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Research Report

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THE RUSSIAN INNOVATION SYSTEM - AN INTERNATIONAL PERSPECTIVE

Lappeenrannan teknillisen yliopisto

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ABSTRACT

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The main objective of this study is to assess the current state of the national innovation system in Russia. The work provides a holistic description of the innovation system and its main actors.

Russia inherited a large research and development (R&D) sector from the Soviet times, and has retained a substantial R&D sector today, compared with other emerging economies. However, Russia is falling behind in all indicators measuring innovative output in comparison with most developed countries. Russia's innovation performance is disappointing, despite the available stock of human capital and overall investment in R&D. The communist legacy still influences the main actors of the innovation system. The federal state is still the most important funding source for R&D. Private companies are not investing in innovative activities, preferring to "import" innovations embedded in foreign technologies. Universities are outsiders in the innovation system, only a few universities carry out research activities.

Nowadays, Russia is a resource-depended country. The economy depends on energy and metals for growth. The Russian economy faces the challenge of diversification and should embrace innovation, and shift to a knowledge economy to remain competitive in the long run. Therefore, Russia has to tackle the challenge of developing an efficient innovation system with its huge potential in science expertise and engineering know-how.

Keywords: Russia, national innovation system, innovative capacity

“What gets us into trouble is not what we don’t know

It's what we know for sure that just ain’t so”

-Mark Twain-

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Abbreviations

bln	Billion
CBR	Central Bank of Russia
CPI	Consumer Price Index
e.g.	exempli gratia
ER	Exchange Rate
FSU	Former Soviet Union
GDP	Gross Domestic Product
ERDI	Exchange Rate Deviation Index
EU	European Union
EUR	Euro
FDI	Foreign Direct Investment
HEIs	Higher Education Institutions
ICT	Information and Communications Technologies
IMF	International Monetary Fund
KAM	Knowledge Assessment Methodology
KE	Knowledge Economy
KEI	Knowledge Economy Index
mln	Million
MSTI	Main Science and Technology Indicators
OECD	Organisation for Economic Cooperation and Development
PPP	Purchasing Power Parity
R&D	Research and Development
RAS	Russian Academy of Sciences
RCA	Revealed Comparative Advantage
RUB	Russian Rouble
SEZ	Special Economic Zones
SME	Small and Medium Sized Enterprise
TE	Transitional Economy
TFP	Total Factor Productivity
USSR	Union of Soviet Socialist Republics
USA/US	United States of America
USD	United States Dollar
WEF	World Economic Forum

1 Introduction

Globalisation and the technological revolution of the last years have reinforced the role of knowledge in an economy. Knowledge has become a key driver of competitiveness. The Organisation for Economic Cooperation and Development (OECD) defines the knowledge-based economy as *"economies which are directly based on the production, distribution and use of knowledge and information"*(OECD, 1996, p.7).

Russia is a country with rich natural resources, with an educated labour force, and a history of major scientific advances. Currently Russia is a resource-dependent economy, exporting mainly natural resources like oil, gas and metals, and depending on commodity exports for its growth. According to World Bank estimates, the gas and oil sector contributed approximately 20 % of the Russian Gross Domestic Product (GDP) and more than 60 % of exports in 2006 (Economist Intelligence Unit, 2007). The energy sector, which employs less than 1 % of the Russian population, can not be the economic locomotive of Russia. If the Russian Federation wants to achieve sustainable growth in future years, it has to move away from a resource-based economy. The Russian economy has to diversify, embrace innovation, and shift to a knowledge-based economy (Desai and Goldberg, 2007, p.14).

Russia started the transition to a market economy with a large research and development (R&D) sector and a long tradition of technological innovation, especially in space and military technologies. The potential for innovation is greater in Russia than in most countries at a comparable level of GDP per capita. These premises should have been a blessing in achieving the transition to a market economy. Surprisingly, Russia's current performance measured by productivity, especially in the manufacturing sector, is disappointing. Similarly, the Russian innovation system is still in transition, and innovative activities of firms are still in incipient stages. After the collapse of the Soviet Union, the science and technology (S&T) sector suffered a decrease in funding and almost collapsed (Komkov and Bondareva, 2006, p.2). Despite the downsizing of the early nineties, Russia still has a substantial R&D sector compared with other emerging economies. In 2004, Russia spent roughly the same amount on R&D as Spain, but the output in Russian institutions was 6 times lower than that of Spanish institutions. Russia is falling behind in all indicators measuring innovative output, compared with most developed countries. Russia's innovation performance is disappointing, despite the available stock of human capital and overall investment in R&D (Schaffer and Kuznetsov, 2007, p.30).

1.1 Research objectives and questions

This research aims to shed some light on the development of the Russian national innovation system from the communist period until today. The main objective of this study is to provide a holistic description of the Russian innovation system and an estimation of whether or not the Russian federation is capable of becoming a knowledge-based economy. The research focuses on few main research questions:

What is the current status of the national innovation system in Russia?

What is the performance of the national innovation system compared to other countries?

1.2 Data collection

This research is generally qualitative by nature, because the data collection was only partly structured and the data analysis is descriptive. This research examines an ongoing process (innovation system) in a given context (in Russia) rather than testing a hypothesis. This study can be considered descriptive qualitative research based on Key's classification of qualitative research methods. According to Key (1997) "*a descriptive research is used to obtain information concerning the current status of a phenomenon to describe what exists with respect to variables or conditions in a situation*". Qualitative research is essentially interpretive, i.e. the researcher makes his or her own interpretation of the data. The researcher filters the data through a personal lens in a specific socio-political and historical moment (Creswell, 2003, p.182).

This study was conducted between September 2007 and March 2008, by collecting data from secondary sources, such as scientific articles, publications, and the Internet. Statistical data was gathered from various institutes; the IMF (International Monetary Fund), the OECD, Rosstat (Russian statistic institute), Russian Analytical Digest, UNCTAD (United Nation Conference on Trade and Development), WIIW (The Vienna Institute for International Economic Studies), and the World Bank, which are valuable sources of information concerning the economic development in Russia and development of the Russian society. Moreover, the study was complemented by an interview with an international expert having more than 15 years' experience with the innovation system in Russia.

The data analysis consists of three concurrent flows of activities: data reduction, data display, and conclusion drawing. Data reduction is the process of selecting, simplifying, abstracting and transforming the data. The second flow of analysis activity consists of data display, which comprises organising, compressing and assembling information, and allowing conclusion drawing. The creation and use of displays is not separate from data analysis but an integral part of the analysis. The third stream of analysis consists of conclusion drawing and verification (Miles and Huberman, 1994, p.21). The process of analysing the data collected for this study is characterised by the fact that it began as soon as the researcher started collecting the data, it was ongoing and inductive.

1.3 Structure of the research

This study consists of eight chapters, which are presented in the outline in Figure 1.The study begins with a theoretical part, which lays the ground for the descriptive part of the work. Chapter 2 sheds light on the basics of innovation management. Chapter 3 describes the commercialisation process of innovation. Chapter 4 introduces innovation on a national level. The second main part of the study is the adaptation of theories to the empirical data of the research focus. Chapter 5 gives a short overview on Russia's latest economic development. Chapter 6 consists of a description of the Russian national innovation system. Chapter 7 sheds light on Russia's current competitiveness and readiness for the knowledge economy. Finally, conclusions are drawn in Chapter 8.

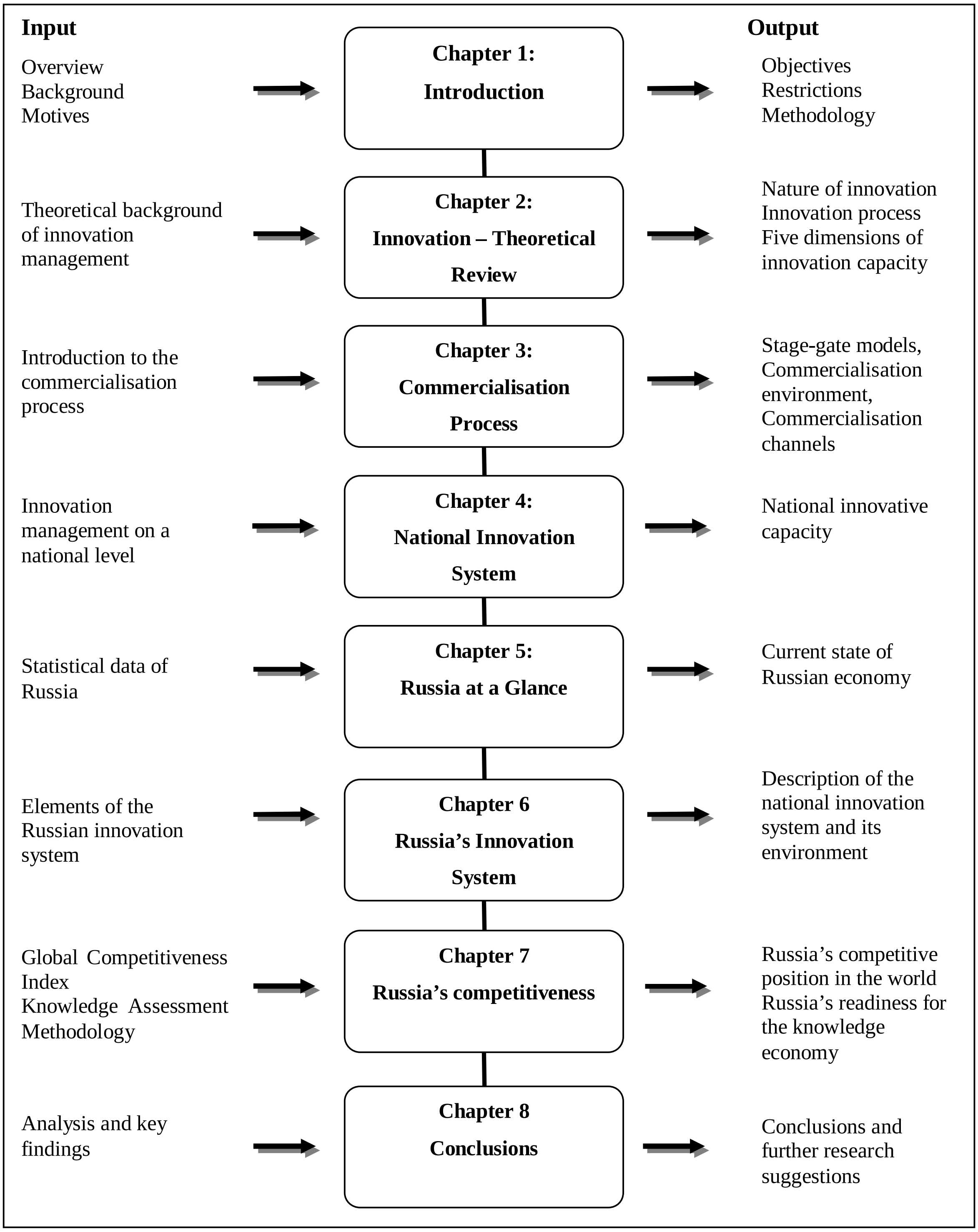


Figure 1. Structure of the thesis

2 Innovation – Theoretical Review

2.1 Definitions of innovations

The term "innovation" does not have a clear definition. According to Webster's dictionary innovation is *"the making of a change in something established"*. Josef Schumpeter (1943), an Austrian economist, was one of the first persons who tried to define the term innovation as *"new combination of existing resources"*. Clayton et al. (1996, p.198) call the term innovation *"a change in technology"*. Rogers (1998, p.5) defines innovation as "*the application of new ideas to the products, processes or any other aspects of a firm's activities*". It can be concluded that the basic definition of innovation is simple, but a precise definition, appropriate to all types and contexts is not straightforward.

According to Fagerberg (2006), it is important to differentiate between innovation and invention. Innovation is more than an invention. Fagerberg (2006, p.4) distinguishes *invention* as "*the first occurrence of an idea for a new product or process",* and *innovation* as "*the first attempt to carry out into practice*". Innovation consists of both invention and commercialisation. Invention is one step and innovation is a whole process that creates change from invention, development, design and production to marketing. Inventions are often successfully commercialised by a different firm than the inventor, and it may happen a long time after the invention saw the light of day. Inventions come into being anywhere, but innovations occur mostly in firms (Galanakis, 2006, p.2). A firm needs different types of knowledge, skills and resources to turn an invention into to an innovation. Firms remain the main actors for innovation but due to the increasing complexity, costs and risks involved in innovation, networking and collaboration with other firms or organisations like universities and public research institutes are becoming more and more important to tackle the innovation challenge (OECD, 1999, p.17).

Innovation involves the combination of new knowledge. Afuah (2003, p.13) distinguishes two kinds of new knowledge: "technological" and "market-related". Technological knowledge is "*knowledge of components, linkages between component, methods, processes, and techniques that go into a product or a service"*. Market knowledge is "*knowledge of distribution channels, product applications and customer expectations, preferences needs, and wants"*. Moreover, innovation is inherently uncertain, it is impossible to predict the cost and performance of an innovation and the reaction of users to it. Therefore, innovation involves a process of learning (Pavitt, 2006, p.88).

2.2 The importance of innovation

The main contribution of the endogenous growth theory has been to show that accumulation of knowledge is the underlying source of sustained growth in per capita income. Based on the endogenous growth theory, Aghion and Howitt (1992) found evidence that innovation generated by a competitive research sector is a source of long-term growth. They use the concept of creative destruction in their growth model to prove the relationship between innovation and growth. The concept of creative destruction was introduced by Schumpeter (1943, pp.82-84). He describes it as a process in which old economic structures are destroyed by new ones. Aghion and Howitt (1992, p.323) demonstrate that the expected growth rate of the economy depends on the amount of research carried out in the economy. Even though this model is on an abstract level, evidence was found that innovation is a motor for sustainable growth underlining the importance of knowledge and innovation for the economy. Innovation introduces novelty in an economy; should the stream of innovation dry up, the economy will settle down in a "stationary stage" with little or no growth (Fagerberg, 2006, p.20).

The capacity to innovate and bring innovations successfully to the market will be crucial for national economies in the next decade, as the OECD (2007b, p.6) pointed out: "*The innovative effort itself, including formal research and development, remains the sine qua non of growth*". Empirical work conducted by the OECD (ibid.) has shown that innovation performance is crucial for competitiveness and national progress. Much of the rise in living standards since the industrial revolution is due to innovation. The importance of innovation has been reinforced notably by globalisation and rapid technological changes in information and communication technologies (ICT). Innovation is a factor that explains differences in performance between firms, regions and countries. Firms that succeed in innovation prosper at the expense of their competitors. Innovative countries and regions have higher productivity and income than less innovative ones (Fagerberg, 2006, p.18).

2.3 Types of innovation

Innovation can be classified into *"types"*. Schumpeter categorised five types of innovation: new products, new methods of production, new sources of supply, the exploitation of new markets, and new ways to organise business (Fagerberg, 2006, p.6).

Tidd et al. (2001, p.6) focus on the first two types. They classify innovation in two forms, "product innovation" and "process innovation". Product innovations are defined as *"changes in* *the things (product/services) which an organisation offers"*. Process innovations are defined as *"changes in the ways such new products/services are created and delivered"*. Other types of innovation are also essential for the economy; to focus only on product and process innovation can be potentially misleading. For example, many important innovations in recent years have been of the organisational kind, such as the reorganisation of production and distribution.

Another way to classify innovation is to distinguish between "technical" and "administrative" innovation (Afuah, 2003, p.15). Technical innovations are totally new products, services or processes, or improved versions of these. A technical innovation can be a product or a process. On the other hand, administrative innovation pertains to organisational structures and administrative processes.

Innovations can also be classified according to their *"degree of novelty"* (Tidd et al., 2001, p.6). There are different degrees of novelty, running from minor incremental improvement to radical changes that can transform the whole economy. Continuous improvements of existing technologies are characterised as "incremental innovations" as opposed to "radical innovations" (such as the introduction of a completely new technology). The knowledge required for conducting incremental innovations builds on existing knowledge, and therefore incremental innovations are considered to be competence enhancing. Innovation can reinforce or destroy the current knowledge-base of the firm and affect its competitive advantage. An innovation is classified as radical innovation if the result of the innovation renders existing products non-competitive. Radical innovations are regarded as competence destroying, because such innovations require knowledge which is very different from existing knowledge, thus rendering the existing knowledge obsolete (Fagerberg, 2006, p.7). Radical innovations have been sources for major structural changes in the economy. Examples of radical innovation are the steam power, electricity, or recently, the emergence of information and communication technologies (Afuah, 2003, p.15).

Henderson and Clark (1990) argue that the traditional categorisation of innovation as either radical or incremental is incomplete. Every industrial innovation can be classified according to its effect on the firm's present knowledge base and technological and market opportunities. Pertinent literature has characterised different kinds of innovations in terms of their impact on the established capabilities of the firm. This idea is presented in Figure 2, where innovations are classified along two dimensions. The horizontal dimension captures the impact of an innovation on components, while the vertical captures its impact on the linkages between components. Radical and incremental innovations are extreme points along the two dimensions. The other points along the dimensions are called “architectural innovation” and “modular innovation”. Architectural innovation is the reconfiguration of an established system in order to link existing components in a new way. A modular innovation is an innovation that changes a core design concept without changing the product’s architecture.

Linkages between Core Concepts and		Core Concepts: Reinforced	Core Concepts: Overturned
	Unchanged	**Incremental Innovation**	**Modular Innovation**
	Changed	**Architectural Innovation**	**Radical Innovation**

Figure 2. Architectural innovation (Source: Henderson and Clark 1990)

It is important to differentiate innovation from imitation and the terms “innovator” and “imitator” from each other (Fagerberg, 2006, p.8). The term “innovator” is widely understood as an organisation that introduces a particular innovation for the first time in a given context. Organisations introducing the same innovation later are characterised as imitator. It may be argued that there is a difference between commercialising something new for the first time and copying it and introducing it in a new context (Afuah, 2003, p.13). However, using Schumpeter’s definition of innovation, the organisation which introduces the innovation later could also be considered as an innovator. To quote van de Ven (1986, p.592) *“As long as the idea is perceived as new to the people involved, it is an “innovation”, even though it may be appear to others to be an “imitation” of something that exits elsewhere”*. What matters is the “perceived” degree of novelty (Tidd et al., 2001, p.8). For example, for a western multinational, the use of enterprise resource planning systems are commonplace, but for a small Russian enterprise this can still be a major challenge.

2.4 Innovation process

Innovations are the outcome of the innovation process. The innovation process can be defined as “*the combined activities leading to new, marketable products and services and/or new production and delivery systems*”(Burgelman et al., 2004, p.2).

Several models of the innovation process have been proposed over the years (Cooper, 1988 or Rothwell, 1994). Innovation processes imply the exploitation of opportunities for new or improved products, processes or services based on either the use of new know-how or a change in market demand, or a combination of both. Therefore innovation is primarily a matching process. A framework to disaggregate the different innovation activities has been presented by Pavitt (2006, p.88). He has identified three broad overlapping sub-processes of innovation: (i) the production of scientific and technological knowledge; (ii) the translation of new knowledge in working artefacts; and (iii) responding to and influencing market demands.

In this work, the so-called chain-linked model of innovation by Kline and Rosenberg (1986) is presented. This innovation model divides the innovation process into five relatively separable stages (Figure 3). In the first stage, a need in a potential market is identified. The second stage begins with an invention and/or analytical concept for a new process or product that is intended to meet the identified market need. The third stage is the actual development of the innovation, the start of detailed design and testing. During the fourth stage, the emerging concept is redesigned and maybe entered full-scale production. The final stage marks the introduction of the innovation to the market, initiation marketing and distribution efforts (Palmberg, 2002, p.11).

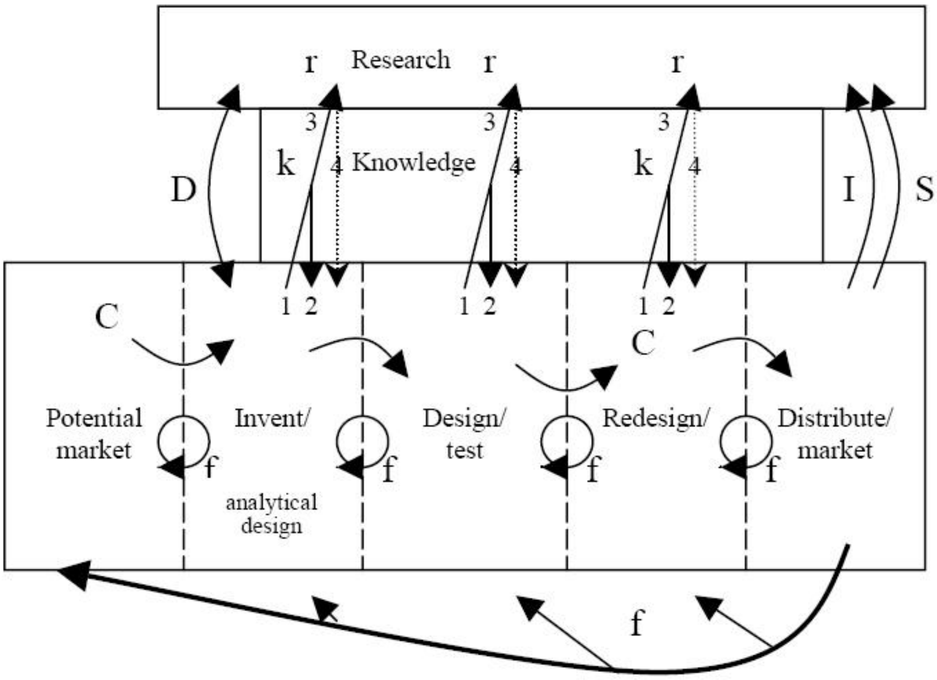


Figure 3. The chain-linked model of innovation (Source: Palmberg 2002)

Another central feature of this model is the identification of five interrelated paths of innovation. These paths describe different sources of innovation and knowledge inputs throughout the innovation process. The first path of innovation is illustrated with the *C*-labelled arrows in

Figure 3. This path generalises the process described above, where the innovation process starts with the identification of market needs, and ends with the introduction of the innovation to the market (Palmberg, 2002, p.11).

The second path of innovation, labelled with *f*, describes the feedbacks occurring throughout the central chain of innovation. This path of innovation comprises the feedback from customers or future users, as well as the feedback loops arising within the firm between the R&D department and production (ibid.).

The third path of innovation links the central chain to scientific knowledge. This interrelationship between the innovation and research is marked by the arrow tagged as *D* in Figure 3. Kline and Rosenberg (1986) argue that some innovations are directly related to basic and fundamental research, usually accessed via collaborations with research establishments or universities. This is often the case in science based industries such as the pharmaceutical industry. Innovations are understood in this path as an application of new research results (ibid.).

The fourth path of innovation, labelled with *k*, captures innovation processes feeding on the pool of existent knowledge. This path acknowledges the finding that development in science and basic research is not the main source of innovation in most industries. Firms innovate to fulfil an identified commercial need and they start by reviewing and combining existing knowledge (indicated by arrows 1 and 2 in the figure). Only if existing knowledge fails to solve the problems relating to innovation, firms will invest in research indicated by arrows 1 and 3 in Figure 3 (ibid.).

The fifth path of innovation illustrates the opportunities opened up by innovation for advances in scientific knowledge. This is marked by the arrows *I* and *S* in the picture. This path is less relevant, but an example of such innovation is the development of faster microprocessors or medical instruments that open up new possibilities for fundamental research in certain fields (ibid.).

The merit of the chain-linked model lays in identifying the true diversity in the sources of innovations described in the five different paths of innovation. Another strength is the acknowledgement of the relative roles of innovation paths across different industries. Moreover, this model is able to capture the serendipitous nature and messiness of the innovation process that the former linear models of innovation were not to able to capture (Hindle and Yencken, 2004, p.796). Nonetheless, this model has also been criticised for being overly mechanical and for ignoring the broader institutional environment where innovation takes place, leaving no room for regulatory change (Palmberg, 2002 ,p.12).

2.5 Diffusion of innovation

Rogers (1995, p.261) defines diffusion as "*the process by which an innovation is communicated through certain channels over time among the members of a social system. In that special type of communication messages are concerned with new ideas"*. Not all the innovations introduced to the market are diffused at the same speed (Martinez et al., 1998) nor the same way (Chesbrough, 2003). From the definition above, it is possible to identify the four main elements of the diffusion process: (i) innovation, (ii) communication channels, (iii) time and (iv) social system.

Figure 4 combines the curves of innovation diffusion and innovation adoption curve. One of the most well-known models describing the diffusion process is the so-called "S-curve of innovation diffusion". The S-curve model explains how fast an innovation will be adopted after the first base of customers has been acquired. The diffusion rates first rise and then fall over time, leading to a rapid adoption taking place between an early period of slow take up and a late period of slow approach to saturation, as shown in the lower part of Figure 4 (Geroski, 2000, pp.603-605).

