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Rajneesh Narula and Irina Jormanainen

United Nations University - Maastricht Economic and social Research and training centre on Innovation and Technology
Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499, e-mail: info@merit.unu.edu, URL: http://www.merit.unu.edu

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Rajneesh Narula* and Irina Jormanainen**

Abstract

Despite a well-developed science and technology base and considerable industrial capacity during the soviet era, Russia has largely failed to create a competitive industrial sector despite two decades of transition. This paper seeks to understand why Russia has not succeeded despite having relatively favourable initial conditions. We develop an understanding of its innovation system and the interplay between the firm and the non-firm sector. We argue that – in any economy - when political and economic regimes were rapidly reformed, there is considerable structural inertia associated with complex interdependencies between the state, domestic firms and the formal and informal institutions that bind them together. In the case of Russia, this inertia has resulted in a system-wide lock-in, and industrial enterprises continued to engage in routines that generated a sub-optimal outcome. Market forces did not result in the western-style innovation system, but a hybrid one, with numerous features of the soviet system. A significant segment of industry maintains a Soviet-style dependence on 'top-down' supply-driven allocation of resources and a reliance on external (but domestic) network of sources for innovation and capital. At the same time, 'new' firms and 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, transition, competitiveness.

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* (**Corresponding author**) Henley Business School, University of Reading, PO Box 218, Whiteknights, Reading RG6 6AA, UK E-mail *r.narula@henley.reading.ac.uk*

** Department of International Business, Helsinki School of Economics.

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1. Introduction

It has been widely recognized that local firms' growth depends on their ability to build technological competences by acquiring knowledge from both domestic and non-domestic sources (Bell and Pavitt, 1993; Kim, 1997; Figuereido, 2002). The last two decades have seen a greater emphasis on the role of MNEs as an especially vital source of advanced technological knowledge. Indeed, 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, as well as through indirect mechanisms such as the competition effect.

However, empirical studies to date on the extent of the benefits of MNEs knowledge for local firms' growth have provided mixed evidence, with increasing emphasis on the simultaneous need for countries to possess a certain threshold level of absorptive capacity and technological infrastructure to benefit from FDI if they are to create linkages and internalise spillovers with MNEs[1]. Indeed the role of the MNE may well be exaggerated – countries such as Korea and Japan have been able to build up domestic capacity without recourse to substantial FDI flows, and there are other means and sources for knowledge acquisition and creation complementary to those from MNEs (Radosevic 2006). But all are in agreement that a certain domestic economic milieu needs to exist to promote the growth of domestic firms through innovation and learning.

However, the need for domestic conditions to be 'right' have not been examined in enough detail, and thus far and the literature 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 growth than firms in countries with more attractive initial conditions (e.g. Russia). Despite having a formidable

[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).

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, to name but a few.

This study attempts to provide an understanding of some of the factors which influence the ability of domestic industrial enterprises to grow and enhance their competitiveness, focusing in particular on how the relationships with other players in the non-firm sector affect this process. We seek to answer the following question: *Why have local firms in some countries -such as Russia- not demonstrated rapid growth, despite having a high science and technology infrastructure standard, a large supply of well-trained scientists and engineers, and where domestic industry was previously capable of producing advanced technologies and products, and for which an economically viable domestic market size existed?*

It is, of course, also well-known that there is a high degree of endogenity and interaction amongst and between institutions, science and technology infrastructure, the competitiveness of industrial enterprises and the endowments of any given economy. A growing literature emphasises that these interactions are themselves worthy of note (Edquist, 1997; Kolodko, 1999; Cassiolato and Lasters, 2000; Rasiah, 2008). However, 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 on 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.

Following other scholars, we argue that the role of institutions (see e.g., Nelson and Winter 1982, North 1990) is crucial. The absence of efficient institutions can retard the efficient accumulation and transfer of knowledge between industrial enterprises and other economic actors within their milieu, influencing growth in general (e.g., Rodrik 1999, Rodrik, et. al. 2004; Lall and Narula 2004; Meyer and Peng, 2005; Asiedu 2006). But we go further and argue that 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 during their transition, or from an import-substituting stance to a more open, export-oriented one, as experienced by many developing countries, the difference being only one of degree (Neuber 1993, Narula 2003).

