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**When a Good Science Base is not enough to Create
Competitive Industries: Lock-in and Inertia in Russian
Systems of Innovation**

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Abstract

Despite having a formidable position in terms of domestic R&D activity and a well-developed science and technology infrastructure prior to transition, Russia has failed to create a competitive firm sector. Using a systems of innovation approach, we argue that institutions are subject to inertia when political and economic regimes were rapidly reformed, and the system structural lock-in, causing industrial enterprises to engage in routines that generated a sub-optimal outcome. Market forces did not result in the western style model, but a hybrid one. A significant segment of industry maintains a Soviet-style dependence on 'top-down' supply-driven allocation of resources and a reliance on external (and domestic) network of sources for innovation and capital. At the same time, 'new' industries have also evolved which undertake their own R&D, and utilise foreign sources of capital and technology, and at least partly determine their production and innovative activities on the basis on market forces.

Key words: innovation systems, R&D, Russia, inertia, institutions, lock-in

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When a good science base is not enough to create competitive industries: Lock-in and inertia in Russian systems of innovation

1. Introduction

It has been widely recognized that local firms' growth depends on their ability to build their technological competences by acquiring knowledge from domestic and non-domestic source allowing for development of competitive products (Bell and Pavitt, 1993; Kim, 1997; Figueredo, 2002). In particular, the last two decades have seen the study of MNEs as a vital source of advanced technological knowledge move into the mainstream, such that neoclassical economists, governments and supranational institutions now consider FDI as an indispensable aspect of promoting economic growth in lagging economies. The belief is that in the medium- to long-term, domestic firms in the host country will benefit from MNE spillovers and linkages, and that indirect mechanisms such as the competition effect will result in a healthy economic activity by both domestic and foreign firms.

However, empirical studies to date largely fail to provide convincing evidence indicating the extent of the benefits of MNEs knowledge for local firms' growth. At the same time, the impact of knowledge acquisition by local firms from domestic sources well as in-house knowledge creation is not taken into account. The literature highlights that countries with a certain threshold level of absorptive capacity and technological infrastructure should receive significant levels of FDI, and should be able to create linkages and internalise spillovers with MNEs, thereby promoting further industrial development. However, the empirical results fail to fully support this assumption¹ and does not offer a comprehensive explanation why domestic firms in countries with less favourable initial conditions in terms of the domestic knowledge base (e.g. China) have demonstrated a faster

¹ The literature on the effects of MNE activity on local firms is quite large and diverse. Some recent highlights include Haddad and Harrison (1993), Aitken and Harrison (1999), Djankov and Hoekman (2000), Konings (2001), Buckley, et.al. (2002), Damijan, et. al. (2003), Bell and Marin, (2004), Aseidu (2006), Smarzynska (2004), Marin and Bell (2006), Meyer and Sinani (2008).

growth than firms in countries with more attractive initial conditions (e.g. Russia). Despite having a formidable position in terms of domestic R&D activity and a well-developed science and technology infrastructure prior to transition, Russia has been outpaced by other laggard countries including India, China, the Czech Republic and , to name but a few.

This study attempts to provide an understanding of some of the factors which influence how domestic industrial enterprises are able to grow and enhance their competitiveness, focusing in particular on how the relationship with other players in the non-firm sector affects this process.

Although knowledge acquisition from MNEs can play an important role for local firms' growth, we recognise that there are other means and sources for knowledge acquisition and creation complementary to those from MNEs (Radosevic 2006). Thus, this study is not about knowledge acquisition from MNEs *per se*. We seek to answer the following question: *Why have local firms in some countries -such as Russia - where science and technology infrastructure was of high standard, where there were plenty of well-trained scientists and engineers, where domestic industry was capable of producing advanced technologies and products, which in many cases had an economically viable domestic market size, not demonstrated rapid growth since the 1990s?*

A partial answer to this question is the role institutions (see e.g., Nelson and Winter 1982, North 1990). The absence of efficient institutions can retard the efficient accumulation and transfer of knowledge between industrial enterprises and other economic actors within their milieu, acts as a major brake influencing growth in general (e.g., Rodrik 1999, Rodrik, et. al. 2004; Lall and Narula 2004; Meyer and Peng, 2005; Asiedu 2006). A fundamental shift from one political and/or economic regime or policy stance to another represents a discontinuity or 'shock' to the system, and this can play havoc with both formal and informal institutions. There is often a strong institutional inertia which must be

overcome, whether this shift is as fundamental as experienced by the former centrally planned economies as they transitioned towards market economies, or from an import-substituting stance to a more open, export-oriented one as in many developing countries, the difference being only one of degree (Neuber 1993, Narula 2003).

It is, of course, also well-known that there is a high degree of endogeneity and interaction amongst and between institutions, science and technology infrastructure, the competitiveness of industrial enterprises and the endowments of any given economy, and a growing literature emphasises these interactions are themselves worthy of note (Edquist, 1997; Kolodko, 1999; Cassiolato and Lasters, 2000; Rasiah, 2008). Our interest in this paper is not the causality of these interactions and their nature *per se*, but how they may act to promote or prevent knowledge accumulation and exploitation by industrial enterprises. We will build upon the literature of systems of innovation (SI), which has argued that the development of firm-level technological capabilities is the outcome of investment undertaken by the firm in response to external and internal stimuli (Lall 1992). That is, in addition to factors that are firm-specific, there are those that are common to firms in given countries depending on their policy regimes, skills and factor endowments, and institutional structures (See e.g., Lundvall, 1992; Edquist 1997). In other words, to examine the strength or weakness of firms, one must turn to understanding the underlying and complementary developments in their associated system (Criscuolo and Narula 2008). We argue that institutions are subject to inertia when political and economic regimes are reformed, and the system as a whole – through its various interactions which are held together by institutions – may experience lock-in, causing industrial enterprises to engage in routines that generate a sub-optimal outcome.

The remainder of paper is organised as follows. Section 2 presents the theoretical premises of the paper and discusses from the system of innovation point of view problems

of institutional inertia and lock-in. Section 3 describes the specific features of pre-transition model of SI and challenges of its transformation towards a conventional model suitable for market economies. Section 4 provides an empirical illustration of the developed theoretical argument in the empirical context of Russian transition economy. Section 5 presents the conclusions of the research.

2. Theoretical underpinning of the paper

2.1. Systems of innovation and role of institutions

Economic growth occurs due to the ability of a nations' industries to develop and sustain their competitive position, and that this requires growth of productivity of its capital and labour. Economic growth concerns not just the development of knowledge through innovation, but also the diffusion of knowledge such that it may be utilized and exploited in an efficient manner. In other words, accumulated technology is an engine of growth *only* if it can be harnessed to make the best use of the available resources, and therefore must also consist of the knowledge to organise transactions efficiently, whether intra-firm, intra-industry or intra-market. The point here is that ownership-specific assets of economic units—be they technological in the narrow sense, or organisational – all share the common characteristics that they are cumulative, and are evolve over time.

Economic units – be they firms or individuals – acquire knowledge by exploring in the vicinity of their existing knowledge assets, by undertaking routines, which leads to incremental innovations. Knowledge is acquired by interaction with its external environment. In the case of firms it may be through interaction (*inter alia*) with customers, suppliers, competitors, government agencies. Firms (as are individuals, who make up firms) are generally averse to radical change, in that they are likely to 'stay close' to successful patterns of behaviour, learning and interaction that have been successful in the past.

Another important factor in understanding the dynamics of knowledge accumulation is that these evolutionary processes do not occur in a vacuum. That is, firms do not make decisions about the kinds of products they will seek to develop, nor where they intend to develop and produce these goods and services, based simply on firm-specific issues and profit maximising motives. Firms exist as part of ‘systems’, much as individuals exist as part of society. They are embedded through historical, social, political and economic ties to other economic units.