The diffusion of an innovation involves the adoption of the innovation by users. The decision to innovate is taken after a cost-benefit analysis in which the major obstacle is uncertainty. People will adopt an innovation if they believe that it will, all things considered, enhance their benefit. Rogers (1995, p.261) has suggested that the adoption follows the normal distribution. He divides adopters into five different categories, differing from each other in terms of individual characteristics. The first 2.5 % of the adopters are called innovators. Innovators are the first users of the innovation. Early adopters cover the next 13.5 %. They serve as a role model for many other customers. The early adopters decrease the uncertainty by adopting the innovation and speed up the diffusion process. The third category called the "early majority" (34 %) adopt new ideas just before the average members of the social system do it. The so-called "late majority", the next 34 %, are sceptical and cautious towards innovations and will not adopt innovation until most of their peers have adopted it. Laggards are the last adopters of the innovation and account for 16 % (Rogers, 1995, p.261). Figure 4 combines the adoption of innovation-curve and the S-curve of innovation diffusion.

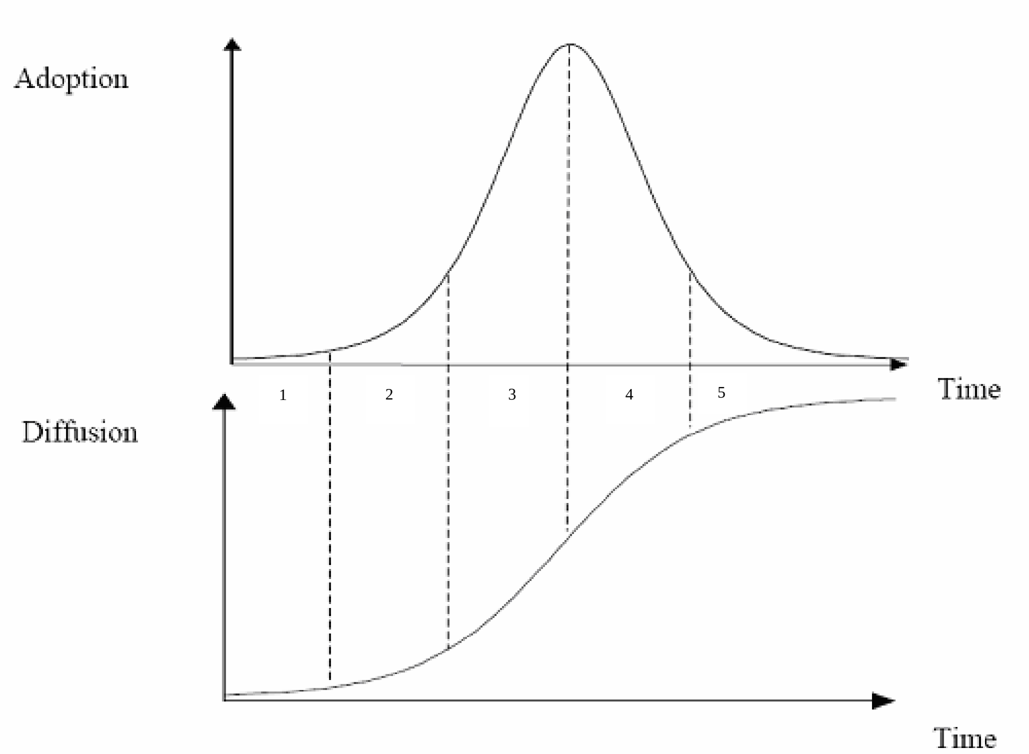


Figure 4. Innovation adoption and innovation diffusion (Source: adapted from Rogers 1995, p.261 ff.)

2.6 Innovation capacity

At firm-level, innovation capabilities can be defined as *"the comprehensive sets of characteristics of an organisation that facilitate and support innovation"* (Burgelman et al., 2004, p.9).

Innovation capabilities can also be assessed at national level. The innovative capacity depends on the capacity to absorb and diffuse knowledge, and on the demand for its generation and utilisation. The innovation capacity depends on five dimensions, as illustrated in Figure 5. The capacity to create knowledge is important, not only to generate new knowledge, but also as a mechanism to absorb it. "Absorptive capacity" is the ability to absorb new knowledge and to adapt imported technologies, as described in the next section (Cohen and Levintal, 1990, p.128). Diffusion is the key mechanism for benefiting from R&D investment and for increasing absorptive capacity. Diffusion particularly depends on the existence and strength of network-based relations as well as on the activity of knowledge-intensive business services. On the other hand, demand for innovation is the key economic mechanism that initiates wealth generation processes in R&D, absorption and diffusion activities. The importance of innovation will depend on the level on which new products, processes and services have been diffused throughout the economy. Successful innovation systems are characterised by good coordination of these four dimensions. In particular a good governance structure is needed to coordinate the different components of innovative capacity so that they generate complementarities and synergies (Muller et al., 2006, pp.2-10).

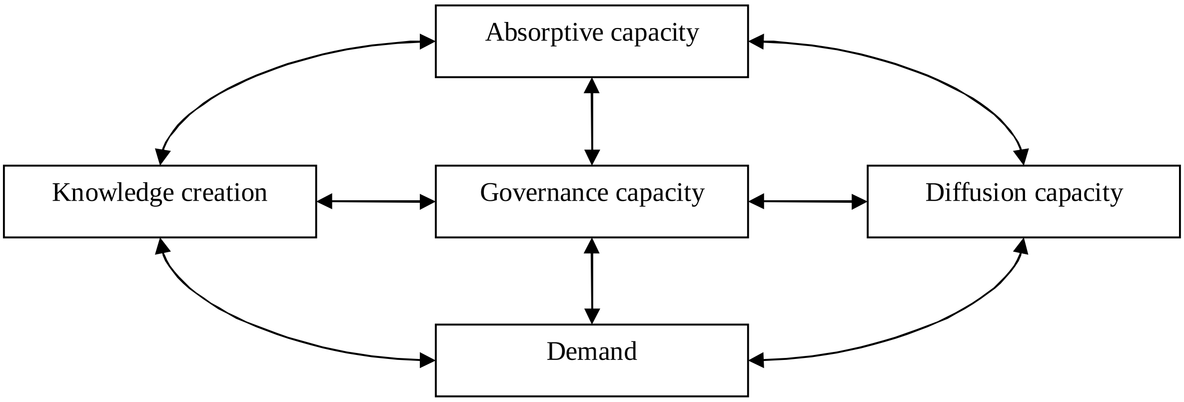


Figure 5. Innovation capacity – five dimensions (Source: Muller 2006)

2.7 Absorptive capacity

Outside sources of knowledge are often crucial to the innovation process, and the ability to exploit external knowledge is thus a crucial component of innovative capabilities. This ability, known as "absorptive capacity" is a function of the previously accumulated related knowledge. Cohen and Levintal (1990, p.128) define absorptive capacity as the "*ability to recognise the value of new, external information, assimilate it and apply it to commercial ends*".

Whatever the organisational level analysis is (firm or national level), the absorptive capacity of an organisation will depend on the absorptive capacity of its individual members. The absorptive capacity of an organisation does not only depend on the interaction with the external environment but also on the transfer of knowledge among the members within the organisation. It is not simply the sum of the absorptive capacities of its members, it also depends on the communication structure between the external environment and the organisation, as well as on the internal communication structures (Cohen and Levintal, 1990, p.128).

Prior knowledge allows the assimilation and exploitation of new knowledge, which has an important impact on the long-term absorptive capacity. Accumulating absorptive capacity in a given period enables a more efficient accumulation of absorptive capacity in the following period. Moreover, prior knowledge will help the organisation to understand technological advances better and therefore to better predict the nature and commercial potential of technological advances. These two features, i.e. cumulativeness and effect on predictions imply that absorptive capacity is path-dependent. As a consequence, a low initial investment in absorptive capacity reduces the incentives to invest in a subsequent period, even if technological opportunities are identified (Cohen and Levintal, 1990, pp.130- 135).

The creation of absorptive capacity is a self-reinforcing cycle. If an organisation carries out little innovative activity and is therefore relatively insensitive to external technical opportunities, it will have a low aspiration level to exploit the new technology, which in turn implies that it will continue to devote little effort on innovation. On the other hand, if an organisation engages in more innovative activity, it will increase its awareness of outside opportunities and have a higher aspiration level to exploit them. An organisation needs prior related knowledge to be able to use an outside technical opportunity. In a case of a radical innovation, the organisation is sometimes not able to profit from this opportunity due to the "irony" that the organisation needs to have created some absorptive capacity for the innovation in order to value it. Absorptive capacity is decisive for innovation. Technical change and innovation are often closely related to the organisation's own R&D. Cohen and Levintal (1990) identify two functions of R&D. It generates new knowledge (innovations) and contributes to build absorptive capacity. R&D creates a capacity to assimilate and exploit new knowledge and it is therefore useful to invest in R&D. Figure 6 depicts how absorptive capacity affects R&D expenditures. The learning effect due to the absorptive capacity has a direct effect on R&D spending. Other determinants are technological opportunity and appropriability conditions. They depend on the organisation's or a rival's absorptive capacity. The appropriability conditions are indirectly influenced by the competitor's interdependence. If a rival has a technical advantage, this reduces the firm's incentives to invest in R&D. Two factors determine the learning effect. The organisation's learning incentives and therefore the incentives to invest in absorptive capacity via R&D are: (i) the quantity of knowledge to be assimilated and exploited, and (ii) the difficulty of learning. The more difficult the learning environment is, the higher the marginal effect of R&D investment on the absorptive capacity will be (Cohen and Levintal, 1990, pp.130- 135).

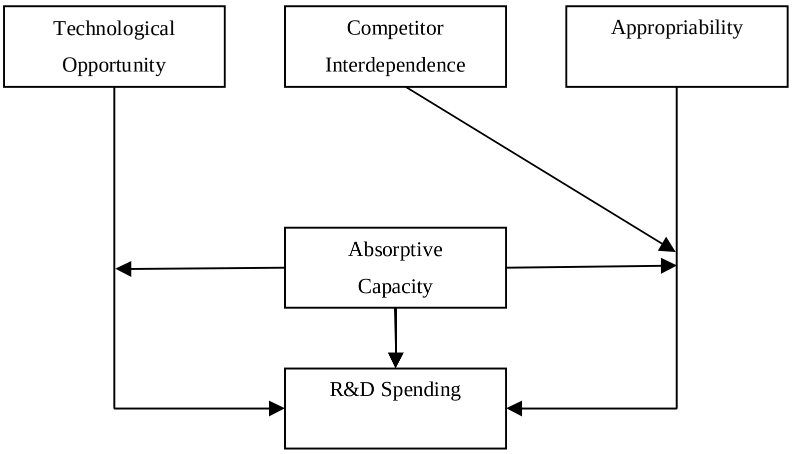


Figure 6. Model of absorptive capacity and R&D incentives (Source: Cohen and Levintal 1990)

3 Commercialisation Process

Commercialisation is the exploitation process of an innovation, in other words, translating promising technologies or new ideas into a stream of economic return (Ganz and Scott, 2003, p.334).

Commercialisation may be identified as the process of transferring and transforming theoretical knowledge into some kind of commercial activity. Jolly (1997, p.3) provided the following definition: "*Commercialisation can be defined as the process that starts with the techno-market insight and ends with the sustaining functions of the market-competent product. The problems of commercialisation include links between technological discoveries and opportunities, demonstration of technology to opinion leaders, incubation of technology, resources for successful demonstration, market acceptance and transfer of benefits, and selection of proper business tools.*"

This definition may induce thinking of the commercialisation process in terms of a stage-gate model. The process begins with the technology-driven development of new knowledge, it is followed by the incubation process in which business opportunities are more systematically explored and developed, and it ends with the creation of a business activity positioned in the market. Different stage-gate models found in the literature are summarised in Table 1. All stage-gate models highlight one important aspect of the process of commercialisation. The process shifts from a mainly technology-driven process to a predominantly market-driven process. In the early stages, technology and technological opportunities are the main driving forces. Gradually, the process shifts towards identifying market opportunities and how they can be exploited by developing new products or services. In the final stage, the main focus is on exploiting market opportunities and on how the business concept and business strategy may be designed to fulfil the needs of the market (Spilling, 2004, p.4).

Table 1. Stage models for commercialisation

	Tübke and Empson (2002)	Jolly (1997)	Virtanen and Laukanen (2002)	Ndonzuau, Pirnay and Surlemont (2002)	Roberts and Malone (1996)
Stages					
Idea generation	Opportunity creation Concept development	Technological discoveries and opportunities	Invention, discovery Proof of principle	Generating business ideas from research Finalising new venture projects out of ideas	Invention Disclosure Evaluation Protection
Commercialisation New venture creation	Internal exploitation	Demonstration of technology to opinion leaders Incubation of technology	Working prototype Marketable product	Launching spin-off firms from projects	New venture creation Product development Incubation
New business activity	Venture development Exit	Market acceptance and transfer of benefits Selection of proper business tools	Product Palette Established market position	Strengthening the creation of economic value by spin-off firms.	Business development Sale/IPO

Source: Spilling, 2004

When the process of commercialisation is described in terms of stage models, it inevitably leads to the assumption that the process goes smoothly through different stages one by one, which could be misleading. The traditional linear model of innovation has been rejected through the development of an interactive innovation model (see Fagerberg 2006). The process of commercialisation is complicated and generally does not follow the linear path suggested by stage models. However, commercialisation implies linearity in the extent that the process of commercialisation takes the existing knowledge base as its originating point and develops commercial activities from this point onwards (Spilling, 2004, p.4).

The process of commercialisation has several characteristics. It is important to highlight these characteristics of commercialisation: (i) *complex*, involving multiple phases, processes and participants; (ii) *broad*, as it can be carried out through a number of different channels ranging from intellectual property patenting and licensing, through open publication and dissemination, to the movement of skilled people; (iii) *multi-faceted*, involving different investments in product development, production marketing and distribution; (iv*) risky*, early investment might not generate economic return; (v) *time consuming*, a huge time gap can exist between the investment phase and generation of economic returns (DEST, 2007).

During the commercialisation stage, the innovator has to make a basic strategic choice between cooperation or competition in introducing the innovation to the market. The challenges of technology commercialisation are often framed with the concepts of appropriability regime and complementary assets, as suggested by Teece (1986, p.286). If an innovation does not have a strong intellectual property protection, the innovator has no choice but to commercialise the innovation alone because any partner would be liable to steal its assets. If an innovation is protected by strong intellectual property rights, the innovator can choose whether to commercialise alone or in collaboration with a partner (Liebars and Hicks, 2007, p.1).

The appropriability regime and the specialised complementary assets are the drivers of the commercialisation strategy (Ganz and Scott, 2003, p.335). The first factor influencing the strategic choice, called "appropriability regime" describes the ease to imitate an innovation. Teece (1986, p.286) has defined the appropriability regime as: "*a regime of appropriability refers to the environmental factors, excluding firm and market structure that govern an innovator's ability to capture the profits generated by an innovation*". Teece identifies two variables influencing the appropriability regime: nature of technology and efficacy of legal protection.

The second factor in Teece's framework is the need for complementary assets. Complementary assets, like new commercialisation capabilities, need to be created or acquired. If successful commercialisation will require manufacturing, distribution or sales assets that the firm does not possess, the firm must cooperate with another firm for the commercialisation process (Liebars and Hicks, 2007, p.2).

If the innovator wants to launch a new product independently and compete on the market with other firms, the success of the commercialisation will depend on several factors. Beyond the intrinsic value of the technology, the innovator must develop key capabilities and acquire complementary assets to ensure that the innovation is turned into a new product with customer value. If the complementary assets necessary for successful commercialisation are themselves a novelty, prior market leadership may be irrelevant. Likewise, the success of the innovation will depend on the competitive strategies of incumbents, including the potential for fierce price competition and the ability of established firms to imitate the innovation quickly. Several challenges have to be tackled by the innovator pursuing this strategy. He/she has to undertake investments (such as in manufacturing and marketing), manage multiple dimensions of uncertainty and focus scarce organisational resources on establishing a market presence (Ganz and Scott, 2003, p.336).

The alternative to the competition strategy is a “cooperation strategy”. This strategy is composed of identifying and concluding contractual agreements with other firms who serve as intermediary for commercialising the innovation to the market. Cooperation strategies take several distinct forms. One possibility for the innovator is to licence intellectual property to another organisation. Another form of cooperation strategy is acquisition of the innovator by established firms. These two forms represent the extreme options along the various forms of cooperation strategies. Furthermore, intermediate contractual relationships are possible, from a joint venture, to alliances, to milestone financing. Commercialising through the “market of ideas” has several advantages. First, cooperation reduces market competition. Moreover, cooperation allows reducing the innovator’s investment in complementary assets needed for commercialisation. Finally, cooperation facilitates the development of complementary technologies. However, several factors discourage innovators to pursue the collaboration strategy. The biggest impediment arising from the so-called disclosure problem occurs when the innovator shows a potential partner the content and nature of the innovation in order to engage in a partnership. After the disclosure, the partner could use the innovation without compensating the innovator for its efforts. Therefore, innovators are sometimes reluctant to choose the cooperation strategy. A second problem that occurs when choosing the cooperation strategy is that the innovator must overcome the cost of identifying and appraising potential partners (Ganz and Scott, 2003, p.337).

An effective commercialisation strategy results from the interaction between excludability and a complementary asset environment. These two factors define four distinct commercialisation environments, as shown in Table 2.

Table 2. Four commercialisation environments

Excludability		Control of necessary complementary assets by incumbents: No	Control of necessary complementary assets by incumbents: Yes
	Weak*	**Attacker's advantage**	**Reputation-based ideas trading**
	Strong**	**Greenfield competition**	**Ideas factories**

* innovator cannot preclude effective imitation of the innovation by an incumbent

** innovator can preclude effective imitation of the innovation by an incumbent

Source: Ganz and Scott 2003

The "attacker's advantage" environment is characterised by poor intellectual property protection, and the incumbents do not control the complementary assets necessary for effective commercialisation. The competition is likely to be intense and the innovators should develop and diffuse competence-destroying technologies to reap benefits of the innovation. Such an environment, characterised by high imitability and low dependence on existing complementary assets, implies tight integration between research and commercialisation. Thus, few opportunities exist to cooperate with the incumbents. Opposite to this, the "ideas factory" environment is characterised by effective protection from imitation and control of complementary assets by current market leaders. In this environment, benefits from a cooperation strategy are the best and it can be expected that the innovation will be commercialised through partnerships with downstream market players.

The two remaining environments do not reinforce clearly a competitive or cooperative strategy but reflect a trade-off between excludability and availability of complementary assets. Reputation-based ideas trading is an environment where the disclosure problem is severe, but the incumbents possess complementary assets needed for commercialisation. This might lead to an expropriation hazard where established firms have an incentive to use the technology revealed to them without remunerating the innovator. Consequently, innovators are discouraged to pursue a cooperation strategy. In such a constellation, a collaborative strategy would be better for both, and therefore established firms should develop a reputation for "fairness" and thus encourage innovators to approach them with promising innovations. In the last environment, "Greenfield competition" environment, complementary assets are unimportant but the innovators can preclude effective imitation. In this environment both competition and cooperation strategy may be effective, the relative returns of competition over cooperation are distinct from the intrinsic value of the technology, e.g. the control of key elements of the value chain (Ganz and Scott, 2003, p.340).

3.1 Channels of commercialisation

Different channels can be used to commercialise innovations. Hindle and Yencken (2004, p.797) have identified eight different channels for innovation commercialisation: publication, education/training, collaborative research, contract research, industrial consultancy, licensing, joint ventures, and spin offs. The process of commercialisation of new knowledge involves three critical decisions: (i) *disclosure,* which consists of the identification of a potential commercial opportunity; (ii) *assessment* of the opportunity to decide if the intellectual property involved is worth protecting and (iii) *licensing,* which is the decision whether to license for a royalty or through a cooperation with an existing firm or whether to create a new company. The sources and potential outputs of the different channels are depicted in Figure 7.

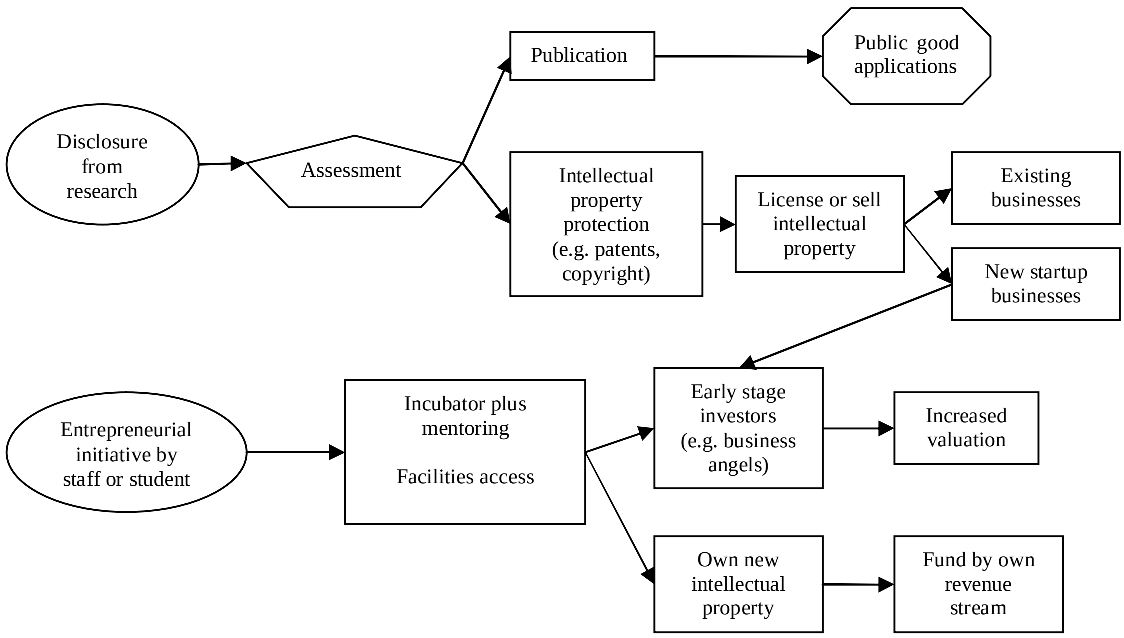


Figure 7. Commercialisation channels (Source: Hindle and Yencken 2004)

3.2 Commercialisation of knowledge in a transitional economy

The demand for new knowledge in the business sector differs in developed and transitional economies. In a developed country, firms compete with each other through innovation, creating new products, and improving the quality of existing products. To generate innovation, firms use highly skilled labour as the main production factor, with universities playing an important role in generating new knowledge. In emerging economies, the labour force is mainly unskilled and firms compete through low prices and imitating technology developed abroad. Firms in emerging markets tend to focus on low-tech sectors with the consequence that demand for new knowledge is low. The technology demand from the business sector is more likely to be oriented towards application-oriented and problem solving technologies rather than new knowledge. Most of the technology transfer is likely to be driven by the government since the overall demand for innovation is low (Kroll and Liefner, 2007).

In emerging markets, universities and public research institutes can choose between three main options to commercialise knowledge. Patenting and licensing technological inventions is the first option. This requires a well functioning market for technological knowledge and effective intellectual property rights regulations, which most emerging markets do not possess. Contract research is another way to commercialise knowledge. For a successful contract research strong links between firms and universities are required. However, in transitional economies the gap between firms and universities is often wide and their interface rather low. Weak industry-science relationships often make contract research an unviable option to commercialise knowledge. Moreover, the framework conditions for science-industry relations are different than in developed economies, with the consequence that most firms are not interested in such cooperation. A third option to commercialise is to set up a spin-off company. This is often the only option in a transitional economy to commercialise inventions, as it allows universities to keep control over the commercialisation process (Kroll and Liefner, 2007, p.2ff).

4 National Innovation System

The innovation process is characterised by its systemic nature. Firms do not innovate in isolation but in collaboration and interdependence with other organisations, and thus interactive learning is crucial for innovation. These organisations can be universities, schools, government bodies or other firms influenced in their behaviour by institutions like laws, rules, norms, and routines that constitute incentives and obstacles for innovation. All these organisations and institutions are the components of an innovation system. An innovation system is a system for the creation and commercialisation of knowledge, which can be defined at regional or national level (Edquist, 2006, p.182). Despite the phenomenon of globalisation, national and regional systems of innovation remain important for economic analysis (Freeman, 1995, p.5).

Edquist (2006, p.183) presents a general definition of national innovation systems as "*all important economic, social, political, organisational, institutional and other factors that influence the development, diffusion and use of innovation*". Nelson (1993, p. 4), defines the national innovation system as *''a set of institutions whose interactions determine the innovative performance of national firms''*. For Lundvall, it *''is constituted by elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge''* (Lundvall, 1992, p. 2).

The main components of an innovation system are organisations and institutions. Edquist (2006, p.188) defines them as follows: Organisations are "*formal structures that are consciously created and have an explicit purpose*". They are the players or actors of the system. Institutions are "*sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organisations*" (ibid.). Edquist describes them as the rule of the game.

