The European Journal of Comparative Economics
Vol. 3, n. 1, pp. 103-129
ISSN 1824-2979

Human Capital in Russia

Bernardina Algieri[1]
Università della Calabria

Abstract

This paper considers the dynamics of human capital in Russia, examining its changes over the transition period. A theoretical model has been developed to explain why a significant endowment of human capital creates the possibility but not the certainty of sustainable economic growth. An overview of the main high tech districts concludes the analysis.

JEL Classification: J24, 015, 030

Keywords: human capital, R&D, information technology, Russia

1. Introduction

The present paper investigates the dynamics of human capital in Russia. The Russian Federation and in general, Eastern European transition countries own a significant stock of human capital enhanced by high levels of education. The economic literature postulates that a relevant stock of human capital improves the competitive structure of an economy, stimulates its high-tech sector, and fosters economic growth. The evidence so far is, however, not supported by the experience of many transition countries, which still lag behind in terms of sustainable economic development.

The aim of the paper is threefold. First, the human capital legacy of Russia is examined. Second, a theoretical model is developed to explain the evolution of human capital over time. Finally, an empirical investigation of the major high-tech districts is carried out. The work is organised as follows. Section 2 gives a brief overview of the economic literature on human capital. Section 3 outlines the main features of the human capital sector in Russia. Section 4 provides a theoretical model of human capital. Sections 5 describes the main high-tech districts in the new Russia. Section 6 discusses the possible policy measures to revive the human capital sector as a potential engine of economic growth. Section 7 concludes.

2. Literature Review

The concept of human capital was originally formulated by Adam Smith (1776 ed. 1976). In his masterpiece, the author stated that:

> "The difference between the most dissimilar characters, between a philosopher and a common street porter, for example, seems to arise not so much from nature, as from habit, custom, and education. When they came into the world, and for the first six or eight years of their existence, they were perhaps, very much alike, and neither their parents nor playfellows could perceive any remarkable difference. About that age, or soon after, they come to be employed in very different occupations. The difference of talents comes then to be taken notice of, and widens by degrees, till at last the vanity of the philosopher is willing to acknowledge scarce any resemblance" ("The Wealth of Nations" pag19-20, Book I).

[1] I wish to thank Prof. Antonio Aquino and Oliver Carsten Füg for helpful comments and valuable suggestions. I would like to express my gratitude to an anonymous referee for comments on an earlier version of the paper.

Afterwards, the theory on human capital was formalised by Schultz (1961), Becker (1964) and Mincer (1974, 1988). The basic idea of the human capital theory is that the variety of talents is mainly acquired through different activities, such as education or working experience. These activities have a cost, but produce benefits in future. In simple words, human capital acquisition is an asset (Mincer, 1993).

Becker (1964) discusses the formation of human capital through the working experience at specific firms or working places. Workers become more productive and qualified over time thanks to "learning by doing" processes, and as a consequence, their wages will tend to increase. On the supply side, workers are aware that their competences and skills are firm-specific and therefore, the same wage level will be not guaranteed if they move to a different firm. On the demand side, employers tend to hold the most productive workers in their firms by keeping wages and working conditions high. Remuneration and other non-monetary aspects of jobs become, in the author's view, a powerful tool used by firms to reduce turnover costs. Both workers and firms have thereby incentives to maintain long run relationships, when investments in education and job formation take place.

Like Becker, Romer (1986) speaks about "learning by doing" processes, but unlike Becker, Romer introduces the term "knowledge" as engine of economic growth. This is a side-product of the production activity, and augments with work. Moreover, knowledge is a public good, non-rival and non-excludable. Therefore once it has been acquired it spills over across the whole economy generating a sustainable economic development.

The most representative model of human capital in the growth literature was elaborated by Lucas (1988). In his two-sectors model, the author points out that human capital and knowledge are synonyms and are a voluntary outcome of the learning process. Based on his theoretical setting, some authors of the new growth literature (Mankiw et al. 1992; Barro and Sala-i-Martin 1997; Acemoglu and Angris 1999; Krueger and Lindhal 2001) have empirically proved that the stock of human capital plays an extremely important role in promoting economic growth and prosperity (Mankiw et al., 1992).

Since their vast pools of human capital and high educational achievements2 inherited from the Soviet era, Eastern European and CIS countries were expected "to exploit their comparative advantage in skill-intensive manufacturing and in high-tech goods and to create significant intra-industry trade both among the Eastern European countries themselves and between East and West" (CEPR's Report, 1990).

Hamilton and Winters (1992) emphasised the high probability of convergence between the present EU members, Eastern Europe and Russia in terms of per capita income levels: "these countries might grow at some 2% faster than the EU."

3. The Soviet Union Legacy

Two singular features characterised the former Soviet Union. Firstly, its industrial sector was unable to produce commodities of good quality and to offer strong incentives for workers and management. Natural resources were misallocated: the significant comparative advantage in the natural sector, in fact, fizzled out going from resource extraction to refined and processed goods (Russian Academy of Sciences, 2000; Intriligator et al. 2001).

[2] See Rutkowski 1996, 1998; Gros and Suhrcke 2000; Micklewright 1999; UNICEF 2000, 2001, 2003

Secondly, the former Soviet Union was a leader in different technology fields such as metallurgy, precision instruments, space technologies, computer software, aircraft building and development of new materials. In line with the international standards, the former Soviet Union gained a significant level of development in transport and infrastructure sectors, mass education and in the basic applied research. This progress relied on the valuable science establishment and broad networks between research institutes and experimental laboratories coordinated at national level (Intriligator et al. 2001).

The high quality of human capital was mainly achieved by ensuring that the labour force had a high level of general education. Moreover, the planned system offered a peculiar scheme of non-market incentives (mainly in the form of a high standard of living) to the Russian intellectual elite. Scientists and researchers, therefore, could benefit from a high social status, several fringe benefits and higher wages than those paid to the rest of the economy. In the early 1990's, Russia had 200 university and college students per 10,000 of population, a value which is similar to most developed countries. About 20% of workers had a university degree, whilst less than 3% had not graduated from high school. In 1985 Russia alone employed more than 1.2 million research workers and more than 3 million people, if specialists are considered (Pomer, 2001, Micklewright 1999).

The new Russia inherited from the former Soviet Union two areas of comparative advantage, one in the resource extraction sector and the other in the human capital sector. While the first area of advantage has already made great strides in the world market, the second one does not keep pace with international standards. Indeed Russia is a net importer in the sectors which make intensive use of human capital (Tab.1, appendix B). More precisely, the specialisation index calculated for 2002 (Tab.2, appendix B) shows that the only human capital intensive products in which Russia is specialised are optical instruments, non-electric engines and steam generating boilers.

3.1 Evolution of the Two Russian Comparative Advantages

The second half of 1989, with the fall of the Berlin wall and the collapse of many communist governments, brought about dramatic developments and accelerated the dismantlement of the communist system in the former Soviet Union3 and in Central and Eastern Europe. The Russian economic transition from a planned to a market economy started with a drastic reform program -a 'Big Bang'- launched by president Boris Yeltsin after October 1991.

This reform program, the so-called "shock therapy", envisaged a quick liberalisation, a massive privatisation and a fast stabilisation programme for the Russian economy. The shock therapy was aimed at making irreversible the economic and political transformation of the Russian Federation. In few months, central controls were outlawed, price and trade barriers were lifted and a colossal privatisation agenda started. The immediate effect of this was an increase in the price level and an upsurge in the

[3] The Soviet Union was a compound of fifteen Union Republics, twelve of them –Russia, Belarus, Ukraine, Moldova, Georgia, Armenia, Azerbaijan, Kazakhstan, Uzbekistan, Tajikistan, Turkmenistan and Kyrgyzstan– have signed an alliance in 1991 and have set up the Commonwealth of Independent State (CIS). The other three Baltic Republics -Estonia, Latvia and Lithuania - instead, have gained independence from each other and declined to join the CIS.

inflation rate. In the first three years of the radical reforms, real GDP dropped by 33 percent, industrial production by 44 percent and investments by 60 percent (Goskomstat, 2005; Pomer, 2001). Over the next four years, albeit at a slower rate, the economic decline continued and the rouble appreciated. Government expenditures, including spending on human capital (science, education, culture, and health care), fell to 37.8 percent of GDP in 1996 and to approximately 35 percent in 1997 (The World Bank, 2001). Relative to 1990, employment in 1998 was off by 11 million workers, poverty became endemic, and social services were halved. The Russian privatisation process brought a small group of people, the so-called "oligarchs", to grab a sizeable part of the public wealth, and as a consequence, inequality increased and mafia influence became prominent in several aspects of Russian life (Glinkina et al. 2001).

The predictions of the proponents of the shock therapy about an economic recovery of Russia within two years of the Big Bang turned out wrong. It took eight years for the country to register the first signs of revival, with the first year of an increase in GDP and an upturn in exports materialising only in 1999.

In the new Russia, natural resources are the most intensively exploited assets and occupy a central place in the economy. In 2005, Russia's real gross domestic product (GDP) grew by 6.4%, marking the country's seventh consecutive year of economic expansion (BOFIT, 2006). Russia's recent economic growth has been fuelled primarily by energy exports, particularly given the boom in Russian oil production4 and relatively high world oil prices during the last seven years. But this type of growth has made the Russian economy dangerously dependent on oil and natural gas exports, and especially vulnerable to the risk of "the Dutch disease" (Algieri, 2004). Although estimates vary widely, the World Bank has suggested that the oil and gas sector may have accounted for up to 25% of GDP in 2003 – while employing less than 1% of the population.

