Restructuring of Research and Development Institutes in Europe and Central Asia

— Draft —

April 13, 2009

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THE WORLD BANK
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R&D institutes (RDIs) in Europe and Central Asia (ECA) are a legacy of central planning, a legacy which represents the unfinished restructuring agenda in ECA. During the socialist period, RDIs were part of a system in which most often R&D was not performed “in-house” within enterprises and therefore was not directly driven by production needs or market demand. Further, the lack of a feedback mechanism from the end users to the sources of innovation limited the diffusion of technology and innovation. The separation between the supply and demand for innovation was particularly visible in the Soviet Union where industry-research linkages were mediated by the responsible ministry. Funding for all these RDIs was provided directly or indirectly by the state.

We draw on case studies of RDIs in several ECA countries — Russia, Ukraine, Croatia, Serbia, Poland, and Bulgaria — to investigate the status of these RDIs today, the role they play in providing R&D services to industry, and the challenges these organizations face. The case studies show that, two decades into the transition, many of the RDIs that are still operating as standalone entities have made limited progress in terms of the intensity and quality of their interactions with the overall national innovation system and specifically in the range of services they provide to industry and it exposes areas that lag far behind, such as knowledge management, licensing, incentive structures and staffing.
As can be seen in the figure below (Figure 1), EAC RDIs in the sample (light blue) have fewer financial resources per staff than their OECD counterparts (dark blue). If the income is adjusted for purchasing power parity (PPP) to account for the fact that salaries are a large share of expenses, the adjusted income of several RDIs is comparable to what one would find in OECD RDIs such as Sintef and TNO. But roughly a third of the RDIs have an income, which even when adjusted, accounts for a fraction of what one would see in OECD RDIs. These RDIs are highly under-resourced, which reduces their capacity of retain and attract skilled personnel.

Figure 1: Total public and private sector funding per staff

Reform Strategy

We build on the extensive literature on enterprise restructuring and privatization in ECA on the one hand, and on the evidence from the RDI statistics and case studies on the other hand, to propose a strategy for reform of RDIs based on their relevance to national priorities, their expected role as providers of public versus private goods, their performance levels and their relation to relevant markets and users. When deciding on what ownership and management structure can provide the right incentives for RDIs, governments need to make a distinction between RDIs that provide mainly public goods vis-à-vis RDIs already selling or with the potential to sell mainly private goods and services. There is a continuum of possibilities and any classification of RDIs must take into account that RDIs often produce public and private goods, both at the institution-level and within individual teams and projects. If an RDI is not assessed to be performing well, another essential distinction is between RDIs whose products and services are developed responding to concrete demands in the market ("market pull") and those RDIs whose R&D is self-initiated, leveraging a core capability to come up with a technology ("technology push").1 This latter dimension is of particular interest to ECA RDIs because it strongly differentiates them from OECD RDIs, which tend to be more demand-driven.

The report discusses: (i) diagnostics that could be used to operationalize the classification of RDIs using readily available data about their activities and outputs, as an initial screening device for policymakers; (ii) RDI governance reform options in more length, reviewing advantages and drawbacks found when ap-

1 — See chapter 2 for clarification on the use of these terms in the literature.
plying these in RDIs globally as well as in the ECA enterprise sector; (iii) public funding options that should be put in place to support RDI governance reform, as well as other policy levers to improve the overall performance of the R&D sector and increase the impact on competitiveness.

We present below the two components of reform: (i) Diagnostic tools to guide RDI reform; and (ii) Options for reform and restructuring RDIs.

### 1. Diagnostic Tools to Guide RDI Reform

RDIs can be classified in terms of optimal management and ownership structure using two sets of characteristics. Figure 2 shows the continuum between private and public goods production on the vertical axis, and on the horizontal axis we classify RDIs by their relation to their relevant markets/users. Within this continuum we make a classification of RDIs that can serve as a basis for governments to decide which RDI should remain government owned and government operated (Quadrant I), government owned but operated by contractors or organized as autonomous non-governmental entities (Quadrant II), restructured or closed (Quadrant III) or privatized to insiders or to outsiders (Quadrant IV).