The function of an innovation system is not addressed systematically in relevant literature. According to Edquist (2006, p.189), a national innovation system has the overall function of pursuing the innovation process. The activities are those factors that influence the development, diffusion and use of innovations. The task of identifying all determinants of the innovation process is too complex, and it will never be possible to identify all of them. Nevertheless, Edquist has identified a set of 10 activities common to most innovation systems:

- provision of research and development and the creation of new knowledge;
- competence building via the provision of education and training, and the creation of human capital is another activity;

§ formation of new product markets;
§ articulation of quality requirements emanating from the demand side with regard to new products;
§ creating and changing organisations needed for the development of new fields of innovation;
§ networking through markets and other mechanisms, including interactive learning processes;
§ creating and changing institutions that influence the innovation process and organisations by creating incentives to innovation;
§ incubating activities and administrative support for new innovative efforts;
§ financing the innovation process and other activities that can facilitate commercialisation of knowledge and its adoption; and
§ provision of consultancy services of relevance for the innovation processes.

The listed activities are provisional, as the concept of a system of innovation is evolutionary, like the innovation process itself (Edquist, 2006 p.190). One problem of the concept of an innovation system is in defining the boundaries of the innovation system. The distinction between what is inside and what is outside a system is crucial if empirical studies are to be carried out. Three ways to define the boundaries of a system of innovation are generally used: (i) spatially/geographically; (ii) by sectors; and (iii) in terms of activities (Edquist, 2006, p.198).

Defining spatial boundaries is easy but it also brings about problems. Firstly, the boundaries can be defined on regional level or national level. The concept of a national innovation system remains one of the most important ones, as huge differences exists between national innovation systems. Defining a regional innovation system can be more challenging, because boundaries of innovation systems do not always correspond with administrative ones (Edquist, 2006 p.199).

Defining the boundaries of an innovation system can also be done by sectoral subdivision. Two challenges to tackle are delimiting the sector geographically if the sector is not global, and define the boundaries of the sector. A sectoral innovation system can be defined as "*a group of firms active in developing and making products and utilising a sector's technologies*" (Edquist, 2006, p.199). Specific technologies or product areas are used to define one sector.

Finally, the boundaries of an innovation system can be defined by identifying all the activities of the innovation system. This approach is more complicated than the spatial and sectoral boundaries approaches (Edquist, 2006, p.200).

The national innovation system is evolutionary and it is influenced by different factors: national history, norms, laws, values, etc. One strength of the concept of a national innovation system is the recognition of the importance of policy aspects for innovation. Public sector institutions play a key role in determining innovation. The government should ensure that all policies are innovation-friendly and reinforce the incentives for innovation rather than counteract innovation. An important feature of the concept to bear in mind is that the national innovation system is a comparative concept. There is not one particular setup of a national innovation system which fits different nations with their specific socio-economic, political, and cultural backgrounds (Varbane et al., 2007, p.108).

The national innovation system is part of the firm's environment and it has a major influence on its innovation strategy. Tidd et al. (2001, p.87) have identified three main factors which influence the rate and direction of technological innovation in a country: (i) the national market incentives and pressures; (ii) their competencies in production and research; (iii) the institutions of corporate governance. Strong local "demand pull" for certain products creates opportunities to innovate for local firms. Local buyers' taste, private and public investment activities, input prices and local natural resources are all factors that influence the national demand for innovation. Competitive rivalry stimulates firms to invest in innovation, because if they do not conduct these activities, their existence will be threatened. Lack of competition renders firms less fit to compete on global markets through innovation. Local demand and local competitive pressure will not lead to innovation if the firms do not have the required competencies to innovate. Competencies in production and research are essential for innovation. National strengths in research are important for the overall innovation activities of a country. Private R&D laboratories seek support, knowledge and skills from public basic research laboratories. The knowledge they seek is mainly tacit, which means that language and physical distance can be real barriers. Therefore, private companies prefer to deal with domestic institutions. The national endowment of research and production competencies influences the innovation activities of domestic firms. Firms will search to identify technological fields and related product markets where the national innovation system has its strengths. In many countries, national advantages in natural resources have been combined with related technologies, which then become the basis of new product applications (Tidd et al., 2001, pp.88-89).

A well defined S&T policy is inevitable in any national innovation strategy (OECD, 2005a, p.55). The main objectives of such strategies are: (i) to support basic and long-term research while ensuring that it is tailored to the need of the society and economy; (ii) to correct market failures which lead business firms to under-invest in R&D and innovation; (iii) to provide the infrastructure needed for the diffusion of knowledge and technologies throughout the economy; (iv) to promote cooperation among all actors filling the gaps in research capabilities, and (v) to foster innovation in areas of strategic interest. These general objectives can only be achieved if the S&T policy takes the country's specific features into account.

4.1 Factors influencing innovation intensity

Several factors influence the innovation intensity of an economy. First, a stable macroeconomic environment and low interest rates facilitate investment in innovative activities (OECD, 2007b, p.9). Second, more competition on the domestic market stimulates business R&D and creates incentives to innovate. Aghion et al. (2002, p.4) have found empirical evidence that the relationship between product market competition and innovation is an inverted U-shape. At a low level of competition, firms have incentives to invest in R&D and innovate to escape competition. Competition stimulates innovation activities through changes in the differences between post-innovation and pre-innovation rents. In other words, competition may increase the incremental profits from innovating. Moreover, with higher competition, monopoly pricing is reduced, which directly improves consumers' welfare. On the other hand, firms facing a high level of competition have no incentive to invest in innovative activities because of the so-called "Schumpeterian effect". The Schumpeterian effect is the assumption that competition decreases the incentives to innovate, simply because it drives down firms' prospects for rents from innovating. In the model of Aghion et al. (2002, p.4), the inverted U-shape results from the interplay between the escape from the competition-effect and the Schumpeterian effect. Further, Aghion et al. (2002, p.43) has looked at the relationship between competition, innovation and growth in transitional economies. They showed that competitive pressures raise innovation in both new and incumbent firms, subject to hard budget constrains and availability of financing for new firms. Overall, higher competition is likely to have a positive effect on innovation, particularly in low-competition industries.

Third, all investments in innovation need access to finance. The availability of funds to finance innovative activities has been identified as a main obstacle for firms to innovate. The traditional financial system is often unable to provide resources to finance innovative activities. This is due to the information asymmetries between innovators and external agents (e.g. banks, venture capitalists). At the stage when the innovator formulates an innovative idea and seeks funds to develop it, banks and other financial institutions are often unable to verify the technical information and claims of the innovator. Potential investors are usually sceptical about the returns of the innovation and are unable to predict the financial returns. As a result, the innovative entrepreneur will not have access to traditional sources of finance and will not invest or will invest too little in innovative projects that may have high social returns (Goldberg et al., 2006, p.5).

International trade can help to increase the innovation level in an economy (OECD, 2007b, p.9). Restrictions on foreign direct investment (FDI) can hinder cross-border knowledge transfer. Cross-border knowledge transfer is especially important in the Russian context, as Russian companies are now facing the pressures from a market economy. Especially now, in the era of globalisation openness toward FDI is becoming more and more important. Moreover, openness to foreign R&D can lead to higher productivity growth, especially when domestic R&D is high as the domestic economy is better capable to reap the benefits of FDI spillovers.

Finally, an increase of public research can boost the innovation level in an economy. Expansion of public research can support the research in the business sector (OECD, 2007b, p.9). For example, fiscal incentives can be an effective tool to raise business R&D efforts. Tax exemptions for private R&D might be a better stimulus for business R&D than direct government support.

4.2 Measuring innovation at national level

The measurement of innovation can be difficult due to the fuzzy definition of innovation and the broad scope of innovative activities. Measurement implies that at least at some level entities should be qualitatively similar so that comparison can be made in quantitative terms (Smith, 2006, p.149). One problem of innovation is that it is by definition a novelty and novelty is difficult to measure. Thus, measuring innovations is not an easy task. The key problems in measuring innovations are the underlining conceptualisation of the object being measured, the meaning of the measurement concept, and the feasibility of the measurement concept.

Novelty implies not only radical innovation but also incremental changes in a product, which may have major implications in the long run. Therefore, a good innovation indicator should be able to include such incremental changes. Another aspect of innovation that an indicator should consider is the importance of non-R&D inputs to innovation (e.g. design activities, exploration of market for new products, etc.) (Furman et al., 2002, p.899ff). Bibliographic indicators are not considered in this work as bibliographic indicators show scientific exploration rather than commercially significant innovation.

Technological innovation is widely believed to be one of the main drivers of economic growth. Therefore, it is important for national policy makers to measure innovation at national level. In order to stimulate innovation through an effective public policy, policy makers are interested to have full knowledge of problems and subjects of the innovation system (Grupp and Mogee, 2004, p.1374).

Two different approaches to measure national innovative capacity exist, the indicator approach and the econometric approach. These two methods are not completely mutually exclusive but can be considered as two different approaches. Innovation indicators are statistics that describe various aspects of innovation. These indicators are often indirect and partial, and they do not measure innovation as a whole as the phenomenon innovation is not directly observable. The innovation indicator method is based on two assumptions. Firstly, innovation consists of a series of different stages such as basic research, applied research, development, and commercialisation. Secondly, certain statistics are valid for the measurement of different stages of the innovation process. Econometric approaches generally focus on indicators of country-level innovativeness based on empirical study of economic theories and relationships (Grupp and Mogee, 2004, p.1374-1380). Using econometric methods would go beyond the scope of this work and will not be discussed further.

The measurement of S&T requires measurement along many dimensions. Multiple indicators measuring science and innovation have been developed because no “catch-all” variable can be found. The need to measure multiple dimensions of S&T has led to the emergence of composite indicators. A composite indicator is an aggregation of different types of indicators into simpler constructs for the purpose of summarising complex multi-dimensional phenomena. The use of indicators is not unproblematic, because many aspects of scientific activities cannot be quantified. Therefore, indicators quantifying scientific activities have a disproportionately strong influence on the result. Moreover, if cross-country comparisons are made, this method is suitable only if the same numbers of indicators for all countries are available. The European Commission has used composite indicators to measure innovation performance of its member countries in a yearly survey called “national innovation scoreboard”. Grupp and Mogee (2004, p.1378) have tested the robustness of the indicators used in national a level scoreboard by sensitivity analysis. They found that applying different weights and a different selection of indicators can lead to a considerable variation in the scores and ranks of the countries analysed. The space for manipulation using different selection, weighing, and aggregation methods is great. Therefore, the use of indicators to measure innovation at national level should be handled with care, but it is often the only data available.

4.3 National innovative capacity

Furman et al. (2002) have developed a new framework for the national level to evaluate the sources of performance differences between countries in the production of visible innovative output. They have labelled this framework "national innovative capacity". National innovative capacity can be defined as "*the ability of a country – as both political and economic entity – to produce and commercialise a flow of new-to-the-world technologies over the long-term*" (Furman et al., 2002, p.899). The framework seeks to integrate three perspectives regarding the sources of innovation: endogenous growth theory, the cluster-based theory of national industrial competitive advantage, and the national innovation system concept. The framework organises the determinants of innovative output into three main elements as illustrated in Figure 8: (i) common innovation infrastructure, (ii) environment for innovation and its clusters, and (iii) linkages between these components (Furman and Hayes, 2004, p.1335).

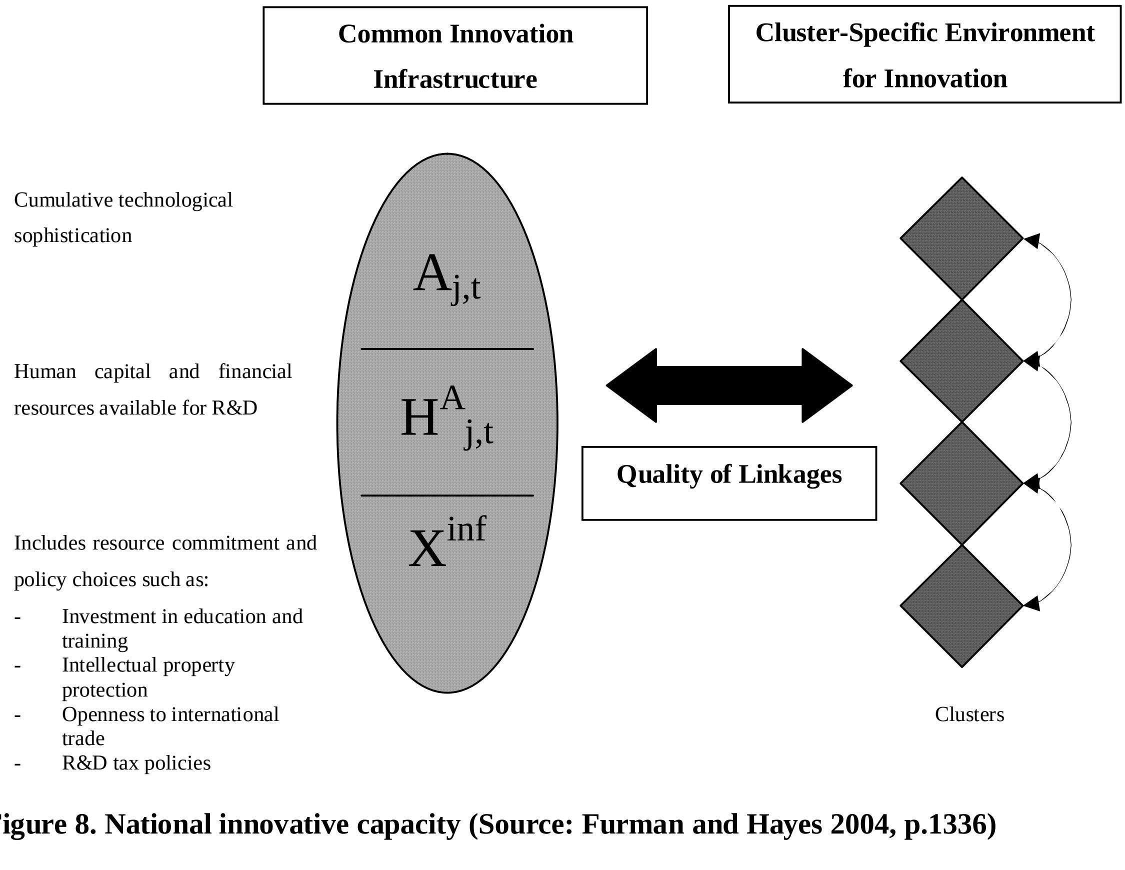


Figure 8. National innovative capacity (Source: Furman and Hayes 2004, p.1336)

First, one source of innovation is based on the endogenous growth theory. The framework suggests that a country's innovative capacity depends upon its historical stock of knowledge ($A_{j,t}$) as well as the amount of resources devoted to the production of new technologies (H^A_t) and on indirect factors such as national investment and policy choices (X^{inf}), including higher education expenditures, intellectual property protection, the extent of R&D tax policies and openness to international competition. All these elements form the common innovation infrastructure (left hand side of Figure 8), which provides the resources for innovation in an economy (Furman and Hayes, 2004, p.1336).

Second, innovative output depends on the environment for innovation. Firms in specific industrial clusters use these resources to introduce and commercialise innovations. The innovative capacity depends on the extent the industry of an economy supports and competes on the basis of technological innovation. In other words, it is the specific innovation environment present in a country's industrial clusters, also knows as the diamond of national advantage. The different clusters are represented as different boxes on the right hand side of Figure 8. Knowledge spillovers may also occur between different clusters, as presented by the lines connecting the different diamonds in Figure 8. Porter (1998, pp.166-170) has identified four broad attributes of a nation's driving forces that individually and as a system constitute the environment of industries. These attributes are: pressures from local demand; presence of high quality inputs; intense local rivalry and the presence of cluster of related industries (Figure 9). These four attributes are considered as an interactive system and create the national environment in which firms are born and learn to compete (Furman and Hayes, 2004, p.1336).

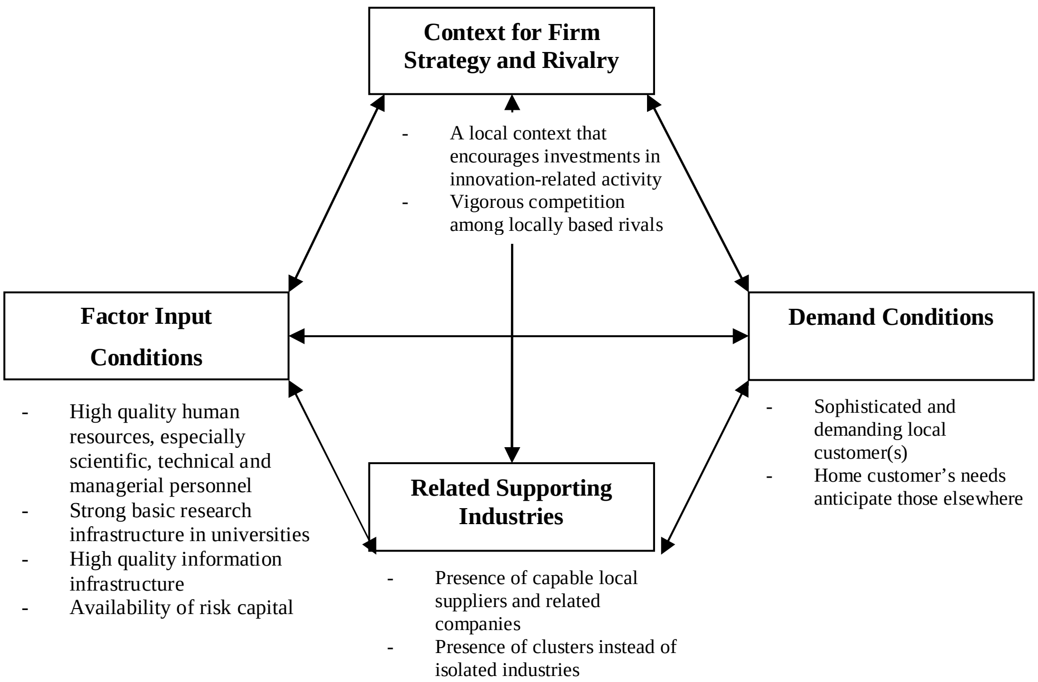


Figure 9. Cluster-specific environment for innovation (Source: Porter 1998)

Third, national innovative capacity depends on the linkages between the common innovation infrastructure and its specific clusters. The strengths of the linkages influence the extent to which the potential for innovative outputs induced by the common innovative infrastructure will be transformed into specific innovative outputs. In the absence of strong linkages, scientific and technical discoveries will spill over to other countries more quickly than opportunities can be exploited by domestic industries (Furman and Hayes, 2004, p.1336). The improvement of national capacity does not come from any single factor alone, but rather from increased investment and commitment across the different drivers of national innovative capacity. Furman and Hayes (2004, p.1331) argue that no ideal institutional configuration exists to improve national innovative capacity, but investment in the drivers of national capacity, both commitment to innovation-enhancing policies and investment in physical and human capital help to strengthen national innovative capacity.

Using a sample of 29 countries, Furman and Hayes (2004, p.1350) examined the factors driving the level of innovative output, during the years 1978-1999. Their results suggest that innovative leadership arises from a range of sustained investment and policy commitments in all fields influencing the national innovation system. Increasing the level of R&D resources for the economy will not automatically increase the innovative output of an economy. A well-functioning innovation structure is necessary but not sufficient to raise the innovative output. The role of industrial organisations and policy environments are factors influencing the national innovative capacity and should not be neglected. On the other hand, policy commitments to innovation are insufficient in the absence of increased investment in innovative activities.

5 Russia at a Glance

The Russian Federation became an independent country after the dissolution of the Soviet Union in December 1991. Russia is a leading country of the Commonwealth of Independent States and a full member of the Group of 8. Russia is by far the largest country in the world with a total land territory of approximately 17 mln square kilometres.

Russia is one of the richest countries in terms of natural resources; it possesses major deposits of oil, natural gas, coal, and other strategic minerals. Moreover, Russia has the largest timber reserves worldwide. However, the severe climate conditions and location obstacles hinder the exploitation of its natural resources. Almost half of the country is covered with permafrost (CIA, 2007).

According to CIA's estimation, Russia had a population of 141.3 mln in 2007, ranking Russia on the eighth position worldwide in terms of population. The population density is about 8.5 persons per square kilometre, making Russia one of the most sparsely populated countries around the globe (CIA, 2007). Russia's population has been decreasing for several years. The birth rate of 10.92 births per thousand persons is lower than the death rate of 16.04 deaths per thousand persons. The net migration rate (0.28 migrant(s)/1,000 population) is not able to compensate for the population decline. All these trends lead to a negative population growth rate (-0.484%); Russia looses approximately half a million of its population per year, creating an important demographic problem. The United Nation has forecasted that Russia's population will continue to decrease to 101.5 million in 2050 (UN, 2004, p.42).

Russia's most important cities are Moscow and St. Petersburg. Moscow is the capital of the Federation with 10.4 million inhabitants. Moscow continues to be the centre of Russian government and is becoming increasingly important as an economic and business centre. St. Petersburg with more than 4.5 million inhabitants is the second largest city and is regarded as the cultural centre of Russia. St. Petersburg is also considered as the scientific and educational centre of the country.

5.1 Economic development

Russia started the transition to a market economy in January 1992. Price liberalisation was introduced, the foreign trade monopoly was abolished and large parts of the economy were privatised in the early nineties. These reforms were accompanied with radical cuts in public spending (Ahrend and Tompson, 2005, p.6). The immediate results of the reforms were a sharp increase in inflation and a 40 % drop of GDP. The first five years of transition were very difficult. The "shock therapy" character of the reform package has been widely criticised, but nevertheless, it succeeded in laying the foundations of a market economy. The year 1997 was the first year of economic growth in the post-Soviet era and the period of stagflation seemed to be over (Tiusanen, 2003, p.9).

In order to counter high inflation, the Russian government adopted a "crawling peg regime" in the second half of 1996. In this exchange rate system, the rouble (RUB) was devaluated permanently, consistently with the expected inflation rate. The new exchange-based strategy was not accompanied with a prudent fiscal policy. This allowed the state to increase budget spending by borrowing heavily on financial markets and finance new spending via bonds. In 1998, the federal budget spending was out of control, and the interest rates for Russian government bonds increased sharply to real interest rates of 40-50%. This system of managed floating became unsustainable and collapsed in August 1998 leading to a severe financial crisis (Tiusanen, 2003, p.10). Falling oil prices, the Asian crisis, strong rise in imports and uncontrolled budget spending were all factors that contributed to the financial crisis of 1998. As a consequence, the rouble was devaluated in August 1998, and followed the stock market into a free fall. By January 1999, the rouble had lost 75 % in nominal terms of its pre-crisis value. The immediate consequence of the financial crisis was that the whole economy came to a standstill and the main economic achievements, low inflation and stable ER, of Russia's early stabilisation policies vanished (Ahrend and Tompson, 2005, p.10; Sutela 1999, p. 5) .

Paradoxically, the major crisis of 1998, which dramatically affected the living standards of the Russian population, was a turning point in the Russian economy. In fact, the crisis was beneficial for future economic development in certain parts of the industry, and the Russian economy started to recover fairly rapidly after the financial crisis. Local producers enjoyed temporarily artificially low energy prices and interest rates. This made locally produced goods price-competitive in comparison with imported goods, which led to an import substitution effect to the benefit of Russian producers. The rouble devaluation gave a clear boost to economic growth (Ahrend and Tompson, 2005, p.20). In 1999, investments increased about 5.3 %, which was the first growth in post Soviet times. However, these effects were largely exhausted by 2001. The remarkable economic growth in 2000 is closely linked to the sharp oil price increase during 1999-2000. The oil sector took over as the main engine of growth straight after the crisis of 1998. During 2001-2003, according to OECD estimations, Russian oil companies accounted for almost one quarter of the GDP growth. The oil sector has lost its status as the main engine of growth since 2004. Since the state took greater control of the energy sector, it has grown at only half the pace of the economy at large. The poor performance of the oil sector, together with the recent disappointing performance of the state-controlled gas sector, may suggest that the state ownership hampers the development of the energy sector (IMF, 2007, p.2). However, due to the sharp rise of oil prices in recent months, the energy sector will continue to play a very important role for the economy in the future. Figure 10 shows the Russia's GDP development for the period 1992 – 2007.