By contrast, the situation in the human capital-intensive sector, Russia's second area of comparative advantage, is gloomy. The country's high-tech sector was particularly affected by the economic turmoil of the 1990s, with research institutes and scientific centres undergoing a severe crisis due to doleful underfunding, and their staffs often obliged to survive thanks to foreign grants and moonlighting. Other scientists simply changed professions or emigrated. Investments into new technology were also very sluggish, since neither the developing private sector nor the financially strapped government was able to provide the funding necessary to finance the high tech sector. (The Moscow Times, January 13, 2005). Moreover, during the first years of the transition, the public expenditure on education declined by 55% in real terms, while the growth in private expenditure did not offset the drop in public funding (Intrilligator, 2001). A study conducted by UNICEF provides evidence of the significant slumps in education expenditure in Russia (-33%) and other transition countries between 1989 and 2001 (Tab. 3).

Public expenditure on basic science dropped even more intensely. The Russian gross domestic expenditure on R&D, expressed as percent of GDP, shrank from 2% in 1990 to between 0.7 and 0.8% in the mid-1990's, remaining under 1% until the end of 1998, before rising to 1.24% in 2002 (OECD, 2004). Such values are far below those recorded in EU countries, USA and Japan (Tab.4, appendix B). To elicit the relation between R&D activities as percent of GDP and per-capita GDP in 2002, an estimation

[4] In 2004, Russia was the world's second largest producer of crude oil, second only to Saudi Arabia (EIA, Top World Oil Producers, 2006) and in 2005 Russia's production of oil with gas condensate reached 470,2 million tons, up from 11,2 million in 2004 (Transneft, 2006).

using the OLS technique has been employed. The sample includes 29 countries. Data have been collected from OECD and IMF databases.

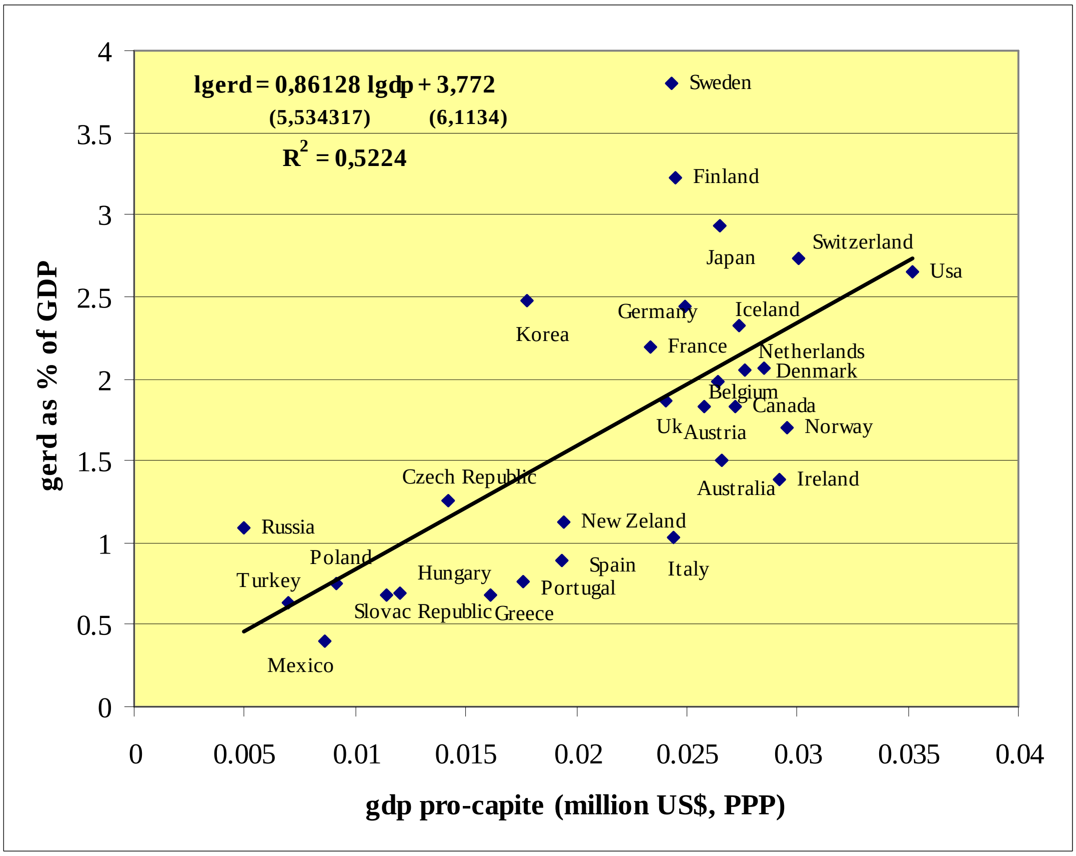
Table 3. Changes in public expenditure on education in real terms, 1989-2001.

	Fall in real education expenditure (per cent)
Hungary	-22
Slovakia	-31
Russia	-33
Latvia	-45
Lithuania	-47
Kyrgyzstan	-71
Bulgaria	-75
Azerbaijan	-77
Georgia	-94

Source: UNICEF 2003

The estimation shows that there is a significant, positive relationship between the two variables (Fig.1). An increase in the GDP of 10% brings about a rise in the gross domestic expenditure on R&D of about 8.6%. Furthermore, the graph shows how considerable the gap is between Western and Eastern countries.

Fig. 1 R&D activities as % of GDP and per-capita GDP in 2002



3.2. Characteristics of the R&D sector in Russia

The gross domestic expenditure on R&D in Russia is mainly financed by the government (about 55%). Other sources of finance are the Russian industry (about 33%), foreign aids (12%) and other national financial supports (0.4%) (Tab.5 a, appendix B). These data differ from those of the other considered countries, where industry mainly finances the R&D sector. A country similar to Russia in terms of consistent public contributions to the R&D sector is Italy (Tab.5 a, appendix B).

The Russian activities in R&D are performed mostly by the business sector and by the government. The first aspect is common to the other considered countries, while the latter applies only to Italy. The private non-profit research sector is almost absent in Russia and completely absent in Italy and Germany (Tab.5 b, appendix B). To have a clear picture of the distribution of R&D among manufacturing sectors, the quotas of the Russian total business enterprise expenditures on research and development have been calculated. Most of the Russian R&D efforts are devoted to machinery and aerospace branches, with quotas respectively bigger than 30% and 20% on the total expenditures. A significant amount of research is then addressed to motor vehicles and TV, radio and communication equipment. Concerning the "new technology" sector, the electrical machinery registers increasing quotas, while the electronic computing and office and computer machinery show until 1997 declining trends (Tab. 6, appendix B).

The R&D sector in the new Russia is characterised by declining wages. In October 1997 the share of workforce being paid below the official poverty line was 49% for the education sector, 31.6% for the research sector and 17.5% for the entire industrial sector (Ushkalov and Malaha, 1999). According to Nezavisimaya Gazeta (2002), a high level of pessimism spread among the Russian intellectual elite due to the consistent cuts in salaries and in the federal budget allocated to research centres. This in turn caused a drop in the number of researchers per 1000 workers in the labour force between 1994 and 2002 (OECD, 2004) (Fig. 2, appendix B) and an intense "brain drain" phenomenon. The outflows of human capital from Russia total more than 1 million people over the past 14 years (EIU, 2004). A large number of emigrants are well-educated people who formed the core of Russia's intellectual capital. The intellectual elite migrated to the United States, Canada, Germany, Israel and other countries. In the last ten years, about 13,000 Russian scientists have settled in Israel (Stone, 1999). The chairman of the unions represented at the Russian Academy of Sciences, Viktor Kalinushkin, said that Russian scientists and programmers in the USA were responsible for developing 30% of Microsoft products (BBC News, 20 June, 2002). In addition, the number of temporary emigrants, i.e. researchers and intellectuals who leave their country for short-term or medium term contracts, exceeds the number of officially recorded cases of migration (EIU, 2004).

4. Low Human Capital Profile and Low Technology Trap Model

An extended version of the Redding model (1996) has been used to explain why human capital creates the possibility, but not the certainty of economic growth. The model, which accounts for all the aforementioned characteristics of Russian human capital, is well suited to explain the dynamics of the human capital sector.

A detailed description of the model is provided in Appendix A. The amended model incorporates the "brain drain" factor, a variable that has not been used by endogenous growth theorists, but that turns out to be a key determinant in explaining the pattern of economic growth in the case of Russia.

The model proves that, given a certain human capital profile, an economy can reach three types of growth equilibrium: a high growth, a low growth and a mixed growth equilibrium. The large endowment of human capital in Russia has not led to high growth. Indeed, in the Russian transition, incentives and conditions to boost any form of human capital based industry were missing. The human capital itself, hence, had little choice but mass emigration.

Specifically, Russia did not have an environment prone to encourage innovation and risk-taking policies. The government's attention was not directed towards the value of research, the provision of crucial services, the supply of efficient communications or the development of transport and other business infrastructures. It is well known that companies investing domestically or internationally seek not only new and enlarged markets, but also simple rules on business start-up and operation, and clear, consistent and reliable regulations (OECD, Observer, 1999). But in Russia, all these basic elements did not exist. Furthermore, the poor living conditions of scientists dissuaded many young people to start a scientific career and motivated established researchers to pursue careers abroad.