This classification of RDIs according to R&D outputs and organizational characteristics is also a good starting point for discussing the advantages of different public funding instruments. If RDIs are producing a large share of public goods (Quadrants I and II), then public support through institutional / strategic funding (e.g., “block grants”) is probably needed to partially subsidize recurrent expenditures such as salaries of researchers and strategic assets. RDIs mostly producing private goods (Quadrant IV) should not have access to such funding streams. At the same time, competitive funding allocated based on peer review and public procurement can help to top-up the budgets of RDIs for high-quality projects in more experimental areas; in the case of RDIs in Quadrant IV. This should preferably be through matching grants that provide incentives for collaboration with industry from early on. Figure 3 summarizes the questions that ECA policy-makers need to address for each RDI.

**Figure 2: Classification of RDIs**
2. Options for Restructuring RDIs

We identify five restructuring options, presented in Table 1 together with their characteristics.

Under this option, the government maintains its ownership and management of RDIs but tries to increase their effectiveness by granting them more autonomy. Governments are interested in this option for RDIs producing public goods with strategic implications such as defense, nuclear, standards, etc. that have no private or commercial, current or prospective clients. Increased autonomy is meant to allow government-owned RDIs more freedom in terms of the direction of the innovation activity, including establishment of small companies. The disadvantages of this option in terms of governance must be kept in mind. Increased autonomy of government-owned RDIs contains a high scope for rent seeking and leaves unresolved the issue of interaction between private and public

<table>
<thead>
<tr>
<th>Option</th>
<th>Relevance to public goods RDIs</th>
<th>Effect on market-pull of RDIs</th>
<th>Effect on RDI governance incentives</th>
<th>Political feasibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Corporatization / autonomy Government-owned</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>2. Insider restructuring, Government-owned</td>
<td>+</td>
<td>±</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>3. Government-owned, contractor operated (GOCO)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>4. Non-profit Foundation</td>
<td>+</td>
<td>-</td>
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</tr>
<tr>
<td>5. Insider privatization</td>
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<td>±</td>
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<td>6. Outsider privatization</td>
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<td>-</td>
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<td>7. Liquidation/closure</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>--</td>
</tr>
</tbody>
</table>
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stakeholders. The form of public/state-owned R&D institutes may not be conducive to science-industry collaboration unless certain preconditions in terms of RDI governance are in place and sweeteners are made available in the form of public subsidies.

**Insider Restructuring of Government-owned RDIs**

Under this option, the government restructures the RDIs with the help of its current management by spinning off non-core activities, but maintains its ownership. A restructuring plan specifies which activities will be core activities, which activities will be integrated to other organisations or ‘spun-off’ and which will be liquidated.

Gradual restructuring of R&D institutes is a voluntary management-driven activity that is funded and facilitated by a government program for supporting restructuring of R&D institutes. It is gradual as it is based on bottom-up initiatives by the management of R&D institutes and their financial participation. Ownership after restructuring under this option will remain in the hands of the government while control will remain in the hands of the current management. It is not clear, however, who will be the residual claimant, if there are any profits, which might be the case in the more commercial RDIs.

**Government-owned, Contractor-operated (GOCO)**

Under this option the government contracts out the management of the RDI to an outside contractor but maintains government ownership. The contractor may be a university or university consortium, a for-profit corporation, a not-for-profit organization, or a professional and external management team or CEO. The logic of this option is that government ownership addresses the objective of public good provision and the contractor management facilitates meeting market demand and ensures improvements in internal governance and management.
GOCO contracts were designed to be insulated from political pressures, and to be better able to attract and retain talented personnel because they did not have to conform to civil service rules. With management contracts, responsibility for managing, operating, and developing an entity is transferred to a contractor or investor from the private sector for a period of time who is paid for these services and simultaneously the level of public funding for operating and investment expenses are agreed upon.

Insider or Outsider Privatization and/or Closure

The privatization and/or closure option is relevant to Quadrants III and IV, where private knowledge-based goods and services provide a revenue stream to run an RDI on a purely or mostly commercial basis. Methods of “privatization” for public enterprises include sale through public subscription, sale of shares to employees or sale to a strategic investor.

We define insider privatization as a sale of the company’s shares to its managers and workers; and outsider privatization as a sale to an investor who is an outsider, i.e. neither as manager or a worker of the company. The 1990’s privatization of RDIs in ECA is considered to have had negative outcomes. In Russia, privatization that took place in the mid-90’s led to acquisitions by investors interested in the valuable real estate possessed by the centrally located RDIs. The investors then typically disbanded the RDI and used the real estate to develop shopping malls and for other commercial urban uses. Another way to deal with the concern about assets is insider privatization: selling the shares of the enterprise to its researchers.

