CHAPTER 3
FOSTERING KNOWLEDGE ABSORPTION IN RUSSIAN FIRMS THROUGH COMPETITIVE PRESSURE

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The Russian Federation devotes considerable resources and manpower to research and development (R&D), yet the Russian economy lags behind other large OECD and middle-income economies in R&D-based outputs. In the face of the challenges for reforming the national system of innovation, microeconomic evidence shows that firms facing stiffer competitive pressures also innovate more—and that firm-level R&D has a strong, positive, and significant association with technological and organizational innovation and absorption. Governmental initiatives to promote innovation do not appear to recognize the significant role of competitive pressure in fostering innovation and absorption.

Improving absorptive capacity—the ability to tap into the world technology pool—can be a major driver of increased productivity growth. Yet this capacity to absorb knowledge is contingent on the effectiveness of trade flows, labor mobility, licensing agreements, and foreign direct investment. It also requires a good investment climate, education, and domestic R&D. This chapter argues that increasing the capacity and incentives of private firms to absorb knowledge and innovate is critical. Based on an empirical study of underlying firm characteristics, investments, and environmental conditions, it shows a positive and significant correlation of a firm's likelihood to absorb or innovate to competitive pressures in their product markets.

The distinction between knowledge absorption (introducing products and technologies new to the firm) and R&D/innovation (creating capital goods and final outputs new to the world) is important in a large economy like Russia's. Although this chapter focuses on new-to-the-firm absorption, the complementarities between absorptive capacity and R&D/innovation are extensively supported by theoretical and empirical work, so R&D/innovation is also discussed at some length.

Specifically, the empirical work deals with a wide range of absorptive activities of firms, including the introduction of new and improved products and manufacturing technology, exports of technology-intensive goods, organizational change and outsourcing, and soft innovation through quality controls, certification, and automated systems.

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This chapter first discusses the specific characteristics and relative strengths of domestic sources of knowledge absorption, including R&D and intellectual property, through international benchmarking. Cross-country comparisons in the second section pinpoint potential obstacles for foreign sources of absorption and innovation operating through trade flows and FDI. The third section identifies the determinants of R&D expenditures and absorption-related activities in Russian manufacturing firms, comparing the results internationally. The last section discusses policies that the government could undertake to support commercial efforts at knowledge absorption and innovation.

DOMESTIC SOURCES OF KNOWLEDGE ABSORPTION AND INTERNATIONAL BENCHMARKING

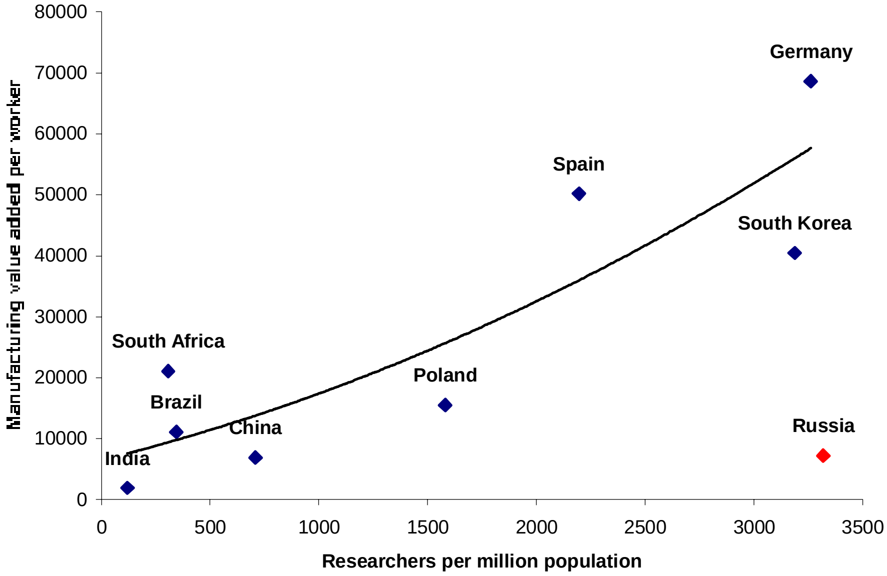
By international standards, Russia spends large amounts of money—and employs many workers—in research and development (R&D). Indeed, Russia now has as many researchers per capita as the R&D-intensive economies of South Korea and Germany. Domestic spending on R&D in Russia, even after plummeting in the early 1990s, was about 1.2 percent of the country's GDP in 2004—equivalent to China's but higher than that of other developing economies such as Brazil, India, and South Africa (0.9 percent 0.8 percent, 0.7 percent respectively).[14]

Much of expenditure is the legacy of Soviet state socialism, under which industrial R&D grew large. The persisting effects (positive and negative) of this legacy have been discussed widely, and a recent World Bank report outlines some of the remaining inefficiencies: "Currently, many of the S&T (science and technology) resources are isolated both bureaucratically (in the sense that they are deployed in the rigid hierarchical system devised in the 1920s to mobilize resources for rapid state-planned industrial development and national defense), functionally (in the sense that there are few links between the supply of S&T output by research institutes and the demand for S&T by Russian or foreign enterprises), and geographically (in the sense that many assets are located in formerly closed cities or isolated science/atomic cities). Overcoming the inefficiencies embedded in these sunk costs incurred during the socialist period and adjusting the S&T system to the demands of a market economy will require a major program of institutional and enterprise reform which, in turn, will make the task more daunting, although no less necessary" (World Bank 2002, p. 2).

Despite the size of the R&D effort (in spending and personnel), Russia's manufacturing productivity has not benefited (figure 3.1). Based on the number of researchers, Russia's productivity should be among the highest—on par with Germany and South Korea. Instead, Russia's R&D activities fall well short of their potential.

14. These figures are from the OECD database on R&D expenditure. Not all figures were available for the most recent year (2004), so figures for the most recent year available were used instead.

Figure 3.1 Russia's many researchers are not associated with high productivity



Source: World Bank (2006e) and OECD (2005b).

The composition of R&D spending by economic sector changed in the 1990s but it still remains largely financed by the government. In 2003 the Russian government was still financing 58 percent of R&D expenditures (OECD average: 30 percent in 2002), and Russian industry financed 23 percent of total R&D outlays (OECD average: 62 percent).[15] Private expenditures on R&D have changed very little over the past eight years.[16] Such imbalances have been underlined as a major problem by a recent study: "The Achilles' heel of the Russian innovation system is the weakness of corporate R&D, despite some encouraging developments over the last two to three years. The efforts to transfer near-market research from public organizations to business firms, to promote the creation of technology-based firms, to encourage private investment in R&D, and to attract R&D intensive foreign investment have not been entirely successful. The reasons are many but the fact is that business enterprises contributed no more than 20 percent of total R&D expenditure in 2002" (OECD 2005b, p. 35).

These expenditures do not seem to translate into R&D-related "outputs"—at least of the kind that can be measured and compared across countries, such as the number of international patents accumulated or the number of articles in scientific journals.[17] The number of patent applications

15. These figures are from the OECD database on R&D expenditure. Not all figures were available for the most recent year (2004), so figures for the most recent year available were used instead. According to Russian official data for 2004, government expenditures on R&D were 59.6 percent of total expenditures (CSRS 2005, p.75).
16. According to CSRS data (2005, p. 75) the share of funding from the "business enterprise sector" was 17.3 percent in 1998 and 21.4 percent in 2004. This indicator is quite difficult to decipher because it includes expenditures of state-owned enterprises and thus is not "private," but it gives an idea of the evolution over time.
[17] The number of patents is highly influenced by export activity in a country. Given the fact that the process to apply for and receive a patent implies costs to the owner of the knowledge, a patent may be pursued only when there is a

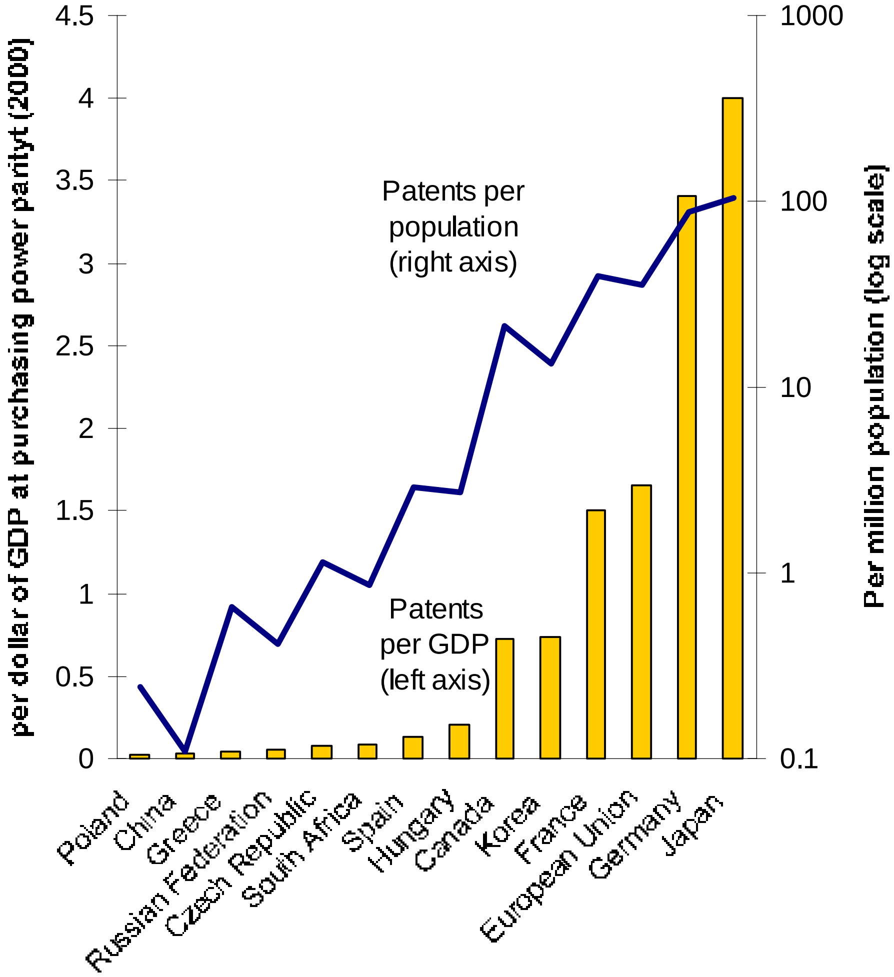
(to U.S., EU, and Japan patent offices) per unit of GDP is significantly lower than in OECD countries and the other BRICS (figure 3.2). Clearly, patents are only an imperfect proxy for cutting-edge (new-to-the-world) innovation, given that much innovation takes place without patenting—and are an even worse proxy of knowledge absorption. Improvements in the manufacturing process normally fall outside the domain of patents. And more important for Russia, patenting normally takes place in the countries in which the inventors have commercial interests—local patenting could be more relevant to Russian inventors than U.S. patenting. In addition, the high costs of applying (and maintaining) a patent may deter many inventors from filing for protection.