Since the existing firms were not profitable, any investment in R&D, technical innovation, work-place organisation and market knowledge was superfluous over the transition. Besides, there was no support for improvements of vocational and technical training, and the government failed to promote mobility between vocational/technical and traditional academic studies.

To survive and flourish in a scientific and technological environment, firms have to re-organise and become more adaptable to changes. They need to build trust and liability; they also need flexibility and durable networks as a fundamental part of maximising value-added in output. Small units have always characterised the service sector, and in recent years the manufacturing sector of the most rapidly growing economies has registered a decrease in average firm size over time. One rationale for the success of smaller businesses is their capacity to adjust swiftly to new situations. Although individually they may be subjected to more upheavals in their life cycles than larger firms, jointly they are essential creators of new employment. In addition, they generate significant spillovers of ideas and innovation. In Russia, however, the role played by small and medium sized enterprises is still very small measured by international standards (Russia Profile, 2005).

This range of factors, together with the need to promote a business-friendly regulatory environment, is essential to guarantee the development of an advanced technological sector. In this context, the Russian human capital legacy alone is not a sufficient condition to create sustainable growth, it tends naturally to depreciate if not properly cultivated. Measures aimed at limiting the cuts in firms' R&D and in education and halting the brain drain phenomenon should be enhanced by policy makers to avoid the risks linked to the low growth trap (Barro and Sala-i-Martin, 1995). The challenge, therefore, becomes both to recover the lost potential and to develop commercial outlets for scientific output.

5. Information Technology in Russia

Against the scenario of the low growth trap, a number of development in the human capital sector seem to be materialising in the new Russia. A first impression is that the high-tech sector is taking first steps towards resuscitation by making use of the massive technological research infrastructure and the highly educated work force (Fig. 3, appendix B). Some areas in Russia might be compared to the Italian industrial districts. Moscow and St. Petersburg in the Western part of Russia, and Novosibirsk in Siberia constitute the most important high-tech cities for manufacturing plants and the best development centres of offshore software. Nevertheless, deeper considerations should be done on these high tech clusters.

The following paragraphs present a more detailed look at the major high-tech districts, against which some conclusions for policy development are drawn.

5.1 Siberia's Silicon Valley: Novosibirsk

Novosibirsk, a Siberian town of more than 1.5 million people, has been dubbed "Siberia's Silicon Valley" by The Moscow Times, thanks to its high concentration of software companies and talented programmers. The heart of high-tech business is located, in fact, in this town. The local computer industry started in the late 1980s and was based at the Novosibirsk State University and the Novosibirsk State Technical University. Immediately, two "computer streets", Morskoi Prospect in Academgorodok (a suburb of Novosibirsk) and Marx Prospect in downtown Novosibirsk, were developed. About 25 computer companies are located in this area.

The sales volume of legal software in Novosibirsk is estimated to be up to 500,000 US$ per month in 2002. This value, which does not include sales of offshore programming, has increased almost by 50% since 1999.

Tab. 6 Sales volume of legal software in Novosibirsk, US$ per month

1999	2000	2001	2002
350000	400000	410000	500000

The main types of software sold are: 1) accounting and production automatic systems (e.g. 1C, Best, Parus-Predpryatic) (53% of sales); 2) software and laws reference systems (e.g. Consultant Plus, Garant, and Codex) (22% of sales); 3) corporate information systems (e.g. Oracles Applications, Parus Korporatsia) (10% of sales); 4) operational systems office and internet applications (10% of sales) and 5) programs for multimedia and games (5% of sales).

Two American companies, Microsoft and Oracle, are active in the local software market. Microsoft holds up to 90% of the market in operational systems and office applications. Oracles holds 30-40% of the market in corporate information systems.

Most of the software companies are involved in the new offshore programming business which generates a market size of US$250 million per year. The biggest company is Novosoft. It has been furnishing offshore programming to foreign, mostly US based companies since 1992. Another local producer is the Centre of Financial Technologies (CFT). CFT specialises in developing and selling a popular banking software named "Golden Crown". The system is supplied to more than 200 banks in Russia and in NIS countries. The company developed an automated payment system called "Gorod (City)", which is designed to collect payments from the local population for municipal services. Another important project involves the implementation of an electronic trade system called Faktura.

At a first glance, it could appear quite odd that a town in Siberia has become so important on the high-tech scene. There are, however, a number of good reasons to explain why the city has turned into a "district" with a highly developed IT market. Because of its geographical location and a well structured transportation infrastructure, Novosibirsk matured in a commercial centre outside of "European" Russia. Computer hardware and software are supplied to a huge number of Siberian regions from the city. The intense concentration of high-quality programmers and scientists fostered by Novosibirsk State University and low labour costs create opportunities for local software companies to be competitive in software market along with Moscow and St. Petersburg.

5.2 Moscow Offshore Software Market

Moscow accounts for about 35% of Russia's offshore software development market which makes it the number 1 software outsourcing centre in the country. A substantial scientific base, as in the other two high-tech towns, fuels the city's software sector. Several major universities that train programmers as well as a few major research institutions are located in the city. Moscow Engineering and Physics Institute, Bauman State Technical University, Moscow State University and Moscow Institute of Physics and Technology have in fact, a reputation for turning out highly qualified specialists. International IT majors often create educational centres on the campuses of Moscow institutes to get access to talent as soon as possible. For instance, the Moscow Technical University of Communications and Informatics supports training quarters from Alcatel, Cisco and Ericsson. The number of experts in IT fields who graduate every year is about 5000-5500. Besides, approximately 16000-18000 graduates in different engineering areas who have a deep background in IT can be employed as programmers every year (Outsourcing-Russia, 2001).

According to most estimates, about 70 Moscow-based software firms work on overseas orders, with the total number of employees being close to 4,000, and with about 1,000 programmers. The total value of the Moscow offshore software market is estimated at $70-75 million a year.

International markets where Moscow suppliers are active include the USA, Germany, United Kingdom, Switzerland, Norway, France, Japan, Spain, Canada, South Korea, Poland, and Netherlands. The leading companies in the districts are the Spirit Corporation, Epsam Systems and Luxoft. The Spirit Corporation is one of the main developers of telephony software who provides its services to global firms like Panasonic, Samsung Electronics, Texas Instruments, Nortel Networks and other telecom companies. EPAM Systems develops software in several areas, including sales force automation solutions, data warehousing, work-flow management, legacy integration solutions, enterprise information portals, e-commerce and warehouse management. The customers of EPAM Systems include Colgate-Palmolive, Halliburton, Samsung America, Danfoss, West Group, Verizon, Park Place Entertainment, and the Mandalay Bay Resort Group, and the company also implements software development orders from established international IT giants, such as SAP, Microsoft, PTC, ServiceWare, Firepond, IntelliCorp and Numerix. Luxoft's main focus is on the development of applications for business processes and integration of new software into existing programs. Forty percent of Luxoft's customers are IT companies, about 30% aerospace companies, and the remaining 30% are made up of finance and insurance groups. Among its international customers are the US Department of Energy, Zurich Financial Services Group, IBM, Boeing and Citibank. About 80% of all software development orders come from overseas customers. Although 80% of overseas orders are accounted for by US customers and the company has offices in Seattle and Washington DC, it is also looking closely at other markets, considering the opening of an office in Europe, where most of the remaining customers are located (Outsourcing Russia, 2002). Luxoft grew by 48% between 2004-2005 (Luxoft, 2006) and this growth is expected to continue.

5.3 St. Petersburg

St. Petersburg is the second largest city in Russia in terms of population, political influence, financial and industrial strength. Many consider St. Petersburg the technological and cultural capital of Russia. Developed infrastructure and geographical proximity to Western Europe give St. Petersburg a cosmopolitan character. A large proportion of imports and exports from/to Scandinavian countries and Finland goes through the transport hubs of the city, reaffirming the city's pronounced orientation towards Western trading partners.

Since 2001, more than 200 software development companies operate in St. Petersburg, 20% of which have access to international markets. The companies hire between 10,000 and 25,000 programmers. The maximum hourly wage of a programmer is $20 compared to $120 in the U.S. This can feasibly contribute to profit margins of 300-800% on finished software products.

There are three types of software developers currently operating in St. Petersburg: software divisions of large international companies; developers offering specialized, proprietary software; and outsourcing companies offering their programmers for specific tasks (offshore software development).

The software development market in St. Petersburg is growing by 50% annually. This is chiefly due to the educational institutions providing a pool of specialists and access to a comparatively cheap labour force.

The first look at the Russian districts is positive and the perspectives of development seem stimulating. The picture is however less rosy than it appears. Firstly, the development of the high tech sector is still in its infancy and limited to the domestic level5. Secondly, the technology clusters are largely controlled by foreign enterprises, notably American ones. Thirdly, the talented professionals tend to concentrate in attractive locations: Moscow, a sophisticated metropolis; St. Petersburg, heart of culture and art, and Novosibirsk, a place of natural, recreational and lifestyle amenities, distant from the nuisances of the Russian industrial core. Owing to the high quality of these surroundings, it is not surprising that a community of talented researchers stays in Russia, although their salary is far below international standards. If the conditions of these research environments could be extended to the whole of Russia, it is likely that fewer scientists would choose to move abroad. In reality, however, most of the new Russia remains characterized by poor living conditions, inexistent property rights, and low level quality social services, ranging from heat and housing to urban transport and public safety.