If the government as owner of an RDI comes to the conclusion that neither of the other options mentioned in Table 1 can resolve the problems of an RDI, the last resort is closure. Obviously, politically this is the most difficult option and we show to in the table with “double minus”.

To the extent that this RDI produces public goods the effect of closure on the economy is negative but the extent that the state-owned RDI sell private goods, the effect of closure is positive: the “crowding out” because leveling of the playing field vis-à-vis private companies (usually SMEs) which produce same products. Finally, if all options fail, i.e. the RDI cannot be transformed into a form of organization that would improve its governance, closure is positive.
R&D institutes (RDIs) in Europe and Central Asia (ECA) are a legacy of central planning that is widely recognized as part of the unfinished restructuring agenda in ECA. During the socialist period, RDIs were part of a production and innovation system in which most often R&D was not performed ‘in-house’ within enterprises and therefore was not directly driven by production needs or market demand (Radosevic, 1998). The lack of a market for technologies or feedback mechanisms between end users and sources of innovation limited the diffusion of technology and innovation. The separation between the supply and demand for innovation was particularly visible in the Soviet Union where industry-research linkages were mediated by the responsible ministry.

Funding for all these RDIs was provided directly or indirectly by the State. In Central Eastern Europe, particularly in the former Yugoslavia, the links between industry and research institutes were closer (Meske, 2004). Although Turkey does not have the same history of central-planning as other ECA countries, its RDI system was created by a very centralized State and faced many of the same challenges as in ECA countries, namely being cut off from the productive economy.

Prior to transition, ECA countries typically had three main actors comprising their science and research systems: the Academies of Science, the branch sector, and universities. Of these, the Academies of Science...
(AoS) were dominant in their influence over the national science and technology system, primarily conducting basic or fundamental science research and helping to establish national science policy. The AoS had their own research institutes, and these typically focused on basic research. Turkey’s RDIs were organized under the Scientific and Technological Research Council of Turkey (TÜBİTAK) in 1963 while others continued to operate under specific ministries.

The branch sector was the primary institutional home for applied R&D. The bulk of applied research in ECA countries pre-transition was concentrated in the industrial RDIs which fell under the purview of the industrial or branch ministries. The state owned these RDIs and various industrial ministries supervised the activities of industrial RDIs located in their respective branches.

The military or defense sector accounted for much of the applied research activity in transition countries, particularly in the former Soviet Union. During the Cold War, most of these countries developed extensive, state-funded, top-down, military-industrial complexes. Before transition, universities in ECA countries were mostly focused on teaching and conducted very little research. Poland is among a few exceptions where the share of R&D performed at universities, even in socialist times, was relatively high.

The overarching feature of ECA RDIs was the centralization of decision-making and administration, which led to little direct cooperation and communication among the various segments of national innovation system. R&D was not organized as an ‘in-house’ activity or R&D in industry, but as R&D for industry (Radosevic, 1998).

Restructuring of industrial RDIs in the transition has proved problematic as they could not be clearly classified as public or private organizations. Their knowledge profile overlapped public–private boundaries, which led to very different privatization approaches across ECA. Many ECA governments believed that by privatizing these institutes, enterprises would lose contact with organizations that were actually substituting for their missing R&D capabilities. On the other hand, these organizations have been producing sector-specific knowledge which could benefit a larger community of enterprises in different sectors.

In ECA, R&D Investments Continue to be Too Low and Ineffective

Although there is a wide variation in the intensity of R&D spending across countries, as shown in Figure 1.1, it tends to be lower in ECA countries. Some Nordic countries like Sweden and Finland spend close to 4 percent of GDP on R&D, which is around double the OECD and EU27 averages. The large OECD countries including the US, Germany, France and the UK have an R&D intensity of between 2 and 3 percent. Russia and Hungary, the economies in ECA with the highest R&D intensity, spend just over 1 percent of GDP.

Moreover, innovation outputs are comparatively low in ECA, even when considering the level of R&D inputs. In the largest ECA country, Russia, for example, inputs in terms of share of researchers in the population and aggregate outlays for R&D in GDP are comparable with those of Germany and South Korea and far ahead of those of Brazil, China, and India. But the high level of inputs does not translate into high value added per capita. Russia lags behind OECD and other large middle-income countries in R&D outputs; it also has a relatively low number of patents and scientific publications per capita.3

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2 — The term “basic sciences” refers to the classical disciplines of mathematics, chemistry, physics, and biology, among others. Such research may have no direct or immediate practical application or commercial benefit.