Comparing patents filed in Russia and other countries may reflect a weaker IPR regime, the tendency of Russian entrepreneurs to avoid registering patents locally due to weak enforcement, the lack of confidence that a Russian patent ensures international protection, and the concern that registration requires disclosure of secret information. So the registration of patents in overseas markets is a more important reflection of patent intensity. The number of "triadic" patent applications by Russian entities (to U.S., EU, and Japanese patent offices) is significantly lower than that by entities in OECD countries and in several non-OECD countries. The use of patenting in the United States as an indicator of knowledge has been pioneered by Griliches (1994, 1998) and followed by Jaffe and Trajtenberg (2002) and Lederman and Maloney (2003b).

Royalty and licensing fees paid by Russian entities in 2004 reached US$1 billion, roughly 0.2 percent of its GDP, and equivalent to that of China and of several other middle-income countries. Licensing and royalty fees received by Russian entities during that same time, however, were only US$220 million. This low figure, together with the modest patenting activity, suggests that the international commercial value so far realized by Russian R&D expenditures is limited.

significant commercial value of the underlying knowledge in the target market (such as the United States or European Union).

Figure 3.2. Russia's large R&D sector produces few patents

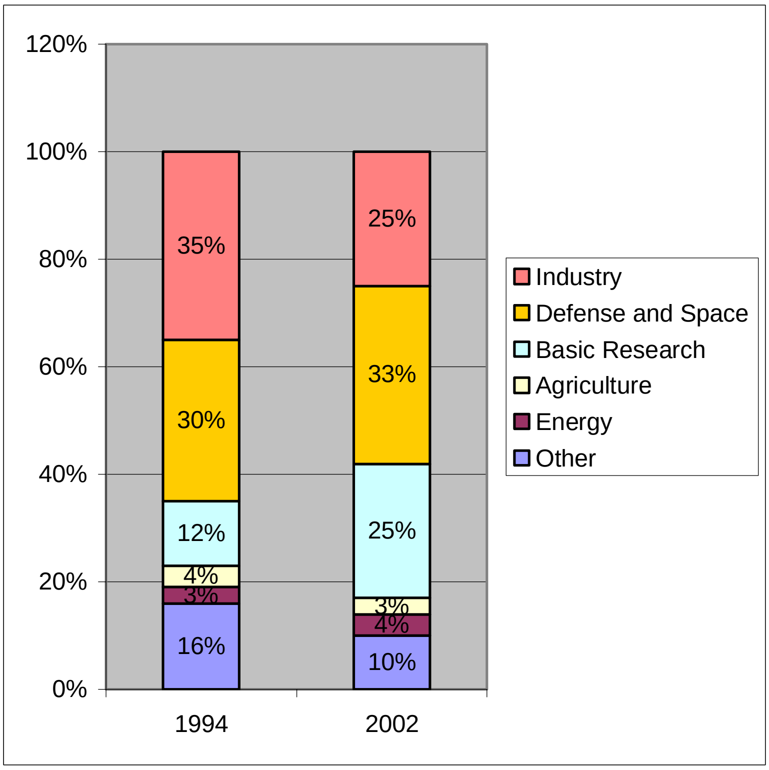


Note: 2002 estimates. Patent counts are according to inventor's country of residence, based on patents applied for at the European, U.S., and Japanese patent offices.
Source: OECD Patent Database (2005a).

The composition of R&D expenditure by economic sector, though, has changed in the 1990s. A breakdown shows reduced emphasis on applied R&D for industrial purposes and, to less degree, for agriculture (figure 3.3). R&D expenditure on defense and aerospace increased from 1994 to 2002, when expenditures on basic research more than doubled. But these expenditures do not seem to translate directly into standard indicators of research activity, such as the number of patents accumulated[18] (per thousand researchers) or the number of articles in scientific journals by Russian researchers.

[18] The number of patents is highly influenced by export activity in the country. Given the fact that the process to apply for and receive a patent implies costs to the owner of the knowledge, a patent may be pursued only when there

Figure 3.3. R&D expenditure by economic sector



Source: Nauka v Rossyiskoy Federatsii, Statistichesky sbornik HSE 2005.

The description of the Russian R&D sector in the OECD's 1994 report on "Science, Technology and Innovation Policies" captures fundamental characteristics that still affect the size and structure of the sector: "Once established, R&D organizations grew inexorably, following the pattern of extensive growth typical of the whole economy. There is no doubt that, in relation to the scale of the economy and its real level of development, Russia now has an excessively large S&T sector."[19] This observation is largely consistent with the data in chapter 2: the Russian R&D sector seems to be quite developed, but surprisingly inefficient. The OECD report identified as a priority the need to downsize what it termed an "oversized, ill-adapted system in rapid deterioration."

Under the Soviet S&T system, the objective of servicing large state-owned enterprises (SOEs) and the defense complex undeniably molded the Russian innovation system.[20] Research was located mainly in specialized technology institutes reporting to the respective 70+ line ministries subject to the central plan. Research institutes were not in universities, and they developed very

is a significant commercial value of the underlying knowledge in the target market (such as the United States or European Union).

[19] See also Russian Science and its statistical indicators (2004, p.75) and OECD (2004b, p.192).

[20] According to Boris Saltykov, 75 percent of Soviet R&D was defense-oriented. Basic science was usually emphasized because in certain areas the Soviet Union was the world leader.

narrow areas of specialization, as lateral interaction between innovative agents was not encouraged by the central planning apparatus. Intellectual property generated anywhere was also formally financed by the government and so belonged by default to the state. Dissemination of new knowledge, know-how, or technological progress from the most advanced establishments within the Soviet system—the isolated defense-oriented "Yaschik"—was prohibited.

Financing for research establishments was allocated largely on the basis of such input indicators as the number of scientists and not necessarily on the research program. Historically the incentive schemes for collaboration between most government-funded research establishments and enterprises were very weak. As a result, following the dismantling of the military complex and the privatization of the SOE sector, the remaining innovation system could hardly meet the needs of the private sector.

In sum, the inherent difficulties associated with transitioning from a state-financed to a market-based innovation system still seem to constrain Russia's knowledge absorption capability. And private financing of R&D seems trapped at pre-transition levels.

FOREIGN SOURCES OF KNOWLEDGE ABSORPTION

Two potential channels[21] of *absorption* of knowledge and innovation are important for Russian industry (Hoekmann and Javorcik 2006):

- **Trade**. Enterprises absorb knowledge through imported capital goods and technological inputs. Exporters benefit from their trade with suppliers and clients in more advanced markets through learning effects.
- **FDI**. Technology spillovers from foreign investors to suppliers and clients are beneficial for the destination country, and foreign entry by itself can increase knowledge absorption by competitors.

This section investigates the necessary but by no means sufficient conditions for the absorption of knowledge and technology from abroad. More specifically, it draws on international comparisons of trade and FDI data to assess whether Russian firms are in a position to absorb knowledge created in other countries.

TRADE

The diffusion of knowledge and technology through trade can be enlarged in primarily two ways: an increase in trade volume, and an increase in the quality of trade (goods with higher capital intensity) (Coe, Helpman, and Hoffmaister 1997; Keller 2002). Gains from international diffusion of technology amplify the overall productivity gain with greater openness. But it is not only the quantity of trade that matters—whom you trade with also makes the difference.

The standard argument is that importing new vintages of capital goods can directly increase manufacturing productivity by increasing the capital-to-labor ratio and by raising the average quality of the capital stock. Consequently, a larger share of capital good imports from more advanced countries would be positively associated with industrial productivity and economic

[21] A third channel is direct trade in knowledge through purchasing patents and licensing.

growth. In 2004 the Russian Federation imported $33.8 billion in capital goods, or 28 percent of total imports.[22] In 2005 the top five countries exporting capital goods to Russia were Germany ($9.3 billion, or 29.3 percent of the total), Finland ($3.3 billion, or 8 percent), the Netherlands ($2.6 billion, or 6.3 percent), Italy ($2.5 billion, or 7.2 percent), and China ($1.8 billion, or 4.4 percent). Overall, a large majority of Russia's imports of capital goods come from partners that are economically and technologically more advanced.

In addition, simply trading with countries that have a more advanced knowledge and technology base—whether capital goods or other commodities—can generate positive spillovers in "learning" from buyers (for exports) or sellers (for imports) (Kraay 1999). As an approximate indicator of the potential supply and demand for learning, table 3.1 presents the volumes of imports and exports for Russia's major trading partners and table 3.2 shows the top commodities in this trade. The tables point to the substantial share of Russia's import and exports to the EU and the United States, the concentration of exports in oil, gas, and natural resources, and the importance of capital goods.