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 nation's industries to develop and sustain their competitive position which 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 evolve over time.

Economic actors – be they firms or individuals – acquire knowledge from the external environment by exploring in the vicinity of their existing knowledge assets, and internally by undertaking routines, which leads to incremental innovations. In particular, external knowledge is acquired by firms through interaction (*inter alia*) with customers, suppliers, competitors, and government agencies. Firms are generally averse to radical change (as are individuals, who make up firms), in that they are likely to 'stay close' to patterns of behaviour, learning and interaction which 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 in 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 the industry and national levels. 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. 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 the pattern, nature and extent of knowledge accumulation within a given industry, which also define 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. There are two groups of economic actors in the system. The first group includes firms – private and public – engaged in innovatory activity. The second group consists of non-firm sector that determines 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 understood as '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 codified and administered by organisations which are themselves formal institutions since their existence is formally defined, and their structures are designed to create and implement new and existing formal institutions[2]. Formal institutions 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 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). It takes considerable effort to create informal networks of government agencies, suppliers, politicians, researchers, and once created, they 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 generation[3].

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. 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. Indeed, more recent work 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] North (1990) differentiates institutions from organisations. However, as explained here, organisations can themselves be institutions.

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

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'etre*. Such institutional restructuring is not an instantaneous or costless process and results in inefficient outcomes. Institutions developed for, or specialised around, a particular economic system or industrial cluster are not efficient in responding to the needs of another. In the case of the import-substituting countries institutional inertia was at a much smaller scale, often associated with a few selected 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 have 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, 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 adapt 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-ins[4] led to the decline of the Ruhr area in Germany.

In the next section, we illustrate this argument in the empirical context of transition economies. In order to do so, we briefly discuss a general model of SI in centrally planned economies.

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[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.

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 actors 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).

FDI in the centrally planned era was non-existent, and thus, the presence of foreign MNEs was a novel phenomenon in post-transition years. Local actors in many instances were reluctant to integrate MNEs into the system (Damijan, et.al., 2003; Yudaeva et al, 2003; Sinani and Meyer, 2004; Javorcik and Spatareanu, 2008). Although some countries such as Hungary and the Czech Republic responded successfully to radical changes in their industrial structure, the response of most of the former soviet states was considerably less successful. The primary difference between these two groups essentially reflected in a fundamentally different policy stance, where some countries maintained 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 SIs around the ‘conventional’ market economy model, with varying degrees of success (Radosevic, 2006). The former soviet states largely maintained their original SI 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 implement reforms (Newman 2000). Roth and Kostova (2003) argue that the variation in firms' responses in transition economies can be explained by the gap between the existing and desired institutional arrangements, in part determined by the strength and pervasiveness of the institutional arrangements that existed prior to 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 aims to demonstrate in the empirical context of Russian economy and the challenges of transformation of the Soviet S&T system towards conventional SI. Our analysis is based on two types of empirical information. The first is primary data acquired by conducting personal interviews with top managers of Russian industrial enterprises and foreign MNEs with production activities in Russia. We asked respondents in selected Russian companies to describe in detail the obstacles in the external environment hindering the development of their capabilities and competitiveness. Also, we asked the respondents' opinion regarding the possible actions to overcome existing problems. We interviewed both 'new' and 'old' types of Russian enterprises which allowed for the comprehensive analysis of the problems existing in Russian firm sector. Further, the discussion with foreign MNEs provided the opportunity to understand the perspective of foreign actors on the same set of issues discussed with the Russian enterprises.

After the interview data was analyzed, we collected secondary data aiming to support respondents' statements with more objective evidence. Hence, we acquired a large amount of statistical information on Soviet Science and Technology (S&T) and Russian SI from the Russian Statistics Office and academic publications which was used in the study as a complementary source of empirical evidence.