3 — Schaefer and Kuznetsov (in Can Russia Compete?, Desai and Goldberg 2008) show that despite Russia devoting significant resources at the aggregate level to R&D, it is not translated into higher levels of TFP. The authors suggest that the coexistence of a large R&D sphere and low productivity in manufacturing indicates low productivity in R&D institutions and weak links between R&D and the economy.
Moreover, most ECA countries are relatively inefficient at turning R&D investments into applied results. A closer examination of their patenting activity reveals that they spend more on R&D than most EU-15 countries for each USPTO patent they generate (Figure 1.2). Hence, ECA’s low patenting performance can be attributed to both its low level of investments in R&D and inefficiencies within its innovation system.

It must be emphasized that USPTO patents measure only innovation at the global technological frontier, while much of the R&D in ECA countries is used for catching up purposes. Radosevic (2005) does not find inefficiencies in R&D in ECA countries when considering national patents, but comparing national patents has its shortcomings since patents may be easier to obtain in one country than in another. However, in his empirical work, Radosevic does find inefficiencies in converting measures of innovation outputs, such as patents, into productivity in ECA countries.

Recent empirical evidence produced by the Austrian Institute of Economic Research⁴ also shows that there is no correlation between R&D expenditures in ECA countries and product quality, namely unit values of exported products and net exports in industries where price is sensitive to quality. The study also finds that after including comparator countries in the sample, namely Germany, Spain, the United Kingdom, South Korea, Brazil and China, the relationship becomes positive and statistically significant for the two first indicators, at the 5 and 10 percent level of significance respectively. The lack of correlation between R&D and the quality of ECA’s products points to a disconnect between investments in R&D and outcomes in the productive sector. Here again, unit values can only provide a rough measure of innovation efficiency since only a portion of the R&D (namely process R&D and R&D for learning) performed nationally aims to improve product quality. Nonetheless, ECA enterprises included in the EU’s

⁴ — To be published in an upcoming World Bank Working Paper
2006 Community Innovation Survey consistently view improving quality consistently as one of the two most important effects of innovation.

As a result, ECA countries are quickly being surpassed by India and China in terms of patenting. Figure 1.3 (Goldberg et al, 2008) compares U.S patents granted for seven ECA countries (Russia, Hungary, the Czech Republic, Poland, Slovenia, Bulgaria, and Ukraine) to those granted to China and India.

Despite the negative impact of the transition period to R&D in the 1990s, until recently inventors based in these ECA countries consistently received more U.S. patent grants than did inventors in India and China. However, there is a clear acceleration in India- and China-based patenting in the most recent years, which is not evident in ECA patenting. The stagnant record of patenting in ECA since 2001 contrasts sharply with the almost exponential growth in China-based inventive activity.

The Rudjer Boskovic Institute, an RDI in Croatia, is receiving World Bank support to commercialize research from both internal and external sources. Its subsidiary company, Rudjer Innovations, helps Rudjer Boskovic Institute as well as other RDIs and universities launch spin-off companies. One of them is **Initium Futuri**, a telemedicine firm founded by a group of four undergraduates from the University of Zagreb. Their flagship product is the Smart ECG Project, which provides real-time electrocardiogram monitoring and diagnostics abilities to offsite medical personnel through a GPS system. In less than a year the spin-off has already signed business contracts and presented its products at international trade shows, including the Microsoft annual Imagine Cup Innovation Program. It was invited to the finals of the International Federation of Inventors’ Associations in China in 2008. Establishing a spin-off created both an opportunity for the young entrepreneurs, and the basis for cooperation on software development with the Rudjer Boskovic Institute.
In ECA, R&D is Dominated by the Public Sector

In ECA, the public sector plays an important and sometimes even dominant role in performing R&D. Figure 3 shows that the concentration of R&D personnel in the public sector is high in most ECA countries. In Bulgaria, Azerbaijan and Kyrgyzstan, more than 60 percent of R&D personnel are employed by the state. Figure 1.4, in parallel, shows that the public sector plays a much larger role in ECA than in comparator countries. Although the data in this figure, drawn from the UNESCO statistical database, shows low levels of publicly performed research for Turkey in 2004, there has been a steep increase in the R&D budgets for RDIs in the past five years. Total funding for RDI research more than doubled over the 2003-2006 period, from €135 million to €284 million. In high-income economies, the private sector typically dominates national R&D activities. R&D in the private sector responds to market incentives and is more likely to lead to useful innovations than public sector R&D, although the two are complementary.