Table 3.1 Russian imports and exports, by country of origin and destination, 2005

Exports

Destination	*Trade value (billions)*
Germany	$19.9
USA	$16.1
China	$15.9
Turkey	$12.9
Ukraine	$12.8
Other reporters	$138.2
Total exports:	$215.9

Imports

Origin	*Trade value (billions)*
Germany	$21.0
China	$13.2
Italy	$7.5
Ukraine	$7.5
Finland	$7.1
Other reporters	$63.7
Total imports:	$120.1

Source: COMTRADE.

[22] Data from COMTRADE on "capital goods (except transport equipment), and parts and accessories thereof," classified as BEC-4.

Table 3.2. Russian imports and exports, by type of commodity (2005)

Top exports

Description	*Trade value (billions)*
Fuels and lubricants, primary	$98.4
Industrial supplies nes, processed	$54.5
Fuels and lubricants, processed	$30.9
Industrial supplies nes, primary	$11.3
Food and beverages, processed	$3.7
Other commodities	$17.2

Top imports

Description	*Trade value (billions)*
Industrial supplies nes, processed	$25.3
Capital goods (except transport equipment)	$24.2
Food and beverages, processed	$12.9
Consumption goods nes, semi-durable	$12.1
Parts and accessories of capital goods (except transport equipment)	$9.6
Other commodities	$36.0

Source: COMTRADE .

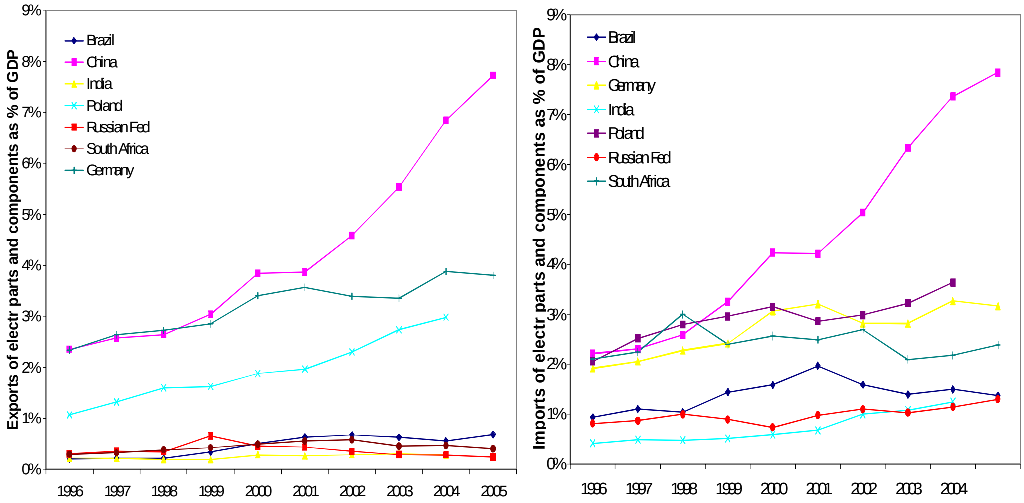
Because of the heavy reliance of exports on natural resources, the overall volume of trade is probably not a very good indicator of the potential knowledge diffusion. It is more useful to look at the trade in parts and components with countries already well integrated in global production networks. Trade in such intermediate goods can facilitate the acquisition of new technology through vertical knowledge spillovers—those between suppliers and customers operating in global production sharing networks.[23] It is also useful to focus attention on this type of trade because some of the literature has shown that "countries that promote exports of more sophisticated goods grow faster" (Rodrik 2006a).

Macro data shows that most BRICS countries and some comparators, like Germany and Poland, are more integrated than Russia in global production networks. The growth of China's share of parts and components is exceptional, but all other BRICS, as well as the other comparator countries, are also exporting more parts and components than Russia as a share of their GDP. The picture is similar for imports, where the evidence shows that Russia is only slightly ahead of

[23] Global production sharing refers to the process where multinational corporations—through FDI—develop international production and distribution networks around the globe. This process facilitates production and distribution in different countries at different phases of the production process, enabling a "true internationalization of the manufacturing process." Intra-industry trade, by contrast, refers to vertically integrated international networks that usually leverage a highly skilled labor force and specialized products.

India. Moreover, imports in parts and components are larger than exports, suggesting that Russian firms are not yet competitive enough in this area.

Figure 3.4 Trade in parts and components for electrical machinery and equipment

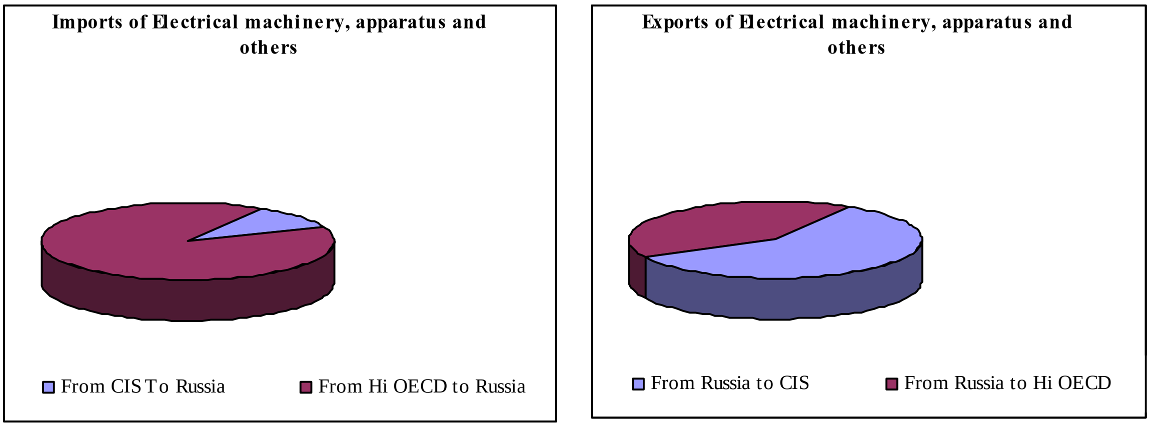


Source: UN Comtrade (WITS) and World Bank (2006e).
Note: The share of exports/imports in parts and components is computed using GDP in current U.S. dollars.

But as mentioned, it's not only the amount of trade that allows a country to be better integrated in global production networks, it's also "whom you trade with." Although the *total* flow of imports and more importantly exports from Russia is to a large extent directed to high income OECD countries, trade in parts and components shows a very different story. While electrical parts and components are mostly imported from high income OECD countries, Russia is exporting the vast majority of its own parts and components to CIS countries.[24] With exports in parts and components as a "litmus test" for integration in global production networks, our evidence suggests that Russia's integration in global production networks is less than complete (figure 3.5). If it is true that exports can boost the spread of new manufacturing methods though learning "from your clients," the data highlight the possible weakness of this channel.

[24] Most CIS countries have not yet made the transition from "buyer driven" production networks (where countries can leverage labor intensive activities and make use of cheap, unskilled labor, typically clothing and furniture) to capital-intensive "producer driven" networks. This transition is usually encouraged by rising wages, but natural resource-rich economies do not always face the same binding constraints (Broadman 2006).

Figure 3.5 Geographical origin of imports and exports in parts and components



Source: COMTRADE

FOREIGN DIRECT INVESTMENT

FDI can promote international technological diffusion if the technological advantage of multinational firms does not remain restricted to one firm or its affiliates (Saggi 2006). Technological spillovers may take place in the recipient country through demonstration effects (imitation), labor turnover, or increased competition. The channels for this spillover can be horizontal (originating from the entry of the multinational investor in the same sector) or vertical (originating in backward linkages if local suppliers supply multinational investors or in forward linkages when local customers buy from multinational investors).

Backward linkages may be more widely observed, since a multinational has more incentive to promote local suppliers, than horizontal linkages inherently linked with increased competition. Recent research by Javorcik (2004) finds a positive effect of FDI on Lithuanian local suppliers working through backward linkages. Another finding is that greater productivity gains are associated with partially owned foreign projects (joint ventures), suggesting that domestic capital participation increases productivity spillovers. This could serve as an interesting model for Russia to attract FDI to complement domestic capital ownership to increase productivity while not displacing the domestic firm's market share by direct foreign competition.

The evidence from Russia indicates that FDI inflows are lagging behind some BRICS comparators (see box 3.1).[25] It suggests that the benefits from international technology diffusion have flowed to a few economic sectors, with FDI heavily concentrated in oil and natural resources (World Bank 2006d). At the same time, the large increases in FDI observed since 2002 suggest a growing balance within manufacturing and between manufacturing and service sectors, indicating that the growing domestic demand for consumer goods is driving a consistent share of the total FDI flow in Russia (Hare, Schaffer, and Shabunina 2004).

[25] The FDI benchmarking analysis in the UNCTAD *World Investment Report 2006* also indicates that Russia has high FDI potential but low FDI performance.

For FDI in joint ventures and mergers, Russian multinationals continue to dominate the outward FDI of the South-East Europe and CIS region, accounting for 87 percent of the total in 2005 (UNCTAD 2006b). This investment includes large deals to acquire and create joint ventures with enterprises in developed economies—notably Lukoil's purchase of Nelson Resources, a Canadian-based oil company, and the recently announced merger of the aluminium and alumina assets of RUSAL, the SUAL Group, and Glencore International. Such partnerships are likely to gain in importance, with evidence that foreign invested enterprises have been important for increasing labor productivity and export competitiveness in such countries as China.[26,27]

One of the most powerful channels for technology diffusion is the ICT channel (Ark and Piatkovski 2004). Usually, a good indicator of a country's capacity to leverage the ICT channel is the amount of FDI in communications, which in Russia remains extremely low (0.4 percent of total annual FDI in 2004–05) (World Bank 2006d). Moreover, according to various private sources (like WITSA 2006), the amount of ICT investment in Russia, as a percent of GDP, is substantially lower than that in CEE countries.