[5] The primary domestic end-users of IT are: governments (Federal and State levels); public institutions; finance institutions; state and private enterprises; computer equipment manufacturers and individuals.

6. Remarks and Some Policy Implications

While Russia is exploiting its comparative advantage in the natural resource sector, it has left largely unexploited its potential in the human capital-intensive sectors and their possible development. Russia's long-term potential as a leader in information and advanced technologies has been continuously ignored by policy makers, technical advisors and international investors who have instead focused on the traditional sectors of the Russian economy, mainly on heavy and extractive industry. And even the positive signs emanating from the "high tech districts" might be of short duration without a proper support strategy.

One of the main obstacles to the development of the high tech sector is thus the lack of a consistent government policy aimed at preserving Russia's human capital endowment and avoid its depreciation. But as government expenditure on fundamental research remains scanty and often inefficiently allocated, rent-seeking activities tend to increase.

Another relevant problem is linked to the general insecurity of property rights, especially in intellectual property, in the Russian economy which prevents domestic and foreign investment in the human capital sector. Currently property rights and business deals are guaranteed and enforced by corrupted private groups and fraudulent insiders. At the same time, relations among economic agents rest on tacit rules which often are the result of a criminal threat. Investors therefore cannot and do not risk investing their money in long-term business ventures in Russia because they do not perceive to be sufficiently protected by the legal infrastructure. As a consequence, many Russian firms that carry out projects in the high tech sector prefer to locate all of their non-production activities outside of Russia.

Many of the policy measures that Russia needs to revive its human capital pool and to promote the IT sector are also measures that are necessary to endorse the development of the entire Russian economy. Necessary interventions include the creation of market institutions and the formulation of responsible government policies (Braguinsky and Yavlinsky, 2000). To this, a range of specific measures aimed particularly at the IT and other knowledge-intensive sectors has to be added in order to achieve lasting development. For example, contacts and access to global markets should be boosted, capital access and financing mechanisms should be fostered and a social capital approach to economic development should be created. Furthermore, protection of shareholder rights, good accounting regulations, and the institutional structures are important elements to develop an entrepreneurial culture in Russia. With these measures in place, Russia could move to the forefront of the information revolution and take a leading place in the world economy. It would no longer be just a supplier of oil and gas, minerals, raw materials, and arms. At the same time, it would no longer be a nation dependent on the support of other nations and international public and private banks. Rather, Russia could diversify its export mix by adding in high technology products and thereby create a broader and stronger basis for economic growth.

The main efforts in providing conditions for the successful exploitation of the comparative advantage in the Russian knowledge-based industries will have to come from the Russian authorities themselves by providing adequate information and the appropriate institutional framework for those who would like to make use of this potential. The situation today is highly unusual. It is extremely hard for an ordinary businessman to get reliable information as to what kind of research is indeed available, who has property rights to it, and how it can actually be commercialised. The government should assist in creating a database, or ensure that relevant information is made publicly available by other means. Given that most research has been carried out and is still being carried out in military-related institutions, failure of the government to take an active role in disseminating information about this research will render its commercial exploitation very difficult indeed.

It should be noted that President Vladimir Putin has recognised the importance to diversify the Russian economy and to develop the nation's high-tech industry. He therefore announced an ambitious plans to expand the high-tech sector by use of tax incentives for investors in special economic zones, saying that the country "must not miss this chance" to catch up with its competitors in international markets (The Moscow Times, January 13, 2005). The construction of Russia's first information technology park officially began at the end of April 2006 in St. Petersburg. Covering a total area of 44 hectares, the IT park will call for about $1 billion worth of investment and it should start operating in 2008 or 2009 (The Moscow Times, April 25, 2006). Surprisingly, the high tech cluster of Novosibirsk has been excluded from the project.

7. Conclusions

Nowadays, human capital-intensive industries are drawing worldwide attention, mainly in the Information Technology (IT) sector. Owing to its abundant, yet underutilised human capital and to the world's largest pool of scientists and engineers, Russia has relevant potentialities in IT and knowledge-based development. If properly fostered, Russia's human resource intensive sector could lead to the revival of the whole economy and promote its integration in the world market.

The Russian Federation enjoys a double benefit in the information technology sector. Firstly, Russia owns a massive technological research infrastructure inherited from the Soviet Union. Secondly, there is a highly educated work force to encourage IT innovation. With such a significant base of expertise, Russia could become a major centre for computer software development similar to India. The reason why Russia still lags behind can be described by an extended version of the Redding model (1996), according to which economic growth is generated by attendant investments in R&D and education. Since expenditure on R&D and education have been cut during the transition, it is clear that Russia's per capita GDP does not match the potential inherent in its human capital endowment. Indeed, the deterioration in the quality of human capital is likely to have adverse effects in the long run. The only way to overcome this problem is to adopt policy measures which will boost the human capital intensive sector , while at the same time strengthening the rule of law and market incentives.

Recently there have been symptoms of recovery in the Russian market for IT-related products. Until 1997, there was a contained demand for engineers and technical professionals, who either had to work for meagre wages, change job or emigrate. Since the aftermath of the August 1998 crisis, firms in the computer, mass communications, and IT industries have been actively employing new personnel and are offering quite attractive salaries by Russian standards. A typical programmer with experience earns between $8,000-$14,000 per year, depending on whether the location is high-priced Moscow or the cheaper provinces. That's a little more than the $ 7,000 to $11,000 an Indian might make, but it is well below the $55,000 or more paid to an American in a similar job (Global Outsourcing, 2005).

The major IT districts are located in Moscow, St. Petersburg and in Novosibirsk, but the situation of these high tech clusters is less rosy than it seems. In fact, the IT districts are still at their infancy stage and de facto colonised by foreign companies, whose contributions to develop and expand Russia's technological potential have remained modest. It will thus depend crucially on Russian policy makers whether these developments can be shaped into a sustainable driver of growth to the benefit of the Russian economy and society at large.

References

Acemoglu, D. (1997), 'Training and innovation in an imperfect labour market', *Review of Economic Studies*, **64**, 445-64.

Acemoglu, D. and Pischke, J. (1998), 'Why do firms train?', *Quarterly Journal of Economics*,. **113**, 79-119.

Acemoglu, D. and Pischke, J.(1999), 'The structure of wages and investment in technology-general training', *Journal of Political Economy*, **107**, 539-72.

Acemoglu, D. e J. D. Angris (2000), 'How Large are Human-Capital Externalities? Evidence from Compulsory Schooling Laws', *NBER Macroeconomics Annuals*, 9-59.

Algieri, B. (2004), 'The Effects of Dutch Disease in Russia', in *ZEF Discussion Papers*, No 83, University of Bonn.

Balassa, B. (1965), Trade Liberalisation and Revealed Comparative Advantage', *Manchester School of Economics and Social Sciences*, **33**, 99-123.

Barro, R. J. and Sala-i-Martin, X. (1997) 'Technological diffusion, convergence, and growth', *Journal of Economic Growth*, **2**, 1-27.

Barro, R. J. and Sala-i-Martin, X. (1995) Economic Growth. McGraw-Hill, New York.

Becker G. S (1964), *Human Capital*, New York, Columbia University Press

BOFIT (2006), Russia Review No.4, Macroeconomic Indicators. Bank of Finland, Helsinki. http://www.bof.fi/bofit/eng/4ruec/index.stm

Braguinsky, S. and Yavlinsky G. (2000) 'Incentives and Institutions: The Transition to a Market Economy in Russia'. Princeton, Princeton University Press.

Central and Eastern Europe,. World Bank Technical Paper No. 340.

CEPR (1990), Monitoring European Integration Report.

EIU (2004) The Economist Intelligence Unit, www.eiu.com

Fukolova, Y. (2000) 'How much they cost', in *Kommersant dengi*, 24-26.

Glinkina S., Grigoriev A., Yakobidze V. (2001), *Crime and Corruption*, in *The new Russia : transition gone awry* edited by Lawrence R. Klein and Marshall Pomer, Stanford, Stanford University Press.

Global Outsourcing (2005), Russia's High Value Call, Issue: Tuesday, August 16.

Goskomstat, several issues.

Gros, D. and Suhrcke M. (2000), 'Ten Years After: What is Special About Transition Countries?', HWWA Discussion Paper No. 86.

Hamilton C., Winters A., (1992), 'Trade with Eastern Europe', *Economic Policy*, **14**, 77-116.

Intriligator M., Braguinsky S. and Shvydko V. (2001) Human Capital, in *The new Russia : transition gone awry* edited by Lawrence R. Klein and Marshall Pomer, Stanford, Stanford University Press.

International Trade Center (2006), http://www.intracen.org/index.htm

Krueger, A.B. and Lindhal M. (2001), 'Education for Growth: Why and For Whom?' *Journal of Economic Literature*, **39**, 1101-1136.

Lucas R.E (1988), 'On the Mechanics of Economic Development', *Journal of Monetary Economics* **22**, 3-42.