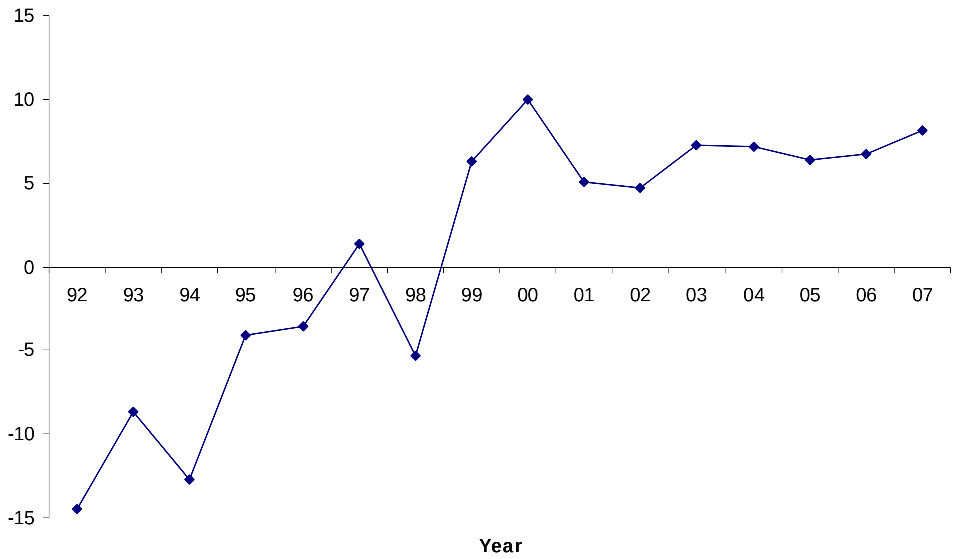


Figure 10. GDP growth, % (adapted from Ahrend, 2005; World Bank, 2007)

5.2 Current economic trends

The Russian economy has been growing at an average growth rate of above 6.5 % since 1999. After the financial crisis, the Russian economy recovered faster than expected. The rising oil prices helped the Russian economy to recover, but also the non-extracting sectors and a booming domestic consumption contributed to the recovery. In 2007, the Russian economy experienced a growth of 8.1% in GPD figures, due to unexpectedly high oil prices and the growth of the domestic service sector. Likewise, domestic consumption has increased with double digit growth rates during last years. In 2007, investments soared with a growth rate of 20 % and Russia seemed to be in the beginning of an investment boom (Sutela, 2008, pp.2-3).

As seen in Table 3 below, wages have been growing rapidly with double digit growth rates since the recovery of the economy in 1999. The growth rates of wages have outperformed the growth rates of the GDP. Since 2000, the average monthly gross wage increased almost fivefolds. The rising wages, rouble appreciation and modest productivity growth have increased the unit labour cost of enterprises. According to WIIW estimates, the unit labour costs have more than tripled since 2000. Unit labour costs (ULC) measure "*the average cost of labour per unit of output and are calculated as the ratio of total labour costs to real output*" (OECD, 2007a). In other words, unit labour costs show how much output an economy creates relative to wages, or labour cost per unit of output. ULCs can be interpreted as a reflection of the cost of competitiveness, not as a measure of competitiveness, because ULCs only consider the cost of labour and ignore changes in the cost of capital. Thus, a rise of the ULC of an economy represents an increased reward for the factor "labour". However, if the rise in ULCs are higher than the rise in labour productivity, it may be a threat for the cost competitiveness of the whole economy, if other costs are not adjusted. The non-extracting enterprises suffer more from the sharp increase in unit labour cost since they are more labour intensive than extracting enterprises (WIIW, 2007, pp.105-107). It can be summarised that the wage inflation is a factor decreasing the price competitiveness of Russian enterprises, because the productivity improvements, with 5-6% per year, were modest compared to the rise of ULC. (Tiusanen 2007, p. 23)

Table 3.Wages and labour costs in Russia in 2000 – 2006

	2000	2001	2002	2003	2004	2005	2006
Average monthly gross wage, RUB	2223	3240	4360	5499	6740	8550	10736
Average monthly gross wage, EUR (PPP)	266	340	406	451	473	512	595
Real wage growth, %	-	19.9	16.2	10.9	10.6	10.0	13.4
Unit labour costs (2000=100)	100	138.8	182.2	213.8	247.6	299.2	356.0

Source: WIIW 2007; World Bank 2006

With rising living standards and declining unemployment, the share of population living under the poverty level has decreased rapidly. In 2007, the share of population with an income below the subsistence level was estimated to be below 15 % (World Bank, 2007, p.10). In 2000, around one third of the population was living under the poverty level. In order to compare living standards, Purchasing Power Parity (PPP) adjustments are necessary. PPP estimates the price-level differences between countries and therefore makes cross-country comparisons possible. The average monthly gross wage (PPP) was 595 euros in Russia in 2006, while in Austria, an old European Union (EU) 15 country, it was 2574 euros. Another possibility to measure living standards is to compare GDP per capita (PPP) figures. For 2007, the Russian GDP per capita (PPP) was estimated to be 10 559 euros, while it was estimated to be 27 021 euros as an average figure in the EU-15 countries. Therefore, Russia's GDP per capita is only roughly 39 % of the GDP per capita of the EU-15 countries. All these figures show that despite the recent increase in living standards, Russia still remains poor compared to the international level (WIIW, 2007, pp.105-107).

Comparison of living standards can be difficult between different economies. The analysis presented above could be misleading, since a substantial part of the Russian economy is not reported in official statistics (Ylä-Kojola, 2006, p.46). First of all, the shadow economy is estimated to account for roughly 40 % of the GDP. Second, barter trade, which is not shown in official statistics, still plays an important role in Russia's rural regions. Third, a traditional family model prevails in Russia. The head of the family usually provides all the income for the whole family. Therefore, when the total population is taken into account, the income figures appear to be lower. Fourth, Russians have lower housing costs compared to Western countries. Most of the population inherited their flats and houses from the communist state. Taking all these factors into consideration, living standards could be higher in Russia than reflected in official statistics (Tiusanen, 2003, pp.22-25).

Since 2000, domestic consumption was the main driver of economic growth, fed by energy and metal exports (OECD, 2006a, p.26). The booming consumption has led to a rapid import growth. Imports have been rising lately with a higher growth rate for imports than for exports. The current account surplus should shrink due to the sharp import growth. However, a rise in oil prices could offset this trend and Russia's current account surplus could further increase. In 2006, the current account ran a record surplus of almost 77 billions euros. The export price for a barrel of Ural crude rose by 50.5 % in 2005 and increased again by 21 % in 2006. With the recent development on oil markets, other current account surpluses can be expected for the year 2008 (World Bank, 2006, p.6). Russia can be classified as a resource-based economy. As presented in Figure 11, natural resources accounted for more than two thirds of the total export and accounted for more than 80 % of export revenues in year.

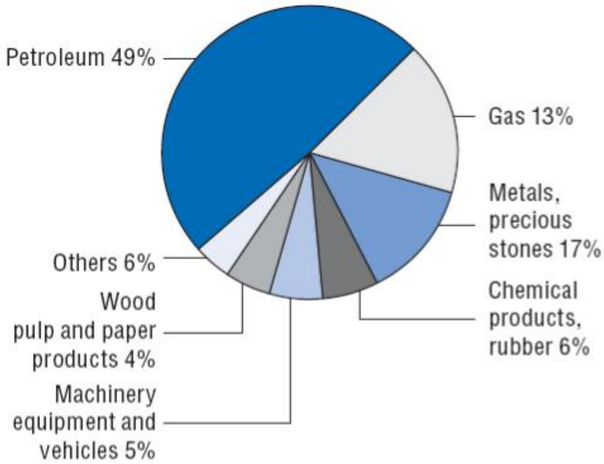


Figure 11. Structure of exports in 2005 (Source: OECD, 2006a)

Resourced-based economies are often defined as economies where natural resources account for more than 10 per cent of the GDP and 40 per cent of exports. One of the most employed methods assessing the trade specialisation of a nation is the so-called Balassa index of revealed comparative advantages (RCA). RCA is defined as *"a country's share of world exports of a good divided by its share of the total world exports"* (Cooper 2006, pp.409-417). A good has a revealed comparative advantage if the index is greater than 1, and a revealed comparative disadvantage if it is less than 1. Russia has RCAs for hydrocarbons, metals, chemicals and timber, mostly at a low level of processing. Many of these products are energy intensive and Russia's strong position derives clearly from the fact that domestic energy prices are still far below the price levels in developed countries. Russia has been raising its energy prices lately, and as a consequence these RCAs are likely to erode over time. Very few manufactured end-products show RCA. Only nuclear reactors, parts and fuel, power machines and rail freight wagons have RCA. The analysis of Russia's RCA shows a common pattern, i.e. Russia has RCAs for goods in extractive industries but not in manufacturing industries based on these raw materials. From this RCA analysis, it can be concluded that the Russian economy is still highly dependent on natural resources. The overall picture is that Russia is an exporter of low-tech raw material and importer of high-tech industrial equipment and consumer goods (OECD, 2006a p.24). Russia fails to produce goods with high added value components competitive on the world market.

As seen below, the RUR exchange rate has nominally lost approximately 30 % of its value in comparison to the euro since its introduction in 1999. However, the average ER change is not a good descriptive figure to reflect the real situation. The real ER, which Consumer Price Index CPI-based, takes into account the inflation and therefore describes better the actual situation.

Recent years have seen a rapid rise of the real exchange rate due to high oil, high commodity prices and much higher inflation rates in Russia than in the EU. The real appreciation of the rouble reached an annual average growth rate of 10 % in 2006 and has now returned to its pre-crisis level of 1998 (Table 4). The strengthening rouble is reflected in expanding imports. Imports to Russia grew by 22% in 2006, while exports grew only by 7% (World Bank, 2007, p.4). In 2008, due to high balance of payment inflows, it is expected that the rouble will continue to appreciate in real terms.

Table 4. Evolution of the rouble between 2000- 2006

	2000	2001	2002	2003	2004	2005	2006
RUB/EUR, ER	26.03	26.13	29.65	34.69	35.81	35.22	34.08
ERDI	3.18	2.8	2.76	2.84	2.5	2.11	1.79
Real ER (CPI-based), (2000=100), (Euro-based)	100	84.4	84.2	88.4	84.0	75.0	67.6
PPP RUB/EUR, WIIW	8.34	9.52	10.74	12.20	14.31	16.70	18.90

Source: WIIW 2007

The Exchange Rate Deviation Index (ERDI) indicates under/over-valuation of a nation's currency. ERDI is calculated with a simple method, PPP adjusted GDP figures per capita are divided with GDP figures per capita calculated at the official exchange rate. An ERDI figure under one indicates overvaluation of the domestic currency; ERDI figures over one indicate undervaluation, which is common in economies in transition. ERDI has decreased below two in recent years, indicating that the Russian economy is maturing (Tiusanen, 2003, p.22).

Conflicting goals challenge the monetary policy of the Russian Federation. On one hand, the Central Bank of Russia (CBR) wants to control the real appreciation rate of the rouble in order to preserve the manufacturing sector. On the order hand, the CBR tries to reduce inflation which remains high, despite a downward trend of recent years (OECD, 2006a, p.86). The development of the inflation rate is presented in Table 5.

Table 5. Inflation, 2000 – 2006

	2000	2001	2002	2003	2004	2005	2006
Inflation , % p.a.	20.8	21.6	16.0	13.6	11.0	12.5	9.8
Consumer price index (2000 =100)	100	121.6	141.1	160.2	177.9	200.1	219.7

Source: WIIW 2007

The large current account surplus due to high commodity prices and a consumption boom created inflationary pressures. However, inflation dropped below 10 % in 2006 for the first time since the transition. In the past, most of the foreign exchange inflows came from a sharp increase in oil prices. These additional oil revenues could be sterilized via a stabilisation fund created in 2004. Lately, the strong growth in balance of payment has been due to capital inflows, not higher oil prices and could not be sterilized via the Stabilisation Fund creating inflationary pressures. Therefore, the CBR was challenged to keep the inflation under control and reach its target of 8 % for 2007 (World Bank, 2007, pp.6-8). The latest estimations expected an inflation rate around 12% for 2007. In order to counter the high inflation of basic staples, the government and the food industry agreed in late 2007 to freeze prices of certain foodstuffs until January 2008 (The Moscow Times, 2007).

Total Factor Productivity (TFP) is a framework used to analyse productivity and growth. The output of an economy is a positive function of human capital and physical capital given the technology. Taking the assumption of constant returns of input factors makes it possible to calculate the growth rate of output implied by the growth of the two input factors. Deviations of actual output from this implied growth rate are due to changes in technology, institutional change or other factors. These deviations are identified as growth in TFP (Baier et al. 2002, p.2ff).

In other words, economic output can be generated by growth in capital or labour (input factors) or by increase in the productivity of these factors. The TFP framework can also be used to compare the productivity of sectors or countries. In many sectors of the Russian economy, productivity remains low. Productivity is crucial for the Russian economy for at least two reasons. First, with an aging labour force and a declining labour supply, growth in labour productivity will be necessary for sustainable economic growth. Second, Russian producers, especially in manufacturing, are facing more competitive pressures due to the increasing openness of the economy and the appreciation of the rouble. At present, a major challenge for the Russian economy is to build productive and international competitive sectors, particularly in manufacturing. During the first 15 years of transition, the Russian economy had three major sources of productivity increase: (i) reallocation of resources among different sectors with different levels of productivity; (ii) dynamics of productivity with sectors due to reallocation of market shares among firms with different productivity levels; and (iii) growth of productivity inside firms due to restructuring and the absorption of new knowledge and technologies (Schaffer and Kuznetsov, 2007, p.12).

The current economic growth is driven by internal demand fed with energy and metal exports, showing the limited competitiveness of Russian manufacturing on world markets. The share of exported manufactured goods is very low and the share of imports is growing. This can be explained by the recent real exchange rate appreciation, but it is also a result of the inability of the Russian industry to produce competitive goods to meet the growing demand. Currently, the Russian manufacturing sector has a low productivity and a poor competitiveness compared with other economies, as presented in Table 6 below. International comparison of TFP relies on data comparing output per worker, because empirical evidence has shown that aggregate productivity figures are closely correlated and data on fixed capital is often unreliable or unavailable for international comparisons. The manufacturing added value per worker is ten times higher in Germany than in Russia. Russian firms have similar manufacturing added value per worker figures than China. but Chinese firms enjoy much lower labour cost than Russian companies. The World Bank has used the Business Environment and Economic Performance Survey to estimate TFP levels in manufacturing firms in different countries. The results show that the TFP of Polish enterprises is about twice that of Russia and enterprises in more advanced economies like Germany have TFP levels more than four times greater than the Russian ones (Schaffer and Kuznetsov, 2007, pp.12-20). Lately, cost pressure on Russian enterprises has risen due to rising wages and real appreciation of the rouble. The appreciation of the rouble is a serious threat for the competitiveness of the non-fuel tradable sector, especially the manufacturing sector. The rising wages have led to rising unit labour costs. The Russian manufacturing sector is loosing its price competitiveness due these factors and it hampers the diversification prospects of the Russian production and exports (OECD, 2006a, p.81).

Table 6. Productivity indicators in selected countries

	Russia	China	Poland	Germany
Manufacturing value added per employee in US$ (2004)	7 226	6 894	15 532	68 640
Manufacturing value added per employee (Russia = 100)	100	95.4	214.9	949.9
Productivity growth, 2000-04	10.6	7.9	7.1	1.8
TFP estimates for manufacturing firms (Russia = 100)	100	102	208	452

Source: Schaffer and Kuznetsov 2007

5.3 Main challenges for sustainable growth

With rising demand for energy resources and high commodity prices, the Russian Federation has benefited from robust growth in the past years. Russia faces now the challenge of using the current advantageous situation to make the growth sustainable. This section addresses Russia's main challenges in achieving sustainable growth in coming years.

Demographical problem:

The demographic development is a particular challenge, as the population in Russia has been declining by 0.5 million people per year since 2002. In the light of the negative demographic development, the labour force is expected to shrink in the next years, which would have a negative effect on economical development (World Economic Forum, 2006).

Skills shortage:

The demand of highly educated people is rising. Despite a well-educated labour force, Russia faces growing skill shortage in industry, which has become a major production constraint for many enterprises. The current population structure will not ease this bottleneck in the future. Moreover, Russia has a grave problem in the quality of education. The current educational system is unable to respond to needs the industry, especially schools providing vocational educational education. The skills supplied by the education sector do not match with the skills needed in the labour market, leading to a waste in public and private resources. Workforce training could be one solution to solve these skills shortages. However, most Russian enterprises have not addressed this matter by employee training which would improve productivity. High cost of training, training externalities from turn-over of skilled workers and information problems are among the key constraint to investment in employee training, as cited by Russian enterprises (Tan et al., 2007, p.86).

Availability of energy:

Russia is the world's biggest energy producer. Paradoxically, the availability of energy is one of the problems that the Russian economy is facing (Gianella and Tompson, 2007, p.17). Russia has a high energy intensity of GDP. Russia's energy consumption per dollar of GDP in 2003 in PPP terms was estimated to be 3.1 times higher than the European average. Sometimes shortages of electricity and gas occur at local level. If Russia wants to increase energy exports, it has to solve this problem. It is not clear whether these shortages occur due to energy waste, low prices or slow growth in production capabilities, but to overcome energy shortages, Russia needs to increase the efficiency of energy use in its economy (BOFIT, 2007, p.46).

Low productivity of the Russian manufacturing sector:

The strong resource sector in Russia implies a high real exchange rate, which makes life harder for companies in other non-mineral tradable sectors. The manufacturing sector suffers particularly from rising cost pressures. Many manufacturing enterprises have been barely competitive at wages and exchange rate levels from the year 2000 (Ahrend, 2005, pp.28-29). With the rising cost pressures in recent years, it has become harder for the manufacturing sector to remain competitive. According to Round (2007), the main problems of the Russian manufacturing sector are the lack of qualified personnel and the excessive size of enterprise inherited from Soviet times. The manufacturing industry in Russia is mostly concentrated in sectors with low added value. The light manufacturing industry, which directly competes with China, suffers even more from the exchange rate appreciation. The manufacturing sector will have to modernize its production capacities to face the rising cost pressures.

Institutional framework:

The basic institutional framework of the new Russian economy does not yet fulfil the requirement of a developed market economy. Structural reforms of the Russian state itself are needed to foster economic growth and development. Currently, the Russian state is not able to perform fundamental tasks like law enforcement and provision of social services. Therefore, it is important to continue to build an honest state and effective framework conditions for a market economy (Ahrend, 2005, pp.30-31). The problem of corruption has worsened since 1991. Corruption is the most cited reason for dissatisfaction dealing with public administration and investors see it as the most problematic factor in doing business in Russia (OECD, 2006a, pp.122-126).

Competition:

Ownership concentration in many sectors of the economy is very high. This concentration is not harmful if enterprises compete on a global level, but if the firm compete only in domestic markets, welfare losses for the society can be substantial (Desai, 2007, pp.103-107). The productivity performance since the transition has been better in sectors characterised by fierce competition and poor in sectors still dominated by state-owned companies enjoying monopoly positions. A high level of ownership concentration can lead to collusive behaviour and prevent new entry or growth of competing firms. The abuse of market power can cause lowered efficiency, slowed growth rates, and higher costs for consumers and producers. An effective anti-trust policy is important and would help to achieve a more diversified economic growth. Firms facing more competitive pressure are also more innovative. And they should be the engines of diversification of the Russian economy. However, competitive firms are facing more severe investment constrains. They are more likely to have problems with governance, taxation, finance constrains than non-competitive firms (Ahrend and Tompson, 2005, p.48).

Privatisation:

Evidence shows that privatisation has usually a positive effect on the performance of an enterprise (Angelucci et al., 2002). Firms show higher average productivity and faster productivity growth, as well as faster sales growth after privatisation. Privatised firms tend to innovate more and adjust their labour force to the firm's needs more rapidly than state-owned firms. Moreover, the positive effect of privatisation increases with the time. In Russia, enterprises having been privatised for less than two years perform almost equally compared with state-owned enterprises. Enterprises having been privatised for more three years or more outperform state-owned enterprises significantly (Ahrend and Tompson, 2005, p.51) Since 2003, the state has increased its control in sectors considered as strategically important. Some of these sectors are in the defence sector or have the characteristic of a natural monopoly, where state presence is desirable. However, many of the sectors like banking and electrical power, would be more efficient if they shifted to private ownership. Privatisation as such is not enough to improve performance of companies. Empirical studies carried out by Bevan and Estrin (2003) and Bhaumik and Estrin (2003) have found little evidence of a positive effect of privatisation in the Russian economy. They conclude that ownership and enterprise performance are not correlated in Russia. The effects of privatisation depend considerably also on other changes in the wider economic environment. Evidence from a Russian enterprise survey in 2002, suggests that enterprise performance depends on four interrelated factors: private ownership, good corporate governance, market structure and competition and financial constrains (Ahrend and Tompson, 2005, p.51).

Restriction on FDI:

Russia eliminated many obstacles to FDI in the first years of transition. However, FDI restrictions still remain in a number of sectors, including insurance, banking, mass media, aviation, land transport, agricultural land, electric power and natural gas. Today, Russia has one of the most restrictive regimes concerning FDI in the world, and the risk of FDI protectionism is considered to be higher in Russia than in any other FDI destination (Drzeniek, 2007, p.26). These restrictions have only one purpose: to protect domestic firms and to discourage foreign investments in strategic sectors. FDI is mainly concentrated in the energy sector, and the business sector is characterised by a low ability to benefit from technologies developed abroad (Ahrend and Tompson, 2005, p.57). For example the financial sector would benefit from a loosening of the FDI policy. Foreign banks would bring more skills, technology and credibility to the sector. A stronger involvement of foreign banks would allow local banks to increase their know-how and develop new banking products. According to UNCTAD (2003), Russia has great untapped potential in efficiency-seeking FDIs. Until now, Russian industries have failed to use the human capital and technological capabilities available in the science sector. If Russia is able to improve the business climate and attract FDI in the science sector, it could become a major international engineering hub (Simaranov et al., 2006, p.53). So far, Russia's level of FDI stock have been disappointing, it is well below that of the more advanced transition countries. Russia's FDI stock was 1 398 USD per capita in 2006 compared to 9 621 USD for Estonia. UNCTAD (2003) has characterized Russia as a "below potential country", meaning that it is a country with high FDI potential but low FDI performance.

Dependence on natural resources:

Russia can be classified as a resourced-based economy as the natural resources sector accounts for more than 10 per cent of the GDP and 40 per cent of exports. Resource-based economies are particularly exposed to fluctuation in the prices of countries' main export commodities, making the economy vulnerable to external shocks. In order to mitigate this external vulnerability, a good macroeconomic management is imperative. The creation of a stabilization fund is an important issue to ensure fiscal balance. The Stabilisation Fund of the Russian Federation was established in 2004, and it is managed by the Ministry of Finance, although some functions have been delegated to the CBR. Such a fund has to be sufficiently large to compensate for years of low prices for commodities. The goals a stabilization fund are three-folds. First, it helps to smooth government revenues where such a fund can be used to finance government spending in years of low commodity prices. Second, it evens out low growth perspectives as money accumulated can be spent when the commodity prices are falling, to achieve same growth rates as in “booming years”. Third, it sterilises foreign currency inflows and reduces current account pressure on the exchange rate. Without a stabilization fund, a large current account surplus would create pressures to appreciate the exchange rate. (Ahrend, 2005, p.35)

Shift to knowledge based economy:

As Erkki Ormalla described in 1999: “*Knowledge has become the driving force of economic growth, social development and job creation and the primary source of competitiveness in the world markets”*(OECD, 1999a, p.3). In a knowledge-based economy, the production of goods and services is becoming more knowledge intensive but not necessarily more R&D intensive. Quah (2007) has identified three critical dimensions of a knowledge economy: (i) human capital embodied in the economy’s labour force; (ii) the real resources expended on R&D, training and education, and (iii) intellectual property rights (IPR) framework providing incentives for ongoing innovation and discovery. All these three dimensions need to be considered when moving to a knowledge economy. Innovation requires more than R&D, a narrow focus on R&D neglects other types of innovative activities, such as market analysis or design. The western economies have moved from resource-based economies to knowledge-based economies since the emergence of new ICT (OECD, 1999a, p.3). Russia will have to achieve this transition, to remain competitive in the long run. Essential tasks involved in this process are: creating a favourable business environment, improving the quality of human capital and business infrastructure, and increasing the efficiency of the innovation system radically. Boosting innovation in Russia is of utmost importance and it will require mobilising Russia’s most ill-used asset, the important stock of human capital with scientific expertise and engineering know-how (OECD, 2005a, p.26).

6 Russia's Innovation System

Russia has a high potential for innovation. Russia possesses a trained workforce experienced in research, research capabilities, and few technical research universities which can compete at the international level. One characteristic of human capital is that it is flexible and mobile. Russia has inherited a sophisticated S&T infrastructure from the Soviet Union. The Russian Federation inherited between 65-70% of the Soviet science resources, and despite large cuts in the early phase of transition, the S&T sector is still substantial. The existing S&T base is eroding rapidly and is today a wasted resource. Russia still has a huge stock of human capital with scientific capabilities. This can either be a threat and lead to a brain drain, or it can be a potential engine for economic growth (Watkins, 2003, p.10).

6.1 The legacy of communism in S&T

Russia has a long scientific tradition, and it had an extremely large R&D base during the Soviet rule, bigger than most industrial nations. The birth of the Russian S&T sector took place during the tsarist period with the foundation of the Academies of Science by Peter the Great. The tradition of performing most R&D in institutes of the academy of science, military laboratories and elite universities found its origin in this period. The R&D in the Soviet Union was concentrated in research institutes of the academy of science and in institutes of the industrial ministries. Business R&D was an exception, only a few large industrial firms had in-house R&D departments. Universities became almost exclusively training centres with little R&D activity. These institutional characteristics were the fundaments of the Soviet R&D system. This evolution was contrary to the trend seen in Western countries, where R&D activities rose in the industrial firms and at universities in the beginning of the 20th century (Gokhberg, 1997, pp.10-15).