Note that trade in capital goods or FDI inflows are not sufficient for the successful diffusion of technology. A country must be ready to absorb foreign knowledge and manufacturing and sales methods. In Russia vertical knowledge spillovers could be hampered by the central planning legacy of large industrial plants, which were more vertically integrated than western plants (Hare, Schaffer, and Shabunina 2004). Moreover, local R&D, domestic research laboratories, and workers with the right skills are key aspects of the process. Trade competition and R&D expenditures are closely interrelated: unless a country is also well endowed in R&D and invests in R&D, spillovers are not likely (Lederman and Maloney 2003a).

[26] Whalley and Xin (2006) indicate that foreign invested enterprises account for over 50 percent of exports and 60 percent of imports, and are a significant driver of economic growth (the authors calculate that around 40 percent of China's economic growth in 2003 and 2004 is due to FIEs). These enterprises have much greater average labor productivity than non-FIEs, and their export capabilities benefit from access to distribution systems and product designs tailored for export markets.

[27] Concerning absorption, the UNCTAD World Investment Report (2006b, p. 188) argues that, "The advantage of forming a joint venture from the perspective of technology diffusion within the host economy is that the local partners and the affiliate, which would be vested with a certain amount of technological and managerial expertise transferred from the parent firm, are likely to have close contacts and exchanges of personnel. Forming a joint venture is therefore the most obvious—and possibly the most effective—means by which local firms can acquire knowledge from TNCs."

Box 3.1 Gains from reducing barriers to trade and FDI flows in Russia

Russia stands only to gain by reducing its barriers to trade and FDI inflows and thus reaping the benefits of global integration, increased competitiveness, and improved access to business services.

Gains from reducing tariff barriers

The CIS has high average tariff and nontariff barriers, which would need to be reduced in the medium term in order to gain from international integration. For Russia in particular, Rutherford and Tarr (2006) show that the average tariff has increased between 2001 and 2003 from 11.5 percent to between 13–14.5 percent , placing these tariff rates (unweighted, or weighted averages) at a higher level than those of other middle income countries which average 10.6 percent. A reduction in the import tariff by 50 percent will produce gains to the economy on two counts: an improved domestic resource allocation due to a shift in the production to sectors where production is valued higher based on world market prices, and an increase in Russian productivity as a result of Russian businesses being able to import modern technologies. The second impact is more important for Russia.

Trade restrictiveness indices

Kee and others compute indicators of trade restrictiveness that include measures of tariff and non tariff barriers for 91 developing and industrial countries. The table shows two of these indicators for the manufacturing sector: one that focuses on the trade distortions imposed by each country on imports and another that focuses on market access for exports in the rest of the world . It is interesting to note that the Trade Restrictiveness Index for Imports (TRI) for Russia is lower than that of Brazil and India, but higher than that of South Africa, China, and the EU. Russia's TRI is the highest in the ECA region, a reflection of the high tariff and non tariff barriers that it imposes on its imports. On the other hand, Russia faces less trade distortions on its exports from the rest of the world, China being the only country facing a lower level of restrictiveness.

Country	Imports	Exports
Albania	0.070	0.139
Hungary	0.073	0.086
Kazakhstan	0.123	0.115
Kyrgyzstan	0.033	0.116
Lithuania	0.048	0.161
Latvia	0.067	0.114
Romania	0.160	0.116
Russia	0.190	0.078
Poland	0.070	0.108
Bolivia	0.116	0.153
Ukraine	0.183	0.106
Brazil	0.217	0.081
China	0.118	0.060
India	0.203	0.131
South Africa	0.066	0.074
E U	0.081	0.085

Gains from reducing barriers to FDI

Russia fares worse than other countries in the region, attracting one of the lowest levels of FDI inflows. Among the key restrictions on foreign service providers in Russia are the monopoly of Rostelecom on fixed line telephone services, the prohibition of affiliate branches of foreign banks, and the restricted quota on the share of multinationals in the insurance sector. The reduction of barriers to FDI in services alone would result in a gain of the order of 3.7 percent of GDP, accounting for about three-quarters of the total gains to Russia from WTO accession. The reduction in barriers to FDI in services' sectors would allow multinationals to obtain greater post-tax benefits on their investments, encouraging them to increase FDI to supply the Russian market. This in turn would lead to an increase in the total service providers in Russia, giving Russian users improved access to telecommunication, banking, insurance, and other business services, lowering the cost of doing business and increasing the productivity of Russian firms using these services, and providing a growth impetus to the economy.

Source: Rutherford and Tarr (2006); World Bank (2005b); Kee, Nicita, and Olarreaga (2006).

KNOWLEDGE ABSORPTIVE CAPACITY—EVIDENCE FROM FIRM-LEVEL SURVEYS

We now investigate the intensity and effectiveness of private investments in knowledge and technology absorption through the survey data available for Russia and for BRICS and EU comparator countries.[28] Russia has a very large R&D sector (roughly employing the same number of researchers per capita as Germany) but its output is comparable only to that in China, reflecting the strong historical orientation towards military research,[29] the obsolescence afflicting R&D in certain fields now that the economy is more open to knowledge and technology exchanges, and the lack of effective links between public and private R&D. This section uses the LME Survey data and BEEP Surveys data (see the box in Chapter 1 for a description of the surveys) to characterize the drivers of absorption in Russia, an analysis which will explore both outputs and inputs of absorption and compare the results with comparator countries.

According to the LME survey, knowledge absorption activities in Russia are associated with medium-low and medium-high technology manufacturing sectors (table 3.3).[30] Electrical equipment is a leading sector in introducing new/improved products, and introducing manufacturing technologies is significantly more frequent in firms in the chemical industry. Firms in electrical equipment and chemicals, and also in machinery, are more likely to export technology-intensive manufactures. These results suggest that capital-intensive sectors are adopting products and technologies more than labor-intensive industries. For example, 29 percent of firms in the textile industry financed a new/improved product, against 47 percent of firms in other sectors. Results are similar for a new/improved production technology and technology-intensive exports. The food and wood sectors also present weaker absorption.

[28] As in other studies using a production function approach and firm-level data, endogeneity is a possible problem in the estimations, owing to the two-way relationship between technology absorption and R&D spending, absorption outcomes and organizational change, and absorption decisions and competition. As a result, the description of the results is careful not to interpret the correlations in terms of causality, but simply as an association between the likelihood of different investment activities and outcomes. For this reason, caution is needed in comparing the magnitudes of the coefficients, between specifications and regressions with different samples.

[29] According to Boris Saltykov, former Minister of Science, around 75 percent of the Soviet R&D complex was defense oriented.

[30] This follows the classification of industries in the OECD STAN Indicators, based on the International Standard Industrial Classification (ISIC) Revision 3. The four technology categories are low, medium-low, medium-high, and high. Examples of low-technology industries include food products, beverages and tobacco, textiles, wood products, and paper. The high technology manufactures are: pharmaceuticals; office, accounting and computing machinery; radio, television, and communication equipment; medical, precision, and optical instruments; and aircraft and spacecraft.

Table 3.3 Absorption activities by sector

Industry	*Introduced new or improved product*		*Introduced new or improved technology*		*Exports technology-intensive products*	
	%	p-value	%	p-value	%	p-value
Food	48.8	0.247	24.6	0.049**	6	0.000***
(Rest of the sample)	44.6		31.2		28.8	
Textiles	29.4	0.001***	21.7	0.085*	5.4	0.000***
(Rest of the sample)	47.3		30.3		24.9	
Wood	28.6	0.001***	29.8	0.963	17.9	0.23
(Rest of the sample)	47.2		29.5		23.6	
Chemicals	53.4	0.124	43.2	0.003***	39.8	0.000***
(Rest of the sample)	44.9		28.2		21.6	
Metallurgic	42.7	0.535	33	0.416	21.4	0.649
(Rest of the sample)	45.9		29.1		23.4	
Electrical	54.1	0.016**	28.9	0.851	38	0.000***
(Rest of the sample)	44.1		29.7		20.7	
Transport	40	0.263	25.6	0.385	30	0.107
(Rest of the sample)	46.2		29.9		22.5	
Machinery	51.6	0.103	34.8	0.116	38.1	0.000***
(Rest of the sample)	44.5		28.6		20.4	

Note: T test performed to assess whether the two groups (each sector and the rest of the sample) are statistically different from each other. *statistically different at 10 percent. **statistically different at 5 percent. *** statistically different at 1 percent.
Source: LME Survey.

ESTIMATING THE KNOWLEDGE ABSORPTION PRODUCTION FUNCTION: METHODOLOGY AND RESULTS

The econometric analysis here is meant to address three relevant policy questions.

- First, what is the impact of investments by Russian firms in absorption and innovation inputs (for example, R&D expenditures and absorption-enabling investments in IT) on key absorption outputs (for example, the introduction of new and improved products and manufacturing processes)?

- Second, how is the decision to allocate resources toward absorption and the capacity to adopt "hard" and "soft" technology related to the firm's characteristics and the wider economic environment? For example, it is generally argued that innovative activities increase with the size of the firm.

- Third, how does competitive pressure affect the frequency of absorption investments such as financing the introduction of products or the potential for exporting advanced technology products? Specifically, is competition increasing the propensity to innovate?