Luxoft (2006), http://www.luxoft.com/about/fact_sheet.html

Mankiw, N.G., Romer, D. and Weil D. (1992), 'A Contribution to the Empirics of Economic Growth', *Quarterly Journal of Economics,* **107**, 407-438.

Micklewright, J. (1999), 'Education, inequality and transition', *Economics of Transition;* **7**, 343-376.

Mincer J. (1993), 'Education and Unemployment', in *Studies in Human Capital*, edited by Jacob Mincer, Cambridge, UK, Edward Elgar.

Mincer, J. (1974), 'Schooling Experience and Earnings' *Columbia University Press*, N.Y.

Mincer, J. (1988) 'Job training, wage growth, and labor turnover' Background paper. New York: Institute on Education and the Economy, Teachers College, *Columbia University.*

Nezavisimaya Gazeta (2002), http://www.pressdisplay.com/pressdisplay/viewer.aspx

OECD (2004), Science and Technology.

OECD Observer (1999), Business and industry policies for knowledge-based economies, Issue No.215, January.

Outsourcing-Russia (2002), various issues, www.outsourcing-russia.com Paper No. 417.

Pomer, M. (2001), Transition and Government, in *The new Russia : transition gone awry* edited by Lawrence R. Klein and Marshall Pomer, Stanford, Stanford University Press.

Redding, S. (1996), 'Low-skill, low-quality trap: strategic Complementarities between human capital and R&D', *Economic Journal*, **106**, 458-70.

Romer, P. M. (1986). 'Increasing Returns and Long Run Growth', *Journal of Political Economy*, **94**, 1002-1037.

Russian Academy of Sciences, (2000) http://www.intertec.co.at/itc2/partners/RAS/Default.htm

Russia Profile (2005), Russia's Venture Capitalists Look for State Initiatives on Innovation, October 26,

www.russiaprofile.org

Rutkowski, J. (1996), 'Changes in the Wage Structure During Economic Transition in Central and Eastern Europe', *World Bank Technical Paper* No.340 - *Social Challenges of Transition Series.*

Rutkowski, J. (1998), 'Welfare and the Labor Market in Poland', World Bank Technical Paper No. 503. Washington DC .

Schultz, T. W. (1961), 'Investment in Human Capital', *The American Economic Review*, **51**, 1-17.

Smith, A. (1776, reprint 1976), *The Wealth of Nations* University of Chicago Press, Chicago.

Stone R. (1999), Russia's Drain, Israel's Gain, in *The Moscow Times, Aug. 7.*

The Moscow Times, www.themoscowtimes.com

The World Bank (2001), Setting Russia's Economy on a New Path, *Beyond Transition*, The Newsletter About Reforming Economies, Washington DC.

Transneft (2006), Press, www.transneft.ru

Unicef (2000) (2001), (2003), www.unicef.org.

Appendix A

Low Human Capital Profile and Low Technology Trap Model

Russia is supposed to be populated by a sequence of non-overlapping generations (g) with a two-period lifetime (τ =1,2). Generations are composed of a continuum of workers (e) and firms (f). Population has been normalised so that each generation consists of exactly two agents: a worker and a tycoon.

The representative worker, who is assumed to be risk neutral, has the standard linear utility function:

$$U_g\,(c_{1,g}\,, c_{2,g}) = c_{1,g} + \left(\frac{1}{1+\rho}\right) c_{2,g} \qquad 1.1$$

where cτ,g is the consumption of generation g in period τ and ϱ is the subjective time-preference rate, that is it measures the individual's impatience to consume. Each individual inherits a stock of human capital from the former generation, as postulated by Lucas (1988), so that:

$$h_{1,g}\,(e) = H_{2,g-1} - \delta\, H_{2,g-1} \qquad 1.2$$

where δ is the human capital depreciation rate across generations and H2,g-1 is the aggregate period 2 stock of human capital of the generation g-1. Workers can improve their period 2 human capital by investing part of period 1 in education and schooling. More precisely, they devote a fraction η of period 1 to education, such that 0 ≤ η ≤1. The remaining fraction (1- η) is instead employed for production. It is furthermore assumed that period 2 is entirely devoted to production.

To take into account "brain drain" effects, we postulate that period 2 stock of human capital of the g generation depends both on a fraction η time spent in education and on the permanence of workers in their country. Formally:

$$h_{2,g}\,(e) = (1 + \gamma\,\eta^{\varphi} - \beta)h_{1,g} \qquad 1.3$$

$$0 \prec \varphi \prec 1$$
$$0 \le \eta \le 1$$
$$\gamma \succ 0$$
$$0 \le \beta \le 1$$

where parameters γ and φ indicate education productivity. It is assumed that if a worker invests in education, the worker's human capital will indeed grow by factor γ, according to an exponential rate φ. β is a parameter which identifies the "brain drain" effect. In particular, β is zero, if well-educated people do not leave their country, β is equal to 1, if paradoxically, all high skilled people migrate. The inter-temporal human capital spillovers across generations, as predicted by Lucas (1988), are positively linked to human capital accumulation in period 2, i.e. the higher the inherited stock of human capital (1.2), the more productive investments in human capital will be (1.3).

Firm's decisions

Each firm (f) has the classical Cobb-Douglas production function that exhibits constant returns to physical and human capital:

$$y_{\tau,g}(f) = A_{\tau,g}\, k_{\tau,g}^{\alpha}\, h_{\tau,g}^{1-\alpha} \qquad 1.4$$

$\tau = 1,2$

where $A\tau$,g is the productivity factor or the technology's quality employed by firm f in period τ. $h\tau$,g and $k\tau$,g denote, respectively, the period τ human and physical capital of the representative worker employed by firm f .

Firms decide whether to invest a fraction χ of period 1 output in costly R&D. χI is the effective fraction of time necessary to get a research facility, with $0 \leq \chi I \leq 1$. If the fraction $\chi \geq \chi$I of period 1 is spent on research, a firm successfully innovates with probability $P=\pi$ such that $0< \pi <1$. Conversely, if the fraction $\chi < \chi$I of period 1 is spent on research, a firm successfully innovates with probability P=0.

Let us assume that the starting technology quality is A0= 1, while A1,g= Z n describes technology growth with n= 0……..ň (where ň is the finite highest technology) and Z >1. Put differently, technology's quality or productivity depends on the number of innovations (n) and it grows exponentially with this number, with Z being a parameter which specifies the technology growth.

According to Acemoglu (1994) and Redding (1996), the economy has a level of full employment and workers and firms are randomly matched one-to-one. The returns to a match are divided between the worker and the tycoon at an exogenous fixed rate, ξ and (1- ξ) respectively. Firm f pays the period t wage per unit of human capital to its employee:

$$w_{t,g}(f) = \xi \cdot A_{t,n}(f) \qquad 1.5$$

In period 1, all firms have the same technology. On the one hand, workers have to make an expectation regarding the innovation of the firm and their future wage and, as a consequence, they decide upon the time to allocate to human capital improvements.

$$E_{n,f}\left[w_{2,n}(f)\right] \equiv \xi \cdot E_{n,f}\left[A_{2,n}(f)\right] \equiv \xi \cdot [PZ + (1-P)]A_{1,n} \qquad 1.6$$

On the other hand, each firm has to decide whether to carry out research (case 1) or keep on implementing the existing technology (case 2). In the first case, the firm defines the fixed fraction χI of the first period to spend on R&D, given the innovation probability $P \equiv \begin{cases} \pi & if \quad \chi \geq \chi_I \\ 0 & if \quad \chi < \chi_I \end{cases}$ and it expects returns on R&D (R (r&d)) according to equation 1.7.

$$R\,(r\&d) \equiv (1-\xi) \cdot A_{1,n} \cdot k^{\alpha} \cdot h^{1-\alpha} \left\{ (1-\chi_I) \cdot (1-\eta) + \left(\frac{1}{1+\rho} \right) \cdot \left[\pi\, Z + (1-\pi) \right] \cdot (1+\gamma \eta^{\varphi} - \beta) \right\} \qquad 1.7$$

In the second case, the expected return of the firm is R (0):

$$R(0) \equiv (1-\xi)\cdot A_{1,n}\cdot k^{\alpha}\cdot h^{1-\alpha}\left\{(1-\eta)+\left(\frac{1}{1+\rho}\right)\cdot(1+\gamma\eta^{\varphi}-\beta)\right\} \qquad 1.8$$

A firm engages in research if R (r&d)-R (0)>0 and this condition depends strongly on the employees' expected period 1 investment η in human capital.