Russia inherited from the Soviet Union an ambiguous S&T legacy described as *"cutting edge and obsolete at the same time"* (Gonchar, 1997, p.71). The Soviet S&T system was characterised as being very large, centrally directed, and financed by the government. The S&T system was primarily driven by political objectives focused on the increase of USSR's military capability. The role of R&D was driven by cultural and ideological factors, not by economic or technological ones. The allocation of resources was motivated by the "superpower ideology", with the result that the emphasis was on engineering. The production of high-tech products, consumer goods and the service sector were neglected. These sectors were small in the Soviet Union compared with Western countries (Gokhberg, 1997, p.11). The main focus of Soviet

R&D was in applied R&D, i.e. in the field of engineering. A share of 95% of R&D resources were allocated to applied research, and only 5% to basic research. The neglect of basic research was not a good precondition for the future development of technologies and led to the loss of technological leadership in many fields (Egorov et al., 1999 p.160).

The Soviet R&D sector had a particular institutional organisation with a rigid administrative system. It was designed to foster specialisation and minimise interaction between different sectors. Research institutes were the main organisations performing R&D in the USSR. Only a few enterprises and leading higher education institutions (HEIs) carried out R&D. The research institutes worked independently and did not interact with enterprises or universities, and applied R&D was carried out separately from production (Watkins, 2003, p.2). In the Soviet era, enterprises had no incentive to be innovative, because R&D was usually supplied to them as a free good. The R&D institutions were under the responsibility of specific ministries. Each ministry supervised a certain branch of the economy and had total control over this branch, including R&D efforts. The structures of Soviet R&D institutes were hierarchical with strong vertical linkages but almost no linkages on the horizontal level. These constellations made scientific interaction and inter-sectoral R&D projects difficult (Egorov et al., 1999 p.160).

Soviet R&D was organised in four main sectors (Gokhberg, 1997, pp.13-15):

- (i) Academy sector: the Academy of Science was the forefront of the Soviet R&D system in terms of prestige, funding and manpower skills. Most of the fundamental research was done in the Academy sector. The Academies of Science carried out also applied research. In 1990, some 20 % of the total applied research was carried out by these institutes.
- (ii) Higher education sector: HEIs were mainly excluded from R&D because their main mission was teaching. Only a few prestigious elite engineering colleges and universities maintained high quality research, mainly in basic research.
- (iii) Industrial R&D: this sector was the largest R&D sector of the Soviet science system where it was carried out at so-called branch ministries. The ministries carried out most of the applied R&D in the former Soviet Union (FSU). Each ministry had its own network, and the R&D activities focused on the needs of specific industrial sectors rather than specific enterprises. This organisation hindered the inter-sectoral diffusion of knowledge and created "technological monopolies" in each sector. The majority of industrial R&D was allocated to defence R&D. The defence R&D units performed not only advanced applied R&D but were also successful in basic research related to military R&D such as, nuclear power, high energy physics, mechanics, new material,

electronics, computer science, and space technology. Nowadays, R&D at branch ministries has almost ceased to exist.

- (iv) Enterprise sector: this sector was the least developed in the Soviet Union. The R&D units of large enterprises carried out research directed to the specific needs of the enterprise, mainly adopting technology to the needs of the enterprise.

Another feature of the Soviet Science system was the geographic concentration of science in certain regions, wherein academies and universities were located mostly in the main cities. Russia employed 68 % of Soviet total R&D personnel and accounted for 75 % of Soviet total R&D expenditures. This uneven distribution of R&D was mainly politically motivated. The system favoured main cities, e.g. Moscow alone accounted for over 30 % of total Soviet R&D. The Soviet system created also science cities (*naukograds*) in the periphery of large cities (Global Security; 2005). Large numbers of highly qualified scientists were developing new technologies in such cities but were isolated from other research communities. These cities had a high concentration of science and research facilities and were created to carry out research in a specific field. Some of the science cities were founded in remote areas to conduct research in the nuclear and defence field in total secrecy (Gokhberg, 1997, p.15).

The Soviet administrative system did not give incentives to manage R&D facilities rationally. The allocation of resources was only based on the size of the institute. No funds were allocated based on performance or scientific output. Such a system favoured large R&D facilities over small units, with the consequence that the average employment per R&D institution grew substantially. This organisational structure reduced the flexibility of the whole R&D system (Gokhberg, 1997, p.16).

Central planning, the hierarchical structure, and barriers between Soviet S&T organisations led to bargaining in the absence of a market economy. All decisions were based on non-economic factors mainly driven by politics. The demand and supply of R&D was controlled by the state rather than the actual demand of enterprises. This system led to the existence of a bunch of technologically outdated companies after the fall of the communist system.

The S&T sector suffered from the isolation policy of the Soviet Union. The S&T sector could not participate in and gain advantages from international scientific cooperation, with the result that Soviet R&D duplicated research program from abroad. This policy of autarky resulted in a technology level that lagged behind the international community, especially in the application of industrial technology. The features of the Soviet S&T system overemphasised research at the expense of innovation. Most innovations were minor improvements of mostly obsolete technologies, which were implemented quickly but were not very useful. One major problem of Soviet R&D was the low diffusion of innovation. The Soviet R&D sector was unable to diffuse its innovations into the whole economy, i.e. innovations were mostly introduced in one or two enterprises only. The low diffusion rate showed the lack of interest for companies to innovate. The command economy ensured that all products would be sold at fixed prices. Therefore, no enterprises had incentives to innovate in process innovation to lower production costs or introduce new products. Overall the Soviet national R&D system was very ineffective in producing innovations (Gokhberg, 1997, pp.17-18).

Privatisation of the R&D sector started in 1992 and took place rapidly. By 1995, around 20 % of R&D institutions were re-established as joint stock companies another 4 % were fully privately-owned organisations mostly in the civilian industrial sector. The government often retained some control over the R&D organisations after privatisation. The process of privatisation continued until today, the government has only retained ownership in strategically important sectors. The most common ownership form for privatised R&D institutions is the joint stock company (Gokhberg, 1997, p.44).

As a conclusion, the Soviet system with its rigid administration and the absence of inter-sectoral cooperation was unable to meet the needs of a market economy. Several features of the Soviet system still harm the development of the Russian innovation system today. Structural reforms in such system will take time. Moreover, a change in the mindset of Russian scientists and authorities is needed before the Russian innovation system can fulfil its true potential.

6.2 S&T in Russia

The concept of producing new knowledge and expanding the frontier of knowledge has a long tradition in Russia. During the Soviet time, scientific activities were not oriented to the needs of a market economy, which resulted in a huge waste of resources (Gokhberg, 1997, p.151). The innovation system of the Soviet Union was based on the system of command economy, with the consequence that all information and research results, including IPR were state property (OECD 2006b, pp.147-157). This hindered the development of collaboration between innovative firms and reduced their interest to carry out competitive research. Moreover, the Soviet system worked against the development of international scientific and technological cooperation. The collapse of the Soviet Union in 1991 led to a massive brain drain as many of Russia’s best scientists left the country. Employment in the research sector fell from 1.22 million to 542 000 researchers in 1995 (Zolotykh, 2006, p.15). The reduction of personnel took place mostly in applied R&D, thus rendering the Russian applied R&D sector inadequate to support high-technology sectors of the economy. However, Russia has still a huge scientific endowment and it still possesses some world-class research facilities, especially in basic research. Russia is, behind the United States the EU and Japan, the world's seventh largest R&D spender (Lopez-Carlos 2005, p.142).

The transition to a market economy was difficult in all the spheres of the economy. The S&T sector suffered in even greater extent because state support fell dramatically. Consequently, demand for new products and technologies from the government and also from the private sector fell dramatically during the first years of transition. For example the share of industrial R&D fell to less than 20% in the early nineties (Egorov et al., 1999, p.163). Expenditures on R&D in Russia declined rapidly in the early years of transition, but in recent years a small recovery has taken place, as shown in Figure 12. In 1990, the R&D intensity ratio for Russia was one of the highest in the world. Today, the Russian Federation is comparable with countries that have relatively low R&D intensity, like Spain or Brazil (Lenchuk and Vlaskin, 2006, p.34). Regarding civilian R&D, the Russian Science Law stipulates that the share of civilian R&D should be equivalent to at least 4 % of the total federal budget. However, despite modest improvement in recent years, the civilian R&D budget does not reach 2 % of the total federal budget, reflecting the low priority government has given to R&D (FINPRO, 2006, p.9).

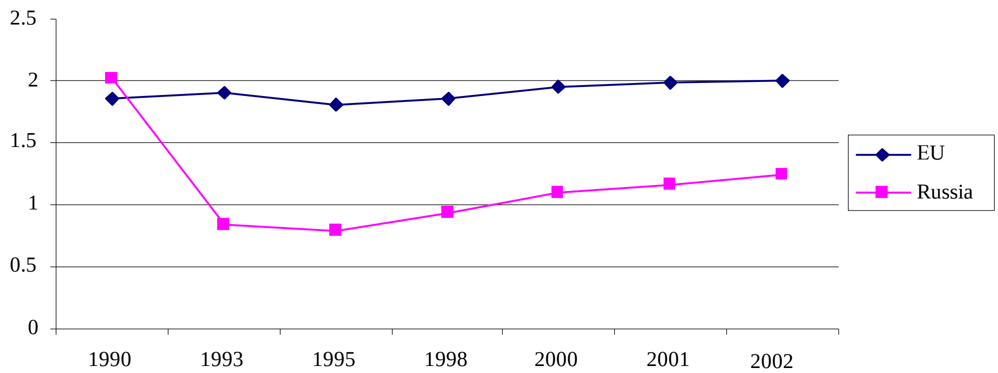


Figure 12. Domestic R&D expenditures as % of GDP in the EU and Russia (Source: Lenchuk and Vlaskin 2006)

In terms of R&D intensity ratio measured by R&D expenditures of GDP, Russia spent just over 2 % of GDP in 1990, and in 1995 this ratio dropped to 0.85%. Since then, the R&D intensity ratio slowly recovered to 1.28% in 2003 and it was estimated to raise to 1.54% in 2007. R&D

expenditures per capita are much lower in Russia compared to developed countries, for example the R&D per capita figures are roughly ten times lower in Russia than in the USA. Similarly, R&D investments measured in absolute terms are much lower in Russia compared to leading developed countries. In 2003, the total R&D expenditures amounted 16.9 billion dollar (PPP) in Russia, whereas the USA allocated 277.1 billion dollar (PPP) to R&D. (Table 7).

Table 7. R&D expenditures in Russia and selected developed countries in 2003

	Russia	USA	Germany	Japan	Sweden
R&D expenditures per capita in dollars (PPP)	98.7	977.7	660.0	838.4	1149.0
R&D expenditures as % of GDP	1.28	2.67	2.50	3.12	4.27
Total R&D expenditures in billion dollars (PPP)	16.8	277.1	54.4	106.9	10.2

Source: adapted from Lenchuk and Vlaskin 2006

At present, Russia's R&D system can be divided into three large sectors: (i) the public sector, including institutes of the Russian Academy of Science and other government academies; (ii) the higher education sector; and (iii) the industry sector, including both private companies, and government-owned R&D organisations. Private non-profit organisations play only a marginal role, but in the past decade the numbers of such organisations has increased five-fold. In the year 2005, the government sector, the higher education sector and the industry sector performed 26.1%; 5.8%; 67.9%, respectively of total R&D in Russia (Dezhina and Zahev, 2007, p.2). According to Goskomstat statistics more than 3500 R&D entities existed in the Russian Federation in 2003, as shown in the Table 8. The institutional structure of the Russian R&D system is different from that of most western countries. About 90% of organisations performing R&D are independent institutions. Only 6% of research entities are integrated in companies and 4 % are within universities (Kovaleva and Zaichenko, 2006).

Table 8. Total R&D capacity by sector for 2003

	Number of R&D organizations	Number of employees in R&D	Share in total number of employees in R&D
Government	1230	258 078	25.3%
Business	1851	537 473	69.1%
Higher education	533	43 414	5.4%
Private non-profit	42	373	0.2%
TOTAL	3656	839 338	100%

Source: nauka Rossii v tsifrakh 2005

Taking a closer look at the ownership structure of R&D expenditures, the picture of the Russian R&D system differs proportionally. In 2004, the share of the government-funded research was very large, totalling 74.2% of all R&D activities performed by government-owned R&D organisations. Most of the government-owned R&D organisations are former “ministries branch institutes” which were privatised in the nineties but are still government-owned (Dezhina and Zahev, 2007, p.3). These organisations are now categorised for statistic purposes in the industry sector. The industry sector includes both private companies and government-owned organisations. Therefore, it is difficult to differentiate R&D expenditures from the public sector and private sector. According to some estimations, private companies contributed only 22.4 % of the national R&D expenses in 2005. This figure stayed almost unchanged in the last decade. Data for the year 1998 indicates that private companies accounted for 22.8 % of total R&D (OECD, 2006b). As shown in Table 9, the share of R&D financed by the public sector is by far the largest contributor to R&D in terms of GDP share.

Table 9. R&D funding in terms of GDP share

	2003	2004	2005	2006*	2007*
R&D funding on the whole, in %	1.28	1.35	1.44	1.49	1.54
Public sector funding, in %	0.93	0.99	1.07	1.08	1.08

*forecasted

Source: OECD 2006b

Looking at the gross domestic expenditures on R&D (GERD) by funding source shows that the share of industry in financing R&D has stayed around 30 % in the last decade, as reflected in

Table 10. The federal state remains the major source of financing for R&D (Dezhina and Zahev, 2007, p.2). The share of the government is much higher compared to the statistics by R&D performers. This can be explained by the fact that many organisations counted statistically in the industry sector are in fact privatised “former branch institutes”, and the research activities in these institutes are still financed by the federal state. A point that needs to be highlighted is that there is a relative underinvestment in in-house R&D by the business sector in Russia (Lenchuk and Vlaskin, 2006, p.36).

The GERD figures have increased during last years, but Russia is falling behind developed countries measured by principal macro-indicators on innovation. In 2005, the EU-15 countries spent approximately twice as much on R&D than Russia. Russia’s share of global R&D expenditures was 0.49 % in 2006, much lower than in leading western countries. However, the internal spending on R&D should rise to 2 % of the GDP by 2010. Despite the growth of GERD for non-military research, the growth rates of GERD adjusted by inflation lag behind the GDP growth.

The share of foreign R&D (7.6 %) is high compared with other developed countries. Foreign organisations concentrate innovative activities to near market development to adapt technologies to the particular needs of Russian customers. Some foreign companies seek opportunities to commercialise Russian achievements in certain fields where Russian science is particularly advanced, but this is mostly cherry picking.

Table 10. Gross domestic expenditure on R&D by funding source

	1995	2001	2002	2003	2004	2005
GERD (in mln. current PPP $)	7373.1	12 988	14 724	16 758	16 412	16 668
GERD (as % of GDP)	0.85	1.18	1.25	1.28	1.16	1.07
GERD financed by industry, in %	33.6	33.6	33.1	30.8	31.4	30.0
GERD financed by government, in %	61.5	57.2	58.4	59.6	60.6	61.9
GERD financed by abroad, in %	4.6	8.6	8.0	9.0	7.6	7.6
GERD financed by other sources, in %	0.3	0.5	0.4	0.6	0.4	0.5

Source: OECD 2007c

The structure of the Russian R&D system is very complex in terms of legal status, ownership and funding mechanisms, which makes it difficult to draw a clear picture of the R&D system (Komkov and Bondareva, 2006, pp.2-18). Most of the research is carried out in the public sector in different types of organisations: research institutes of academies, university laboratories, design bureaus and R&D departments of state-owned companies. A figure representing the national innovation system is shown in Appendix 1.

A clear division of responsibility for carrying out different types of research based on old Soviet tradition still exist today (Listsyn, 2007). The Russian Academy of Science is responsible for fundamental research, while the federal R&D centres are responsible for applied research. Most HEIs are still standing aside of the R&D system because they are still considered to be primarily responsible for education. Such a distribution of roles creates inflexibility of the whole science system and hampers scientific development. The links between fundamental science, higher education, and applied and experimental research institutions are rather weak compared to other western countries (Dezhina, 2004, p.2).

In the past, the commercialisation process of the Russian innovation system followed the traditional Soviet technology push model. This model had several disadvantages. First, it focused on the early stages of the innovation process and with the risk that customer needs and feedback were ignored in the innovation process. Second, this approach was very expensive because a large number of innovation projects were needed, only few of which make it to the market and the demand for innovation results were uncertain. Third, the innovation process started from scratch and experiences from other innovation projects could be used. One of the legacies inherited from the Soviet linear innovation system is structural imbalance and weak linkages between actors in the current innovation system in Russia (Simaranov et al., 2006, p.56). In Russia the traditional approach of performing state orders for R&D prevails, which is a practice inherited from FSU. Enterprises as users of R&D are weakly connected to the R&D institutes. As a consequence, demand and supply of R&D meet each other poorly, and feedback between users and developers of R&D is almost inexistent. The relationship between the main actors - R&D organisations, universities and private sector - is complicated by fragmented interest of different policy institutions, by uncertainties regarding intellectual property rights, and by a lack of consistent policies providing incentives for long-term co-operation. Moreover, most R&D institutions owned by the government have no incentives to cooperate with the private sector. For successful commercial use of innovations, the technology push model may be inadequate. In such a system, the development of linkages between science and business is very difficult. The innovation process should be based on market demand rather than “pushed” by R&D institutions (Kovaleva and Zaichenko, 2006, p.5).

6.3 Higher education system in Russia

Russia has one of the most educated populations in the world. Education, particularly higher education, had a high prestige in the Soviet society. As shown in Figure 13, more than half of the Russian population aged between 25 and 64 have accomplished higher education, which is one of the highest rates in the world.

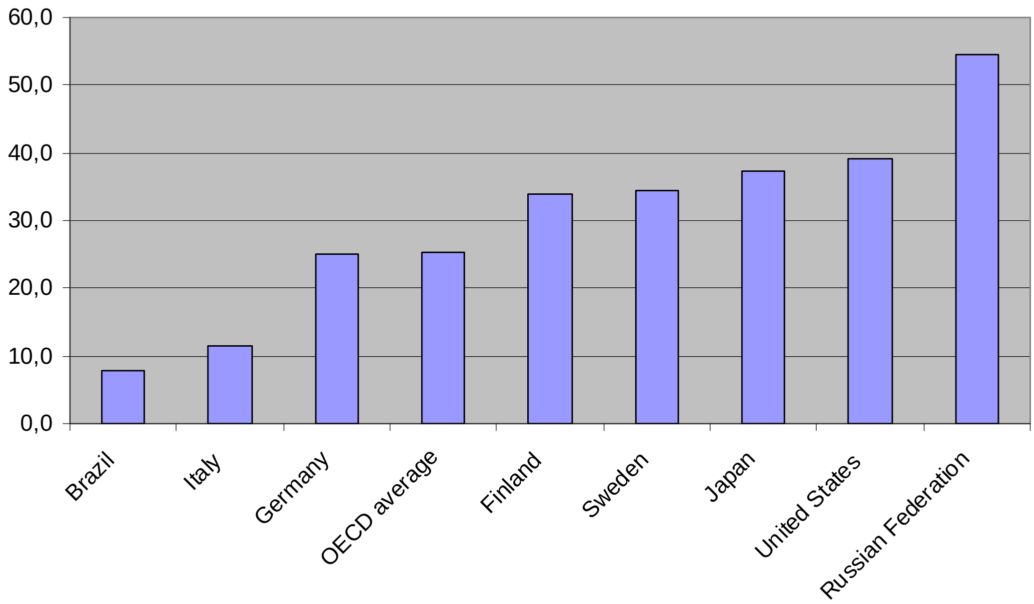


Figure 13. Attainment of tertiary education for the age group 25-64 (as a percentage of the population, 2004 or latest available year) (Source: OECD, 2007c)

Nowadays, like in the communist period, the attainment of university level education of the Russian population is high. Russia ranks in the top 10 countries in an international comparison. Russia shares a remarkable 9th place with Japan with 21 % of its population having tertiary education (Tan et al., 2007, p.155).

However, when expenditures on education are considered, Russia's international position is less favourable. Education is underfunded and of low quality in Russia. Especially professional education is of low quality, orientated to teach narrowly defined skills at the expense of more general knowledge. According to the Russian Federation law "On Education" (1996), the state is committed to ensure no less than 10 % of the national income on financing the educational sector (this corresponds to roughly 7% of the GDP). However, these obligations have not been fulfilled during the last years, as the actual expenditures on education have remained far below the funding levels mandated under law (Teichmann, 2008). As presented in Figure 14, the share of GDP spent on education was only 3.6% in 2007, which was lower than in any other selected country. Despite the high educational attainment, Russia faces serious problem in the quality of the education. Nowadays, the skills provided by the educational system do not match with the skills required in the labour market (Tan et al., 2007, p.157).

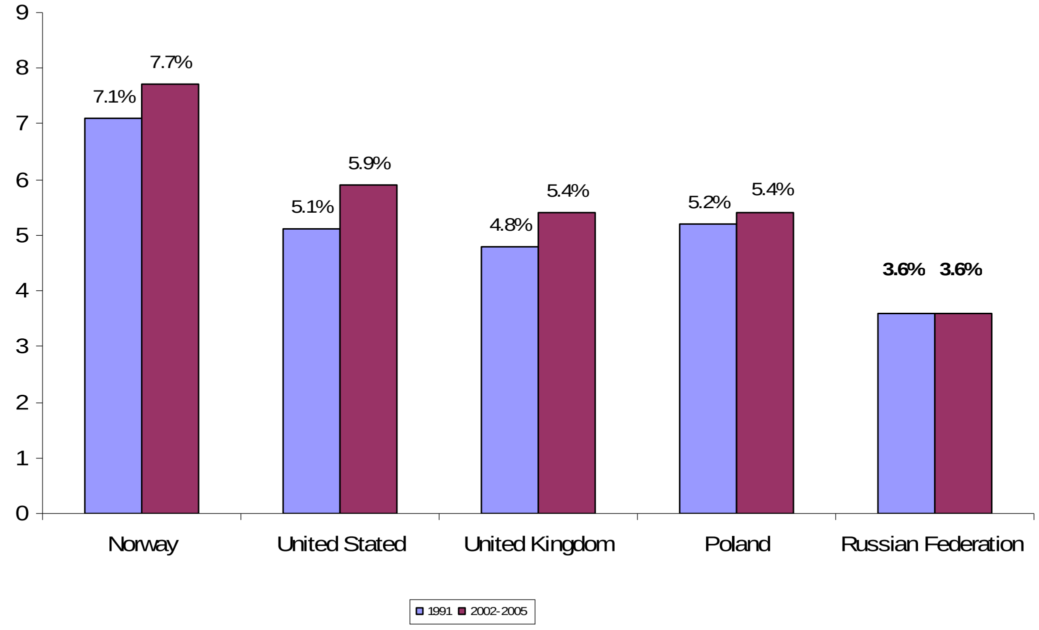


Figure 14. Public expenditure on education in international comparison (% of GDP) (Source: Russian Analytical Digest, 2008)

The expenditure for higher education is much higher than for primary and secondary education. Russia allocates fewer resources to secondary education, which has negative consequences in term of quality (Tan et al., 2007, p.157). In 2005, the proportion of expenditure for higher education was 70% of the total federal expenditure on education, while in 2006 it rose up to nearly 77%. By the year 2000, the overall expenditure on education grew slightly (IET, 2006). However, this is only a rise in absolute terms. The share of resources allocated to education remained stable when the rise in federal budget expenditures of GDP is considered as illustrated in Figure 14.

Most HEIs are located in the central or north-western regions of Russia. Moscow and St. Petersburg are the two centres for higher education. The educational reform of 1992 allowed the establishment of private educational institutions. Private HEIs offer degrees mainly in business and law which were subjects neglected under the Soviet rule. The newly established HEIs have often been criticised for their low quality of education. They are characterised by being usually smaller than state HEIs, having mainly a local importance in their respective regions, and focusing on teaching activities. In the academic year 2005/2006, 1068 HEIs were operating in Russia. The HEIs community consists of 655 state HEIs and 413 non-state HEIs, indicating that the number of HEIs has doubled since 1991 (HSE, 2007). The high increase of HEIs is mainly due to the establishment of new private HEIs (Figure 15).