Figure 1.4 and Figure 1.5 may actually even underestimate the government’s role in R&D in ECA since large portions of the business enterprise sector are still state-owned in Russia, Ukraine and other CIS countries.

The case of Bulgaria is illustrative. The Bulgarian Academy of Sciences, an autonomous state-funded institution, performs most of the research in the country, even after significant downsizing since 1991. With 69 institutes, laboratories centers and museum and a staff of 8,100, it employs approximately half of Bulgaria's R&D workforce, is responsible for over half of the country’s scientific publication and patent output (BAS 2006) and consumes more than half of total government R&D funding. In Poland, the 232 RDIs consume more than one-third of the overall public allocation for research.

Further, government funding to RDIs have been increasing over the years in a sample of ECA countries

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5 — Eurostat database

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Figure 1.4 R&D personnel by sector of employment

Note: 2004 data used for Croatia, Romania, Malaysia, Spain and Turkey. 2005 data used for all other countries.
Source: UNESCO.

Figure 1.5 Gross Expenditures in R&D by Sector of Performance

Note: 2004 data used for Croatia, Romania, Malaysia and Turkey. 2005 data used for all other countries.
Source: UNESCO.
for which data is available. For example in Russia these subsidies represented 0.17 percent of GDP in 2002 and have increased to 0.26 percent of GDP in 2007 (Figure 1.6). In Croatia, the equivalent numbers are 0.16 percent of GDP in 2002 and increased to 0.22 percent in 2007. In Turkey, these numbers represent a lower yet increasing share of GDP: 0.02 percent of GDP in 2002 and 0.06 percent of GDP in 2007.

Several Models for Organizing R&D Existed in ECA Before 1990

The low investments in R&D, the limited efficiency of R&D and the disconnect between R&D and the private sector all stem from a history of centrally-planned research system and on the effects of transition on ECA countries’ research capacities. The literature refers to three distinct groups of transition countries on the basis of their science and technology systems up to 1990 (Meske 2004). The first group consists of former Soviet economies. The second group consists of the Central Eastern European countries that were closely linked to the USSR as members of the Warsaw pact and the CMEA but were independent states prior to 1990. The third group consists of the former SFR Yugoslavia which shared the least in terms of their institutional structures with the Soviet system. Turkey as a non-transition country is in a group of its own.

The degree to which countries were close to the Soviet R&D model was determined by various aspects. These included: the share of R&D activities carried out within industrial enterprises (share of ‘in-house’ R&D); the extent to which R&D was carried out by industrial institutes; the degree to which universities played a teaching versus research role; the degree to which economies were open or closed for S&T cooperation (Gokhberg, 1997).

The major source of commercialization of research differed according to these characteristics. Table 1.1 indicates that Hungary and former-Yugoslavia had by far the highest share of enterprise patenting. Bulgaria and Czechoslovakia had patents both from enterprises and industrial institutes, while Polish and Romanian patenting was dominated by industrial institutes. Enterprises played a very marginal role in the Soviet model.
The 1990s Transition Led to Incomplete Restructuring of RDIs

The collapse of state funding and budgetary difficulties led to greatly reduced R&D funding in the 1990's. In addition to the lack of funds, the decentralization of decision-making and abolition of central planning led to the hastened dissolution of many research units. RDI units saw a collapse in their funding from the state budget but also a collapse in their orders from firms. This reduced demand stemmed from a dismantling of the large enterprises. In the former Soviet economies, the demand of the military-industrial complex enterprises for civilian R&D was never high and in the wake of transition it practically disappeared (Sedaitis, 2000).