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 performing applied research and development. In particular, as 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. 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 by the direction of arrows in the Figure 3. The Communist Party defined the priorities for R&D activities, which were further communicated to Academy of Science and Ministries, which, in turn, were responsible for detailed planning and implementation 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. In particular, construction bureaus and research institutes were responsible for new product development; the experimental plants were responsible for its standardisation and test- manufacturing. Only after these steps would production be shifted to the industrial enterprises responsible for 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 by the state, which clearly defined how much output was expected from each enterprise. Initiative at this stage was discouraged, as managers were keen to avoid missing targets, since they were often personally responsible for achieving their targets. 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 impetus 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 the 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, 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 lacked 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.

Second, 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 were used by the Head of the Bureau to influence the decision [of the politicians]”.

Third, most R&D units had little or no management staff and were administered by leading researchers appointed by the Communist party who were responsible for such tasks as 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. Therefore, the Soviet system of education was able to produce a required number of specialists for all branches of the national economy. This had the advantage of stability, but it also meant that new disciplines and subject areas were not easily catered for.

To conclude, the main characteristics on Russian S&T system were (1) a high degree of state coordination and control which often had a political nature and was highly bureaucratic; (2) a low R&D activity in industrial enterprises, and (3) underdeveloped links with western scientific world 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 financial stabilization, inflation were the main 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 towards civilian R&D. The principle of the science funding changed: before the transition period it was a high priority in state spending whereas after the start of reforms funds to the R&D sector were limited. In 1992 the state finance of science has decreased in 2.2 times compare to 1991 (Dezhina, 1997). As Table 2 indicates, in 1991 there were 100% state-owned R&D organizations whereas in 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 managed by small teams of scientists.

Insert Table 2 about here

As illustrated in 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 were 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 on the overall innovation network 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 the remaining organizations which were forced 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 sciences with a much smaller decrease in the humanities and social sciences. The explanation for this situation is that Soviet science was technically oriented, and 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, during first years of transition only 40 per cent of costs were covered by the state (Dezhina, 1997), and organizations gained a high degree of autonomy and were allowed to define independently their range of specialties, the number of students and the 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. Hence, during the transition to market economy there was an acute need for specialists in such fields as management, marketing and law, as well as other various services areas. Thus, the education sector has started a massive reorientation of the educational programs. However, on the negative side, the growth of these new specialties often took place at the expense of the closure of others technical 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 a serious 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. 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 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 the few first years of transition, the Russian government managed to undertake some actions towards the stabilization of the 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 were 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 and illustrates the result of the transformation, 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 establishment of new types of organizations in each of sectors of the 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. These funds did not belong to any of the Ministries, and their resources were distributed on the basis of an open project competition. Thus, these funds represented a new form of selective state support. Further, foreign sources of capital were now available and foreign investors became increasingly interested in the cooperation with Russian scientists. These various funds allocated grants for the financing of scientific projects and for the support of prospective students in leading institutes and universities.

In the R&D sector, small innovative enterprises appeared whose activities were primarily focused on the implementation of applied research and commercialization of innovations. Also, technology parks and science cities (*naukogrady*) established in the Soviet era were reoriented and adjusted to new economic conditions. However, the number of enterprises decreased over the transition period (Dezhina, 2004). Among the major obstacles were underdeveloped infrastructure in the area of technology commercialization; incomplete and misleading legislation; lack of financial resources.

In the higher education sector a large number of private universities were established whose activities were financed entirely by their own funds. Table 5 shows the number of organizations of higher education illustrates 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. Figure 6 shows two-way arrows indicating the existence of close cooperation between some successful ('new' type) enterprises and organizations of R&D sector. However, large number of ('old' type) companies failed to re-structure their activities, or re-establish links with other actors.

Nonetheless, the overall structure of innovative activities did not change significantly, and the increase in R&D activities performed by industry was not noticeable. Table 6 provides 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 the main source of R&D funding. 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 here has indicated that a large part of Russian SI failed to overcome structural inertia after the start of economic reforms and to adopt new practices in their activities. The Russian enterprise sector still faces numerous problems in promoting innovatory activities necessary for manufacturing. According to the interviewees, a large number of modern Russian enterprises still do not have an internal R&D unit. The point here is that in reality the government tools did not work as efficiently as it was expected, and new practices were not adopted by the majority of actors in the SI, and the state was either unwilling or unable to implement important changes to the formal institutions.