Firms are also constrained by the kinds of knowledge competences they can acquire and internalise by the extent of their absorptive capabilities (Cohen and Levinthal 1990). It takes years to develop new competences, and to achieve a level of expertise that will provide them with a technological advantage to be a front-runner. The skills to acquire and successfully internalise external assets are non-trivial. In other words, firms are constrained in what they can learn by what they know.

Understanding the systems’ view of an economy and the underlying dynamics of learning helps us to comprehend the creation of competitive advantage both at an industry and a national level. It also – if one takes a linear and developmental view of technological accumulation and innovation systems – helps us to understand how industrial development occurs. Systems always exist, but they do not always result in an efficient outcome in the sense that firms in that location are able to sustain an advantage. Furthermore, systems may be ‘incomplete’ or ‘unbalanced’ because some aspects of the systems are inefficient, or simply non-existent. Nor, even where an efficient, complete and balanced system exists, does this imply that this will continue *ad infinitum*.

It is important to realise that few countries have truly ‘national’ systems. Of course, some innovation systems are more national than others, and the term is indicative rather than definitive. For instance, smaller countries’ innovation systems may have a larger

dependence on non-national actors. Others have argued that innovation systems need to be viewed from an industry-level (Nelson and Rosenberg 1993). However, by and large, most economic actors within an innovation system have a growing interdependence on economic actors outside their national boundaries (Narula 2003). It is safe to say that prior to transition, the centrally planned economies were much more ‘national’ and self-contained, as were the import-substituting economies to a lesser extent.

The innovation system concept suggests that there exist certain structural influences (scientific, political, and socio-economic) within any nation state that help to define that pattern, nature and extent of knowledge accumulation within a given industry, which also defines the extent and nature of industrial innovation within its borders. Technological specialisation patterns are distinct across countries, despite the economic and technological convergence associated with economic globalisation (Archibugi and Pianta, 1992; Narula, 1996). Other studies have shown that these patterns of technological specialisation are fairly stable over long periods (see Cantwell, 1989; Zander, 1995) and change only very gradually.

Insert Figure 1 about here

Figure 1 gives a stylised version of a conventional *national* innovation system. An SI approach essentially allows us to map the complex interactions between a firm and its environment. The environment consists, firstly, of interactions between firms—especially between a firm and its network of customers and suppliers. Secondly, the environment involves broader factors shaping the behaviour of firms: the social, political and cultural context; the institutional and organisational framework; infrastructures; the processes which create and distribute scientific knowledge, and so on. By economic actors we refer to two

groups. The first group are firms – private and public – engaged in innovatory activity, and the second consists of non-firms that determine the knowledge infrastructure that supplements and supports firm-specific innovation. We define ‘knowledge infrastructure’ in the sense proposed by Smith (1997) as being ‘generic, multi-user and indivisible’ and consisting of public research institutes, universities, organisations for standards, intellectual property protection, etc that enables and promotes science and technology development. For simplicity, we can broadly define the non-firm sector as consisting of (1) A public R&D sector including various organizations conducting R&D activities; (2) An education sector consisted of universities, institutes and other organizations providing training and education. The interactions between the various actors within a system are governed by institutions. Institutions are the ‘glue’ that bind the various actors together, and determine the efficacy of their interaction (or lack thereof). Institutions are taken here to be of two types, informal and formal, and are generally taken to be the ‘sets of common habits, routines, established practises, rules, or laws that regulate the interaction between individuals and groups’ (Edquist and Johnson 1997). Institutions create the milieu within which all economic activity is undertaken and establish the ground rules for interaction between the various actors. We take formal institutions to include the appropriate intellectual property rights regime, competition policy, the creation of technical standards, taxation, the establishment of incentives and subsidies for innovation, the funding of education, etc. They are by and large codified and are administered by organisations which are themselves formal institutions since their existence is formally defined, and are structures that designed to create and implement new and existing formal institutions². They are generally politically defined and legally binding rules, regulations and organisations. Indeed, the political and economic spheres are rarely independent, and this is all the more so where a high degree of

² North (1990) differentiates institutions from organisations. However, as explained here, organisations can themselves be institutions.

central planning was undertaken, whether in developing countries that had implemented import substitution programmes, or in the former centrally planned economies. In general, the policy environment in which economic actors function has a high degree of interdependency between the economic and political spheres.

To modify and develop informal institutions is a complex and slow process, particularly since they cannot be created simply by government fiat. Perhaps the most important aspect of informal institutions is the ‘know-who’ (Narula 2002). Informal networks of government agencies, suppliers, politicians, researchers and so on take considerable effort to create, and once developed, have a low marginal cost of maintaining. For an outsider, the high costs of becoming familiar with, and integrating into, a new system may be prohibitive (Narula 2003). For an insider, however, such membership comes with privileges which provide opportunities for rent generation³.

Informal institutions are rarely codified. They are also necessary for creating and promoting links between the various actors, and are closely tied to norms and values, and represent routines which are essential to the implementation of formal institutions. To modify and develop informal institutions is a complex and slow process, particularly since they cannot be created simply by government fiat. Perhaps the most important aspect of informal institutions is the ‘know-who’ (Narula 2002). Informal networks of government agencies, suppliers, politicians, researchers and so on take considerable effort to create, and once developed, have a low marginal cost of maintaining. For an outsider, such as an MNE, the high costs of becoming familiar with and integrating into a new location may be prohibitive (Narula 2003). For an insider, however, such membership comes with privileges which provide opportunities for rent generation. The informal aspect in particular will probably have taken years – if not decades – to create and sustain. Indeed, more recent work

³ The literature on network theory provides a useful discussion on the complexities of interaction with informal institutions.

on informal institutions – which are notoriously difficult to quantify – point to the absence or inefficiency of institutions as a primary force inhibiting economic development (e.g., Rodrik 1999; Rodrik, et. al., 2004, Asiedu, 2006).

2.2. The challenges of institutional inertia and lock-in

Since informal institutions are very imprecise in nature and are harder to measure and quantify, there has been a tendency for policy makers and the academics to underemphasise their importance, focusing instead on formal institution building. This has included promulgating new laws, reducing corruption, improving the regulatory apparatus, creating monetary and fiscal institutions, strengthening corporate governance, enhancing the functioning of the legal system. However, informal institutions are not so easy to change, partly because the formal and informal institutions are inextricably locked together – organizations that must implement changes in formal policy are also the custodians and the creators of the informal institutions that are required to be modified. As Johnson (1994, p. 973) explains in her evaluation of the problems of reforming the Russian banking system:

Even in crisis the old institutions remain and must continue to function in order to prevent a complete atomization of society. In such a crisis period, then, the structure and practices of the old institutions will have a fundamental impact on the way in which the institutions react and adapt to the new circumstances.... Large gaps almost always exist between legislated changes from above and their implementation by the institutions affected by these changes.... Something is regularly lost or altered in the translation, and the institutions themselves determine

exactly what these ‘somethings’ will be... Those wishing to abolish existing institutions often find that they must settle for changing them slowly and painfully.

In other words, systems are bound by institutional inertia, because formal and informal institutions constrain and pre-determine what firms and governments can and cannot do (Hannan and Freeman 1984). To paraphrase the concept of inertia in the current context: *industrial enterprises will prefer to maintain existing institutions with competitors, customers and external organisations, produce similar products and remain in similar locations, unless an external force is applied.* That is, they prefer to maintain their current state of equilibrium, if it does not threaten their survival. It is worth emphasising that inertia as a concept is neither ‘positive’ nor ‘negative’. The reluctance to change is a state of nature and always exists. Inertia is even *required and depended upon*, as it is the basis for stability, accountability and reliability within any system. Stable institutions are an essential condition to reduce uncertainty in any environment (Peng 2002, 2003).