Behaviour of Workers

The representative worker (e) living in two –periods maximise his utility

$$U_g(c_{1,g}, c_{2,g}) = c_{1,g} + \left(\frac{1}{1+\rho}\right)c_{2,g} \qquad 1.9$$

subject to the inter-temporal budget constraint:

$$w_{1,g}\cdot(1-\eta)\cdot h_{1,g} + \left(\frac{1}{1+\rho}\right)\cdot \mathrm{E}_{n,f}[w_{2,g,n}(f)]\cdot h_{2,g} \geq U_g(c_{1,g}, c_{2,g}) \qquad 1.10$$

where the first term expresses the period 1 wage and the second addendum is the present value of the expected wage according to eq.1.6. Under the risk neutrality assumption, the inter-temporal optimisation problem of the worker consists of choosing the proper η that maximises the expected discounted lifetime income. Therefore, substituting the expressions for h1,g , h2,g and wt,g in the budget constrain, the problem can be written as follows:

$$\underset{\eta}{Max}\ \xi\cdot(1-\eta)\cdot A_{1,n}+\left[\xi\cdot\left(\frac{1}{1+\rho}\right)\cdot[PZ+(1-P)\cdot A_{1,n}]\right]\cdot\left[(1+\gamma\eta^{\varphi}-\beta)(H_{2,\tau-1}-\delta H_{2,\tau-1})\right] \qquad 1.11$$

$$\eta^{\varphi-1}\cdot\left[\left(\frac{PZ}{1+\rho}\right)\varphi\gamma+\frac{\varphi}{1+\rho}\cdot(1-P)\right]\cdot\xi\cdot A_{1,n}\cdot(1-\delta)\cdot H_{2,\tau-1} \equiv \xi\cdot A_{1,n}\cdot(1-\delta)\cdot H_{2,\tau-1} \qquad 1.12$$

$$\eta \equiv \left[\frac{1+\rho}{\gamma\varphi\cdot[PZ+(1-P)]}\right]^{\frac{1}{\varphi-1}} \quad for \quad 0 \leq \left[\frac{1+\rho}{\gamma\varphi\cdot[PZ+(1-P)]}\right]^{\frac{1}{\varphi-1}} \leq 1 \qquad 1.13$$

$$\eta \equiv 1 \quad for \quad \left[\frac{1+\rho}{\gamma\varphi\cdot[PZ+(1-P)]}\right]^{\frac{1}{\varphi-1}} \succ 1 \qquad 1.14$$

Considering just the interior solution $0 \leq \eta \leq 1$, it is clear, from equations 1.5 1.13 and 1.14, that the investments of workers in education rely strongly on the expected firms' investment in R&D. Formally:

$$\eta \equiv \begin{cases} \eta_\pi \equiv \left[\dfrac{1+\rho}{\gamma\varphi \cdot [\pi Z + (1-\pi)]}\right]^{\frac{1}{\varphi-1}} & if \quad \chi \geq \chi_1 \\ \eta_0 \equiv \left[\dfrac{1+\rho}{\gamma\varphi}\right]^{\frac{1}{\varphi-1}} & if \quad \chi \prec \chi_1 \end{cases} \qquad 1.15$$

with $\eta\pi > \eta 0$.

Nash Equilibrium

In a game theory framework, the Nash equilibrium solution has been obtained using equations (1.7) (1.8) (1.15). A Nash equilibrium is a certain kind of rational expectation equilibrium, which consists of probability beliefs over strategies and the probability of choosing strategies such that: 1) the beliefs are corrects and 2) each player chooses strategies so as to maximise his expected utility given his belief. In this context, tycoons make investments before entering the labour market and before knowing the decision of the workers to invest in human capital, but conjecturing on it (eq. 1.7, 1.8). Equally, for employees: their total and marginal returns from investing in human capital depend on whether they expect the firm to invest in R&D (eq.1.15). Since the two types of investment are, in Redding's words, "strategic complements" and show monetary externalities, and since research technology is indivisible, three possible equilibria exist: a high growth, a low growth and a mixed growth equilibrium.

In a high growth equilibrium, workers expect that the firm will engage in R&D and since they suppose they will earn higher wages, they will invest in human capital. In turn, a higher expected stock of human capital increases the expected returns on research and therefore firms will raise their investment in R&D. R&D is optimal if

R (r&d) - R (0)> 0 1.16

That is, we require:

$$(1-\xi)\cdot A_{1,n}\cdot k^{\alpha}\cdot h^{1-\alpha}\cdot\left\{(1-\chi_I)\cdot(1-\eta)+\left(\frac{1}{1+\rho}\right)\cdot[\pi Z+(1-\pi)]\cdot(1+\gamma\eta^{\varphi}-\beta)\right\} \succ (1-\xi)\cdot A_{1,n}\cdot k^{\alpha}\cdot h^{1-\alpha}\cdot\left\{(1-\eta)+\left(\frac{1}{1+\rho}\right)\cdot(1+\gamma\eta^{\varphi}-\beta)\right\}$$

1.17

By explicating the above equation and rearranging it, we get:

$$\left\{(1-\chi_I)\cdot(1-\eta_\pi)+\left(\frac{1}{1+\rho}\right)\cdot\pi Z\cdot(1+\gamma\eta_\pi{}^{\varphi}-\beta)+\left(\frac{1}{1+\rho}\right)\cdot(1-\pi)\cdot(1+\gamma\eta_\pi{}^{\varphi}-\beta)\right\}\succ\left\{(1-\eta_\pi)+\left(\frac{1}{1+\rho}\right)\cdot(1+\gamma\eta_\pi{}^{\varphi}-\beta)\right\}$$

$$\left\{\left(\frac{1}{1+\rho}\right)\cdot(1+\gamma\eta_\pi{}^{\varphi}-\beta)\cdot(\pi Z+1-\pi-1)\right\}\succ\left\{(1-\eta_\pi)\cdot(1-(1-\chi_I)\right\} \qquad 1.18$$

$$\left(\frac{\pi\cdot(Z-1)}{1+\rho}\right)\succ\left(\frac{(1-\eta_\pi)\cdot\chi_I}{(1+\gamma\eta_\pi{}^{\varphi}-\beta)}\right)$$

According to 1.18, to have a "high growth equilibrium" is necessary that:

1. the probability of successful innovation π is high;
2. the technology growth parameter Z is high;
3. the subjective time-preferences rate ϱ is small;
4. the fixed cost parameter χI is small;
5. the amount of time devoted to education η is high;
6. the education productivity parameters γ and θ are large;
7. the migration parameter β is very small.

In a low growth equilibrium, the firm does not consider it profitable to carry out R&D and the only source of growth is human capital accumulation. At the same time, workers, expecting a drop in firms' R&D, trim down their investments in human capital. At this stage of human capital accumulation, the workers expectations are met as the returns from investing in further R&D are lower than the returns gained using the existing technology.

The low growth equilibrium implies that P=0 and η=η0. In this case, no R&D is an optimal solution if it holds R (r&d)-R (0) <0. This means:

$$\left(\frac{\pi\cdot(Z-1)}{1+\rho}\right)\prec\left(\frac{(1-\eta_0)\cdot\chi_I}{(1+\gamma\eta_0^{\varphi}-\beta)}\right) \qquad 1.19$$

The high growth equilibrium (1.18) is characterised by a high accumulation of human capital, a high amount of R&D and thus, high-quality technology and no brain drain. The low growth equilibrium (1.19) is instead characterised by no research, a low accumulation of domestic human capital and migration. Equations 1.18 and 1.19 might hold simultaneously, therefore a multiple equilibrium exists:

$$\left(\frac{\pi \cdot (Z-1)}{1+\rho}\right) \succ \left(\frac{(1-\eta_{\pi}) \cdot \chi_I}{(1+\gamma \eta_{\pi}{}^{\varphi} - \beta)}\right)$$ Simultaneous Equilibria

and 1.20

$$\left(\frac{\pi \cdot (Z-1)}{1+\rho}\right) \prec \left(\frac{(1-\eta_0) \cdot \chi_I}{(1+\gamma \eta_0^{\varphi} - \beta)}\right)$$

While the high and low growth equilibria are stable, the simultaneous ones not.

The presented model extended to the Russian case shows that a large endowment of human capital does not ensure economic growth. It is necessary that investments in human capital, investments in R&D and incentives for the workforce exist in order to reach a high growth equilibrium. Therefore, the human capital legacy of Russia is a necessary but not sufficient condition to have sustainable growth. When expenditures on education drop, R&D declines and brain drain effects occur, it is more probable that the economy will finish in a bad equilibrium. Hence measures aimed at preventing the cuts in R&D and education and arresting the brain drain phenomenon should be endorsed by policy makers to avoid the threats linked to the low growth trap.

Appendix B

Table 1. Exports and Imports of the Russian Federation

Exports	Value 1997	Value 1998	Value 1999	Value 2000	Value 2001	Value 2002	Value 2003	Value 2004
	US$ '000	US$ '000	US$ '000	US$ '000	US$ '000	US$ '000	US$ '000	US$ '000
751 - OFFICE MACHINES	11,889	6,534	5,871	4,775	5,937	8,126	12,070	13,287
752 - COMPUTER EQUIPMENT	41,495	44,677	66,114	37,988	27,077	68,023	41,896	60,345
759 - OFFICE EQUIP PARTS/ACCS.	14,979	10,322	8,937	14,600	4,188	12,111	9,803	12,835
761 - TELEVISION RECEIVERS	1,597	2,332	8,682	2,705	12,654	1,416	3,128	9,097
762 - RADIO BROADCAST RECEIVER	2,412	3,309	0,785	1,352	1,069	1,122	1,427	1,075
763 - SOUND/TV RECORDERS ETC	6,106	9,323	2,301	2,050	1,578	1,591	2,153	3,088
764 - TELECOMMS EQUIPMENT NES	347,643	175,442	219,085	131,417	174,947	202,779	283,119	401,923
773 - ELECTRICAL DISTRIB EQUIP	97,307	94,849	78,39	112,881	136,039	113,354	136,089	176,560
774 - MEDICAL ETC EL DIAG EQUI	5,836	6,367	5,689	33,732	10,950	11,785	11,072	24,625
781 - PASSENGER CARS ETC	406,919	315,971	206,625	349,459	298,659	351,878	395,866	558,338
782 - GOODS/SERVICE VEHICLES	163,.314	145,605	109,946	133,675	289,414	465,253	397,611	521,424
783 - ROAD MOTOR VEHICLES NES	29,156	32,732	33,584	37,459	58,424	80,203	98,894	141,611
792 - AIRCRAFT/SPACECRAFT/ETC	698,089	603,614	101,419	166,392	319,297	380,665	2,819,752	769,349
793 - SHIPS/BOATS/ETC	998,689	1008,46	724,192	987,195	387,503	442,430	349,361	543,277
871 - OPTICAL INSTRUMENTS NES	44,202	49,372	41,067	39,799	36,504	48,089	68,631	57,987
872 - MEDICAL/ETC INSTRUMENTS	16,888	15,298	16,766	17,996	22,406	22,981	32,809	36,834
881 - PHOTOGRAPHIC EQUIPMENT	22,957	11,330	7,678	4,404	5,130	4,921	3,577	4,252
882 - PHOTOGRAPHIC SUPPLIES	7,655	4,681	4,738	3,964	3,971	3,522	5,447	6,044
884 - OPTICAL FIBRES	16,095	13,402	38,203	41,106	31,512	19,798	20,195	26,369