Moreover, many enterprises remain lumbered with technologically and physically old equipment and production facilities which are no longer suitable or efficient. The inefficient organization of production processes has increased production costs despite the fact that labour costs are still at a relatively low level. Formal policies developed over the last two decades have, thus far, failed to create incentives for undertaking innovation activities and the modernization of industrial sectors, as there has been little to motivate industrial enterprises to make long-term development plans require significant 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 and 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'.

Thus, investment policies of Russian enterprises are not focused towards long term goals, but aresurvival oriented. The disappearance of tight linkages between the various actors in the SI p has resulted in difficulties with finding appropriately qualified workers in certain technical specialties The President of an MNE 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".

However, there have been some positive changes and increasingly, private sources of finance from domestic and foreign investors are gaining in importance (Figure 6). In particular, indigenous 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, 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 various actors within the SI has 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, they have not yet been 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. These interactions between the various organizations determine informal institutions and the 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 in 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 been faced by 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 sudden exposure of these economies to the vagaries of international competition will not necessarily facilitate their institutional setting.

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Figure 1 The conventional model of an innovation system

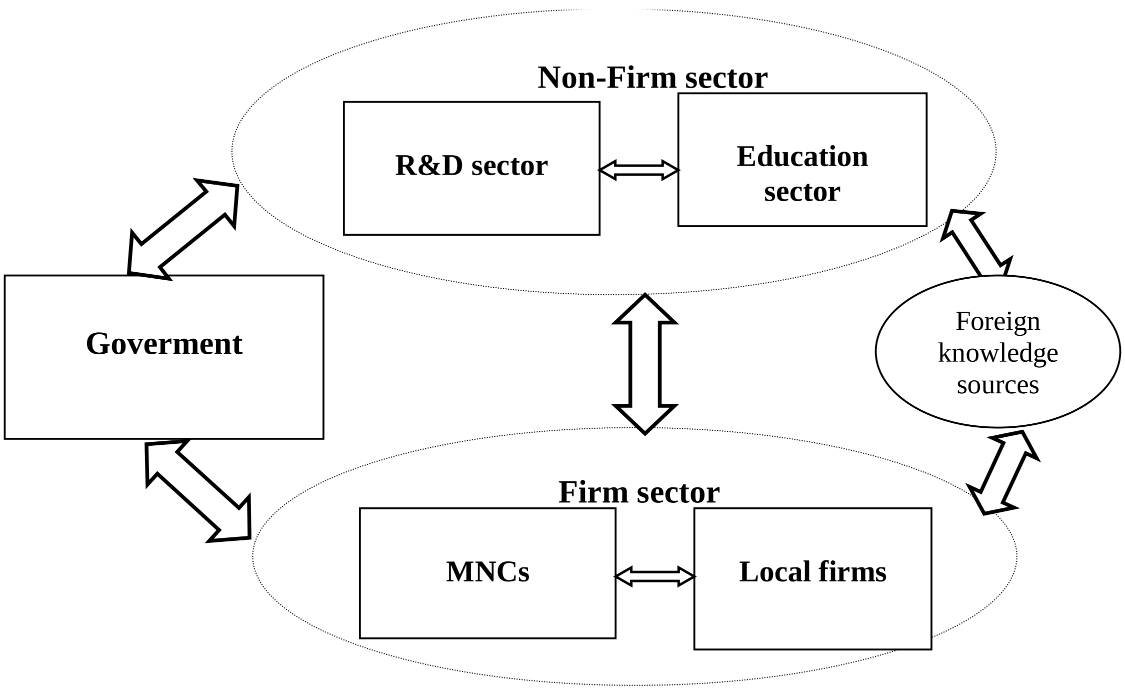

Figure 2 The pre-transition model of innovation systems in centrally planned countries