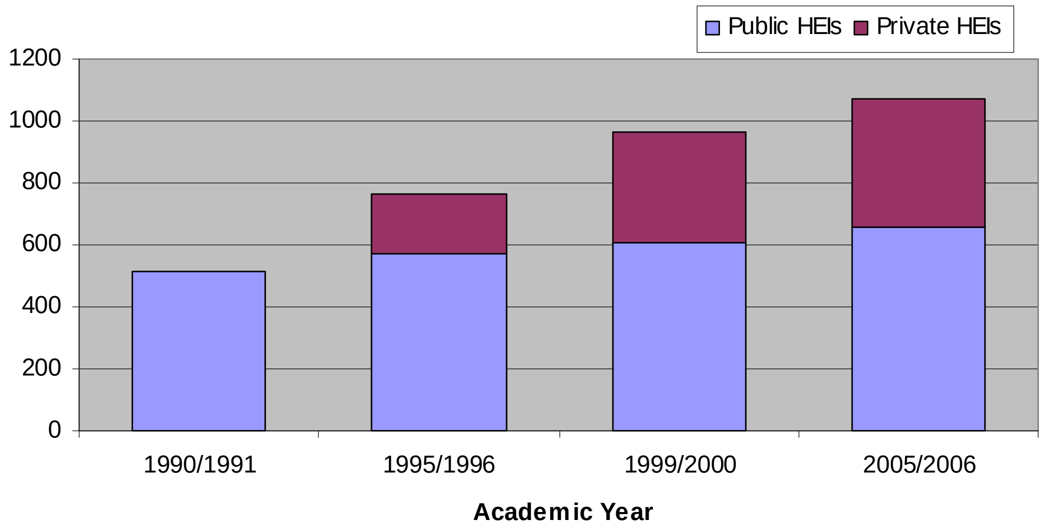


Figure 15. Number of HEIs (Source: Meister, 2007)

Today, the demand for higher education remains high. After a small decline in the early phases of transition, the demand for higher education rose over the years and peaked in the academic year 2004/2005. Nowadays the demand for higher education is exceeding supply in Russia. Table 11 shows the admission numbers of new students at Russian universities between the academic years 2001/2002 - 2005/06. In the academic year 2005/2006, over 7 million students were studying in Russia, most of them at federal institutions (Meister, 2007). This represents a number of 495 students per 10 000 of population. One possible explanation for this continuous strong demand is the high return of one additional year of education. Males graduated from a university earn 50 % more than those who complete only secondary school, and for women the wage premium is about 70 % (Tan et al., 2007, p.161).

Table 11. Number of higher education students and admission to universities

Academic Year	2001/2002	2002/2003	2003/2004	2004/2005	2005/2006
Number of higher education students per 10 000 population	373	410	448	480	495
Number of higher education students	5426.9	5947.5	6455.7	6884.2	7064.6
Admission to public universities by thousand students	1263.5	1299.9	1411.7	1384.5	1362.7
Admission to private universities by thousand students	198.2	204.0	231.7	274.5	268.0
Total admission by thousand students	1461.7	1503.9	1643.4	1659.0	1630.7

Source: IET, 2006; Rosstat, 2007

A country rich in human capital will be more able to absorb and disseminate knowledge and new technologies with an educated population. Moreover, it will be able to benefit better from sources of technology diffusion such as FDI or trade. Education is therefore one of the crucial levers to foster innovation and improve absorptive capacity. Today, the inadequate funding and problem of governance constrain HEIs in responding to the skills needs of the economy. Human capital or education have an important role in the relationship between innovation and growth. The high level of education available in Russia is an advantage, but it does not translate automatically into innovation success and even less to commercial innovation if adequate incentive structures and institutions are not in place (Goldberg et al., 2006 p.37). The historical separation among the private sector, universities and research institutes has prevented the economy from benefiting fully from the high levels of human capital. The policies of the Soviet times have still a negative influence on scientific activities in Russian universities, and the consequences for the quality of higher education are serious (OECD, 1999b). Therefore, the educational institutions as well as research institutions have to be reformed.

6.4 Research at HEIs

HEIs have traditionally played a marginal role in R&D in Russia. Unlike in western countries, Humboldt's concept of unity of science and research at universities was uncommon in Russia.

Since the foundation of the Academies of Science in 1742, the academies were responsible for conducting research, and universities were in charge educating students (Kovaleva and Zaichenko, 2006, p.9). The Soviet regime even reinforced this separation. The Soviet educational system was fully financed by the state, centrally planned and directed toward the needs of Soviet industry. Only some elite universities retained some research activities. The main disadvantage of the separation between teaching and research is that recent research results are introduced with a delay in the curriculum having negative consequences in terms of the quality of education (OECD, 1999b, p.12). Only since the adoption of the law "On Higher and Postgraduate Education" in 1996, research is one of the basic tasks of HEIs.

Teaching remains the main activity of universities. Research is a non-existent or relatively underdeveloped activity among Russian universities. Currently, less than 40 % of HEIs are engaged in research activities. Among the more than 1000 HEIs, only 393 universities were identified as being engaged in some kind of research activity in 2003. In the past, universities were not considered as a priority for investment in research. The funds allocated to the higher education sector to carry out research have more than doubled in the last ten years, but the higher education sector still plays a modest role in S&T in Russia (Gianella and Tompson, 2007, p.15). The state funding accorded to R&D in the higher education sector was strikingly low compared with the number of researchers working in the HEIs. In 2005, HEIs received only about 4.3% of budgetary funds for R&D. The government projects target to increase this figure to 20% over the coming decade (IET, 2006).

In most universities, the research equipment is outdated and the research facilities are below satisfactory standards. This will affect both the quality of research and teaching in the long term (Kouptsov and Tartur, 2001, p.45). Research in Russian universities has been traditionally oriented towards basic research. However, a reorientation to increase the share of applied research and innovation activities would be beneficial for the HEIs (Ivanova and Roseboom, 2006, pp.28-29). It would create stronger links with the private sector and be beneficial for the HEIs in times of financial hardship. Until today, research and teaching have remained separated from each other at universities, but in the coming years, universities will become more and more engaged in research and they will shift to the model of "University of technology" common in western countries (e.g. Massachusetts Institute of Technology).

Table 12. Human resources in the higher education R&D Sector

	1999	2000	2001	2002	2003	2004
Researchers at HEIs	40 781	40 787	43 463	44 135	43 120	43 414
Percentage of national total	4.6	4.6	4.9	5.0	5.0	5.2

Source: Ivanova and Roseboom, 2006

Table 13 shows the expenditure for R&D in the higher education sector. Only 5.5% of R&D expenditure was allocated to the higher education sector in 2004. In France, the HEIs account for 20 % of total R&D and in Germany the share is 16 %. No significant changes in policies with respect to university research have been taken place since the nineties. In an international comparison, when higher education expenditures on R&D (HERD) are compared, Russia allocates much less money to universities than other western countries. The HERD expenditures have risen sharply in nominal figures but measured as a percentage of GDP, which has been almost unchanged since 1995. In 2005, Russia spent only 0.06% on HERD as a share of GDP compared to the 0.66% for Finland or 0.41% for Germany.

Table 13. Higher education expenditures on R&D

	1995	2001	2002	2003	2004	2005
R&D by the Higher Education sector in %	5.4	5.2	5.4	6.1	5.5	5.8
HERD (in mln. current PPP $)	398.9	677.2	798.7	1016.0	895.5	963.3
HERD as % of GDP	0.05	0.06	0.07	0.08	0.06	0.06

Source: OECD 2007c

One major challenge that Russia has in the field of S&T is to integrate higher education with the other R&D institutes. The government has identified this issue as a crucial one and has launched some initiatives to create links between state research institutes by attaching them to HEIs, although the reform process is moving very slowly.

During last years, few measures have been adopted to further integrate research institutes with universities. The only step taken has been to merge the research institutes with higher education establishments. Most of the research institutes were reluctant to cooperate and reacted negatively to this reorganisation. They were afraid of loosing their autonomy, of an increased control from the HEIs, and a repartition of different research projects between different university departments. On the other hand, the HEIs expected that a closer collaboration with R&D institutes would have positive aspects on the integration of science and education. The positive outcome of these mergers can be questioned. The current legal framework applying to universities is inappropriate as regards commercialisation issues. Research institutes are being merged within the organisational structure of the HEIs, whose legal status is more restrictive for the use of intellectual property rights. Therefore, there might be fewer incentives to conduct research and development at "integrated" research institutes (IET, 2006).

6.5 Institutional framework

The institutional framework of S&T in Russia has undergone several changes since the communist period (UNESCO, 2006). The restructuring process with its several reform attempts led to great organisational instability in the science sector. The ministry responsible for S&T was reformed several times between 1991 and 2004. The reorganisation process from 1991 can be divided into different stages. During the first stage (January 1992 – August 1998), the S&T sector faced an important decrease of funding. All the undertaken institutional reforms in S&T were unsuccessful due to the climate of economic and social uncertainty. With the financial crisis of 1998, all institutional reforms, including reforms aiming at restructuring S&T were suspended. The last phase of reforms began with the economic recovery of Russia, as economic growth enabled certain Russian firms to catch up in the field of technological innovation. During this period, an effective reform of R&D financing was adopted. The reforms aimed at making the financing of public R&D more transparent, target-oriented and efficient. However, the new approach seemed to worsen the problem of corruption and lobbying. The reform led to favouritism in S&T, only a narrow circle of organisations was granted project funding which is a threat for scientific development in Russia (Dezhina, 2004, p.2).

In March 2004, a reorganisation of federal executive bodies was adopted, which also affected the S&T sector (Ahrend and Tompson, 2005, p.39). This reform reorganised the federal executives into three different types of institutions:

(i) *Federal Ministries* are responsible for policy analysis, development and evaluation in their respective fields of duties. They are policy making bodies and responsible for drafting new legislation;

(ii) (ii) *Federal Services* are supervisory and regulatory bodies; they have the power to issue individual regulation and are funded by the state budget;

(iii) (iii) *Federal Agencies* are direct providers of public services to the state or private sector and are therefore also partly funded by fees paid by their "customers".

The administrative reform of 2004 led to the creation of the new Ministry of Education and Science, which is the result of the reorganisation of the Ministry for Education and the Ministry of Industry, Science and Technology. The new ministry took over all functions of the two old ministries. Synergies between the spheres of science and education and an increase in the efficiency of executive bodies were expected from this reform. Unfortunately, there is yet little evidence that the reorganisation has achieved any of these goals, because the reorganisation disrupted most work of the government bodies. Moreover, the reform created a strong competition between the two spheres for state funding (Ahrend and Tompson, 2005, p.39).

The Ministry of Education and Science remains the main organisation in the field of education and science. It is responsible for drafting federal polices in the following fields:

(i) education, youth policy, intellectual property, R&D and innovative activities;
(ii) determining priorities in the field of education, technology, science;
(iii) coordinating research projects funded by the federal state;
(iv) development of new technologies in education and science;
(v) developing national education standards;
(vi) certification of educational organisations.

Simultaneously, the ministry coordinates and monitors subordinated services and agencies. The ministry carries out the policy drafting and ensures legal regulation. Implementation and administration of the programmes are the responsibilities of the agencies. The services monitor the implementation of the federal programs (Kamensky, 2006).

The structure of the ministry incorporates the Federal Agency for Education (Rosobrasovanije), the Federal Agency for Science and Innovation (*Rosnauka*), the Federal Service for Supervision in Education and Science (*Rosobrnadsor*) and the Federal Service for Intellectual Property, Patents and Trademarks (*Rospatent*).

The Federal Agency for Education is responsible for the implementation of the national education policy and strategies. Since 2006, together with the Ministry of Education and Science, it has carried out the implementation of the priority national project "education" with the aim to modernise the Russian education sector. The main goals of the program are: (i) the support and promote the best model of the national education; (ii) introduction of modern educational technologies; (iii) creation of world-class national universities; (iv) improvement of the level of pedagogical work at schools; and (v) development of the vocational training system in the army (DFG, 2007).

The Federal Agency for Science and Innovation is responsible for the policy implementation in the field of science. The agency is responsible for tendering and promoting innovative and technology intensive research projects. The agency works on an intersectoral level, supporting science and innovation through a variety of instruments, such as the federal programme "R&D by priority fields", science parks, technology transfer and commercialisation centres, and business incubators (Ivanova and Roseboom, 2006, p.21). In 2007, the agency was granted a budget of more than 480 mln EUR to carry out several programmes, which is almost six times higher than the ministry budget.

The Federal Service for Supervision in Education and Science monitors the implementation of national policies in the sphere of science and education. The Service provides control and supervision in the field of education and science with the main goal of ensuring high quality education (DFG, 2007).

Rospatent is the Russian patent office founded in 1993. This federal service performs the functions of examination, registration, control and supervision of legal protection and use of intellectual property, including patens and trademarks (DFG, 2007).

The federal budget share accorded to science and education has been growing steadily in recent years, as presented in Table 14, and a further increase of budgetary funds is expected for the coming years. The total budget accorded to education and science was roughly 8.3 bln EUR for 2007, but the ministry itself has only a budget of 68 mln. A major share of the funds allocated to science and education are allocated to the agencies *Rosnauka* and *Rosobrasovanije*. In 2007, 483 mln were allocated to *Rosnauka* and 6.06 bln EUR to *Rosobrasovanije*. Other important budget items are the funds allocated to the Russian Academy of Science and its branches, as well as the funds granted to Lomonosov University and science foundations. Other federal entities financing R&D are listed in the next section (DFG, 2007)

Table 14. Budget of the Ministry of Education and Science in 2005-2010

(in mln EUR)	Budget for			Forecast for		
	2005	2006	2007	2008	2009	2010
Ministry of Education and Science	**15.9**	**114.1**	**68.0**	**321.2**	**273.7**	**250.4**
Applied research	4.4	6.6	8.4	-	-	-
Rosobrasovanije	**2520,6**	**3468,4**	**6063,4**	**6462,4**	**6120,3**	**5891,6**
Basic research	19.2	59.0	89.1	-	-	-
Applied research	-	-	0.3	-	-	-
Rosobrnadsor	**1.6**	**3.0**	**3.6**	**5.5**	**16.1**	**17.0**
Applied research	-	-	0,4	-	-	-
Rosnauka	**294.3**	**329.2**	**483.2**	**528.9**	**652.7**	**805.4**
Basic research	10.6	20.6	11.7	-	-	-
Applied research	59.6	69.5	131.6	-	-	-
Rospatent	**29.3**	**32.9**	**37.8**	**49.8**	**55.7**	**58.7**
Applied research	23.3	26.6	35.6	-	-	-

Source: DFG 2007

6.6 Public agencies financing R&D in Russia

The state is the principal source of R&D in the Russian Federation. Most resources are allocated as direct grants. Much of the funding is “cost-based” and distributed according to employment levels and the amount of fixed assets. Such a system does not give incentive for institutes or researchers to think about commercial application of their research and of efficient use of resources because, greater efficiency could lead to a loss of funding. The government has recently reformed the budgeting procedures and has started to introduce so-called budgeting by objective. As a result, state funding is nowadays distributed according to output objectives rather than inputs. However, the consequences of these reforms are still unknown. Various channels are used by the state to channel state funding for R&D. Table 15 lists the most important agencies playing a role in the allocation of state R&D resources.

Table 15. Public support for civilian R&D

Type of agency	*Approved budget for 2006*		
	1 EUR = 34,08 RUB	*(EUR, million)*	*(RUB, million)*
Academies of Sciences			
Russian Academy of Sciences		834.89	28 453
Sector Academies of Science		117.81	4 015
Ministerial R&D budgets			
Ministry of Economic Development and Trade		13.73	468
Ministry of Industry and Energy		73.12	2 492
Ministry of Information Technology and Communication		0.73	25
Ministry of Education and Science		12.27	418
Federal agencies: non-industry-specific			
Federal Agency for Education		84.74	2,888
Federal Agency for Science and Innovation		328.40	11 192
Federal Service for Intellectual Property Rights		25.56	904
Federal agencies: industry-specific			
Federal Agency for Information Technology		4.48	289
Federal Agency on Atomic Energy		60.74	2 070
Federal Agency on Industry		248.94	8 484
Russian Space Agency		688.73	23 472
Competitive funding schemes			
Russian Fund for Basic Research		125.67	4 283
Russian Fund for Humanities		21.03	717
Federal Fund for Small Innovative Enterprises		31.54	1 075
TOTAL		**2677.38**	**91 245**

Source: Federal Budget Law 2006

A majority of the R&D budget is distributed via direct subsidies. Only a small part of the federal R&D budget is allocated on a competitive basis through grant-awarding foundations. In 2006, only 14.6% of all civil science budgetary funds were allocated on a competitive basis (OECD, 2005a, p.63). These grant-awarding foundations were established in the early nineties and were the new main mechanism of government support for R&D. Their main distinctive features are: open competition for funds, bottom-up definition of research projects, and accountability. A fund to foster innovative enterprises was created in 1994. The main problem of these agencies is that they are underfunded and try to support too many projects (Gianella and Tompson, 2007, p.21). The next section describes the most important science foundations in the Russian federation.

(i) The Russian Foundation for Technological Development

The Russian Foundation for Technological Development was established in 1992 and is subordinated to the Ministry of Science and Education. It awards interest-free credit to research projects with interdisciplinary and inter-industry applications. The credits are offered through open competition and the main beneficiaries come from the industry sector (30%), institutes of the RAS (10%), and higher education institutions.

(ii) The Russian Foundation for Basic Research

The Russian Foundation for Basic Research was created in 1992 with the aim of supporting basic research in all fields through a grant-awarding system of open competition. This Foundation is considered by researchers as a major source of support in basic science and for acquisition of small pieces of equipment. However, the fund is limited by its modest budget. Its budget is set to make 6 % of all funds allocated for civilian R&D, but this target has not been met in the last years.

(iii) The Russian Foundation for Humanities

The Foundation works under the same principles as the Russian Foundation for Basic Research. It is a former sub-division of the Russian Foundation for Basic Research and became an independent foundation in 1994. Its budget is set at 1 % of the federal expenditures on civilian R&D. The funds of the foundation are used for research and education projects in humanities with a focus on questions concerning the current Russian society.

(iv) Federal Fund for Assistance to Small Innovative Enterprises.

This fund was established in 1994 with the aim of supporting small innovative firms already established on the market. Its budget is set to make 1.5% of the federal allocation on civil R&D. During its 10 years of existence, the fund has supported more than 2 000 SMEs, which is 3% of the total number of Russian innovative SMEs (Ivanova and Roseboom, 2006, p.22). Among other initiatives, the Foundation has started a seed financing programme called "*START*". The "*START*" program is aimed at supporting researchers ready to commercialise their research developments. The fund gives a research team seed money, and after one year an innovative start-up should be established. During the first two years of existence, this program helped to establish more than 850 new innovative SMEs (FINPRO, 2006, p.11).

6.7 The Russian Academy of Sciences

The Russian Academy of Sciences (RAS) is the supreme scientific institution of the Russian Federation. It is the leading centre for basic research in natural and social sciences in Russia. The RAS is organised by science subjects into nine different departments and divided into three regional branches (Far East Branch, Siberian Branch and Ural Branch), as well as 14 regional scientific centres. The RAS is the biggest scientific organisation of the country comprising 463 institutions with 106 000 employees, of which approximately 62 000 are researchers. Although its mandate is to carry out basic research, it also conducts applied research. The RAS represents about two thirds of all basic research and about 10 % of all applied research conducted in the country (Ivanova and Roseboom, 2006, p.26).

The RAS is funded by direct funding from the federal state and has the status of self-governance. During the nineties, the academy suffered a tremendous decline in budget which, led to a reduction of manpower, a decline in salaries and a deterioration of its research facilities. At present, the RAS still suffers from severe underinvestment, but the decline of funding has stopped and some recovery has taken place. Table 16 shows the position of the RAS in the Russian R&D System (DFG 2007).

Table 16. RAS in the Russian R&D system

	2000	2001	2002	2003
Share of RAS in national R&D expenditures	9.7%	10.1%	10.3%	11.0%
Share of RAS in civilian R&D support	31.0%	31.8%	33.5%	32.5%
Budget per RAS researcher (in thousand RUB)	70.5	99.9	130.1	176.3

Source: Ivanova and Roseboom 2006

The RAS has been able to keep all the responsibilities it had during the Soviet period and has even gained new ones. It is the principal organisation conducting fundamental research and is also the coordinator of any applied research carried out within the framework of the state run program “national scientific progress”. In October 2005, a reform program to reorganise the Academies of Science was adopted. Among other goals, it includes measures to increase average salaries of RAS scientists to 30 000 RUB and to cut the total number of employees to 90 000 (DFG, 2007).

The decided wage increase has been done at the expense at other expenses. The funds allocated for the renewal of new equipment were frozen for 3 years. This might further deteriorate the working conditions in the academies, because most of the equipment is already more than 10 years old. But according to an expert opinion, both the working conditions and the infrastructure have improved and the decay of the science sector has stopped.

Since the nineties, the number of research institutes has increased, but the scientific output has stagnated. According to a survey carried out by the Ministry of Education and Science, only 50 RAS institutes are actively pursuing research, and in some other 50 institutes small research groups are conducting research. The number of research institutes will be reduced in the future. The scientific community should decide which of the unproductive research institutes should be closed down. According to a survey conducted in 2005 by the Center for Strategic Research, only 40 % of the research staff was actively involved in research. Therefore, job cuts are necessary to reduce the “deadweight” in the RAS (Dezhina, 2004, p.4).

The research sector as a whole with its large number of various R&D organisations is considered to be excessive in comparison with their contribution to innovation in the economy. The number of scientists and engineers is sufficient, but their qualifications do not meet the needs of the industry. Moreover, the age structure of Russian scientists is precarious. During the nineties, the best and smartest scientists left the country and Russia suffered from a massive brain drain. Nowadays, Russia has nearly no “middle age” generation, researchers aged between 35 and 45 years. Most of the researchers are close to retirement. With the wage increase for scientists, young graduates are coming again to the science sector but they do not often stay in the sphere of science. After getting their doctoral degree they continue their scientific career abroad or go to the business sector, attracted by better wages. Recent initiatives aimed at improving the financial situation of scientists have been implemented. But also other factors, like working conditions or good career prospects are also important aspects for young scientists and action should be taken to improve these factors. The age structure problem is one of the biggest challenges the science sector has to solve in the near future (Ivanova and Roseboom, 2006, p.42).

6.8 Innovation activities of Russian firms

Russian firms are characterised by a comparatively low knowledge-intensity in their production, as a result of their low interest in innovation (OECD, 2005, p.35). The weak spot of the Russian innovation system is the scarcity of corporate R&D because business enterprises contribute less than 30% of the national resources for R&D (Kovaleva and Zachenko 2006). The share of 30% company financed R&D is much lower in Russia than in the United States (64.9 %) or Austria (46.6 %).

Two national intersectoral surveys demonstrate that Russian companies are not as innovative as western companies. According to *Goskomstat* (2001), the percentage of innovative firms was reported to be only 10.3%. Other data from Kozlov and Yudaeva (2004) suggests that the innovation rate among Russian firms is much higher. According to this small enterprise level survey, 41% of Russian firms have innovated in the last three years. Kozlov and Yudaeva (2004) suggest two factors that could explain the different results. Firstly, the small enterprise level survey was conducted later (in 2004) when the economic situation was better with a more stable business environment. It is reasonable to assume that the turbulent first years of transition and the financial crisis of 1998 reduced the incentives of enterprises to innovate. Secondly, the methodology used in the *Goskomstat* survey was different. It might have suffered from underreporting, and incremental innovation might not appear in the *Goskomstat* survey (Kozlov and Yudaeva, 2004).

Very little domestic demand exists for Russian-made equipment and very little high quality high-tech manufacturing equipment is produced in Russia (OECD, 2005a, pp.31-35). One problem is that companies are able to achieve high profits with “low innovative” activities, and existing IPR uncertainties reduce firms’ incentives to carry out innovative activities. Both intersectoral surveys show that more than 60 % of innovating firms buy new machines and equipment and only 30% of Russian firms are involved in R&D activities. They prefer to buy ready-to-use technology from abroad and import innovation embedded in components than innovate themselves. Moreover, when Russian firms are engaged in R&D activities, they prefer to outsource such activities to third parties rather than carry them out in-house. In 2003, 49% of the Russian expenditures on innovation were allocated to the purchase of equipment and machineries. Only 18.3% of the expenditures on innovation were used to buy new technologies.

The private sector does not play an important role in the diffusion of innovation and new technologies, and no demand for technological innovation exists among the Russian private enterprises. One reason for the low demand is that scientific results from Russian R&D institutes are often not ready to be introduced to the market. These results are only at the stage of a technical concept or a prototype. Often, Russian firms are not willing to take the risks of commercial implementation and pay for the development costs of the innovation (Watkins, 2003, p.14). Therefore, Russian companies prefer to import investment and consumer goods with embedded foreign technologies rather than rely on domestic producers. The main reason for Russian firms to conduct innovation is to improve their financial situation. The main benefits of innovation cited by Russian firms are threefold. By innovating, Russian firms hoped to decrease their production cost, increase their market share or access new markets. Foreign firms do not have many R&D facilities in Russia yet. The innovation activities from these firms are mainly developing their products and technologies to the particular needs of Russia (Kozlov and Yudaeva, 2004).

Looking at the manufacturing sector alone, Roud (2007) has compared innovative knowledge-intensive manufacturing firms of three countries: Russia, Sweden and Germany. He estimates the share of innovative companies among Russian firms to be 14% among manufacturing firms. This share of 14% is almost four times lower than the ones in Germany (49%) or Sweden (50%). Similarly, the share of innovative expenditures in the total sales is more than five times lower in Russia compared with Sweden and Germany.