This section begins to tackle these questions by characterizing the relationship between firm-level probabilities of introducing a new or significantly improved product or production technology and exports of high-technology goods and firm and environmental characteristics. Within this framework, and to shed light on the underlying determinants of absorption outcomes, the section also estimates a technology absorption production function:

$$Absorption = f\,(K, L, ICT, R\&D, COMPRESS, IC)$$

where *K* is access to finance, *L* represents workers' education, skills, and training, *ICT* captures various variables to proxy for technological capability, such as the availability of broadband Internet, a firm website, and an information technology department, *R&D* captures various measures of the expenditure on research and development and related metrics, such as purchase of machinery and equipment and purchase of patents and know-how, *COMPRESS* refers to competitive pressures in the market, and *IC* stands for investment climate. See the annex for a further description of the variables and econometric methods in the regressions.

Technology absorption outcomes are the left-hand variable in the equation. These include the introduction of new and improved new products and production technologies, which in general can be expected to be new to the firm or the country but not new to the world. Different types of investments—among which two key outlays are research and development and purchases of new machinery and equipment—are complements in the outcomes of absorption. The absorption of products and knowledge often goes together with the adoption of advanced production methods.

The rationale for using these variables as indicators of absorptive and innovative capacity in Russian manufacturing firms is as follows. The motivation for including ICT variables is that the most notable increase in productivity in manufacturing since the 1990s has been linked to the adoption of information and communication devices. The Internet allows businesses, their suppliers, and their clients to share and exchange vast amounts of information and knowledge. Indeed, like electricity and steam power, ICT is a "general purpose technology" with the potential to spur growth as it spreads across different sectors of the economy, prompting a transformation in the organization of labor and production (Helpman and Trajtenberg 1996).

ISO certification is a relevant and much-used management standard that directly tries to raise quality to internationally comparable levels. Because reaching these standards requires a minimum level of technological capabilities, ISO norms can be seen as a possible "proxy" for technological adoption. Moreover, because standardization reduces transaction costs, it enables economies of scale and eliminates duplication, good for productivity gains. So, ICT use and ISO certification are not only indicators but also variables of interest themselves.

The relationship between firm-level R&D and innovative outcomes has been investigated thoroughly. The literature, particularly for OECD countries, generally finds a positive and significant association, yet the complexity and uncertainty surrounding knowledge-based activities means estimating a firm-level or aggregate relationship between absorption inputs and outputs is not trivial.[31] To investigate the relationship between private R&D and absorptive

[31] For example, Acs and Audretsch (1988) confirm a positive relationship between R&D expenditures and the number of innovations of firms. The relationship is "sensitive to the total amount of innovative activity. That is, in industries in which there is little innovative activity… the correlation between all the measures of technical change becomes considerably weaker" (p. 682). The authors also refer to results by Griliches (1986), which show that the estimates depend on the definition and measurement of R&D.

outcomes, we used a probit model[32] for the sample of Russian firms (tables 3.4 and 3.5). The results confirm a positive and significant relationship between investments in R&D and the three absorption outcomes: introducing new and improved products, introducing new and improved production technologies, and exporting technology-intensive goods.

Table 3.4 Summary of one by one regressions for product and process innovation (*only significant results shown*)

	Introducing a new or improved product	*Introducing a new or improved technology*	*Exporting technology-intensive products*
Workforce tertiary education	(+)**		
Exporter		(+)**	
Website	(+)***	(+)***	(+)***
Intellectual property	(+)***	(+)***	(+)***
R&D expenditure (>1million)	(+)***	(+)***	(+)***
Third-party R&D	(+)***	(+)***	
ISO certification	(+)***	(+)***	(+)***
Financial constraints	(-)*		(-)**
Access to finance	(+)**		(+)**
Domestic competitive pressure	(+)***		
Imports competitive pressure	(+)***	(+)*	(+)***

Note: All regressions include a constant, size, new private firm, firm holding, foreign owner, and sectoral dummies and use a random effects model. See annex tables A3.2–A3.4 for detailed results. Significance is given by robust standard errors clustered by regions. * significant at 10 percent; ** significant at 5 percent; *** significant at 1%.

Source: LME Survey.

The fact that Russian firms show a positive association between R&D spending and absorptive results is definitely a positive sign for the capacity for modernization (especially for LMEs in manufacturing). But this result does not imply that there are no remaining obstacles for Russian firms to make effective investments in R&D. Additional econometric estimations compare the probability of achieving an innovative outcome between firms in Russia and comparator countries (see table A3.6 in the annex, which describes the data and model used for the estimations). They show that firms' efficacy in absorption activities is higher in Russia than in China, but lower than in South Africa and Brazil. There is thus leeway for improving the innovation and absorption capabilities of firms and to correct some of the external obstacles that reduce incentives to improve the outcomes of R&D expenditure.

32. Random effects and clustering are used to control for regional specific variables that may be driving innovative activities. This empirical model is meant to test for partial correlations and links between innovation outputs and inputs, but it is not an attempt to identify causal effects between these variables.

As expected, there are some significant and positive correlations between absorption outcomes and absorption-enabling inputs, such as ISO certification and IT use. ISO certification is significant only for advanced technology exports in the full model (table 3.5). But when taken alone—with the firm characteristics as controls—ISO certification turns out to be significant for all three absorption outcomes. IT use, in this case measured by the existence of a corporate website, is strongly associated with a higher likelihood of innovating. Finally, the purchase of intellectual property in Russia or abroad (patent rights, licenses for using inventions, production prototypes, and utility models) is strongly and positively associated with the probability of introducing product and process improvements at the firm level and positively associated with high-technology exports. This result implies that technical knowledge codified in intellectual property rights contributes to a learning process that improves absorptive capabilities.

Table 3.5 Regression results for the full model of product and process innovation

(*only significant results shown)*

	Introducing a new or improved product	*Introducing a new or improved technology*	*Exporting technology-intensive products*
Size (<250)			(-)***
New private firm			(+)**
Website	(+)***	(+)**	(+)**
Intellectual property	(+)***	(+)***	(+)*
R&D expenditure (>1million)	(+)***	(+)***	(+)***
Third-party R&D	(+)***	(+)***	
ISO certification			(+)***
Access to finance		(+)*	
Macroeconomic instability	(-)*		
Domestic competitive pressure	(+)**		
Imports competitive pressure			(+)**
Observations	729	729	729

Note: See annex table A3.5 for full regression results. All regressions include a constant, size, new private firm, firm holding, foreign owner, and sectoral dummies and use a random effects model. Significance is given by robust standard errors clustered by regions. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent. P-values given in brackets.

The coefficients related to other firm characteristics show mixed significance. Firm size is not related to introducing new or improved products or processes, but larger firms are significantly more likely to export high-technology products. This suggests that scale is a factor in export-oriented absorption policies. But there is a positive relationship between exporting and introducing new technologies (table 3.4), yet no evidence for a relationship with the other dimensions of absorption. Tertiary education levels of employees have a positive impact on introducing new products (table 3.4), but this effect is lost in the full model (table 3.5), perhaps a reflection of the relatively weak impact of skills after adding other controls (chapter 4).

Lack of finance is often cited as a major constraint on the innovative activity of firms. We use two variables to gauge the effect of finance, one measures the firms' financial constraint and the other gauges the access to finance and financial institutions. The estimation indicates a negative and significant relationship (table 3.4) between financing shortages and adopting product or process improvements, as well as exporting technology-intensive products. Similarly there is a positive and significant relationship between these two absorption outcomes and the access to finance variable, the expected result (table 3.4). Because the finance variables and the size of the firm are highly correlated, if the model is estimated without the size variable, the finance variables become significant for all the absorption outcomes. On investment climate variables, macroeconomic instability has a negative and significant effect on the probability that a firm will introduce a new product, suggesting that firms tend to absorb knowledge when the macroeconomic environment is stable (table 3.5).

EMPIRICAL ANALYSIS OF "SOFT" INNOVATION AND ORGANIZATIONAL CHANGE

The econometric analysis of the determinants of firm-level R&D expenditures (table A3.7 in the annex) reiterates many of the findings reported in the previous section. Again, firms that are larger and have adopted ICT and ISO certification are likely to spend more on R&D. The significance of ISO certification points to possible complementarities between the organizational capability of the firm and its capacity to conduct in-house R&D. In this case the educational level of the workforce also has a positive relation with R&D expenditure. Exporters have significantly greater R&D expenditures.

Even though public R&D spending in Russia is much larger than private R&D spending, only 23 percent of firms surveyed outsourced part of their R&D activities to third parties.[33] The positive relation between third-party R&D and in-house R&D by firms underlines the fact that the two are probably complementary for firms. Given the imbalances between public and private research, there is surely a great deal of room for additional collaboration.

To complete the analysis of innovativeness in Russian firms, we turn now to the determinants of investment activities that aim to improve organizational capabilities. These activities are referred to as "soft innovation" because they are tied to changes in processes and systems that seek to increase productivity of the existing capital stock and workforce. The econometric analysis examines five dimensions of soft innovation that reflect how firms absorb and implement production practices: implementing a reorganized organizational structure, hiring external management consultants, outsourcing functions and business-processes to specialized third-party contractors, introducing input quality control for materials and production, and introducing an automated system of inventory management.

The reason for enlarging the examination of absorption is that improving the characteristics of how firms are organized can be critical for knowledge absorption and innovation, in a sense capturing "how ready" firms are to apply and enhance new products and technologies. In the light of international differences in "innovative efficiency," this seems very relevant for the process of catch-up by Russian firms (table A3.6 in annex).

The results of the regressions show that organizational absorption is an investment activity that is also more likely in larger firms (tables 3.6 and 3.7). Firm size apart, the significance of the other determinants really depends on the form of organizational change. Firms more likely to restructure are those:

[33] In 2004 the government share of R&D spending was 59.6% (CSRS 2005, p.75).