When a large external ‘shock’ is applied – a change in the economic and political milieu, by legal and governmental fiat - actors will seek in the first instance to continue to use the institutions and routines with which they are familiar, even where they no longer provide efficient returns. Oliver (1992) shows that even when change is recognized by firms, it may be immobilized by the previous institutional arrangement. Actors loathe radical change. Radical change is costly and highly risky, and because routines and institutions develop slowly, *radical change that is undertaken rapidly is even more risky* (Narula 2003). Thus, inertia in transition between two different economic systems implies a ‘lag’ between adapting informal institutions in response to a change in the formal institutions. The lack of congruity between the formal and informal aspects of institutions means that reform will lack legitimacy as long as there is a void between the formal and informal aspects (Neuber

1993), and especially so where the new institutions are not native to the domestic environment (Palma, 1991).

Inertia can be a pervasive phenomenon at the level of a whole economy, because often there is a self-reinforcing interaction between industrial enterprises, the infrastructure and politics which perpetuates the use of specific technologies, production of specific products, and/or through specific processes, and specific customer-supplier associations. Political reform resulting in economic reform may act as an external shock, forcing wholesale changes in the formal institutions which are incompatible with the informal institutions. The situation is exacerbated when elements of the industrial system and its associated infrastructure are either shrunk, or transferred to the control of another branch of the economy, or are obliged for other reasons to alter their *raison d'être*. Such institutional restructuring is not an instantaneous or costless process and results in inefficient outcomes. Institutions developed for, or specialised around, an economic system or industrial cluster are not efficient in responding to the needs of another. In the case of the impost-substituting countries institutional inertia was at a much smaller scale, often associated with a few select industries built around national champions. In the transition economies, this was on a much larger scale, covering almost all aspects of economic activity.

An important source of institutional inertia derives from the paradox that when radical reform is implemented, formal institutions are both the objects and the agents for change (Johnson, 1994). The 'insiders' who represent both key members of formal governmental organisations as well as more informal interest groups often have much to lose from reform and actively resist change, either because of potential adverse effects on their status or their ability to derive rents. As Fernandez and Rodrik (1991) show, there is a bias towards the status quo, even where it is inefficient. In the case of Russia, Dyker (2000)

argues that the continued dominance of insiders and their resistance to implementing reform has been the main cause for economic stagnation.

2.3. When inertia results in lock-in

Interaction within an SI is a self-reinforcing mechanism which may or may not lead to *ex post* efficiency. That is, a single dominant paradigm of interactions built around specific relationships between economic actors that are supported by specific institutions may prevail which may or may not be the most optimal set of associations. In essence, actors are structurally locked-in to specific institutions, locations, actors and products/technologies. Lock in represents a self-reinforcing interaction between firms and infrastructure perpetuating the use of routines. This often results from increased specialisation because of structural inertia (Hannan and Freeman 1984; Hannan, et. al. 2002).

Lock-in (as with inertia) can be a 'positive' if a virtuous relationship that sustains or improves the competitiveness of firms exists between parties within an SI. This may be because the SI provides the best resources and opportunities on a global level, or because the industry is purely a domestic one. Institutions develop that support and reinforce the interwoven relationship between firms and the knowledge infrastructure through positive feedback. However, a negative outcome from lock-in is also possible where there is systemic lock-in such that the SI cannot respond to, or adopt to, external shocks due to radical shifts in the technological, economic or political paradigms.

Over-specialisation of knowledge infrastructure to meet the specific needs of a specialised cluster can also lead to *ex post* inefficiencies. Firm-infrastructure relations can be so closely interdependent that the boundaries and functions of firms and the various components of the knowledge infrastructure are unclear, and *de facto* operate as one large

unit. Grabher (1993) illustrates how the myopia generated by systemic lock-ins⁴ led to the decline of the Ruhr area in Germany.

3. A stylised systems of innovation model in a centrally planned economy

Figure 2 shows the stylised version of pre-transition SI model. Prior to economic reforms, transition economies had a largely domestic innovation system where knowledge sources were determined primarily by domestic elements (Radosevic, 1999; 2003). The technological development trajectory had been planned centrally in response to state-defined priorities. Likewise, domestic governmental organisations formulated domestic industrial policy, which in turn determined domestic industrial structure. National non-firm sources of knowledge also defined the kinds of skills that the local labour force might possess; the kinds of technologies that these actors had appropriate expertise in; the kinds of technologies in which basic and applied research was conducted, and thereby, the industrial specialisation and competitive advantages of the firm sector. FDI was non-existent in those countries prior the transition era and any linkages to international sources were sporadic and state controlled.

Insert figure 2 about here

Figure 2 indicates that the other important feature of SI in centrally planned economies was the extensive and pervasive coordination between actors, when the one-way information flows in the forms of plans and directives existed between the state and the other actors of the system. The change, which took place after the beginning of economic reforms, was dramatic in respect of scale and speed (Peng, 2003).

⁴ Grabher does not use the term ‘systemic lock-in’ but refers to three simultaneous lock-ins: functional lock-in, cognitive lock-in and political lock-in.

FDI in the post centrally planned era was thus a novel phenomenon from both perspectives. Local actors in many instances were reluctant to integrate MNEs into the system, as is indicated by the mixed evidence on knowledge spillovers from FDI in transition economies (Damijan, et.al., 2003; Yudaeva et al, 2003; Sinani and Meyer, 2004; Javorcik and Spatareanu, 2008), although countries such as Hungary and the Czech Republic, were much more responsive to undertaking radical changes to their industrial structure, while most of the former soviet states considerably less so. The primary difference between the two groups essentially reflected a fundamentally different policy stance, with some countries maintaining the basic principle of domestic firm-led industrialisation, while others moved to a MNE-led development strategy (Radosevic, 2006). Largely speaking the latter group modified their institutions and attempted to redesign their systems of innovation around the 'conventional' market economy model, with varying degrees of success (Radosevic, 2006). The former soviet states largely maintained their original innovation system focused around traditional areas of competence and dominant economic actors. This often reflected the extent to which there was a political imperative and a popular sentiment to distance themselves from the pre-transition dependence on the Soviet Union and realign their economies with the European Union. In other words, the ability of different economies to transition reflected the strength of the existing institutional arrangements and the political will to reform (Newman 2000). Roth and Kostova (2003) argue that the variation in the firms' responses in transition economies can be explained by the gap between existing and desired institutional arrangement, and institutional baggage determined by the strength and pervasiveness of the institutional arrangements that existed prior radical change. In cases such as Russia, economic transformation deepened the deficiencies inherited from the pre-transition SI, and the mixture of changes in incentives structures played a negative role in the innovation processes in indigenous firms.

On the one hand, institutional transformation faced a significant degree of inertia when local actors were not able to respond efficiently to the challenges of reforms. On the other, government failed to create and develop appropriate institutions supporting the organizational transformation of local firms, and this was not helped by the reluctance of interest groups to implement change. Therefore, the failure took place at two levels: at the performance level and at the policy level. The next section will elaborate in greater details the inertia in transformation of the Soviet SI towards the conventional model of SI in Russia.

4. Evidence from Russia

This section presents the empirical illustration of the argument developed in previous sections. In particular, we aim to demonstrate in the empirical context of Russian transition economy the challenges of transformation of the Soviet S&T system towards conventional SI able to support capabilities development in firms. In our analysis we use the empirical data collected from various sources. The first part of the material consists of secondary data on Soviet Science and Technology (S&T) and Russian SI was obtained from the publications of the Russian Statistics Office as well as from academic publications. The second part is based on a series of interviews which were conducted with top managers of local industrial enterprises as well as Russian Headquarters of MNEs which have manufacturing facilities in Russia.

4.1. The organization of the Soviet science and technology system

The most important feature of the Soviet S&T system was the strong role of state in coordinating activities of all the actors in the system. The state defined the priorities for development of science and education, allocated funds, and coordinated the implementation of the plans. Figure 3 illustrates the structure of the Soviet S&T system which was highly

hierarchical in nature and where ultimate authority belong to the Communist Party determining the directions for the development of S&T system on the basis of its ideological principles. Specifically, the Soviet S&T system had two main sectors, namely the R&D sector and the education sector, which were governed by the Council of Ministries (Figure 3).