SMEs play an increasingly important role for the development of the Russian economy. The emergence of an SME sector has been slow due to lack of entrepreneurial spirit and support by the government. Russia still lacks a vibrant SME sector, despite its growth in recent years. The SME sector accounts for approximately 50% of employment nowadays. In western countries, the creation of knowledge intensive SMEs often arise through university spin-offs. In Russia, the potential for the creation of spin-off from universities is low because universities are hampered by legal obstacles and are often not involved in research (Dezhina and Zahev, 2007, p.4).

SMEs are critical actors of the national innovation system, as they are a major source of employment, entrepreneurial skills and especially innovation (European Commission 2006). SMEs have limited financial and human resources and therefore are disadvantaged to access new technologies and innovate (Kotonen, 2007, p.30). They should receive special attention in the federal innovation policy with the aim to connect SMEs to innovation networks. Innovative

SMEs are exposed to a higher level of risks and uncertainty and if they want to compete on the domestic and global markets, they have to improve their market knowledge and management competencies (Ivanova and Roseboom, 2006, p.39).

7 Russia's Competitiveness

According to Garelli (2006, p.608) "*Competitiveness of Nations is a field of Economic theory, which analyses the facts and policies that shape the ability of a nation to create and maintain an environment that sustains more value creation for its enterprises and more prosperity for its people*". The OECD's definition of a nation's competitiveness is "*the degree to which a country can, under free and fair market conditions, produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the long-term"*. The concept of competitiveness of countries is a relative term. What is of interest is not the absolute performance but how well a country performs relative to others. According to Fagerberg and Srholec (2007), four factors explain the diversity in how countries perform. These four factors are (i) technology competitiveness, (ii) capacity competitiveness, (iii) price competitiveness, and (iv) demand competitiveness. Technology competitiveness is the ability to compete in markets for new goods and services. Capacity competitiveness refers to the ability to exploit technological opportunities. Price competitiveness refers to the overall price level of a country, usually measured in unit labour costs. Demand competitiveness refers to favourable demand conditions on world markets for domestic products. The relationship between a country's production structure and the composition of world demand may also be of importance for competitiveness (Fagerberg and Srholec, 2007, p.1599).

For almost 30 years, the World Economic Forum (WEF) has been assessing the competitiveness of different economies around the world. The WEF defines competitiveness *as the set of institutions, policies and factors that determine the level of productivity of a country* (WEF, 2006, pp. 3-12). The WEF uses the Global Competitiveness Index to assess the competitiveness of an economy. This index includes both quantitative and qualitative elements. By using qualitative methods (surveys), it is impossible to achieve exact results since surveys are always subjective (Tiusanen, 2008, p.34). In the index scoreboard a scale of one to seven is used. This index is divided into different pillars to examine the strengths and weaknesses of the competitiveness of an economy. These so-called 12 pillars of competitiveness are: Institutions, Infrastructure, Macroeconomic Stability, Health and Primary Education, Higher Education and Training, Market Efficiency, Labour Market Efficiency, Technological Readiness, Market Size, Business Sophistication, and Innovation. The WEF differentiates three different stages of economic development based on the assumption that countries move along a development path. Countries are classified according to their level of GDP per capita at market exchange rates into different stages of development. In the first stage, called *factor-driven* stage, countries compete according to their factor endowment, primarily unskilled labour and natural resources. As the countries develop, they move into the *efficiency-driven* stage of development. These countries must begin to develop more efficient production processes and increase product quality. Finally, countries reach the *innovation-driven* stage, when they are able to remain competitive only if they compete with new and unique products. At this stage innovation is of utmost importance (World Economic Forum, 2006, pp. 3-12).

Russia ranks 58th among the 131st countries analysed in WEF's global competitiveness report 2007-2008. Russia achieves a score of 4.19 from 7 in the global competitiveness index. The country's position improved compared to the previous year, rising from rank 62 in 2006-2007 (World Economic Forum, 2007). However, Russia performs worse compared with other post-communist countries in Central and Eastern Europe, as well India and China, mainly due to weaknesses in the business environment and institutional framework (Tiusanen, 2008, p.34). Russia's main problems are the worsening of protection of intellectual property rights (122nd rank in this pillar) and doubts about the independence and administration of the judiciary system. Corruption and tax regulation are the most problematic factors for doing business in Russia (Drzeniek, 2007, p.21). A major issue is the perceived lack of governmental efficiency, reforms are needed and the state sector should become more transparent and more efficient to improve the business environment. Similarly, the business ethics of private corporations are regarded as poor, with the 120th rank in this pillar.

The WEF classifies Russia as an efficiency enhancing economy (WEF, 2006, p.12). In this state of development, countries should focus on improving three areas: Higher Education and Training, Market Efficiency, and Technological Readiness. At the same time, it is important not to neglect the basic pillars, Institutions, Infrastructure, Macroeconomics, and Health and Primary Education to remain competitive (Drzeniek, 2007, p.23).
In the area of higher Education and Training, despite the skills shortage, Russia performs fairly well due to high enrolment rates in secondary and tertiary education. In terms of Market Efficiency, Russia (rank 48) has still to catch up with the most competitive economies of the world. The policies are not fully supportive toward an efficient allocation of goods, improvements could be made i.e. by improving anti-trust policies, removing trade barriers, and liberalising regulations concerning foreign ownership (Drzeniek, 2007, p.24).

The Russian business sector has a low ability to absorb technologies developed abroad. FDI are mainly concentrated in the energy sector characterised by low spillovers. Moreover, Russia does not have a high penetration rate for the latest technologies and shows low rankings in the area of technology transfer. All these factors explain a poor score in the Technological Readiness index where Russia is 72nd. This index is particularly important for Russia for the diversification of the economy and future growth (Drzeniek, 2007, p.26). Therefore, it is important to improve Russia's absorptive capacity.

Russia can not compete with other emerging economies like China and India only with its natural resources and unskilled labour. Russia is not price-competitive due to the rising unit labour costs. In the long run, Russia cannot rely only on its natural resources to achieve long-term economic growth. These resources are finite and will not last for ever, therefore diversification is a crucial issue for the future of the Russian economy. Diversification does not mean weakening the natural resources sector, but increasing competitiveness and knowledge intensity of the non-commodity sectors (Ahrend, 2005, p.30). Therefore, Russia should improve the basic requirements: Institutions, Infrastructure, Macroeconomics and Health and Primary Education to improve its competitiveness. Russia should use the windfall revenues of natural resource exports to diversify the economy. Innovation capabilities, a strong high education sector and capacities to adopt new technologies will have key roles in the diversification process and will help Russia to move to the next step of development. Diversification is an important long-term goal for Russia, but its economy is bound to remain resource-based in the short and mid-term. Analysing the pillars important for countries in the innovation-driven stage in detail, it can be concluded that Russia has still major challenges ahead. Russia ranks only 72nd in the technological readiness pillar. This pillar aims to evaluate the existing technological infrastructure and a country's capacity to absorb knowledge. Similarly, a 57th rank in the innovation pillar shows Russia's low performance. This pillar assesses the ability of an economy to produce brand new technologies. Russia ranks 88th in terms of business sophistication. This pillar assesses the quality of a country's overall business networks, as well as the quality of individual firm's operation and strategies. The poor performance in technological readiness, innovation, and business sophistication reveal that Russia is far from reaching the innovation-driven stage in the near future (Drzeniek, 2007, p.27).

7.1 Russia and the knowledge economy

A consensus exists in the economics literature that knowledge is important for long-term economic growth (see Romer 1986; Aghion and Howitt 1992). With globalisation and the emergence of ICT, knowledge has become a key driver of competitiveness. Thus, for the development of an economy it is important to achieve the transition to a knowledge economy (KE). A knowledge economy is "*one that utilizes knowledge as key engine of economic growth.*

It is an economy where knowledge is acquired, created, disseminated and used effectively to enhance economic development" (Chen and Dahlman, 2005, p.4).

The World Bank has developed a framework providing a basic assessment of a country's readiness to be a knowledge economy and gauging the readiness of 137 countries with "Knowledge Assessment Methodology" (KAM). KAM allows a holistic view of the different factors relevant to the knowledge economy. For a successful transition, the following elements are crucial: long-term investments in education, developing innovation capability, modernizing the information infrastructures, and having an economic environment favouring market transactions. These elements are identified by the World Bank as the four KE pillars, which are estimated by 80 structural and qualitative indicators. Since the different variables of KAM consist of different ranges of values, all variables are normalised from 0 (weakest) to 10 (strongest) and ranked on an ordinal scale (World Bank, 2008). The four pillars of the KE framework are described by the World Bank (2008) as:

- An *economic incentive and institutional regime* that provides incentives for the efficient use of existing and new knowledge and fostering entrepreneurship.
- An *effective innovation system* of firms, research centres, universities, consultants, and other organizations that can keep up with the knowledge revolution and tap into the growing stock of global knowledge and assimilate and adapt it to local needs.
- *Educated and skilled workers* who can continuously upgrade and adapt their skills to create and use knowledge efficiently.
- A *modern and adequate information infrastructure* that can facilitate effective communication, dissemination, and processing of information and knowledge.

In order to compare regions and countries more easily with each other the World Bank has developed the KAM Basic Scorecard constructed with fourteen variables (two performance variables and 12 knowledge variables). The reduced number of variables are, in general, available for a wider time series and are updated regularly. Figure 16 presents the basic scorecard for Russia where the dotted line shows Russia's performance for the year 1995, and the continuous line shows Russia's most recent performance. The centre of the chart denotes the minimum normalised value of 0, while the outer perimeter of the chart denotes the maximum normalised value of 10. Thus, the closer the lines on the chart are to the outer perimeter, the better the country or region is positioned in terms of the knowledge economy. In Figure 16, it can be seen that Russia still needs huge improvements before making the transition to the knowledge economy, especially in the areas of rule of law, regulatory quality, and, tariffs and non-tariff barriers. These variables assess the economic incentive and institutional regime (Chen and Dahlman, 2005, p.11).

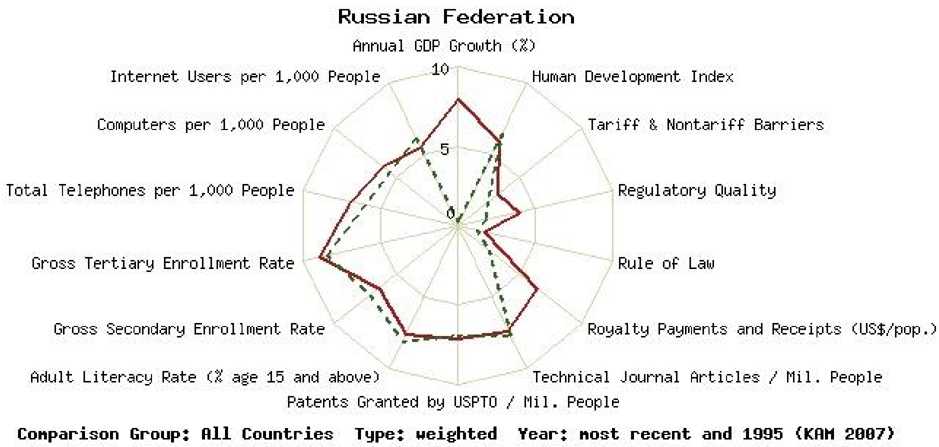


Figure 16. Basic KAM scorecard (Source: World Bank 2008)

Table 17 presents a cross country comparison with the scores in the different KE indexes and pillars normalised from 0 to 10. The Knowledge Economy Index (KEI) is an aggregate index representing the overall level of development of a country in the knowledge economy. This index is constructed as average of the normalised values of the 12 knowledge indicators of the basic scorecard, summarising performance over the four KE pillars. Russia ranks 47th, far behind developed economies, but first among all BRIC[1] countries. Another index known as the KAM Knowledge Index (KI) indicates the overall potential of knowledge development in a given country. It measures a country's ability to generate, adopt, and diffuse knowledge, but does not consider the country's economic environment. It is calculated as the average of the pillars of innovation, education and ICT. Russia scores better on the KI Index, indicating that the current economic regime hampers innovation in Russia, which is also shown by the low score of 2.99 for the pillar economic incentive regime (World Bank, 2008). Four charts showing in details Russia's performance for the four KE pillars are presented in appendices 2 to 5.

[1] BRIC is a term used in economics to refer to the combination of Brazil, Russia, India, and China

Table 17. Knowledge for development index - Cross-country comparison

Rank	Country	KEI	KI	Economic Incentive Regime	Innovation	Education	ICT
1	Sweden	9.26	9.49	8.59	9.72	8.98	9.76
10	United States	8.80	8.91	8.45	9.44	8.35	8.95
15	Germany	8.54	8.60	8.38	8.93	8.08	8.79
47	Russia	5.94	6.92	2.99	6.92	7.66	6.19
75	China	4.42	4.46	4.27	5.09	4.09	4.21

Source: World Bank 2008

7.2 Russia's innovative capacity

Russia's innovative performance is poor despite its large R&D basis, R&D investment, and accumulated stock of human capital. Russian enterprises are much less involved in innovative activities than western enterprises. In 2002, only 10 % of Russian enterprises reported innovation, compared with a share of 50% for companies in the EU. Moreover, Russian exports of science-based products are strikingly low. Russia's share in world trade of science-based exports is estimated to be only 0.3 – 0.5 %. Currently, most of the innovations in Russia are of the incremental type. Most innovations are adoption of existing technologies and non-technical innovations like new marketing methods, new business models etc. Science-based innovations are marginal because of the low demand of scientific input by industry and the lack of clear commercialisation strategy in public research centres. Russia and its innovation system suffers from a lack of innovative end-users (OECD, 2005a, p.29).

The European Commission has assessed the innovation performance of the EU-25 and other major R&D-performing countries in the study "Global Innovation Scoreboard report". The innovation performance is measured by a composite indicator called the Global Summary Innovation Index. This index is composed of 25 indicators divided over five broad innovation dimensions: (i) innovation drivers, (ii) knowledge creation, (iii) knowledge diffusion, (iv) knowledge application, and (v) intellectual property rights. The aim of this scoreboard is to compare the innovation performance of the EU-25 to other main R&D-performing countries in the world. Based on their innovation performance and on a hierarchical cluster analysis, the countries have been divided into different groups: innovation leaders, next-best performers, followers and laggards. Russia ranks 25th from 49 countries and performs worse than the EU-25, as shown in Figure 17. Russia is characterised as a follower, among others with Italy, Spain, Slovenia, and Czech Republic (Global Innovation Scoreboard, 2006).

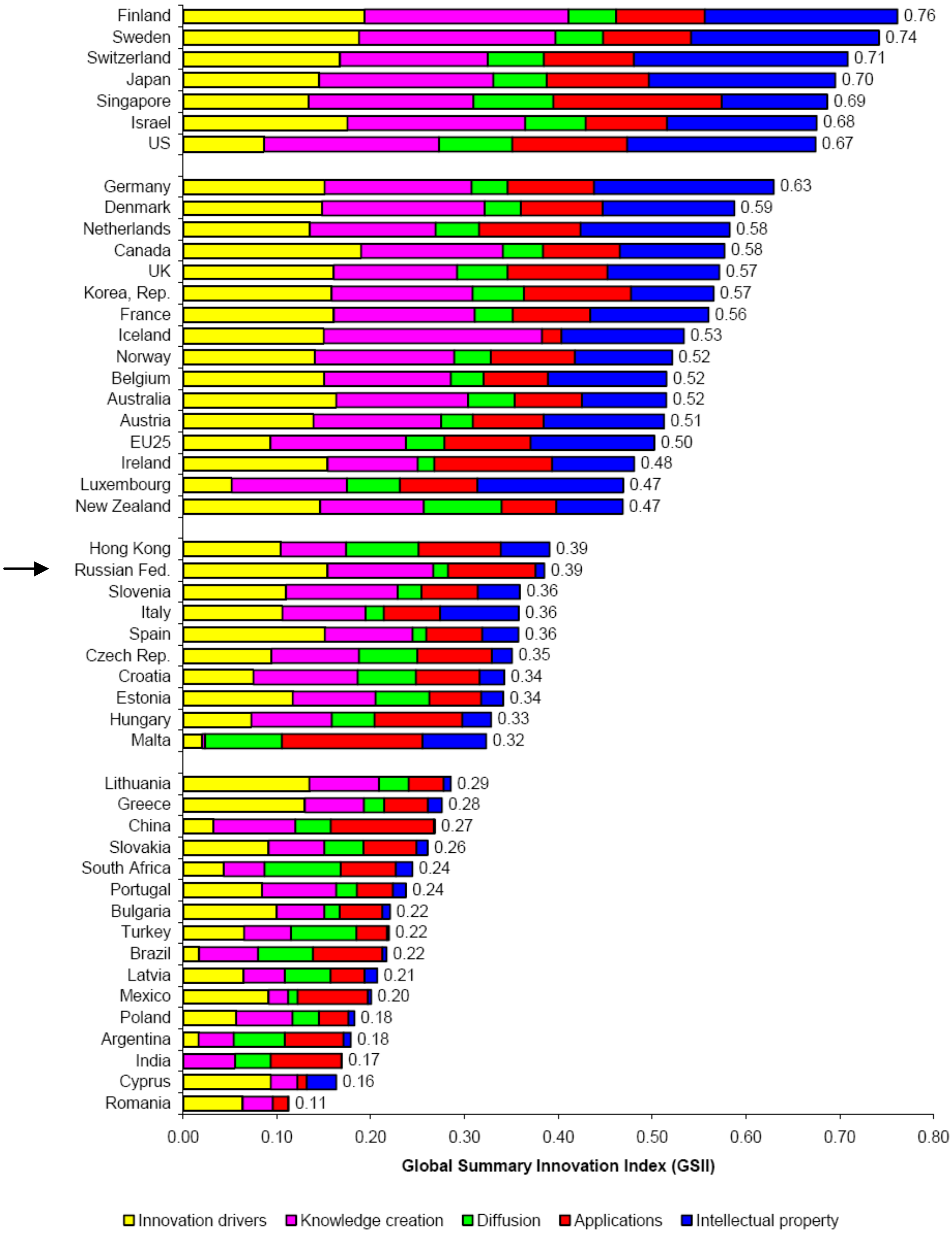


Figure 17. Global innovation performance (Source: Global Innovation Scoreboard 2006)

Interestingly, analysis of the five innovation dimensions in detail shows that Russia performs fairly well in some innovation dimensions but badly in other dimensions. Russia performs well in the innovation drivers dimension, ranking in the top ten. This can be explained by looking at the sub-indexes used as proxies for the dimension innovation drivers. The indicators have a positive impact on Russia's performance, other indicators would have not have given such a positive score for Russia. For the second innovation dimension, "knowledge creation", Russia performs slightly better than the average. Two of the three indicators used to estimate the dimension knowledge creation are indicators of input R&D indicators. These input indicators do not show how effectively resources are used to create knowledge. In the third dimension, "diffusion of innovation", Russia ranks at the bottom of the sample, indicating the main weakness of the current innovation system in Russia. This poor performance is in line with the findings of Gokhberg (2003) who identified the low diffusion of innovation as a major weakness of the Russian innovation system already in the Soviet Union. In the fourth dimension, "knowledge application", Russia performs surprisingly well, as good as Sweden and Finland. A deeper analysis of the sources used for the calculation of this dimension is needed to understand this result, which cannot be made within this work. In the last dimension, "intellectual property rights", Russia does not perform well. The indicator used to assess this dimensions used international patent statistics indicating the number of patents Russian organisations have applied abroad. Two reasons can explain the poor performance. First, most Russian firms have an internal market orientation and are not interested to patent abroad since they focus on the domestic market. Second, international patenting activities are often too expensive for Russian companies (Global Innovation Scoreboard, 2006). Overall, Russia's performance in the Global Innovation Scoreboard is unexpectedly good. Russia performs much better in the Global Innovation Scoreboard then e.g. in the Global Competitiveness Index. Different indicators and different methodologies used to compute the Global Innovation Scoreboard explain the diverging result.

7.3 Russian paradox: high R&D input - low R&D output

The major weakness of Russia's innovation performance is the imbalance between inputs and outputs. The resources (input) allocated to the R&D sectors have soared during the last years due to windfall revenues from the energy sector and the strong economic growth. The output of the Russian innovations system is so far mediocre. Measuring innovation outputs is a challenging task. One of the most commonly used methods to measure innovation is to use patent statistics. Grilliches (1990) calls patent a "good index of inventive activity." International comparable patent indicators can be used to compare the innovative output across a wide array of countries. Like all indicators, patent indicators have many advantages and disadvantages. Advantages of such indicators include: (i) close link to innovation; (ii) cover a wide range of technologies; (iii) rich source of information and (iv) data availability. On the other hand, shortcomings of patent indicators are: (i) the value distribution of patent is distorted as many patents are not commercialised; (ii) many inventions are not patented because they are not patentable or are protected through other ways; (iii) the disposition to patent differs across countries and industries; (iv) different patent regulations makes cross country comparison difficult. Moreover, one problem arising when comparing innovative activities across countries based on a single patent office data is the problem of "home advantage bias". This problem describes that proportional to their innovative activity, domestic applicants tend to fill out more patents in their home country compared to foreign applicants (Dernis and Khan, 2006, p.7).

Dernis and Khan (2006) have assessed innovative activities based on international comparable patent indicators among OECD countries and the largest non-OECD countries using different data sources from the triadic patent families. The triadic patent families are defined as a set of patents taken at the European Patent Office, the Japanese Patent Office and US Patent and Trademark Office. These figures show the patent intensity of a country. The share of Russian triadic patents per million people was only 0.40 in the year 2002. The Russian pattern (0.40) is very low compared with the German pattern (88.2) (Dernis and Khan, 2006, p.23).

Dernis and Khan (2006) have found a high internationalisation of innovation activities in Russia. Over 60 % of Russian inventions filed at the European Patent Office are owned or co-owned by a foreign resident. With data from the US Patent and Trademark Office, they found similar results. By analysing patent data they found out that the overall level of international patent activities is very low in Russia compared with other countries. In order to make reasonable cross-country comparisons, patent statistics have been made relative by taking into account e.g. the size of the country . Patent data are usually expressed relative to population or GDP. Analysing triadic patents over GDP figures, it can be seen that the Russian figure (0.05) is much lower than the German one (3.41). Russia has the lowest patent intensity expressed in triadic patent families over GDP, as shown in Figure 18 below. The low triadic patents over GDP figure reflects the low level of innovation activities in the Russian economy. Dernis and Khan (2006) have found a strong positive correlation between the number of triadic patent families and industry-financed R&D. Countries with high level of industry-financed R&D expenditures such as Germany, United states or Japan also have a big number of triadic patent families. In Russia, innovative activities are still mainly financed by the state and private companies financed only one third of R&D activities, which explain the low share of triadic patents.

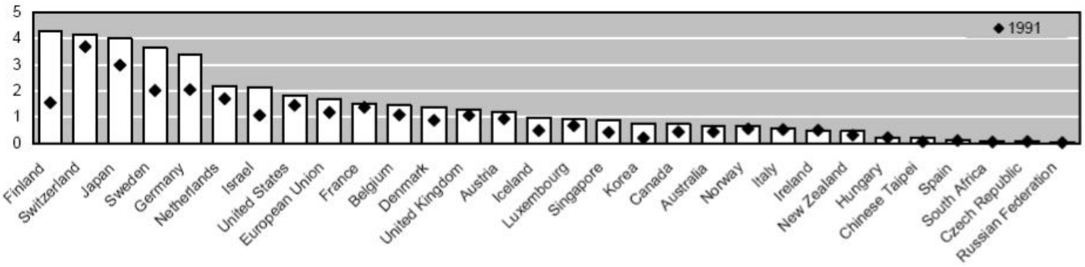


Figure 18. Triadic patent families over GDP, 2002 (Source: Dernis and Khan 2006)

One possible explanation, besides the low business R&D expenditures, is that international patenting activities are uncommon for Russian firms and usually too expensive for Russian companies mainly focusing on the domestic market. Russian companies can rely on a large domestic market to sell their (new) products and do not need to patent a product abroad. An alternative explanation is that Russian inventions are not competitive on world markets. As a conclusion, if firms are involved in international patenting activities in Russia, it could be assumed that they are often western companies established in Russia or western companies cooperating with local firms. The results of the analysis made above should be considered with caution because using only international patent statistics without taking national data can give a distorted picture of the Russian innovative activities.

Figure 19 shows the development of patent applications and patents granted at Rospatent for the period 2000 - 2006. The numbers of patent applications and granted patents have increased in recent years. These positive trends are signs of recovery in the knowledge generation of the national innovation system after the deep economic crisis in the early nineties. However, when the domestic patent applications statistics are compared with Germany, Russia’s output is poor. In 2006, 60 585 patent applications were made at the German Patent Office, compared with the number of 39 776 in Russia. It shows that Russia has still a long way to go to catch up with the most developed countries in terms of innovation generation. Moreover, the number of granted patents does not answer the question on how the patents are used. Gokhberg (2003) estimated that only 5 % of usable models produced during 1992 – 2002 have reached the stage of commercial application. Overall, the output of the Russian innovation system is disappointing and far behind its potential (DPMA, 2006).