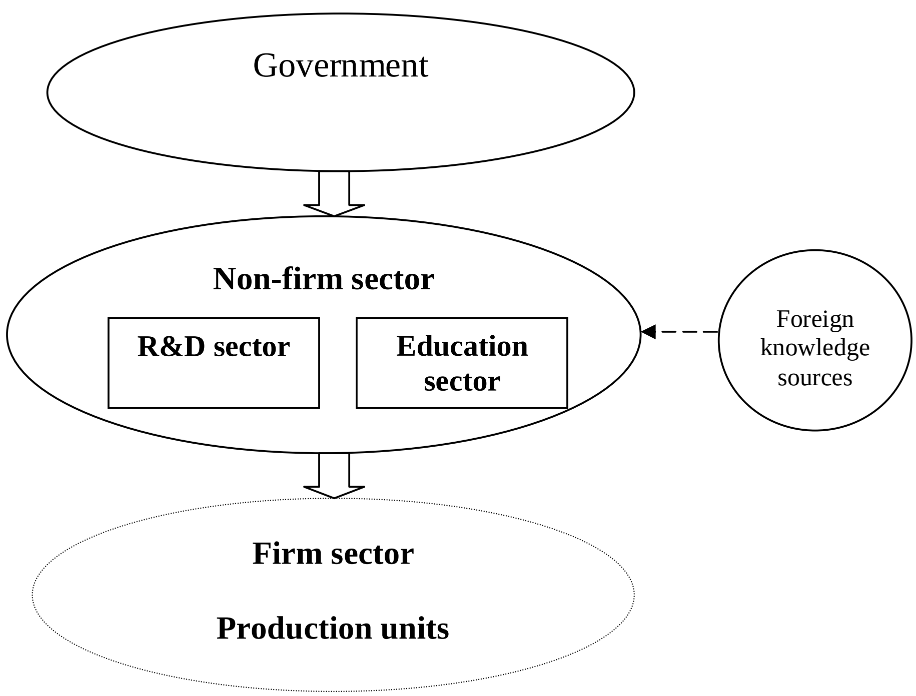

Figure 3 Organization of R&D and Higher Education: The Soviet Model

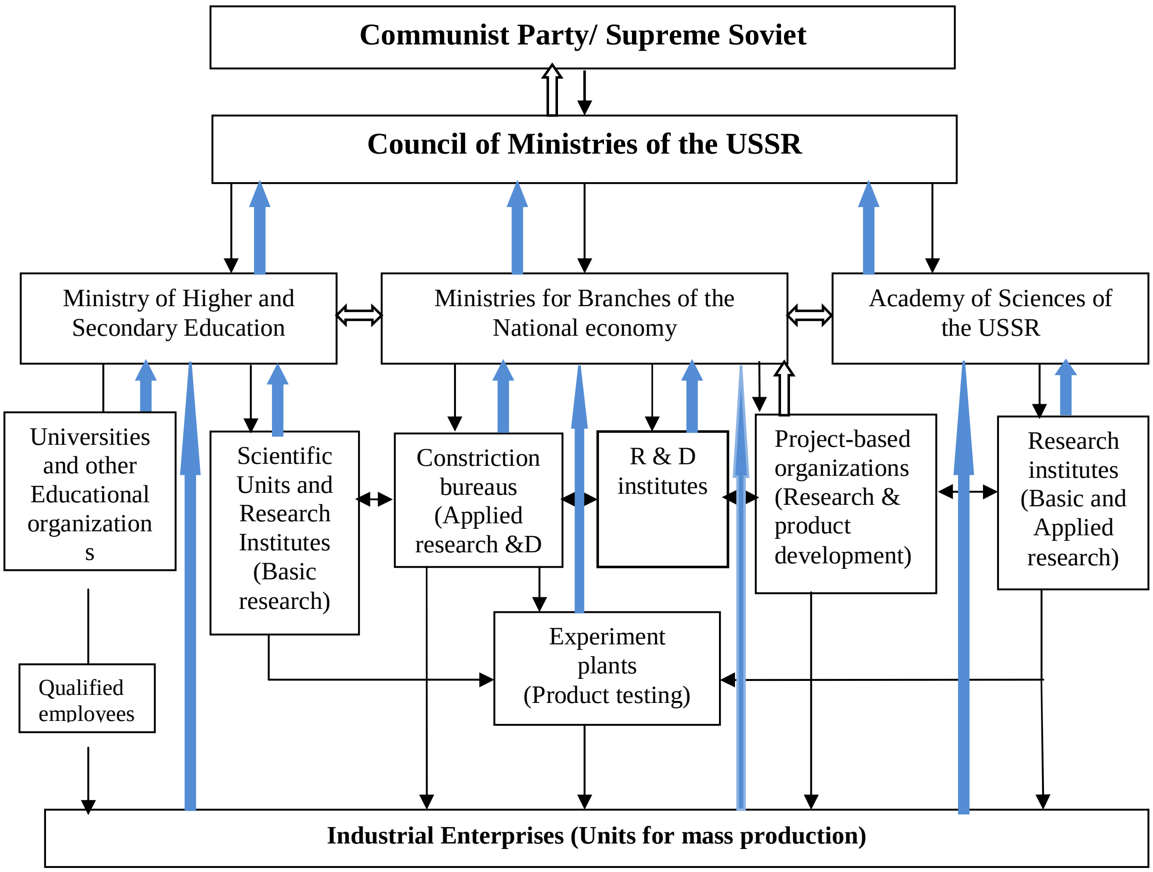

Figure 4 A typical network of co-dependent R&D organizations: the Soviet model.