Insert Figure 3 about here

The R&D sector consisted of three groups of organizations.

1. The first group were organizations which were under administration of the Soviet Academy of Science and consisted of a number of large Research Institutes performing the basic research, such as the Space Research Institute and the Institute of Applied Mathematics.
2. The second group of organizations of R&D sector consisted of Ministries for branches of National Economy such as e.g. Aviation, Machine Building, and Nuclear Industry. The Ministry of each industrial branch had its own R&D units which were concentrated to a large extent on applied research and development functions. In particular, as it is shown in Figure 3, this part of R&D sector included
 - a. construction bureaus concentrating on the new product planning and development functions;
 - b. small- and medium-size research institutes conducting research and development functions;
 - c. project-based organizations conducting a range of functions depending on the project;

d. experimental plants whose activities were mostly restricted to the product testing functions (Figure 3).

These organizations represented a major part of Soviet R&D sector and about 90% of all scientific activities were concentrated in industrial branches, which was the distinctive feature of the organization of R&D sector.

3. The third group of organizations were coordinated by the Ministry of Education. These units mostly conducted basic research.

The coordination of activities of all these organizations and distribution of financial resources took place according to the 'top-down' principle as indicated the direction of arrows in the Figure 3. The Communist Party defined the directions of the research, which were further communicated to Academy of Science and Ministries, which, in turn, were responsible for the detailed planning and implementation of R&D activities and for the allocation of specific tasks to various organizations in the R&D sector. Then, as a result of coordination at the Ministries level, the tasks of the research projects were normally divided between various organizations according to their specialization.

A distinctive feature of the Soviet S&T system was that the organization of the R&D sector required a high level of coordination between organizations involved in the project. It was not uncommon that several research institutes, construction bureaus and experimental plants might be involved in the process of development and testing of a product. Hence, Figure 4 provides a graphical illustration of the intricate network of organizations involved in innovation. Once a new product had been developed (by the construction bureaus and research institutes) and test manufactured in the experimental plant (where both standardisation of products and manufacturing processes were fine-tuned), production was then shifted to the industrial enterprise, which was focused on large scale production.

Insert Figure 4 about here

It is important to emphasize that industrial enterprises did not engage in R&D themselves, and their activities were limited to the mass production function. They normally received the already developed technological knowledge from other R&D organizations in a form suitable for the manufacturing of the final products (Figure 4).

The production process itself was organized according to the five-year plans defined centrally by the state, which clearly defined how much output was expected from each enterprise. Any initiative at this stage was discouraged, as managers were keen to avoid missing targets, since they were often personally responsible for achieving their target. In this type of environment industry lacked both the stimuli and the capabilities for development of new technologies and better quality products. Sales of output were also known well in advance, and were carefully matched with supply at fixed prices that were not always related to their actual value. This practice further undermined the desire and necessity to improve the quality of the products and modernize the production facilities.

Linkages from the ‘bottom to the top’ also existed in the Soviet S&T system, primarily in the planning process. All actors had to communicate back to the higher authorities how they planned to achieve their output, and specify the kinds of inputs and resources they would need to achieve their targets (Figure 3). This communication allowed the higher authorities to exercise a tight control over industrial sector and inhibited any flexibility in the activities of the soviet enterprises.

To summarize, this structure of R&D sector had several serious drawbacks. First of all, innovative activities were concentrated outside the industrial enterprises which were highly dependent on the intricate network of institutes and construction bureaus for

development of their products. Soviet enterprises functioned as mere production units, and there were a lack of motivation to conduct serious R&D activities. Technological knowledge produced in R&D organizations was not linked directly to consumer needs and was partly responsible for the low level of consumer goods development in the Soviet Union.

The second disadvantage of the Soviet R&D sector was its highly bureaucratic and political nature where priorities for development were defined by the higher authorities, and the practice of interests lobbying by R&D organizations and research groups was particularly common. Funds for development of certain scientific projects were received on the basis of the strength of ties between R&D organizations and the Soviet party, rather than being based on project competition. This feature has been inherited by Russian R&D sector. As one of the respondent stated:

“There is such a concept as lobbying of the interests... It has been inherited from the Soviet times when, in order to get a state order for one’s own construction bureaus, various means are used by the Head of the Bureau to influence the decision [of the politicians]”.

Most R&D units had little or no management staff, with leading researchers appointed by the Communist party running the organisations including the distribution of funds, definition of priorities for the future research, and scientific publications.

The third part of the S&T system was the education sector which was represented by the institutes providing secondary and tertiary education. They were mainly responsible for the supply of qualified graduates for all sectors of economy, and to some extent performed basic research, financed entirely by the state. As Figure 3 shows, the Ministry of Education was in charge of all educational organizations, and was authorized to define the nomenclature of specialties according to the expected needs of the national economy. These

needs were defined 5-10 years ahead, and certain quotas for new graduates were defined on the basis of the demand in each industrial sector and approved centrally. Consequently, according to those quotas, a certain number of students were accepted to educational organizations of different levels. This type of coordination allowed for a balanced structure of new graduates, who, were placed in industrial enterprises of the appropriate specialization. This practice of graduates' distribution across the enterprises allowed for acquiring the practical skills in the exact field in which a young graduate was studying. Therefore, the Soviet system of education was able to produce a required number of specialists for all branches of the national economy, which was its important advantage. This had the advantage of stability, but it meant that new disciplines and subject areas were not easily catered for.

To conclude, the main characteristics on Russian S&T system were high degree of state coordination and control which often had a political nature and was highly bureaucratic; low R&D activity in industrial enterprises. Also, it is worth to note that the links with western scientific world were underdeveloped which slowed the pace of the technical progress and development of new advanced technologies.

4.2. Transition period

First phase of reforms, 1992-1995

The first years of transition were a very hard time for Russian science when the state priorities were oriented towards other national needs, and R&D and education sectors faced severe competition for the budgeted funds. These sectors were excluded from the priorities of the government development policy due to the fact that other problems such as e.g. financial stabilization, high inflation were in focus of the government attention. The overall negative background existing in the national economy and the significant decline of

industrial output decreased the incentives and resources of all actors in the economy to conduct R&D activities.

Table 1 gives the share of industrial output in industry in 1995 as a percentage from 1991, and shows that the most significant fall in production occurred in consumer goods and machine building industries, where the share of output in 1995 was 18.5 per cent and 41.1 per cent correspondingly compared to that in 1991. The energy sector was protected to a large extent, where the decrease in output was much less significant and was sustained at the level of 82 per cent.

Insert Table 1 about here

During this turbulent time the Russian government has significantly reduced its research and development (R&D) funding as part of the restructuring and downsizing of Russia's R&D system and its reorientation toward civilian research and development. The principle of the science funding has change: before it was a high priority in state spending, after the transition funds were allocated according to the 'what is the rest' principle; in 1992 the state finance of science has decreased in 2.2 times compare to 1991 (Dezhina, 1997). In 1991 there were 100% state-owned R&D organizations. As Table 2 indicates, by 1995 only 29.4% were owned by the state (Statistical yearbook of Russia, 2007). However, the overall number of these organizations decreased only by 12.4 per cent from 4564 in 1991 to 4059 in 1995 which can be explained by the fact that some large organizations such as research institutes were broken-down into smaller independent organizations which were more easily managed by teams of scientists.

Insert Table 2 about here

As can be understood from the Table 2, the most significant downsizing took place in number of construction bureaus and project-based organizations. In 1991 construction bureaus and project-based organization represented 20.4% and 12.2% of the total number of R&D organizations respectively. By 1995 the corresponding numbers were 13.3% and 1.6%. Some of these organizations simply did not survive transition, although some were privatized and started to undertake various (non-state directed) commercial activities in order to get additional financial resources. In particular, many construction bureaus and research institutes has been transformed into manufacturing units (e.g. Antonov Construction Bureau).