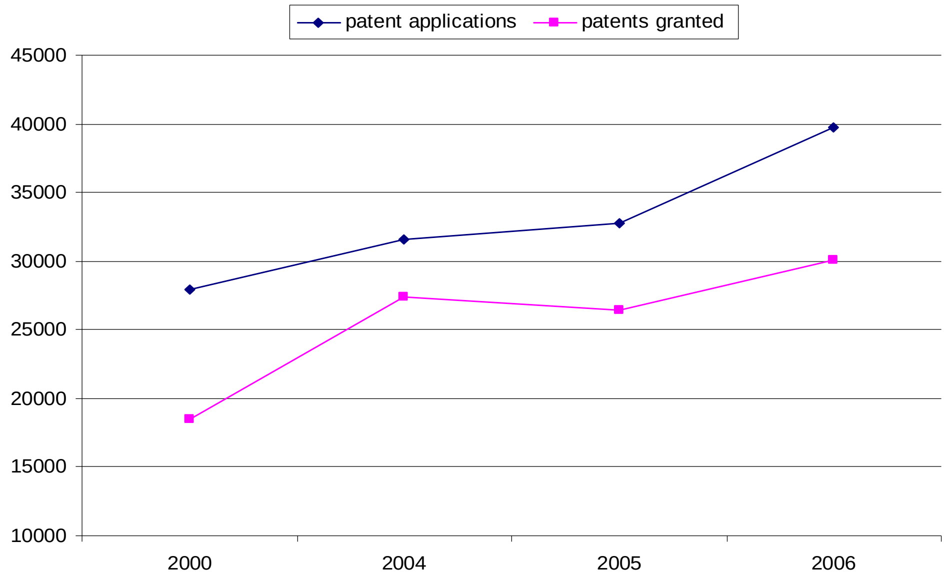


Figure 19. Russian patent statistics (Source : Regiony Rossii 2007)

Some features of the Soviet times explain the low output. In the Soviet Union, R&D was oriented to military applications, where a regime of secrecy was cultivated and less attention was paid to journal publications compared with western countries. Egorov (1999) identifies three additional reasons for the lower initial condition in the output indicators. First, a general overestimation of the real R&D potential, in general Soviet invention certificates contained 13 times less valuable information than an average US patent. Second, reverse engineering which formed a part of R&D was common practice in the FSU. This kind of R&D can not be reflected correctly in most output indicators. In condition of autarky, reverse engineering was used to keep up with the western countries in the civilian production. Third, a high share of researchers concentrated in the traditional sectors with relatively lower innovation potential, like oil extraction and mining (Egorov et al., 1999).

Patenting habits differ in western countries and Russia. The objective to patent in Russia is to mark priority, which is a different objective than patenting as first step of the commercialisation process, like in western countries. The result of research is often patented in the early stages of development of a new technology and it is difficult to estimate their commercial value. Since patent activities are expensive over years, only 35 % of registered patents in Russia are active. Hence, intellectual property cannot often be applied into productive use i.e. only 1 % of innovations are introduced to the market and have a commercial use (Panfilo et al., 2007, p.17).

7.4 Challenges for innovation in Russia

Intellectual Property Rights Legislation:

The legal framework for technology commercialisation was relatively simple in the former USSR. All economic activities were generated with state property, and the results of intellectual activity were legally protected via certificates of authorship for a given invention, thus giving the state exclusive ownership. IPR have been introduced in the Russian economy during the transition to a market economy. At the end of 1992, a set of laws regarding intellectual property rights was enacted. These laws are the groundwork in the area of protection and of scientific results and technological activity. Nowadays, Russia possesses a legal framework comparable with western countries, and the current IPR laws are in accordance with the provisions of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) (Mechcheryakov, 1998 p. 60). However, uncertainties regarding the ownership of IPR create problems for the innovation system in Russia. The IPR law introduced in the nineties stipulates that an invention developed with state funding remains de jure state property. Today, uncertainty about the ownership, use, and disposal of intellectual property rights created with federal budget resources still exists. Moreover, no consensus exists about who rightfully owns IPR developed during Soviet times. The uncertainty regarding IPR ownership is one of the main impediments for the transfer of S&T results from Russian research organisations and third parties. The current unclear regulations complicate the partnership of research institutes with the private sector, hinder technology transfer and impede the development of spin-offs into growing businesses. Moreover, the uncertainties regarding IPR create conflicts of interests for the research institutes, and even between researchers and their organisations (Zolotykh, 2006, p.16ff).

Another major problem of the current IPR regulation is the weak enforcement. Even if an adequate legal framework for IPR is created, the exercise of IPR will not be effective if enforcement of such legislation is weak. Currently, the public authorities are unable or unwilling to prosecute IPR violation which is a particular concern for foreign investors and exporters facing copyright piracy or patent violation by domestic firms (Desai, 2007 p.110).

In 2005, a draft law on IP was issued, indicating that the government should only remain the owner of IP from public research relating to defence and national security, and that in all other cases ownership rights should be transferred to the organisation performing the research. However, this law still waits to be officially enacted, and several aspects of the draft law should be clarified (Zolotykh, 2006, p.32). As a conclusion, the current inadequacy of the IPR framework affect has a negative effect on the transfer of knowledge from public research institutes to the business sector thus hindering the creation of technology-based spin-offs (Simaranov et al. 2006 p.63).

Innovation Policy:

According a survey of the Foundation for Assistance to Small Innovative enterprises (2003), the main constraint to the innovative activity of R&D performing SMEs was the underdeveloped infrastructure in the area of technology commercialisation. Special innovation policies are needed to address the specific needs of SMEs (OECD, 2005a, p.60). These policies should address SMEs that are users of technology and SMEs seeking to assess new markets for their knowledge and technologies. The creation of innovative networks with larger firms should be considered. Large firms should be encouraged to increase their demand from public R&D institutes rather than import technology from abroad. Moreover, a policy initiative is needed to promote and support the transfer of Russian technology abroad. Today, Russia lacks of consistent national innovation policy that includes all actors of the innovation system. Russia has not launched an initiative like the Lisbon Agenda, which acknowledges the importance of the private sector, especially entrepreneurship, to shift to more competitive economy (Simaranov et al. 2006, p.64)

The recent innovation policy initiatives are, first and foremost, oriented toward the public R&D sector, ignoring the business sector as an important part of the innovation system. The strategy "Basic Principles of the Russian Federation Policy in the field of Development of the Innovation system for the Period up to 2010" does not consider important issues such as appropriate legislation to protect own R&D, financial incentives to invest in innovation and nurturing of start-up companies (Gianella and Tompson, 2007,p.8). The government has set the goal that in 2008, 58 % of non-military R&D resources will be allocated to basic research (IET, 2006). Currently, the Russian R&D system has an unbalanced structure as fundamental research is well developed, while applied research, technology design and commercialisation are underdeveloped. A sound innovation policy is needed to facilitate contact between knowledge producers and businesses and reallocate resources to create wealth-creating activities from new knowledge. Given the potential for "imitation-based" innovation, it will be important to facilitate technology transfer from abroad (Varshavskiy et al., 2006, p.2).

Improving the business environment:

A healthy business environment is a precondition for boosting innovation activities, therefore it is crucial to improve the framework conditions. Sound macroeconomic conditions like robust GDP growth, low inflation and low real interest rates have a positive influence on the growth rate of R&D. Similarly, micro level factors like secure property rights, and low barriers to market entry influence innovation. The Russian business environment suffers still from significant administrative costs, policy-induced risks and formal and informal barriers to competition (Desai, 2007, p.90). To foster innovation, a clear commitment to stable regulations for private businesses including a competition policy is needed. Latest surveys report a worsening of corruption, informal practices and the quality of the legal system. Transparency International, a global civil society organisation fighting against corruption, publishes annually the Corruption Perception Index ranking different countries by their perceived level of corruption (Transparency International, 2007). In this ranking, a score under five is considered as threshold for serious corruption problems. Russia's score of 2.3 indicates that corruption is a huge impediment for doing business. In the past two years, reforms aiming to improve the business climate have slowed down. As a conclusion, it is difficult to exaggerate the importance of framework conditions to foster innovation (Gianella and Tompson, 2007, p.8).

8 Conclusions

Russia's economy has been growing rapidly after the financial crisis of 1998. Russia has enjoyed a period of good economic performance mainly due to a strong natural resources sector. Some two-thirds of export income and half of central government budget income derive from oil and natural gas, which makes Russia a resource dependent-economy. Lately, the growth was supported by a boom in domestic consumption, allowed with the rise in living standards. Commodities such as oil gas and metal are considered to be goods of low added-value and highly dependent on the volatile world mark prices. Therefore, the sustainability of the economic growth is in serious doubt.

Foreign currency inflows from commodities exports and other sources, such as investments, have caused an increase in the country's currency volume. This increase has consequently caused excess inflation in comparison to EU-countries. In order to counter these inflationary pressures, the nominal value of the domestic currency should decrease to achieve an unchanged real exchange rate. In Russia, the nominal value of the RUB has not decreased sufficiently to avoid an appreciation of real exchange rate. This had mainly two effects on Russia's economy: a decrease of competitiveness of industries outside the natural resources sector (e.g. manufacturing sector) and a surge imports of foreign goods becoming relatively cheaper compared with domestic goods. China, Russia's direct competitor in the market of low value-added goods, has an advantage in labour cost with only slightly worse productivity figures as shown in Table 4.

Due to the globalisation of the world economy and the facts presented above, economic diversification and the shift to a knowledge-based economy will be a key challenge for Russia's economic future. The next challenge for Russian firms will be to start producing goods of higher added-value to remain competitive on world markets. Innovation will become an important topic for the Russian economy in coming years.

The objective of this research was to produce a holistic description of the Russian innovation system. This study aims increasing the knowledge and understanding of the functioning of the Russian innovation system and describing the linkages between its main actors.

The innovation capacity of the Russian federation can be described using the framework introduced in Figure 5. The following section estimates the current innovation capacity in Russia along the 5 dimensions of the innovation capacity.

Knowledge creation

Russia has a great history in scientific discoveries and a huge stock of accumulated knowledge. Russia has today a well educated workforce, but the current age structure of Russian researchers is worrying for the innovative potential in the long term. Most of the researchers are close to retirement. However, attainment at university education is high and the important number of enrolled students will ensure a well qualified labour force for the future. Currently, the educational sector in suffering from underinvestment and the quality of education at certain universities is a source of concern. Human capital or education have an important role in the relationship between innovation and growth. The high levels of education available in Russia are an advantage, but that does not translate automatically to innovation success, and even less to commercial innovation if adequate incentives structures and institutions are not in place.

Russia has a large stock of world class scientific knowledge, but it needs now to adapt the infrastructures to transform this knowledge and capabilities into marketable assets. Much of Russian science expertise is still waiting to be exploited. Untapped potential still exists in the national innovation system, and the existing infrastructure should be adapted to make use of this great potential.

Governance capacity

The Federal state has identified innovation as an important issue for economic development but often fails to implement innovation policies drafted. Moreover, no holistic innovation policy exists at national level, embracing all actors of the innovation system. Recent policy initiatives have not succeeded to incorporate the private sector in a national innovation strategy. The Federal state is still the most important source of funding for R&D activities and firm are not given enough support to invest in innovation.

The Federal state has identified innovation as an important issue for economic development but often fails to implement innovation policies drafted and the state fall short of its coordination function within the innovation system. Hardly any linkages exist between the private sector (companies) and the public research sector (R&D institutes).

Also in other areas the state could improve the environment of the innovation system needs improvement. The overall business environment is not fully supportive towards innovation, no incentives are given to companies to perform R&D activities. Market incentives and pressures are not in place to foster innovation in companies (e.g. competition is still weak in certain sectors of the economy). Also, the current legal framework for IPR is inadequate for commercialising intellectual property from public research institutes.

Demand

Today, Russia lacks strong clusters of innovative firms that can benefit from the knowledge stock available in the innovation system. In Western Europe such clusters have been very important to put innovation forward in the economy. Russian firms show little interest in innovating in- house and have little demand for innovative products/services developed in Russia. They prefer to "import" innovation buying components or products developed abroad with Western technologies. Egorov et al. has (1999) pointed out that a major challenge in the Soviet countries for their R&D system would be to ensure sufficient demand for innovation during the transition period. They emphasise that privatisation itself would not guarantee stimulating innovative activities. He suggests that the creation of a dynamic innovative SME sector would become increasingly important for the national R&D system. Years later, after the transition to a market economy is almost achieved, the current situation in the national innovation system confirms the hypothesis of Egorov et al (1999). Today, one of the main bottlenecks for the development of the innovation system is the lack of demand from innovative end users for Russian innovative products.

Diffusion

The innovation diffusion is and was already during Soviet times one main weakness of the national innovation system. This legacy still affects the current innovation system today. The majority of the research institutes are still working in isolation. Most universities are outsiders of the innovation system, focusing on their teaching mission. Hardly any linkages exist between all the actors of the innovation system and the current infrastructures of the innovation system are not efficient to use and commercialise the Russian expertise in science.

Absorptive Capacity

This dimension of the innovation capacity is the hardest to assess and to describe since no quantitative nor qualitative data could be found in the literature. In line with the theory, it can be assumed that the level of absorptive capacity of Russian firm was low after the break up of the Soviet Union. Companies had not the tradition of performing any innovative activities. During the first difficult years of the transition many Russian companies fought to survive under the new market condition. They had no resources to invest in R&D activities. Lately, with the booming economy, companies have had more cash to invest. Russian firm, if they are investing in innovation, prefer to outsource their R&D activities. All these factors explain why in-house R&D is a recent phenomenon among Russian firms. It can be assumed that the absorptive capacity of Russian firms is growing slightly but is still at a very low level compared with more developed economies. Further research is needed to test this hypothesis.

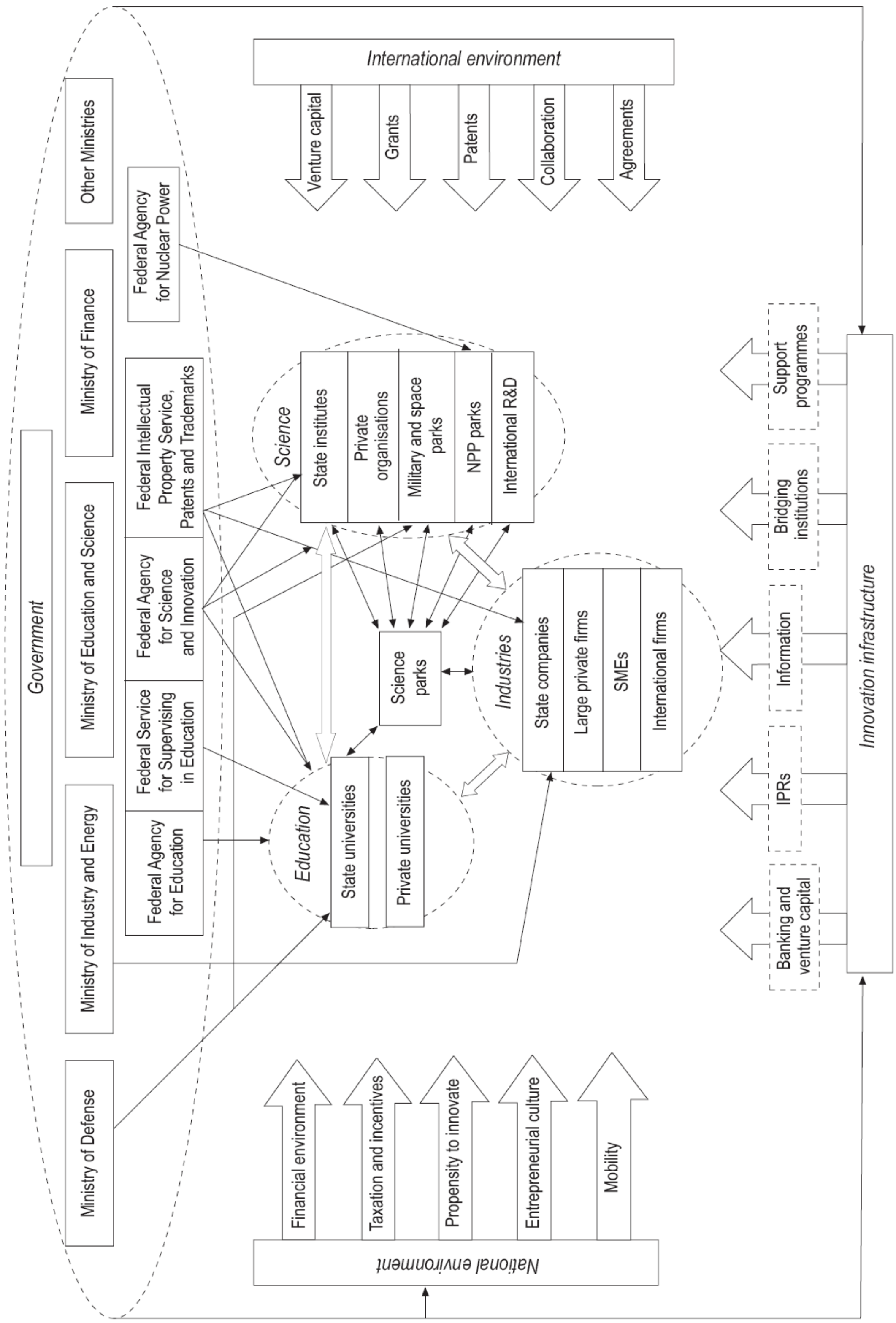
8.1 Further research

Russia has not yet reached the stage of a mature market economy and innovators do not enjoy a fully innovation friendly environment. Russia's strengths lay in its historical stock of knowledge and in the human capital and financial resources available for R&D. The weaknesses of the Russian innovation system are the microeconomic environment for innovation, the indirect factors influencing the innovation system, and the lack of linkages between the main actors of the innovation system.

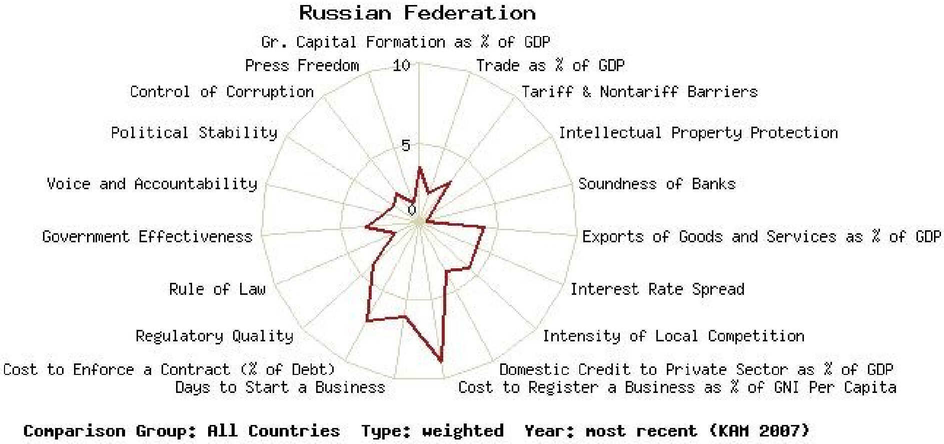
The overall business environment is a main determinant to stimulate innovation. Currently, little incentives are given to private companies to invest in innovative companies. The next challenge for the innovation system in Russia is to increase the involvement of the private sector and create better linkages between public research institutes and private companies. The public research institutes possess great scientific skills but have no commercial applications to utilise these skills.

The development of the Russian national innovation system is and will remain an intriguing topic for research in the near future. The Russian R&D has undergone dramatic changes in the last 50 years. During the Soviet period, the R&D system tried to compete for the worldwide technological leadership with the USA. The collapse of the Soviet Union was followed by a long period of economic recession. In the nineties, the Russian R&D system was falling apart and fighting to survive, struggling to achieve its basic functions. In recent years the economy has recovered and the decay of the S&T sector has stopped and a recovery process has started. Egorov et al. (1999) argue that the level of national development and the structure of R&D system are related to each other. In developing countries, R&D Systems have primarily educational and cultural functions. In developed countries, R&D systems have additionally the function of developing new technologies and innovation actively. Further research is needed to analyse whether the process of recovery will continue in the next years and start to produce more innovations and new technologies, which would confirm the hypothesis of Egorov et al. (1999). Moreover, an interesting research topic is to analyse whether Russia will be able to develop the infrastructure necessary to commercialise the huge stock of knowledge and technologies available and turn to a knowledge economy. An interesting research subject would be to assess the current status of the absorptive capacity of Russian firms and to analyse its development since the transition to a market economy. It would be interesting to analyse if any correlation exist between increase in absorptive capacity and innovative activities of companies or if Russian firms were able to increase their absorptive capacity by other means (e.g. FDI spillovers).

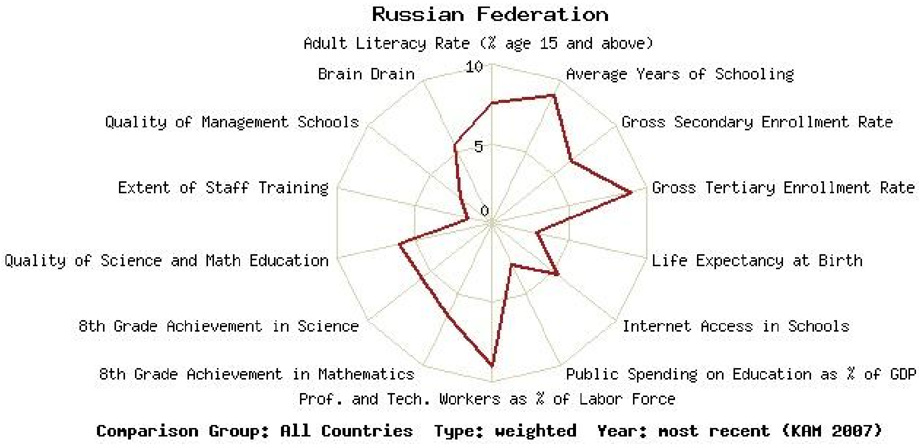
Appendix 1. The Russian Innovation System (Source: OECD, 2005)



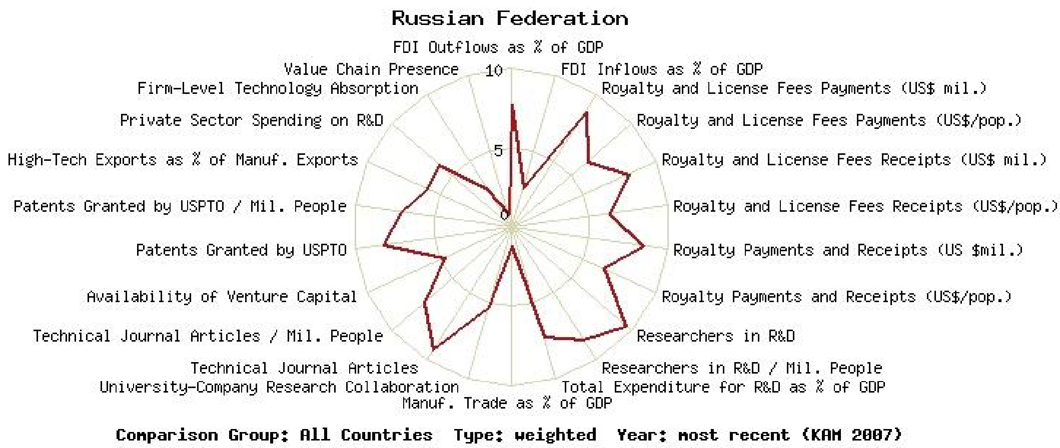
Appendix 2 Economic Incentive and Institutional Regime



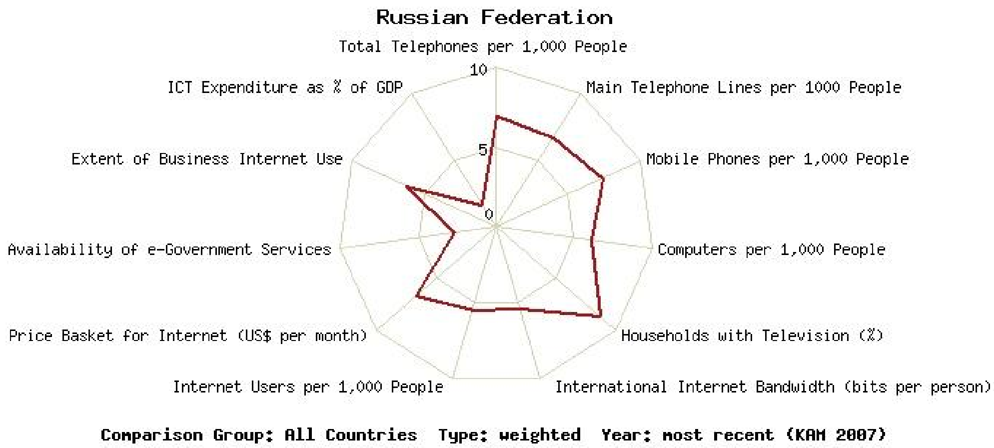
Appendix 3 Education and Human Resources



Appendix 4 Innovation System



Appendix 5 Information Infrastructure



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