Imports	Value	Value	Value	Value	Value	Value	Value	Value

	1997	1998	1999	2000	2001	2002	2003	2004
	US$ '000	US$ '000	US$ '000	US$ '000	US$ '000	US$ '000	US$ '000	US$ '000
751 - OFFICE MACHINES	72,264	41,531	27,372	29,105	51,387	42,887	49,204	67,745
752 - COMPUTER EQUIPMENT	279,931	181,346	185,891	202,444	412,516	528,581	607,811	968,627
759 - OFFICE EQUIP PARTS/ACCS.	140,781	92,617	61,780	61,536	69,102	115,267	147,296	191,323
761 - TELEVISION RECEIVERS	170,117	55,266	38,751	29,784	144,012	153,126	103,715	204,105
762 - RADIO BROADCAST RECEIVER	21,494	9,519	2,211	16,512	73,387	133,812	148,660	240,040
763 - SOUND/TV RECORDERS ETC	56.226	20,465	12,207	17,456	45,319	71,349	79,841	238,041
764 - TELECOMMS EQUIPMENT NES	1,573,115	1,170,255	723,482	802,617	1,169,980	1,446,784	1,552,908	2,481,847
773 - ELECTRICAL DISTRIB EQUIP	226,590	208,960	105,280	117,828	135,938	156,931	186,847	301,907
774 - MEDICAL ETC EL DIAG EQUI	449,266	510,226	338,571	205,048	433,049	360,842	465,328	457,073
781 - PASSENGER CARS ETC	993,993	825,572	304,316	443,298	951,688	1,288,829	2,460,645	5,163,769
782 - GOODS/SERVICE VEHICLES	329.491	217,031	108,469	155,146	323,590	293,122	419,802	497,345
783 - ROAD MOTOR VEHICLES NES	466,720	286,107	114,697	142,422	199,186	263,761	311,510	475,946
792 - AIRCRAFT/SPACECRAFT/ETC		9,284	12,348	16,351	115,143	210,477	324,184	229,109
793 - SHIPS/BOATS/ETC	846,963	657,779	446,746	221,209	285,207	299,914	246,190	154,835
871 - OPTICAL INSTRUMENTS NES	9,402	15,200	14,271	9,122	14,778	23,076	45,012	45,086
872 - MEDICAL/ETC INSTRUMENTS	424,245	438,924	214,572	234,661	389,229	311,568	479,545	521,977
881 - PHOTOGRAPHIC EQUIPMENT	63,313	28,659	8,353	13,395	17,394	26,016	24,169	32,350
882 - PHOTOGRAPHIC SUPPLIES	143,210	85,320	79,805	89,908	95,471	98,452	106,603	114,685
884 - OPTICAL FIBRES	52,424	35,108	26,511	35,810	42,476	39,702	49,946	61,571

Source: International trade center, 2006

Table 2. Inter-Industry Specialisation Index

Russia	2002		2002
Inter-industry specialisation		De-specialisation	
247 - WOOD IN ROUGH/SQUARED	25,391.86	782 – GOODS/SERVICE VEHICLES	91,60
672 – PRIMARY/PRODS IRON/STEEL	23,363.73	792 - AIRCRAFT/SPACECRAFT/ETC	84,59
562 - MANUFACTURED FERTILIZERS	19,285.53	034 - FISH,LIVE/FRSH/CHLD/FROZ	81.73
343 - NATURAL GAS	9,125.08	641 - PAPER/PAPERBOARD	79.93
683 - NICKEL	8,623.62	654 - WOVEN TEXTILE FABRIC NES	76.11
282 – FERROUS WASTE/SCRAP	7,211.14	281 - IRON ORE/CONCENTRATES	58.42
248 - WOOD SIMPLY WORKED	6,336.96	716 - ROTATING ELECTR PLANT	48.27
334 - HEAVY PETROL/BITUM OILS	5,386.85	722 - TRACTORS	47.07
333 - PETROL./BITUM. OIL,CRUDE	4,825.18	613 - FURSKINS TANNED/DRESSED	46.90
325 - COKE/SEMI-COKE/RETORT C	2,805.95	773 - ELECTRICAL DISTRIB EQUIP	45.13
673 - FLAT ROLLED IRON/ST PROD	1,152.98	635 - WOOD MANUFACTURES N.E.S.	44.89
682 - COPPER	1,150.91	793 - SHIPS/BOATS/ETC	34.53
686 - ZINC	1,061.38	612 - LEATHER MANUFACTURES	34.02
684 - ALUMINIUM	956.94	621 - MATERIALS OF RUBBER	30.62
712 - STEAM/VAPOUR TURBINES	857.00	842 - WOMEN/GIRL CLOTHING WVEN	29.63
232 - RUBBER SYNTH/WASTE/ETC	842.58	322 - BRIQUETTES/LIGNITE/PEAT	29.53
512 - ALCOHOLS/PHENOLS/DERIVS	613.44	884 - OPTICAL FIBRES	28.28
321 - COAL NON-AGGLOMERATED	496.79	841 - MENS/BOYS WEAR, WOVEN	22.11
211 - HIDE/SKIN (EX FUR) RAW	403.75	122 – TOBACCO, MANUFACTURED	21.59
611 – LEATHER	374.93	657 - SPECIAL YARNS/FABRICS	20.27
671 - PIG IRON ETC FERRO ALLOY	329.98	724 - TEXTILE/LEATHER MACHINRY	19.03
522 - ELEMENTS/OXIDES/HAL SALT	262.19	737 - METALWORKING MACHINE NES	17.23
676 - IRON/STEEL BARS/RODS/ETC	260.19	658 - MADE-UP TEXTILE ARTICLES	16.69
678 - IRON/STEEL WIRE	254.94	721 - AGRIC MACHINE EX TRACTR	15.99
871 - OPTICAL INSTRUMENTS NES	164.17	723 - CIVIL ENGINEERING PLANT	15.42
714 – ENGINES NON-ELECTRIC NES	111.86	781 - PASSENGER CARS, ETC	15.11
711 - STEAM GENERATING BOILERS	106.18	666 - POTTERY	14.43
		541 - PHARMACEUT EXC MEDICAMNT	14.39
		783 - ROAD MOTOR VEHICLES NES	14.32
		751 - OFFICE MACHINES	13.53
		848 - HEADGEAR/NON-TEXT CLOTHG	13.04
		741 - INDUST HEAT/COOL EQUIPMT	13.00
		881 - PHOTOGRAPHIC EQUIPMENT	11.79
		744 - MECHANICAL HANDLING EQUI	9.95
		001 - LIVE ANIMALS EXCEPT FISH	9.65
		752 - COMPUTER EQUIPMENT	8.88
		112 - ALCOHOLIC BEVERAGES	8.67
		764 - TELECOMMS EQUIPMENT NES	8.22
		812 - SANITARY/PLUMB/HEAT FIXT	8.09
		759 - OFFICE EQUIP PARTS/ACCS.	6.88
		851 - FOOTWEAR	6.28
		653 - MAN-MADE WOVEN FABRICS	6.00
		553 - PERFUME/TOILET/COSMETICS	5.31
		872 - MEDICAL/ETC INSTRUMENTS	4.32

		725 - PAPER INDUSTRY MACHINERY	3.69
		726 - PRINTING INDUSTRY MACHNY	3.32
		583 - MONOFILAMENT RODS/STICKS	2.72
		846 - CLOTHING ACCESSORIES	2.08
		882 - PHOTOGRAPHIC SUPPLIES	2.03
		774 - MEDICAL ETC EL DIAG EQUI	1.82
		763 - SOUND/TV RECORDERS ETC	1.55
		727 - FOOD PROCESSING MACHINES	1.34
		762 - RADIO BROADCAST RECEIVER	0.72
		761 - TELEVISION RECEIVERS	0.53
		012 - MEAT NES,FRESH/CHLD/FROZ	0.09
		011 - BEEF, FRESH/CHILLD/FROZN	0.00

Source: Own calculations on ITC data.