Overall, these processes had a strong negative influence on the innovative capabilities of Russian industrial enterprises which were closely cooperating with these organizations for the development of new products. Thus, the most negative consequence of the downsizing of S&T system was not the decrease in the number of organizations as such, but the manner in which they were eliminated, and the consequences this had on the overall innovation network. Each of the organizations had its rather specialised functions in the coordinated state network. As a number of players were made to 'exit' the field, the chain of innovative activities and the consequent level of output was severely compromised. This in turn put an additional pressure on those organizations which have survived to perform a much wider range of activities and establish new networks of partners. As one of the respondents stated:

“In Soviet times 5-6 construction bureaus were doing the same volume which now does one bureau and one enterprise”.

Hence, Figure 5 shows many organizations and, consequently, linkages between them disappeared which was resulted in inefficient functioning of the whole R&D sector.

Insert Figure 5 about here

The downsizing of the number of organization in R&D sector has also resulted in the decrease in the number of scientific staff. Table 3 indicates that number of researchers and scientists in 1995 decreased by 58.7 per cent compare to the level of 1991. This fact supports the point suggested previously that although the number of organizations did not change dramatically, the real scale of activities conducted in R&D sector decreased significantly.

Insert Table 3 about here

Also, according to the information provided by Statistical yearbook of Russia (2007), the decrease in personnel was the most significant in technical science whereas in the humanities and social sciences the number of scientific staff occurred to a considerably smaller extent. The explanation for this situation is that Soviet science was technically oriented when the humanities and social sciences were not included into the state development priorities. However, after transition the lack of qualified staff in these areas was realized and more resources have begun to be directed there.

In the education sector, where during first years of transition only 40 per cent of costs were covered by the state (Dezhina, 1997), organizations gained a high degree of autonomy from the state and were allowed to define independently the range of specialties,

the number of students and content of educational programs. These changes had a significant influence on the structure of education and, to a certain extent, on its quality. Due to the fact that in the Soviet Union the education was to the large extent technically oriented there was a lack of graduates in humanities and social sciences, especially in economics and law, and during the transition to market economy there appeared an acute need in specialists in such fields as management, marketing, and law as well as in various branches of services. Thus, the education sector has started a massive reorientation of the educational programs oriented towards mentioned specialties, which could be pointed as a positive aspect on its own. However, the negative side of it is that the opening of new specialties often took place at the expense of the closure of others technical traditional specialties. New programs in these fields were also cheaper to implement since they did not require the expensive training equipment as in the case of engineering specialties which was an important issue in the situation of limited financial resources. As it has been mentioned by an interviewee:

“Technical colleges were transferred to the regional supervision which meant in practice that many of them re-oriented their educational programs from technical specialties requiring expensive teaching materials (e.g. class rooms equipped with new equipment for practice) towards educational programs in services such as e.g. hairdressers, restaurant staff, etc., where education process is much more easy and cheaper to organize”.

This statement emphasizes the fact that a mismatch has appeared between the professions taught in educational organizations of all levels and industry needs in graduates. Table 4 shows the change in the number of professional training graduates and supports the respondents' statement that the number of qualified factory floor workers has decreased significantly in the post-soviet time. Hence, in 2000 the total number of graduates fell by

53.4 per cent compare to the level of 1994. Further, such sectors as machine building and metal processing and metal processing had experienced the most dramatic decrease which was 251.3 per cent and 158.6 per cent correspondingly (Table 4).

Insert Table 4 about here

Second phase of reforms, 1995-2007: slow recovery

After a few first years of transition Russian government has managed to undertake some actions towards the stabilization of science and technology sector and its further transformation into conventional type SI suitable for market economy. However, although various changes in formal policies regulating the SI functioning have been made, the ministerial principal in the coordination of SI was preserved from the pre-transition time.

Figure 6 shows the stylised version of new Russian SI aiming to illustrate the new elements appeared as a result of transformation processes, and the change in the nature of the links between various actors of SI.

Insert Figure 6 about here

The important feature of the new system was the appearance of new types of organizations in each of sector of SI. First, at the higher level, a number of budget and non-budget funds was established in order to finance R&D and education sectors. They do not belong to any of the Ministries, and their resources of the majority of them were distributed on the basis of open project competition. Thus, these funds represented new form of selective state support. Further, foreign funds have been founded when foreign investors became increasingly interested in the cooperation with Russian scientists. These funds

allocated grants for the financing of scientific projects and for the support of prospective students in leading institutes and universities.

In R&D sector, among new players were small innovative enterprises which activities were primarily focused on applied research and commercialization of innovations. However, the number of those enterprises has decreased over the transition period due to the face numerous legal obstacles influencing the efficiency of their operations (Dezhina, 2004). Among the major obstacles are underdeveloped infrastructure in the area of technology commercialization; incomplete and misleading legislation; lack of financial resources. Also, technology parks and science cities (*naukogrady*) from the Soviet era were reoriented and adjusted to new economic conditions.

In the higher education sector a large number of private universities were established after the start of the reforms which activities were financed entirely by their own funds. Table 5 shows the number of organizations of higher education, and it is clearly illustrate the rapid growth of private universities from 193 in 1995 to 430 in 2006.

Insert Table 5 about here

Lastly, in the enterprise sector, a large number of companies with foreign (both full or partial) ownership was established during both the first and the second phase of transition (Figure 6).

It is worth emphasizing that although the nature of relationships between actors within the SI changed, it did not change completely. There have been different types of responses at the organizational level to the changing conditions of the external environment, when some organizations succeeded to establish efficient bilateral links with other actors of SI joining their efforts in the creation and development of innovations. As it is shown in the

Figure 6, the two-way arrows indicate that the close cooperation exist between some successful enterprises and organizations of R&D sector. However, there still exist large number of companies which failed to re-structure their activities, and re-establish links with other actors still functioning in the old fashion manner.

The overall structure of innovative activities did not change significantly over the decade was there a noticeable increase in R&D activities performed by industry. Table 6 provides an empirical data on the Gross Expenditure on R&D by the performer in 1995-2004, and clearly indicates that the change in R&D activities conducted by industrial enterprises was marginal, from 68.5 per cent in 1995 to 69.1 per cent in 2004. Moreover, the government remains to be the main source of funding of R&D activities. Table 7 shows the data on Gross Expenditure on R&D by the finding source, where the share of government remains significantly large and represents 60.6 per cent in 2004.

Insert Table 6 about here

Insert Table 7 about here

The continuing challenge of institutional inertia in the Russian SI

The discussion in the previous section indicates that large part of Russian SI failed to overcome structural inertia after the start of economic reforms and adopt new practices in their activities. Russian enterprise sector still faces numerous problems in the creation and development of innovations and manufacturing the competitive products. According to a number of the interviewees, a large number of modern Russian enterprises still do not have an internal R&D unit. The point here is that in the reality the government tools did not work

as efficiently as it was expected, and the new practices and means of functioning were not adopted by the majority of actors in the SI. The participation in these new types of relationships represents a specific type of capabilities which development is extremely time-consuming process, and subject to inertia. The other problem of Russian enterprises originated from implementing formal institutions when the presence of Soviet types of informal institutions was still strong.

Moreover, many enterprises are still lumbered with technologically and physically old equipment and production facilities which were no longer suitable or efficient. In other words, companies do not have conditions for the manufacturing of the technologically advanced products due to the dilapidated state of the production facilities and equipment. This inefficient organization of production processes has increased the costs of products despite the fact that labour costs are still at a relatively low level, implying a low level of productivity. Formal policies developed over the last two decades have thus far failed to create incentives for undertaking innovation activities or the modernization of industrial sectors as there has been little to motivate industrial enterprises to make long-term development plans that required capital investments. After the beginning of transition, economic and political environment also became highly unstable which undermined local firms' ability to make long-term plans. As one of the respondents pointed out:

“At least during the Soviet Union times, we knew that as time goes we will achieve certain types of things such as establish a family, get an apartment and a summer house. But then at one point everything collapsed, and during the transition time it was very unclear what is going to happen which made it difficult to plan ahead and think about future”.