With the collapse of state funding, payrolls correspondingly shrank. Before transition, ECA benefited from a highly educated workforce: an abundance of scientists, engineers, and other R&D personnel. But during the transition thousands of scientists and engineers emigrated or moved overseas. In Latvia, at the start of the transition there were 50 RDIs that employed roughly 13,000 people. By 1993 there were only 13 RDIs, employing 887 employees. In Bulgaria, the number of researchers decreased from 15,000 to 10,000 over the 1996-2004 period and many researchers continue to leave Bulgaria for opportunities abroad today.7

The question faced by most ECA countries’ RDIs at the onset of transition was how to cut costs in the face of greatly reduced state funding. For most, the solution meant drastically cutting payrolls. Moreover, industrial RDIs needed to change their portfolio of activities to seek new sources of revenue such as contract research, technical consulting services, and even small-scale production. These non-R&D activities grew in the industrial RDI's share of total activity. There has been limited integration of industrial RDIs into the manufacturing sector even as industrial RDIs became hybrids — part R&D unit, part commercial entity.

In Hungary, there was some privatization of state RDIs. In some cases, multinational companies took over RDIs. After 1988, RDIs increasingly became enterprises in order to generate sufficient revenue to maintain operations. For example, the Telecommunication Industrial Research Institute became the Microelectronics Company. However, there were not many prospective domestic investors interested in the state-owned RDIs given the large amounts of financial capital needed, not only to turn them around, but also to purchase them.

In Hungary, many RDIs were closed. According to Bouche (1998), until 1992 there were 25 industrial RDIs, and of these, 17 fell under the auspices of the Ministry of Industry and Trade. In the first wave during transition, beginning 1992/93, five of these 17

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7 — UNESCO Science & Technology Statistics

<table>
<thead>
<tr>
<th>Academy of Science</th>
<th>Bulgaria</th>
<th>Former Czechoslovakia</th>
<th>Hungary</th>
<th>Romania</th>
<th>Poland</th>
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Source: Radosevic and Kutlaca (1999)
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were closed down. That left 12 industrial RDIs remaining and these were transformed into limited or joint stock companies.

In Estonia, branch RDIs were dissolved along with other branch R&D units. Many were reorganized into joint stock companies. These institutes simply no longer had a role to play in new innovation “since they formerly served the interests of the Soviet industrial and military complex” (Martinson et al., 1998) and after transition the Baltic States no longer conducted military research. Indeed, there was no longer any type of closed or secret research. In addition, the Academy of Sciences was transformed into an organization made up of “scientists without administrative functions,” and membership became largely honorary. In another landmark reform, universities were integrated with the Academy of Sciences institutes.

In the Czech Republic, almost all the industrial RDIs were privatized via vouchers, as part of the Mass Privatization Program, within the first years of transition. They became independent entities, separate from the state but their governance remained in the hands of the management and employees. Indeed, state aid to RDIs was abolished at the beginning of transition. To survive, many former RDIs became accredited testing centers for international technical, quality and security standards and engaged in other commercial activities, even production (Schneider, 1998).

In Poland, the status quo has arguably prevailed in that the same structure — with the Academy of Sciences dominating the branch institutes and universities — still persists. There was no plan to amend this system by eliminating RDIs, for example, or to privatize R&D units. Moreover, the state continues to provide funds to institutes, albeit depending on their rankings. Initially, during the first phase of transition there was an abolishment of state R&D funds and central planning (Schneider, 1998) but they were later reinstituted. To this day, the institutes are still dependent on the Ministry of Economy for funding.

In Russia, many branch RDIs were closed. In addition, many large Russian institutes divided into smaller ones even as new ones were established by the Academies of Science (Gokhberg, 2002). Mostly, industrial RDIs that survived have been partially reorganized and are still owned by the state. Indeed, 63 out of the roughly 3,000 former RDIs were even forbidden from privatizing on the grounds of state security concerns. The government claimed that the RDIs were of strategic national importance and therefore must be retained under state control. In addition, approximately 20 former military production companies were also banned from privatizing (Sedaitis 2000).

Given the size of the ex-Soviet countries’ military-industrial complexes and R&D systems, the lingering effects of the fiscal crises, and the uncooperative bureaucratic system, it is no surprise that the transformation of the research systems in these countries has been slower relative to other ECA countries. This slow pace has been attributed by one observer to the Stalinist model of R&D that arose in late 1920s/early 1930s. This model was characterized by top-down planning of R&D, massive bureaucracies, “emphasis on applied research at the expense of basic science,” isolation from science in other countries, and little autonomy granted to scientists (Bouche, 1998).