- Established before 1992 (probably because they have an unfinished restructuring agenda).
- Spending more than average on R&D.
- Less likely to face a financial constraint.
- More likely to face intense competitive pressures.
- More likely to be exporters of high-technology products.
- More likely to outsource R&D to third-parties.
- To be in environments where regulatory problems are perceived.
- On the direction of causality for some of the foregoing associations, one might expect that restructuring leads to an easing of the financial constraints and to greater R&D spending, but the data do not allow a test of this question.

Table 3.6 Summary of one by one regressions for organizational innovation
(only significant results shown)

	Reorganized organizational structure	*Hired external consultants*	*Outsourced to third party*	*Introduced input quality control*	*Automated system of inventory management*
Workforce tertiary education					(+)***
Exporter			(+)**		
Intellectual property		(+)*	(+)***		(+)***
R&D expenditure (>1million)	(+)***	(+)**	(+)**	(+)***	(+)***
ISO certification	(+)***			(+)***	(+)***
Financial constraints	(-)**	(-)**			
Access to finance	(+)**	(+)***	(+)*	(+)*	
Domestic competitive pressure	(+)**				
Imports competitive pressure	(+)***				
Foreign producer competitive pressure	(+)**	(+)*			
Financed new or improved product	(+)*	(+)**		(+)***	(+)**
Financed new or improved technology	(+)*	(+)***		(+)***	(+)***
Exported technology-intensive products	(+)**			(+)**	
Third-party R&D	(+)**	(+)**			
Machinery & equipment	(+)*	(+)**	(+)**	(+)***	(+)*
Macroeconomic instability		(+)**			
Regulatory constraints	(+)**				
Infrastructure constraints					(-)***

Note: All regressions include a constant, size, new private, holding, foreign owner, and sectoral dummies and use a random effects model. Significance is given by robust standard errors clustered by regions. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent. *Source*: LME Survey.

For firms to hire external management consultants, the significant determinants are having foreign equity participation, introducing a new/improved production technology (which points to the interrelatedness between "hard" and "soft" technology), outsourcing R&D, and being affected by macroeconomic instability. Business-process outsourcing is more likely for firms that are part of a holding with foreign ownership. Input quality control is strongly associated with introducing a new product, an expected result. Last, the introduction of an automated inventory management system is positively associated with firms that have a more educated workforce, that have obtained ISO certification, and that have introduced new production technologies. The overall pattern suggests a very natural correspondence between the capabilities of the firms, particularly in their innovativeness, and the decisions to implement costly management improvement measures to raise quality and optimize production systems.

Table 3.7 Regression results of the full model for soft innovation and organizational changes

(only significant results shown)

	Reorganized organizational structure	*Hired external consultants*	*Outsourced to third party*	*Introduced input quality control*	*Automated system of inventory management*
Size (<250)	(-)***	(-)**	(-)*		(-)**
New private firm	(-)*				
Firm holding	(+)*		(+)***		
Foreign owner		(+)**	(+)***		
Workforce tertiary education					(+)***
Exporter					
ISO certification					(+)**
Financial constraints access to finance		(+)***	(+)*		
Imports competitive pressure	(+)**				
Financed new product				(+)***	
Financed new technology		(+)*			(+)*
Exported technology-intensive products	(+)**				
Third-party R&D	(+)**	(+)**			
Macroeconomic instability		(+)**			
Regulatory constraints	(+)**				
Observations	731	731	731	731	731

Note: See annex table A3.8 for detailed results. All regressions include a constant and sectoral dummies and use a random effects model. Significance is given by robust standard errors clustered by regions. * significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent. P-values given in brackets.
Source: LME Survey.

COMPETITION AS AN INCENTIVE TO ABSORPTION

One of the most robust results to draw from the estimation of the absorption production function is that competitive pressures have a positive and significant effect on a variety of innovative and absorptive outcomes. To investigate this relation further in a Russia-specific context, we turn to analyzing the evidence on competitive pressures from the firm-level data available.

We test the hypothesis that competitive pressures have a positive impact on innovative activities of firms, using a variety of samples to test the robustness of the results (see annex table A3.9 for the full range of specifications tested). In the LME sample, as expected, firms subject to competitive pressure are more likely to engage in innovative activities. In particular competitive pressures coming from domestic firms are positively and significantly correlated with the introduction of new and improved products. Unexpectedly, competitive pressures from domestic firms are negatively correlated with exports of advanced technology goods.[34] Firms that face significant competitive pressures are about 20 percent more likely to introduce new and improved products, controlling for sectors, firm characteristics, and the like (figure 3.6). In contrast, firms that enjoy monopolist positions or other forms of protection are less likely to change their products and production methods than firms facing greater competitive pressures. They also contribute to an unpredictable and uncertain regulatory environment. In sum, a monopolistic position can seriously hurt investments in technology absorption and innovation.

Competitive pressure arising from imports, by contrast, seems to bear most heavily on exports of advanced technology products, as captured by the econometric results in annex table A3.9. Because exports of high technology are often considered a key element and a crucial contribution to sustained long-term growth, this finding seems particularly important, especially in the light of the recent debate on diversifying the structure of the Russian economy (Litwack 2005).[35]

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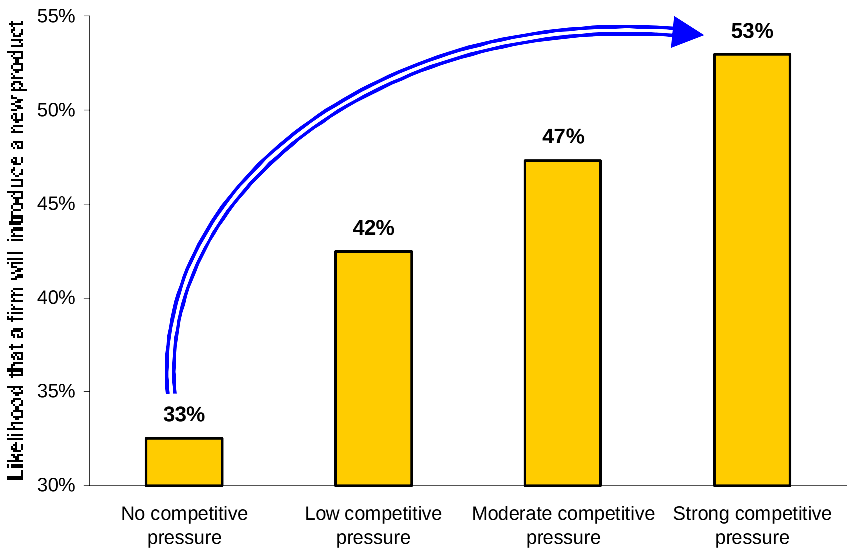
[34] The evidence here is based on different indicators, mostly based on a firm's assessment of the level of competition in its main market. Even though we tested a number of different indicators and specifications, these findings should be interpreted more as the confirmation of a quite developed part of empirical findings on the same topic.

[35] As indicated by Rodrik, "China's experience indicates that it *not how much* you export, but *what* you export that matters" (2006b).

Figure 3.6 Competitive pressure and absorption activities



Source: Based on simulations using the LME survey; for details, see the annex to chapter 5.

The robustness of the association between competition and knowledge absorption under different specifications is important given the methodological difficulties of the simultaneous determination of these two variables: industry structure shapes the incentives to adopt technology and innovate and innovative activities modify the competitive environment. The most recent theoretical and empirical thinking about this relationship points to an inverted U-shape curve between competitive pressure and innovation (Aghion and others 2002).

The upward sloping segment of this curve reflects the fact that product differentiation and cost advantages are more important when industries are more competitive—and that innovation and absorption are effective instruments for firms to improve product quality and reduce manufacturing costs. In neck-and-neck industry structures, firms compete on the basis of lowering prices because their product lines and manufacturing processes are identical. So their absorptive and innovative activities become a solution to escape price competition and compete on quality and cost. The downward sloping segment indicates that very intense competition erodes firm profits, which in turn reduces the resources available to invest in R&D.

The impact of competitive pressures on knowledge absorption, innovation, and productivity has been studied quite extensively in the literature. Carlin, Schaffer, and Seabright (2004, p. 20), using a dataset from a survey of nearly 4,000 firms in 24 transition countries (BEEP Surveys), "find evidence of the importance of a minimum of rivalry in both absorption and growth: the presence of at least a few competitors is effective both directly and through improving the efficiency with which the rents from market power in product markets are utilized to undertake innovation." They conclude that: "our findings strongly reinforce the message that unchallenged monopoly is a drain on dynamism" (p. 25).[36] Moreover, the World Development Report 2005 on the investment climate focused on the importance of a vibrant, competitive business environment for firms' investments in skills, absorption, and innovation: "If firms are not subject to competitive pressures that stimulate technical progress and the demand for more skilled workers, then effective demand for education will be weak" (World Bank 2005e, p. 157).

THE ROLE OF GOVERNMENT IN SUPPORTING ABSORPTION

The government of the Russian Federation is already proposing to strengthen and create several new initiatives to promote absorption and innovation in smaller firms and larger industrial firms.[37] For smaller firms, the measures include more effective infrastructure (technology parks, incubators), centers that offer specialized services, and financial support for small firms and start-ups. Support for larger firms and the development of absorption networks and clusters include indirect measures to stimulate exports, quality certification assistance, cofinancing for venturing into global markets, support for patenting abroad, and support for the development of joint R&D projects. For these proposed measures to have the expected impact, it will be very important to translate them into specific interventions. The strategy does not appear to recognize the crucial role of competitive pressures for the modernization of the Russian economy or the emerging trend toward increased exposure to foreign R&D (primarily through FDI, imports, and licensing, but also by encouraging mobility and exchanges abroad).

There have been many official efforts to support firms but information on the scope of those measures is scarce, limiting the possibilities to evaluate their impact. One of the most successful support instruments is the Fund for Assistance to Small Innovative Enterprises (*Bortnik* Fund), with a budget of about $30 million a year. Although the fund has an important demonstration role, it does not have a major impact on the R&D sector in Russia, and it has yet to be replicated on a large scale (box 3.2).