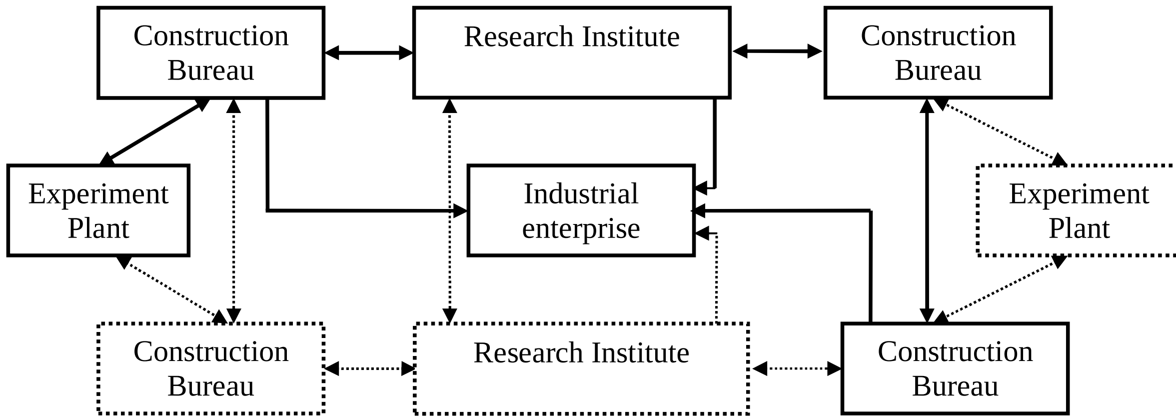

Figure 5 incomplete networks of R&D organizations after transition

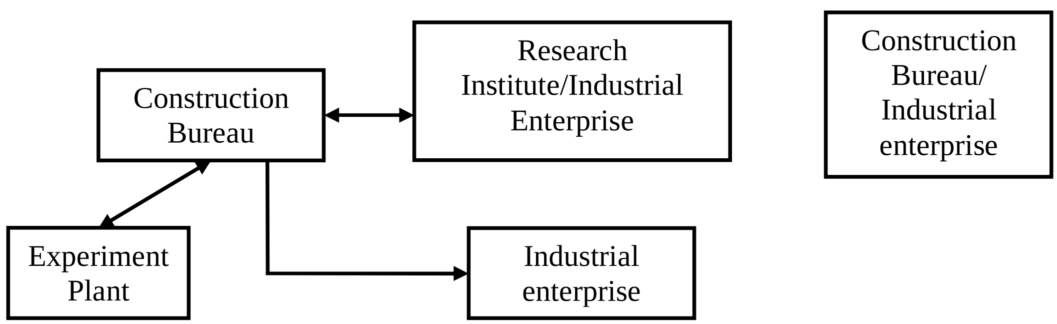

Figure 6 Theoretical model of organization of the Russian SI