This instability has resulted in the managers' attitude to get the most benefits as soon as possible while they will be able to enjoy these benefits. The long-term development and

modernization requires significant investment which in most cases has to be found internally in the enterprises, and will give a return only after a number of years. As another interviewee said:

“The problem is the desire to get an immediate return”.

Thus, investment policies of Russian enterprises are not focused towards long term goals, but survival oriented, since and the main problem for the modernization was in part the lack of financial resources. Government support is limited, and other mechanisms of attraction of financial resources are not used by Russian enterprises.

Further, the disappearance of tight linkages between organizations providing education, the state and industrial enterprises has resulted in difficulties with finding appropriately qualified workers in certain technical specialties. The manager of one of the industrial enterprise stated:

“There is catastrophic lack of working specializations, and not only working specialists but also technologists, constructors. Engineers are in very high demand, and the market for engineers is extremely tight in Russia. There is a lack of engineers, of accountants, HR managers. There is a lack of a lot of people”.

Specifically, one of the most important problems pointed out is lack of factory-floor technical workers:

“It is clear now that there would be a catastrophic lack of ‘working hands. Difficulties occur when people from technical colleges, which are medium-level professional education, trained to work as the technologists are working instead as the machinery operators”.

However, there have been some positive changes and currently, private sources of finance from domestic and foreign investors are gaining in importance (Figure 6). In particular, companies seek various ways of cooperation with foreign investors such as joint ventures, R&D projects, etc. This cooperation has been promoted by a gradual change in the attitude towards MNEs, and at a number of levels, appropriate policies to attract MNEs and stimulate the creation of linkages with local firms (e.g. the Saturn-Snecma joint venture for development and production of aircraft engines), which suggests that there is a potential in the future.

5. Conclusions

It has become increasingly clear that the capability to generate knowledge, the provision of basic and advanced infrastructure and availability of a well-trained and skilled labour force are insufficient in themselves to promote industrial development and local firms' competitiveness. This is especially obvious when examining the former centrally planned economies of central and eastern Europe and their inability to exploit their not-inconsiderable science and technology base in a post-communist environment. Almost two decades later, some of these countries - such as Russia - have failed to demonstrate a discernible improvement in their industrial landscape whereas such laggard economies as China or India have succeeded in creating a vibrant and competitive domestic sector. This paper seeks to better understand the reasons for this discrepancy.

We have taken a system of innovation approach and highlighted how the role of institutions and institutional inertia has impeded the process of transition. The resultant absence of strong linkages between government agencies, the R&D, education and firm sectors has in turn negatively influenced the development of technological capabilities of local enterprises. Although the functions and roles of all actors have been defined by formal

rules and policies, informal institutions have taken considerably longer to change, and in many instances, not yet adapted in an efficient manner.

We have emphasised that the political and economic spheres are highly inter-related and political and economic reform are often inseparable. As Johnson (1994, 2001) has stressed, institutions are highly resilient, and in the Russian case, have demonstrated incredible stability over the last century, despite several radical changes in the political and economic regime. Firms are interdependent and co-dependent on other domestic economic actors which determine institutions and policies which have not only formed them – and with which they are most familiar – but which they have also helped create. This process can be a self-reinforcing mechanism that perpetuates the use of certain technologies and networks of suppliers, customers and collaborators. Innovation systems change only very slowly and this can result in what Hannan and Freeman (1984) describe as structural inertia, which in turn can lead to systemic lock-in. Both inertia and lock-in are the result of actors within the system acting for or against reform. In the case of Russia, insiders and interest groups have a vested interest in maintaining existing institutions and they impede radical change. This lends credence to the principle that gradual changes are more likely to result in longer lasting and more ingrained reform than when shock therapy is used (Fernandez and Rodrik 1991; Dewatripont and Roland 1992, Rodrik 1996; Peng 2003), except perhaps cases where popular sentiment has been overwhelmingly behind fundamental reform.

The example of Russia provides considerable evidence of this. Market forces did not result in the innovation system restructuring itself to a western style model, but a hybrid model. A significant segment of industry maintains a soviet style dependence on ‘top-down’ supply-driven allocation of resources and a reliance on external (and domestic) network of sources for innovation and capital. At the same time, ‘new’ industries have also evolved

which undertake their own R&D, and utilise foreign sources of capital and technology, and determine their production activities on the basis of both demand and supply.

Similar challenges – albeit at a smaller scale – have also faced developing countries that have shifted from an import-substituting model to a more open, market economy. liberalization (among other forces related to the Washington Consensus) has acted as a major ‘shock’ to the institutions within most of these countries, since it has introduced not just new economic actors (MNEs), but it has also required major restructuring of existing institutions (legal codes, political structures, policy orientation). Despite the view of the Washington Consensus, the exposure of these economies to the vagaries of international competition suddenly will not necessarily facilitate their institutional setting.

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Figure 1 The conventional model of an innovation system

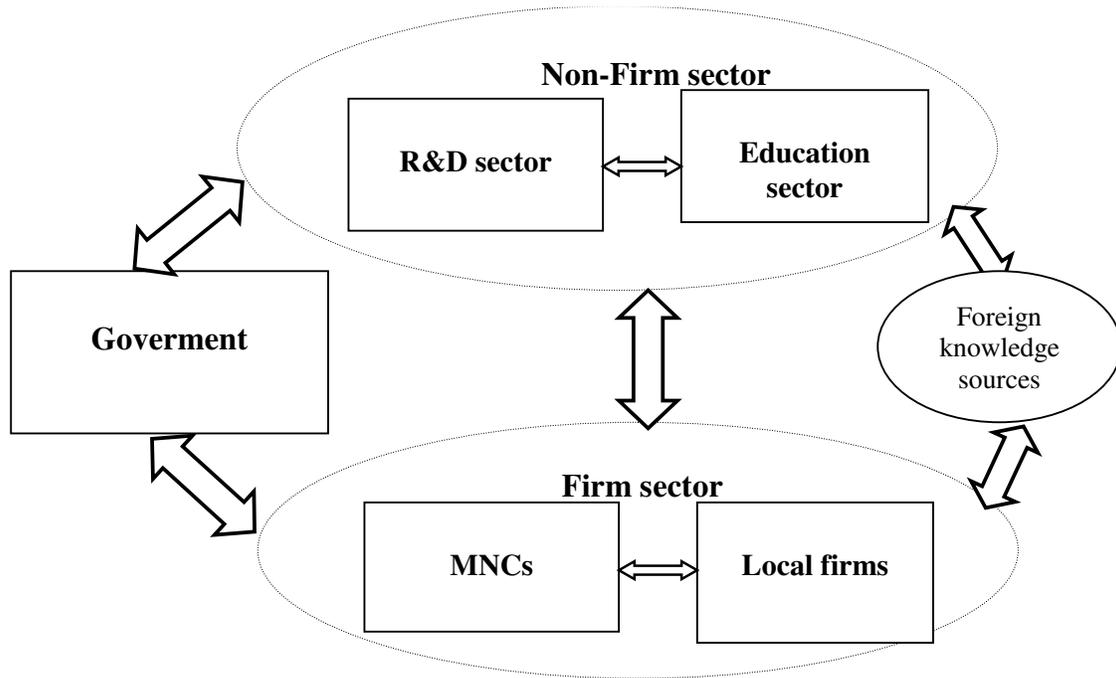


Figure 2 The pre-transition model of innovation systems in centrally planned countries