[36] We follow in this paper the example of Carlin, Schaffer, and Seabright (2004) in using measures of market power that correspond to the perceptions of individual firms as to the competitive pressures they face. They argue that: "These are an important supplement to more conventional measures, such as shares of markets based on conventional industrial classifications. These can help not just in illuminating the overall pressures faced by firms but also in the way in which different constraints on managerial decision-making interact."
[37] See the "Strategy of Russian Federation in the Area of Development of Science and Innovations until 2015," approved in March 2006.

Box 3.2 The Fund for Assistance to Small Innovative Enterprises

The Fund for Assistance to Small Innovative Enterprises was created in 1994 by the Russian government.[38] The budget, from the government, is 1.5 percent of the total federal expenditures for civilian science. The Fund supports small innovative companies through open competition. The proposals for support prepared by the innovative companies are submitted to peer review by external reviewers from science and business sectors (including representatives of banks and venture and investment funds). The financial share of the Fund in the winning projects cannot exceed 50 percent, and the companies have rights to the intellectual property created in the projects. The Fund provides support only to projects included in a list of government-approved critical technologies.

In the late 1990s, the Fund began to increase support to companies at the seed and start-up stages, obviously a riskier strategy. The change was stimulated not only by a stabilization of the general economic situation but also by the fact that the financial resources of the Fund were becoming larger. In addition, the return to the Fund from earlier loans was stable and provided additional money.

1. In 2003 the Fund initiated a program called START to support start-up companies. About half of the Fund's budget has since been devoted to the START program ($10 million when the Fund was started in 2003; approximately $15 million in 2006). In its composition and instruments the program resembles the American SBIR program. The first results show that about 20 percent of supported firms managed to find investors and thus get support from the Fund for the second year. This is a rather encouraging result showing that there are quite a few technology-intensive goods and services created by small firms whose commercial potential may be realized.

2. With a budget of about $30 million a year, the Fund has not had a large impact on the R&D sector in Russia. It can only demonstrate the success of this or that instrument or approach. So far, it seems the experience of the Fund is not replicated by other government agencies.

3. Saltykov and Kuznetsov did a cost benefit analysis of a proposed bank loan for innovation infrastructure. The results gathered on the Bortnik's Fund show that the scale is small, that the number of participants is limited, and that the fund finances only firms with impeccable credit history. Thus, it was concluded, the fund doesn't allow for financing start-ups.

Source: Bortnik (2004).

Yakovlev (2006) addresses the reach of government support in Russia using information collected through the Enterprise survey. Even though there is the perception that government support to enterprises has been limited, a quarter of firms surveyed received direct support to either investment, absorption, or exports, although the amounts are low.[39] Among these types of support, incentives to export appear least pervasive, with only 3 percent of firms receiving it. At the same time, 28 percent of firms surveyed receive indirect support through procurement contracts with the government. Almost half the companies surveyed (44 percent) received some sort of support, either direct or indirect. Direct support is provided more often to companies that have had significant innovative activity or exported a considerable proportion of their production.[40] This finding goes against the perception that government support is granted mainly to inefficient firms. The overall perception of the impact of state policies on the firms' own performance is low, and more than 50 percent of firms considered that no support is given. This perception does not appear to vary significantly across firms of different sizes, industrial sectors, and locations. Moreover, most firms felt that the actions of the different ministries with a role in support had no impact on their activities.

[38] Resolution No. 65 of February 3, 1994.

[39] 5.6% of firms received two or more types of support.

[40] This is not the case for indirect support, so it cannot be affirmed that effectiveness is a consideration in the granting of procurement contracts. Exporting by itself is considered as a factor signaling effectiveness of firms.

Proposal 1: *Reform the IPR regime to encourage researchers at public R&D institutes and universities to engage in private innovation while protecting the public's IPRs—and support patenting activity of firms, especially patenting abroad and patenting by smaller firms with less capacity.*

The legacy of the Soviet science and technology system is still negatively affecting the orientation and overall level of appropriation and exploitation activities in the NIS (OECD 2005b). The incentive conflicts in the current arrangement have resulted in a de facto privatization of R&D activities. This can be observed in multiple scientific research teams based within the public system providing R&D services on an informal yet commercial basis to LMEs and SMEs. Some may see this as an encouraging beginning of an organic R&D industry. But there are negative consequences, including conflicts of interests between researchers and institutes, uncertainty surrounding the ownership of technical results, and the state not capturing the rents due to it from the intellectual property generated through this quasi-private research. Consider India's Council of Scientific and Industrial Research: founded in 1942 it has evolved with the changing economic structure of the country to become an internationally competitive institute (box 3.3).

Box 3.3 From autarkic self-reliance to internationally competitive research and development in India

The Council of Scientific and Industrial Research (CSIR), founded in 1942, was modeled after the U.K. Department of Scientific and Industrial Research. Predating most other specialized research and development institutes in India, it took on a wide range of functions from promotion of scientific research to setting up research and development institutions and collecting and disseminating data on research and industry. In the first two decades after India's independence, it focused on building up an extensive research and development infrastructure from metrology to research and development over a wide range of industries with a strong focus on supporting emerging industry, especially small and medium enterprises.

When India changed from an inward-oriented development strategy to a more outward and market-driven one as a result of the 1991 crisis, the focus of the CSIR also changed from technological self-reliance to "research and development" as a business. There was more emphasis on output and performance in a more competitive market and on doing work that was relevant for the productive sectors and that could earn income. Each laboratory was considered a subsidiary corporate entity. Incentives and rewards for meeting targets were introduced. The laboratories were given autonomy in operations in relation to how well they delivered on committed output and deliverables. In addition there have been continuous efforts to streamline the CSIR further to improve its effectiveness and efficiency.

Although the CSIR is going through further restructuring, the results have been impressive. Between 1997 and 2002 the CSIR reduced its laboratories from 40 to 38 and staffing from 24,000 to 2,000. At the same time, output increased noticeably. Technical and scientific publications in the internationally recognized journals increased from 1,576 in 1995 to 2,900 in 2005; and their average impact factor, from 1.5 to 2.2. Patent filings in India increased from 264 in 1997/98 to 418 in 2004/05, patent filings abroad, from 94 in 1997/98 to 500 in 2004/05. And the CSIR accounted for around 50–60 percent of all U.S. patents granted to resident Indian inventors. In addition CSIR increased its earnings from outside income from 1.8 billion rupees in 1995/96 to 3.1 billion rupees in 2005/06 (about $65 million). Today, it has 4,700 active scientists and technologists in 37 research laboratories, supported by 8,500 scientific and technical personnel.

Source: Bhojwani (2006).

The government should consider additional policies to create incentives for spinning off research groups. The objective would be to lower the public financing burden in R&D institutes, foster commercial innovation and knowledge absorption by firms, and reallocate basic research funding in favor of universities. Although downsizing R&D institutes has occurred, the most promising and active researchers have also been lost. The average age of those employed in R&D has risen along with the reduction in the number of personnel. University-based research would create a nurturing ground for young researchers, following the experience worldwide. In moving to a more efficient and effective national innovation system, it will be important to hasten the dissolution of R&D institutes and teams within them that work on obsolete scientific and industrial problems given the advances in global science.

Proposal 2: *Provide incentives for firms to invest more in knowledge absorptive capacity to encourage productivity growth. Specifically, more use should be made of instruments such as matching grants for supporting the absorption of new technologies and processes, access to ICT and ISO certification, and investments in "soft" technology.*

Since the 1980s there has been increasing awareness in OECD countries of the benefits of matching grants in encouraging firms to share and manage risk.[41] We recommend matching grants because they encourage public-private risk-sharing and orient the selection process toward R&D programs most likely to generate outcomes with a high commercial impact.[42] The justification for supporting ICT technologies and international certification is that these investments have strong and positive effects on productivity and innovative behavior.

Clearly, there are major risks to the effective allocation of matching grants—including program corruption, capture, and sectoral targeting. So, one prerequisite for the success of these instruments is an institutional design that would immunize the funding allocation from interference by political actors, corruption, and other state or specific interests. A second prerequisite is neutrality: the program should not try to steer the grants in any predetermined direction by targeting ("picking winners").

To avoid government capture and failure, a matching grant program should be as neutral and transparent as possible. The decision-making processes for funding allocations need to have sufficient checks and balances through a wide representation of private sector, academia, civil society, and foreign expertise. An optimal design should include the following key elements:

- The administration and funding decisions are located in an independent institution with a clear mandate and control mechanism, separating it from other public policy goals.
- The funding decision is made by an independent investment committee. To enhance transparency it is advisable to staff the investment committee with technical experts and foreign experts who are less likely to be subject to political influence. A potential problem is the question of confidentiality and fear of industrial espionage.

[41] The following paragraphs are based on a World Bank report, *Public Financial Support for Commercial Innovation,* which analyzes the various financial instruments to encourage innovation and recommends a series of reforms before these instruments can be put to good use (2006c).
[42] The importance of matching stems from the fact that it reduces the marginal cost of research to the firm. A firm facing a downward-sloping marginal research return schedule will always increase total expenditure when the marginal cost falls, precluding dollar-for-dollar crowding-out.

- The investment policy and decision processes are instituted and supervised by a supervisory board consisting of representatives of different government institutions and international advisors.
- Technical assessments of the project proposals are based on external peer reviews involving international experts where possible.
- All project proposals and decisions are recorded, tracked, and made publicly available. E-government procurement technologies should be considered to aid the process.