As a result of this inertia, the status quo has prevailed in many former Soviet Union countries with respect to the way research is organized or structured. For example, many still maintain the traditional division between research (represented by the Academy of Sciences) and higher education institutions. In Russia and the Ukraine, the Academy of Science still maintains a tight reign over the R&D institutes. In Table 1.2, on the next page, we summarize key features of the restructuring process of R&D industrial institutes and other public R&D organizations in ECA:
Table 1.2: Key features of restructuring process of R&D industrial institutes and other public R&D organizations in select ECA countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Key Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belarus</td>
<td>Explicit policy of preservation of R&amp;D organizations irrespective of institutional sector</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>Industrial R&amp;D institutes have gained autonomy and were left without state funding. Between 1996-2000, 150 branch R&amp;D units were liquidated or privatized.</td>
</tr>
<tr>
<td>Croatia</td>
<td>Public R&amp;D institutes have continued to be funded by public funds. There are no plans for the privatization of state research institutes. Enterprise R&amp;D institutes have been either closed or downsized.</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Industrial R&amp;D were immediately transformed into state limited companies and later privatized in two waves of voucher privatizations (109 institutes with workforce of about 30000). Privatization of the enterprise-based R&amp;D sector was completed in mid-1990s. Significantly downsized sector and transformed industrial R&amp;D organizations has been reoriented towards market demand offering often non-R&amp;D services.</td>
</tr>
<tr>
<td>Estonia</td>
<td>All of the 23 Soviet-era R&amp;D institutes, except in agriculture and two in energy, have been closed. Research institutes of Academy (17) have been integrated into four universities. Seven State RI have retained that status.</td>
</tr>
<tr>
<td>Hungary</td>
<td>Industrial R&amp;D institutes were in 1992/93 transferred to the State privatization Agency but the state retained controlling share. Institutes have been left to their own devices and majority of them have closed. Only three have been privatized. From 25-30 industrial institutes in the 1980s only 3-4 remain today and are involved in non-R&amp;D activities. FDI have established several tens of R&amp;D labs in Hungary and several enterprises R&amp;D unites have been preserved and expanded.</td>
</tr>
<tr>
<td>Kazahkahstan</td>
<td>Industrial R&amp;D institutes have been converted into government-owned R&amp;D organizations which operate based on Ministry funding and market contracts. There has not been a policy of active restructuring of these organizations.</td>
</tr>
<tr>
<td>Latvia</td>
<td>Most Soviet era R&amp;D organizations have been either closed or left without core funding. Industrial science has been ignored in restructuring and funding. State research institutes not integrated into the university system will remain or become national research centres (centres of excellence).</td>
</tr>
<tr>
<td>Lithuania</td>
<td>Out of 29 state research institutes, 13 have been merged into HES while 6 have become part of HES. Others have been retained as State RI but without core funding.</td>
</tr>
<tr>
<td>Poland</td>
<td>RDIs represent a government-run enclave in the economy (115 supervised by Ministry of Economy). Organizational and ownership transformation has not been undertaken. Privatisation is voluntary. So far, none of industrial RDIs has been privatized. However, partial privatization of R&amp;D units is common (50 percent of R&amp;D units). Continuous state funding of R&amp;D institutes enables them to carry out research without much regard for users needs. They have transformed themselves in hybrid organizations conducting R&amp;D and commercial production or service activities.</td>
</tr>
<tr>
<td>Romania</td>
<td>Industrial R&amp;D institutes were commercialised and gradually transformed themselves into non-R&amp;D organizations or in hybrid organizations which combine a variety of activities. Some of them have been privatized.</td>
</tr>
<tr>
<td>Russia</td>
<td>Partial differentiation among R&amp;D organizations by establishing State Research Centres. Policy of preservation of R&amp;D organizations which gradually adjust by shifting to non-R&amp;D activities. Policy influences their restructuring only by changing funding criteria.</td>
</tr>
<tr>
<td>Serbia</td>
<td>There is still no specific government policy on restructuring and privatization in R&amp;D sector. Gradual reorientation towards non-R&amp;D activities. Enterprise R&amp;D institutes have been either closed or downsized.</td>
</tr>
<tr>
<td>Slovakia</td>
<td>Similarly to the Czech Republic privatization of R&amp;D organizations during the first wave of privatization in 1992.</td>
</tr>
<tr>
<td>Slovenia</td>
<td>No inherited industrial institutes. Public research institutes have not been privatized.</td>
</tr>
<tr>
<td>Turkey</td>
<td>RDIs have been subject to limited restructuring and a number of management and funding reforms were made in the early 2000’s to increase linkages between RDIs and the economy.</td>
</tr>
<tr>
<td>Ukraine</td>
<td>Unreformed R&amp;D system dominated by policy of preservation of the overall R&amp;D system.</td>
</tr>
</tbody>
</table>