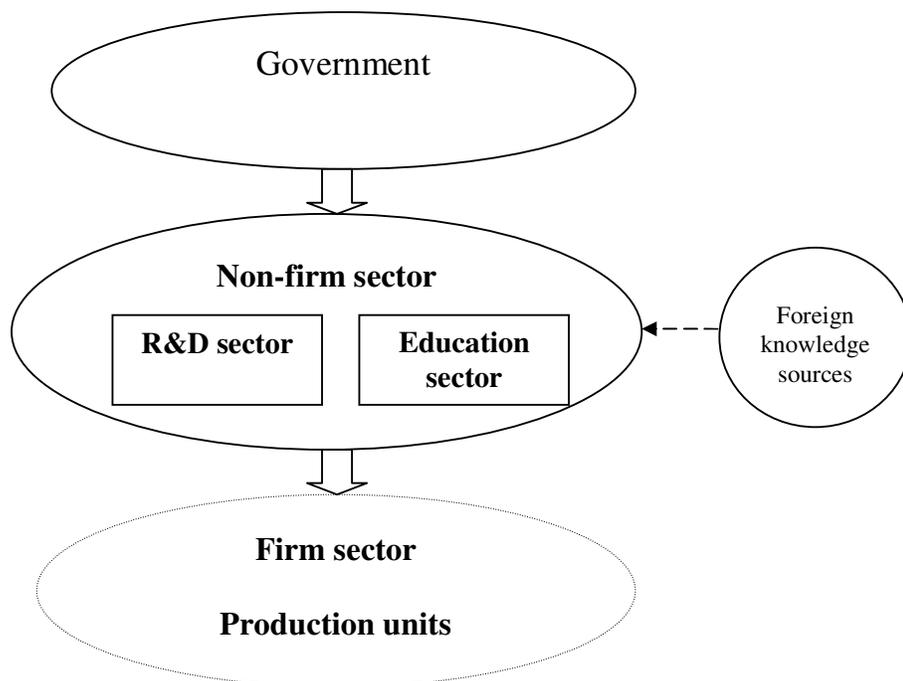


Figure 3 Organization of R&D and Higher Education: The Soviet Model

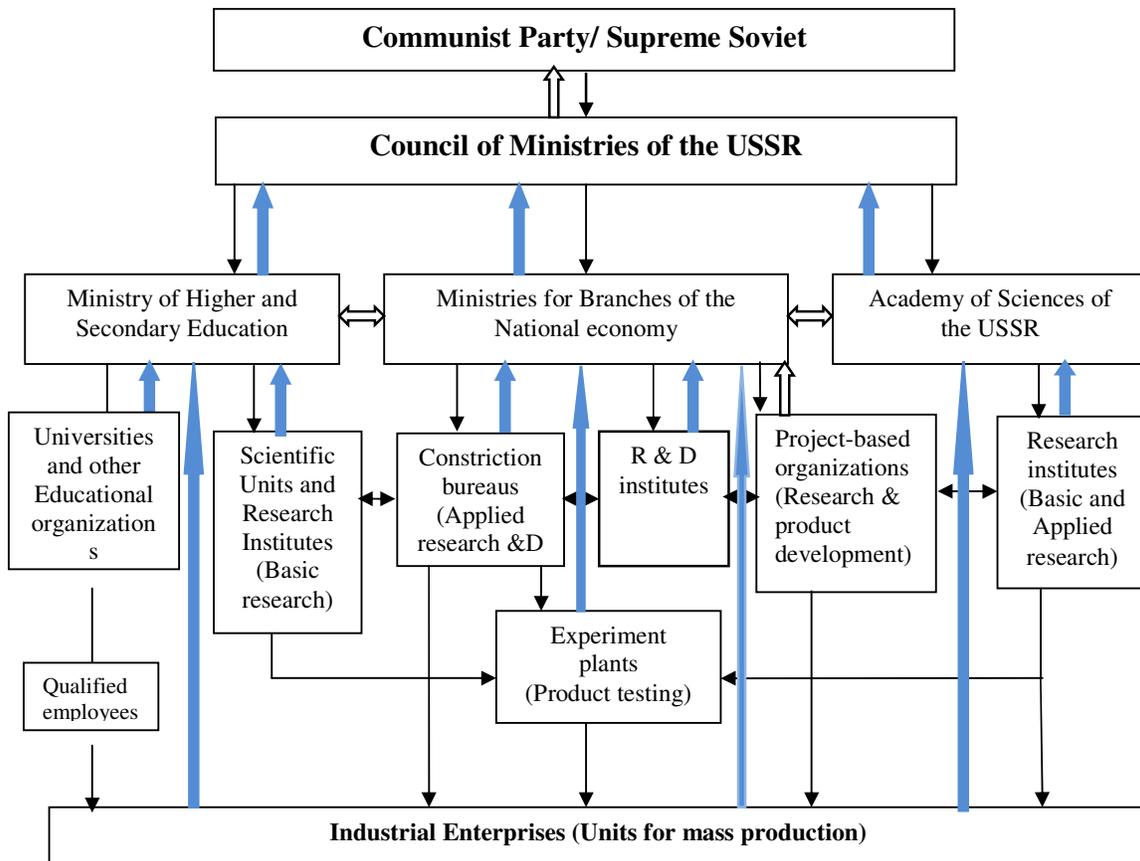


Figure 4 A typical network of co-dependent R&D organizations: the Soviet model.