A traditional approach to innovation, absorption, and R&D support for firms has been through tax incentives (tax credits or lower tax rates), widely used in Europe to encourage investors or companies to invest in R&D. But tax incentives have weaknesses that make them less applicable to post-socialist economies, and these seem significant enough to not recommend them. First, tax benefits are meant to help existing enterprises that can use profits from related products to take advantage of the credits or offsets. But they do not help start-ups that have not yet accumulated sufficient profits and therefore cannot offset tax liabilities. Second, in countries with a weak tax enforcement system, tax incentives may promote distorting tax avoidance behavior rather than productive investment. Third, tax incentives cannot be used (as grants can) to promote networks and linkages between the private sector and universities and research institutes, which lie at the heart of the type of instrument we recommend. The IET study unsurprisingly finds that most respondents are keen about tax benefits.[43]

Proposal 3: *Private "seed" capital funds should be encouraged, but state-owned and state-managed VC funds proposed by the government should be avoided.*

The government's program on "Generating incentives for development of the manufacturing sector" envisages the establishment of the OJSC, a Russian venture company that would be a government-owned institution supporting innovation by acquiring participations in existing venture funds and by contributing to the creation of new funds. This would augment the existing provision of state financing for the creation and especially the expansion of new high-growth firms through venture funds, building on the experience and organizations of the regional venture funds created in the 1990s with EBRD support. An open question is whether the funding is meant to be a transitory support that leads to the creation of a private venture market. That would require an "exit mechanism" for the government if and when a critical mass of venture projects is in place and incentives for private investment using venture funds are also satisfied.

International best practice suggests that the government could "seed" the venture capital industry by investing in privately managed funds. In these public-private partnerships, government participation mitigates some of the risk in technology-oriented start-ups, and the "seed" capitalist provides commercial and managerial expertise. It would still be advisable for the "seed" capital program to be flexible in targeting small start-up high-technology companies by allowing public-private risk sharing with flexible contracting between investors and managers, free from excessive regulation, and the use of limited partnerships.

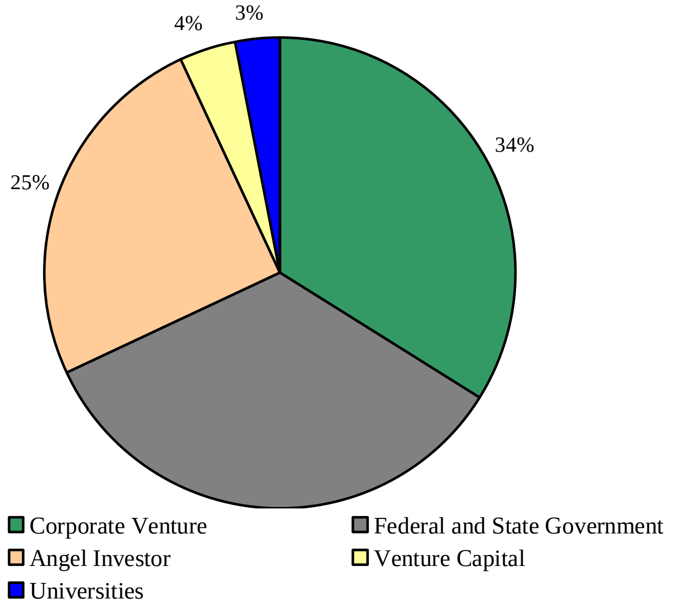
[43] Respondents in the IET survey express preferences for the introduction of incremental tax privilege for R&D costs and purchase of foreign technologies.

Internal financing by enterprises, government funding, and angel investors are all important in early-stage technological development (ESTD) (figure 3.7). But most important, it emphasizes the virtual absence of more mainstream intermediaries such as banks, private equity, and other institutional investors. Even in one of the most advanced and innovative economies, early-stage finance of innovative projects is undertaken directly by firms, if they have the resources, or by very specialized institutions, with a significant role for the government. Not surprisingly, internal funds account for the biggest share of ESTD financing in the United States because that is the most straightforward way of overcoming information asymmetries. Established enterprises know the track record of their own inventors and employees—and they typically have a better understanding of the market and the commercial potential of internally proposed innovations than outside agents do. Enterprises use the cash flows generated by established operations to finance innovation or tap external funds on the basis of the strength of their balance sheet.

Angel investors are another important source of ESTD funding in the United States and to some extent in Europe. The term refers to successful entrepreneurs who look for new opportunities to invest private funds (earned from their previous economic activities) and are willing to invest in ESTD projects in technological fields that they understand well (having "been there and done that"). Studies of the behavior of angel investors frequently find that they are often heavily involved in commercial decision making and that this "business support" function can be as important as the financing. Managerial advice and commercial control over the ESTD entrepreneur are typical characteristics of the angel investor and venture capital funding models—as well as internal funding models.

Given the short history of capitalist accumulation and profit-generating enterprises in Russia, internal financing by enterprises and angel investors is rare in the region and does not provide a viable basis for promoting innovation. The absence of angel investors is problematic not only from a funding perspective but also given their role as sources of managerial expertise, as information brokers, and as access points to formal and informal networks of entrepreneurs and innovators. The role of government is therefore different in Russia from that in OECD countries. The lack of angels and internal financing is acute, and the capacity of government agencies to fill their place is extremely limited.

Figure 3.7 Funding in the United States



Source: World Bank (2006c)

In this respect, some caution is warranted for the Russian government's initiative to establish venture capital funds companies with 100 percent state participation. International experiences show that publicly financed and managed venture capital funds may be ineffective in fostering the commercialization of new and improved goods and services and the expansion of innovative firms. The role of state-owned and state-managed venture capital funds in financing innovative projects in India, for example, was limited. Most of the funds set up in India in the relatively high-growth period (1995–2000) tended to be private funds, financed heavily from overseas by communities of "Non-Resident Indians" (box 3.4).

Box 3.4 Mixed experiences with state support for venture funds: India

Over the last two decades the Indian government has supported the VC industry through the creation of a regulatory framework for VC activity beginning in the late-1980s and direct support for setting up VC funds in the early 1990s (Dossani and Kenney 2001). It is considered that the rise of the Indian IT industry owes part of its success to the availability of VC finance, yet the evidence is mixed about the true impact of government support measures for fostering VC.

Regulatory framework

It is likely that the early interventions to improve the institutional structure affecting the VC industry were good for its development. Specifically, some positive factors are the gradual streamlining of regulations for VC funds, deregulation of the business environment in general, and liberalization policies for capital markets (participation by foreign institutional investors). These reforms loosened the conditions that allow innovative businesses to prosper and VC funds to invest. Regulatory reform of venture investing by private funds is an area where Russia could draw positive lessons, as legal obstacles to these investment activities are still significant according to government reports and other studies.[44]

Direct support

In the early 1990s the government provided $45 million to four public sector financial institutions to establish their venture capital operations: a development financial institution (Industrial Credit and Investment Corporation of India, ICICI), a nationalized bank (Canara Bank), and two state finance corporations in Gujarat and Andhra Pradesh.[45] In 1988 the first venture capital organization, the Technology Development and Information Company of India (TDICI), had been established in Bangalore as a subsidiary of ICICI in collaboration with Unit Trust of India, the largest public sector mutual fund in India.

The performance of these funds was unsatisfactory, and they (and the industry in general) were plagued by inexperienced management, regulatory constraints, prescriptive regulations with mandates to invest in specified sectors and states/provinces, and a tendency to invest in lower risk projects. Only TDICI's performance was reasonable. Subsequently, APIDC's fund management was privatized in 1995. The government's stake in ICICI was progressively diluted over the years through regular divestments in the public equity markets, and the venture capital subsidiary (now ICICI ventures) is no longer constrained by public sector bureaucracy in its day-to-day operations and has become the largest venture capital-private equity player in India today.

This experience indicates that state-run VC funds have seldom been successful, in India, or in other countries. Any positive impact has been mostly through learning "spillovers" of training investment specialists and demonstration effects, rather than through the start-ups and innovative projects actually funded.

It can be argued that the single most important factor for the VC and IT industries in India was the combination of the diaspora returnees and a generous supply of engineering and IT talent. The nexus of successful businesses created out of this talent pool sparked spin-off and investment activities. This, in turn, influenced the government to improve further business conditions. The lesson is that directly intervening to manage the allocation of VC funds is unlikely to lead to the expected results.

When venture capital funds managed by government entities operate with commercial success, it is often because the funds are invested in small, more mature companies with less risky product lines, rather than in innovative ventures. Moreover, capture and rent seeking are prevalent and problematic because these types of funds are dominated by political interests.

One advantage of implementing proposals 2 and 3 simultaneously is that the synergies between the two can establish a more integrated framework for supporting entrepreneurial companies. A seed capital program aimed at promoting knowledge absorption is likely to work best when a

[44] This issue is treated at length in a 2001 report by the Ministry of Industry Science and Technology of the Russian Federation, "Role of State in Creating Favorable Innovation Climate in Russia: Background Report". It continues to be an important element of recent policy discussions and was included in the "Russian Federation Policy on the Development of Science and Technology for the Period to 2010 and Beyond" (Schweitzer and Guenter 2005).

[45] Through a World Bank supported project.

grants program provides critical funding at the earlier stages of technological development, subsequently supported by private seed capital funds. The reason is that commercial venture capital funds typically avoid the risk connected with early-stage companies and target projects that have passed the early stage. Matching grants can fill this gap in the support framework for "early stage" technology development.

In the more mature stages of technological development, seed capital provides funds to expand production and the customer base, and supports the later (and most visible) stages of commercialization. To minimize the potential negative distortions of both these proposals, the instrument design should ensure "neutrality," wherein the government does not decide which sector or technology to support but responds to market demands (World Bank 2006c). When applied to matching grants or to the funding of seed capital funds, this translates into the government establishing universal criteria for submission and eligibility but allowing an independent and transparent selection mechanism to choose projects for support.