sphere, they have to find some other job outside of R&D. For a more than a decade, the state supported this kind of activity indirectly by compelling people to take long unpaid leave or by delaying salary payments. A similar 'social policy' has been used in state-owned enterprises since the early 1990s. However, the majority of these are now privatised, while research establishments still need some assessment of their research productivity.

The state officials and the institute's bosses excuse this situation by the above-mentioned lack of demand from the side of industry. While the situation is changing and, although a formal procedure of internal assessment exists, a system of independent assessment of institutes and individual achievements has not yet been established. The old budgeting principles therefore still dominate.

5. Conclusion

The R&D sector in post-Soviet countries has passed through what we hope will have been the most difficult period of the economic transformation. The largest of them, Russia and Ukraine, have been able to preserve substantial parts of their scientific potential. Unfortunately, the R&D sectors in both countries remain largely unreformed and underutilized. It is evident now that lessening state control over the process of transition is not having the desired effect in many cases, especially in transforming the R&D system. Weakness and uncertainty of S&T policy has conspired with the economic crisis to inflict losses in terms of manpower and technical assets, and indeed to produce unfavourable structural changes.

While the principles and practice of financial support of R&D are of considerable concern, the aging of the research community, the outflow of research personnel from R&D institutes and the obsolescence of their research equipment pose other threats to the future of the R&D systems in the former Soviet Union. The majority of researchers in the main post-Soviet countries are mature in age, and the opportunities for recruiting young scientists are very limited. Gifted young persons can chose between a research career in developed countries and work in business that brings a much higher income than work in the national research establishments. The same applies to the aging of research equipment. It is clear that without remedial action, the productivity of the system will continue to fall, with negative consequences in the longer term for the economy as a whole.

The government research sector is still relatively large, and the government has generally failed to bring about its modernization. R&D organizations still depend mostly on central budgets, and developing linkages with industry is not their major interest. There is also a lack of monitoring and on-going correction of applied measures, aimed at supporting R&D. Once introduced, they remain unchanged until the government stops them. More generally, government support tends to be rather limited and inflexible, and therefore unable to exert a wider influence. Some demonstration models may work well but the problem is that they do not become more widely disseminated at the level of industrial sectors. Important elements of the innovation system are supported but without any connection to other elements of the system, and without taking into account the broader economic context. This fragmentation of support inevitably means that state initiatives in R&D have a rather modest impact.

Both Ukraine and Russia urgently need not only a serious transformation within the R&D system, but also important changes in the wider environment. The state has to create favourable conditions for the introduction of innovation. There is a lack of indirect measures to encourage cooperation between research organizations and industry, as well as a relatively weak stimulus for larger industrial enterprises to increase their innovation activities because of underdeveloped regulations in a variety of areas, including the protection of intellectual property rights. The introduction of adequate legal protection for intellectual property rights, especially in foreign countries, is of critical importance for individual researchers, S&T institutes and science-based SMEs. It is also very important for foreign companies seeking to engage in direct investment or some other form of business alliance, and for domestic companies that seek to co-operate with them.

It will also be important to develop co-operation with the EU countries, as Ukraine has expressed its intention to join the EU in the future, while Russian authorities have proclaimed that the strengthening of contacts with the Europe is their main priority. We should note that EU officials have never rejected the idea of closer co-operation between scientists from the EU and neighbouring countries, including post-Soviet states. This proposal could receive new impetus, even though the prospect of these states joining the EU remains remote. More active utilization of the S&T potential of these countries could have substantial positive effects for both parties (Mitsos, 2004).

For Russia and Ukraine, the introduction of new forms of co-operation between Western companies and research centres, on the one hand, and local research organizations and individual researchers, on the other hand, would be very useful in selected areas. This could help to save resources and to obtain new results more quickly. At the same time, leaders of the post-Soviet states have to realise that it would be prohibitively expensive to develop and maintain the potential research capabilities of all of a nation's research institutes at a uniformly high standard, as they unsuccessfully tried to do in the past.

To summarise, we have seen how the largest post-Soviet states have yet to create the relevant institutions and proper instruments needed for the effective transformation of their R&D systems. Unfortunately, every year the possibilities for the implementation of effective transformation policies are shrinking, as the number of researchers declines and the research centres lose their ability to conduct research. With time running out, what remains of the R&D sectors face mounting problems in ensuring that they possess the creative capabilities needed to compete internationally. Very recently, the Russian government started an ambitious program of financial support for R&D, accompanied by the creation of university-based research centres throughout the country. However, it is still too early to reach any conclusions about the impact of these reforms on the research community or on indicators of R&D performance. In Ukraine, major transformations of R&D still lie ahead. Reforms of the R&D sector have to be an integral part of the general economic transformation. In the economic sphere, a key precondition for successful change in the R&D system is the switch to an intensive growth policy accompanied by appropriate structural changes, which, in turn, have to be based on innovation.

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