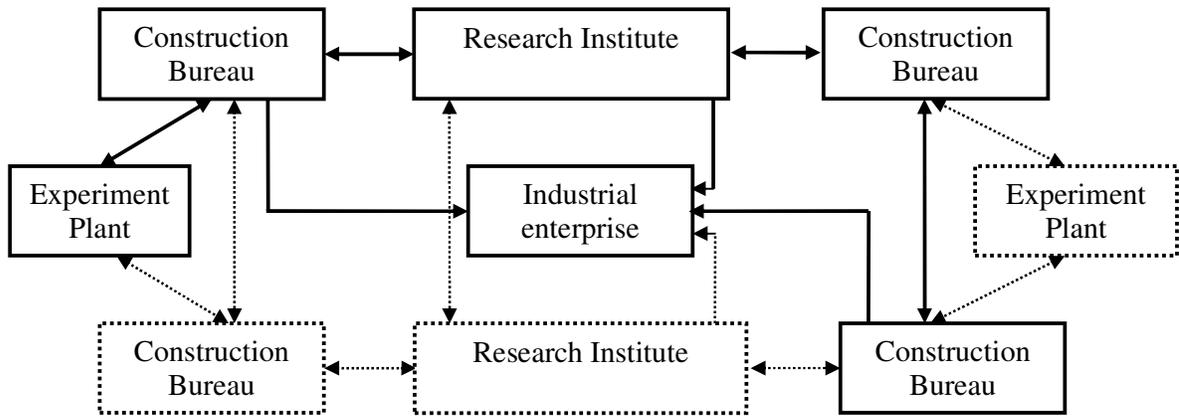


Figure 5 incomplete networks of R&D organizations after transition

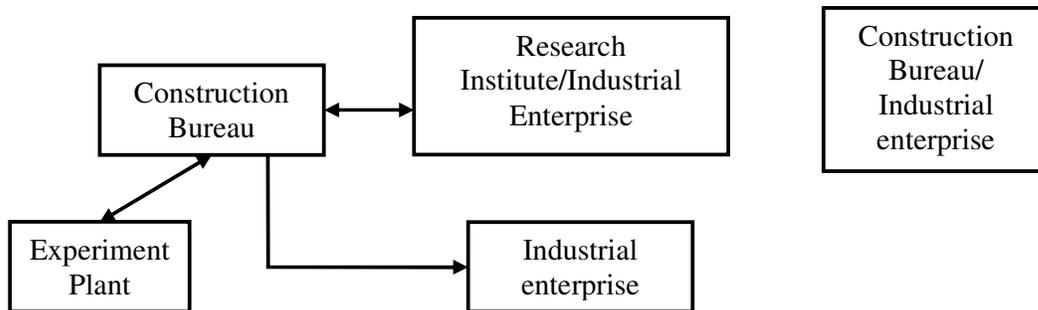


Figure 6 Theoretical model of organization of the Russian SI

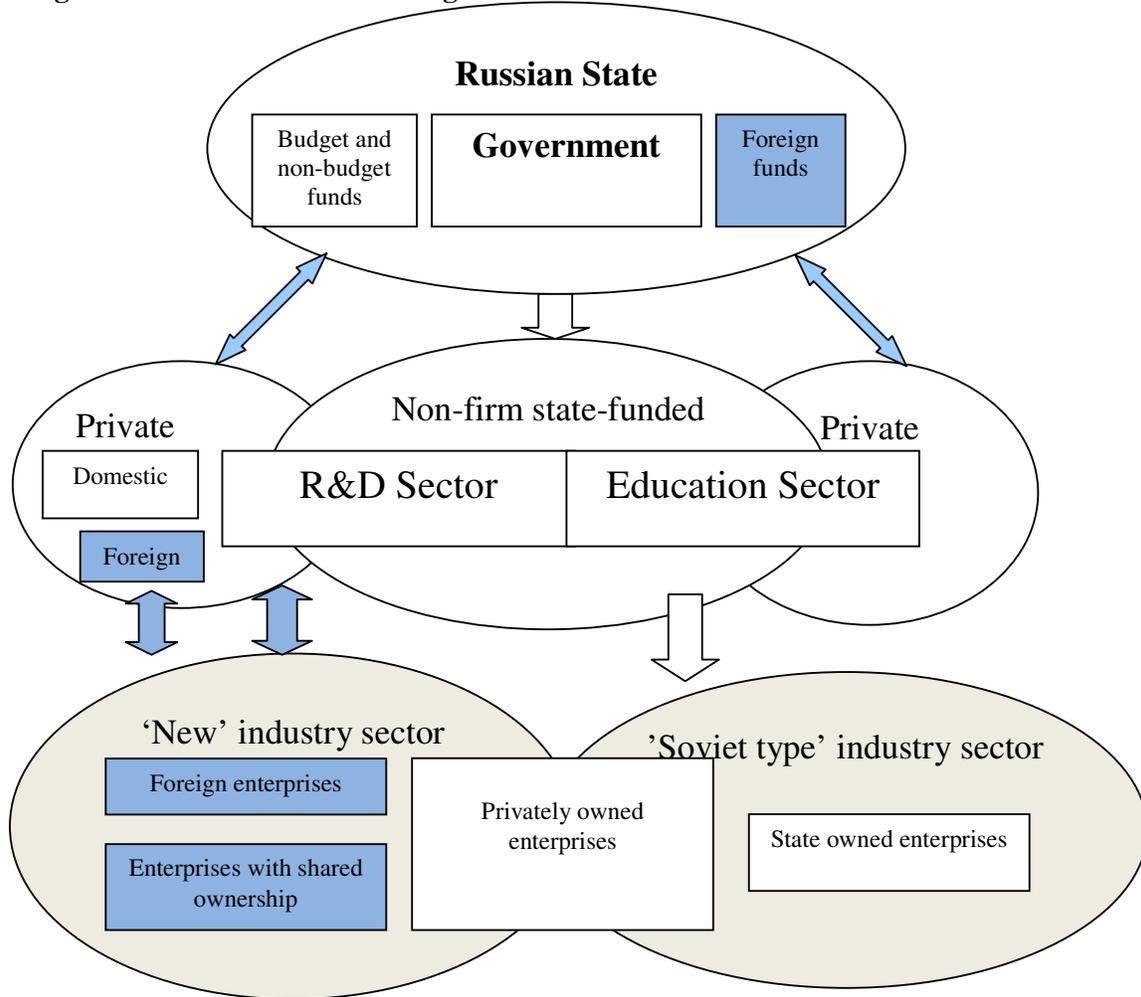


Table 1 The share of industrial output in 1995 (% from 1991)

Industries	%
Energy	82.0
Black Metallurgy	57.4
Chemical	45.8
Machine building	41.1
Forestry	43.1
Building materials	43.3
Consumer goods	18.5
Food	52.4

Source: Bobilev, Y (1997)

Table 2 Number of R&D organizations, 1995-2006

R&D organizations		1991	1995	Absolute change 1995/1991 (%)	2000	2005	2006	Absolute change 2006/1991 (%)
R&D institutes	Total	1831	2284	19.8	2686	2115	2049	10.6
	%	40.1	56.3		65.5	59.3	56.6	
Construction bureaus	Total	930	548	-69.7	318	489	482	-92.9
	%	20.4	13.5		7.8	13.7	13.3	
Project-based organizations	Total	559	207	-170.0	85	61	58	-863.8
	%	12.2	5.1		2.1	1.7	1.6	
Experiment plants	Total	15	23	34.8	33	30	49	69.4
	%	0.3	0.6		0.8	0.8	1.4	
Organizations of high education	Total	450	395	-13.9	390	406	417	-7.9
	%	9.9	9.7		9.5	11.4	11.5	
R&D units in other organizations	Total	779	602	-29.4	587	465	567	-37.4
	%	17.1	14.8		14.3	13.0	15.7	
The total number of organizations	Total	4564	4059	-12.4	4099	3566	3622	-26.0
	%	100	100		100	100	100	
Of which state owned:	Total	4564	1193	-282.6	1247	1282	1341	-240.3
	%	100.0	29.4		30.4	36.0	37.0	

Source: Statistical yearbook of Russia (1995; 2007).

Table 3 scientific staff in R&D organizations (thousands)

Scientific staff		1991	1995	Absolute change 1995/1991 (%)	2000	2005	2006	Absolute change 2006/1991 (%)
Researchers & technicians	Total	1227	623	-97.0	500	456.1	454	-170.4
	%	63.2	58.7		56.3	56.1	56.3	
Assistants & non academic staff	Total	716	441	-62.4	387	356.1	352.1	-103.4
	%	36.8	41.6		43.6	43.8	43.6	
Total	Total	1943	1061	-83.2	888	813.2	807.1	-140.8
	%	100	100		100	100	100	

Source: Statistical yearbook of Russia (1995; 2007).

Table 4 professional training graduates in industry (thousands)

Qualified graduates in:	1994	1995	1998	2000	Absolute change in %
Metallurgy	7.5	4.6	2.9	2.9	-158.6
Chemical	10.1	10.5	6.3	7.8	-29.5
Machine building and metal processing	27.4	31	11.6	7.8	-251.3
Forestry	13.2	12.7	11.8	14.1	6.4
Building materials	1.7	1	0.9	0.8	-112.5
Consumer goods industry	98.9	99.6	77.6	70.1	-41.1
Total:	158.8	159.4	111.1	103.5	-53.4

Source: Statistical yearbook of Russia (1995; 2007).

Table 5: Organizations of Higher Education

Number of:	1991	1995	2000	2005	2006
State Universities	514	569	607	655	660
Private Universities	-	193	358	413	430
Total	514	762	965	1068	1090

Source: Statistical yearbook of Russia (1995; 2007).

Table 6 GERD by performer, %

Years/ Researches in:	1995	1998	2002	2004
Government	26.1	53.5	24.5	25.3
Industry	68.5	69,0	69.9	69.1
Other national sources	5.4	1.2	5.4	5.5
Abroad	0.0	10.3	0.2	0.1

Source: Dezhina and Zashev (2007)

Table 7 GERD by funding source, %

Years/ Researches in:	1995	1998	2002	2004
Government	61.5	53.5	57.4	60.6
Industry	33.6	34.9	33.6	31.4
Other national sources	0.3	1.2	1.0	0.4
Abroad	4.6	10.3	8.0	7.6

Source: Dezhina and Zashev (2007)