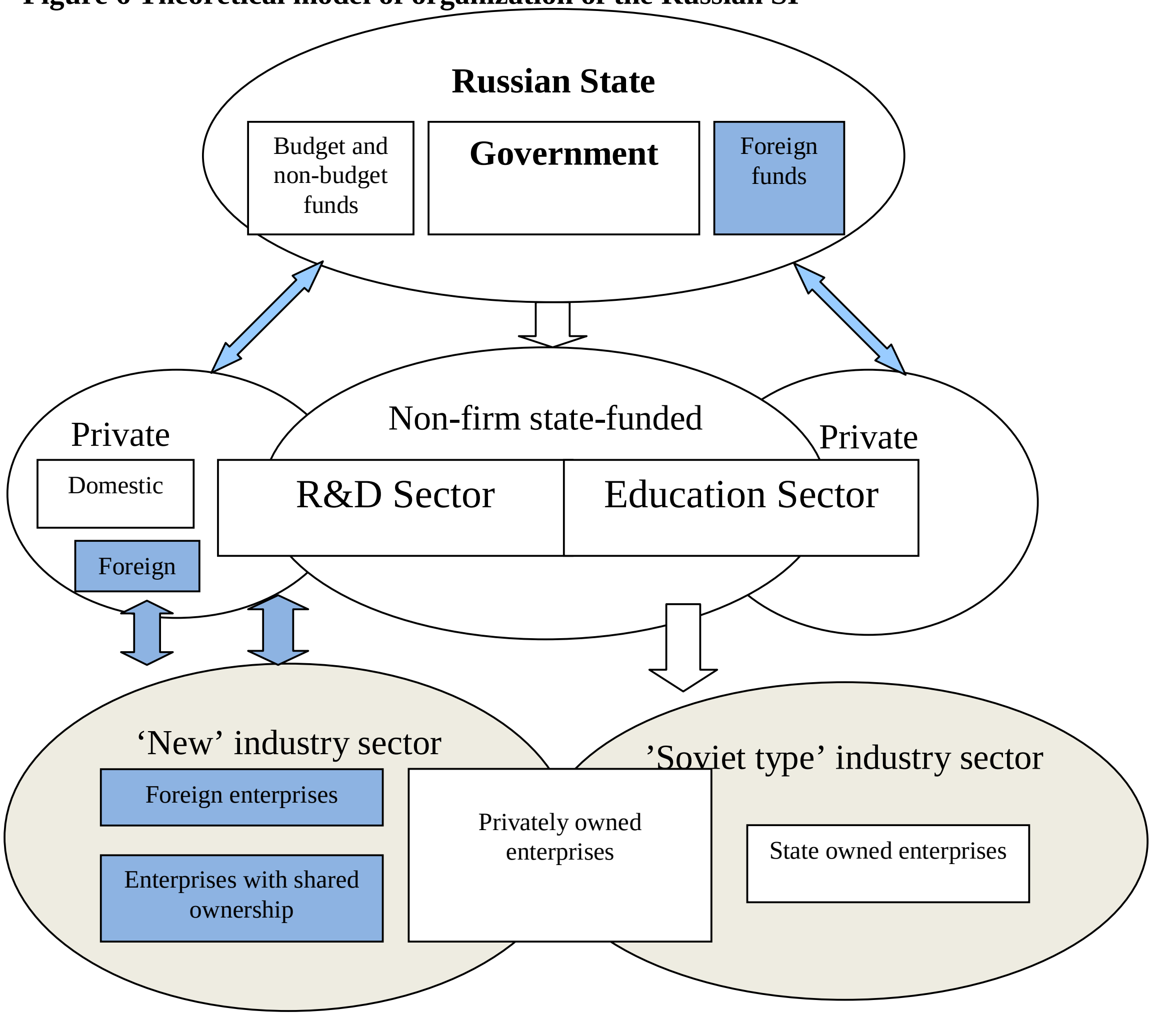

Table 1 The share of industrial output in 1995 (% from 1991)

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)

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