Note: The index is the ratio between the Balassa index (1965) calculated for exports and the Balassa index for imports. Formally it is given by:

$$Sp=100*\left(\frac{x_{ki}\Big/\sum_{k=1}^{M}x_{ki}}{\sum_{i=1}^{N}x_{ki}\Big/\sum_{i=1}^{N}\sum_{k=1}^{M}x_{ki}}\right)\Bigg/\left(\frac{m_{ki}\Big/\sum_{k=1}^{M}m_{ki}}{\sum_{i=1}^{N}m_{ki}\Big/\sum_{i=1}^{N}\sum_{k=1}^{M}m_{ki}}\right)$$

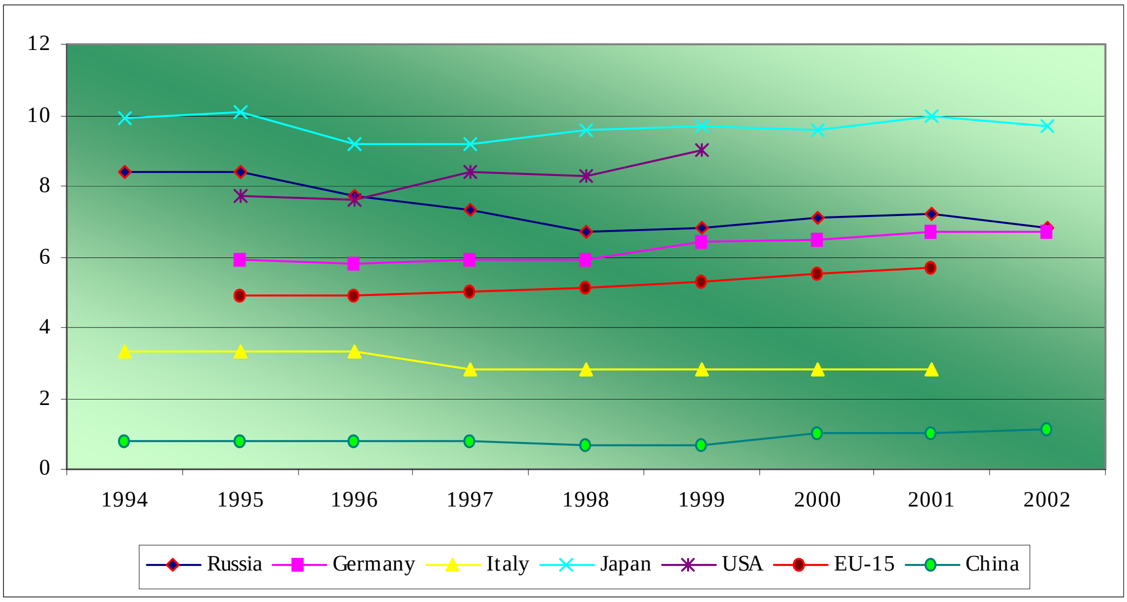
where xki refers to the exports of commodity k by country i and mki to the imports of commodity k by country i. The numerator represents the share of commodity k in the exports of country i relative to the share of commodity k in world exports. The denominator represents the same relative share for imports. By considering the normalised quotas of exports and imports, this indicator ostensibly provides an unbiased measure of specialisation, as well as an unbiased predictor of the intensity of comparative advantage. Values above 100 indicate the presence of comparative advantages.

Table 4. International gross domestic expenditure on R&D as % of GDP.

	Russia	Germany	Italy	Japan	USA	EU-15	China
1992	0.74	2.4	1.18	2.89	2.65	1.87	0.74
1993	0.77	2.33	1.13	2.83	2.52	1.86	0.72
1994	0.84	2.24	1.05	2.77	2.43	1.82	0.65
1995	0.85	2.25	1	2.9	2.51	1.8	0.6
1996	0.97	2.25	1.01	2.78	2.55	1.8	0.6
1997	1.04	2.29	1.05	2.84	2.58	1.8	0.68
1998	0.95	2.31	1.07	2.95	2.6	1.81	0.7
1999	1	2.44	1.04	2.96	2.65	1.86	0.83
2000	1.05	2.49	1.07	2.99	2.72	1.88	1
2001	1.16	2.51	1.11	3.07	2.74	1.92	1.07
2002	1.24	2.52	..	3.12	2.67	1.93	1.23
2003	..	2.5	..	..	2.62	..	..

Source: OECD, Science and Technology, 2004.

Fig. 2 Total researchers per 1000 labour force.



Source: OECD, Science and Technology, 2004

Table 5. % Gross domestic expenditure on R&D (2003)

a) financed by

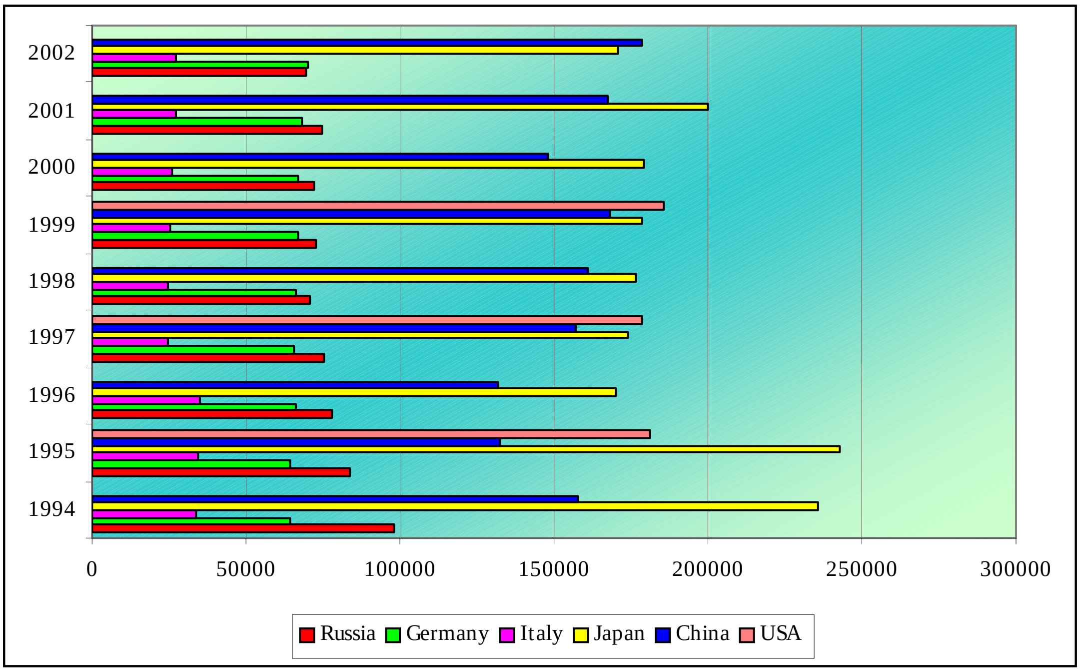
	Government	Private sector	Other national sources	Abroad
Russia	58.40%	33.10%	0.40%	8.1%
Usa	31.20%	63.10%	5.70%	0%
Japan	18.20%	73.80%	7.60%	0.40%
Germany	32.10%	65.10%	0.40%	2.40%
Italy	50.80%	43.60%	0.60%	5%
Total OECD	29.90%	62.30%	4.80%	3.00%

b) performed by

	Government	Private sector	High education sector	Private no-profit sector
Russia	24.50%	69.90%	5.40%	0.20%
Usa	9.10%	68.90%	16.80%	5.20%
Japan	9.50%	74.40%	13.90%	2.20%
Germany	13.80%	69.10%	17.10%	0%
Italy	22%	52.80%	25.20%	0%
Total OECD	11%	68%	18.10%	2.90%

Source: OECD, 2004

Fig. 3 Researchers with higher education, 1994-2000



Source: OECD, Science and Technology, 2004

Table 6. Russian total business enterprise expenditure quota on R&D

	1995	1996	1997
machinery n.e.c.	32.95	30.60	32.21
aerospace	19.09	22.74	23.68
moto vehicles	7.82	8.75	8.76
Tv, radio & communication equipment	6.03	5.98	5.91
chemical products	6.27	5.64	4.79
ships	7.02	7.61	4.14
other transport equipment	1.59	2.85	3.89
electrical machinery	2.54	2.66	3.45
electro. comp	4.24	3.23	2.66
instruments	2.98	2.46	2.24
basic metals, non-ferrous	2.33	1.51	1.51
basic metals, ferrous	1.06	0.50	1.46
coke, ref. petrol. prod & nuclear fuel	1.29	1.39	1.36
rubber & plastic products	0.79	0.72	0.95
fabricated metal products	0.64	0.63	0.57
non-metallic mineral products	0.93	0.45	0.61
pharmaceuticals	0.77	0.89	0.49
pulp, paper & paper products	0.26	0.14	0.32
food, beverages and tobacco	0.28	0.23	0.15
leather products	0.05	0.08	0.15
textiles	0.21	0.13	0.14
office, account & computing	0.37	0.24	0.12

machinery			
furniture	0.06	0.05	0.06
wearing apparel & fur	0.02	0.01	0.06
recycling	0.14	0.26	0.03
publ. print. & repro. of rec. media	0.14	0.20	0.20
other manufacturing	0.08	0.04	0.01
wood & cork	0.04	0.02	0.10
total manufacturing	100	100	100

Source: own calculations on OECD data.