Source: Adapted from Meske (ed.) (2004) and Radosevic.
Today, RDIs Contribute Little to Productive Sector Innovation

Evidence from the Community Innovation Survey suggests that cooperation with industry remains lower than in most EU-15 countries. Overall, ECA’s public RDIs receive small shares of their research funding from the private sector. Compared to EU-15 economies, most ECA countries lag behind in terms of business income per researcher as well as on the share of total government-performed research financed by the private sector (Figure 1.7). The data for Spain and Italy do not reveal enterprise funding for their extensive networks of publicly-supported non-profit RDIs. Going forward, the restructuring of RDIs in ECA faces important legacy challenges (Box 1.1).

Figure 1.7: Business enterprises funding of government-performed research in 2005

Source: Community Innovation Survey 2006
### Box 1.1: Restructuring of RDIs faces important legacy challenges

**Lack of market experience.** RDIs lived for decades in a protected environment controlled and supported by the State, and have a superficial understanding of market-oriented R&D. Their scientists and engineers had limited cooperation with industry. They were working for a single customer and, although some claim their work had potential application; they have little concerns about the cost of potential innovation and of market value.

**Limited experience with application oriented R&D.** They were very strongly focused on scientific achievement, with no real concerns about application. They had a strong interest for basic research, usually quite far away from the needs of their local economy. For this reason they are more interested by cooperation with foreign partners, even if they are often not fully competitive at the international level, than to support national industry.

**“Old fashioned” administration.** Most managers are in their fifties; they were trained during the old Soviet era and are not far from retirement. For these reasons the administration of RDIs is based on outdated principles and faces difficulties to adopt a more pragmatic approach. Most managers are not motivated to stimulate major changes; they have a tendency to assume that the system, even if it slowly degrades and becomes less and less attractive both financially and intellectually, will last at least long enough for them to reach retirement.

**“Old fashioned” governance.** The management boards have characteristics comparable to the administration. Most members are appointed for scientific and/or political reasons. These boards include a small number of industry representatives. Although they should stimulate the restructuration process it seems that, on a general basis, they are not very much involved with such an issue.

**A large number of non-productive employees.** In the past, RDIs had a large number of supporting staff providing non-productive services (gardeners, cafeteria employees, etc.). Although some scientists left the institution most of the non productive employees had very little opportunity to find jobs elsewhere. Consequently the ratio of unproductive to productive employees, which was often quite high in the 80s often increased again to reach values as high as 25 to 30 percent of the work force. As a consequence, the overhead is high.

**Loss of dynamic scientists.** During the last decade many young and dynamic scientists left the RDIs. They joined some more lucrative position often provided by foreign subsidiaries of western firms or moved to United States or Western Europe where they were offered more financially and intellectually rewarding jobs. As a consequence these institutes lost some of their most dynamic employees and they have aging staffs who are not motivated to make some important changes.

**Lack of transparency:** The accounting techniques were not very rigorous and the financial data were usually very confidential. For these reasons, the figures provided by the institutions during the preparation of the restructuring program are neither very accurate neither very credible.
Chapter 2: The Role of R&D Institutes

Many economies relied on industrial research institutes to fill gaps in their national innovation systems during their initial stages of industrial take-off. Central governments played an important role in promoting R&D through KIST in South Korea (Suh and Chen 2007), ITRI in Taiwan and HKPC in Hong Kong (Arnold et al. 1998, Rush et al. 1996). Regional governments and the industry associations also played a role in more decentralized models of technology centers in Spain and Italy. The function of industrial RDIs is to acquire, maintain and supply technologies and technology-related services to firms that cannot access them in-house. Their clients often include SMEs, which lack the capability and market intelligence to identify their own technological, organizational and managerial needs. Supporting this market segment requires specific skills in marketing and business that most universities do not have. Many RDIs, now operating at the technology frontier, such as VTT in Finland and TNO in the Netherlands, were originally established as providers of testing and technology advisory services for SMEs and gradually moved up to more experimental development and applied research as national demand for R&D grew (Arnold et al. 2006).
This chapter discusses the role of RDIs in the innovation system and the economic rationale for public support of RDIs. Examples of RDI outside of the ECA region are then provided, along with a discussion of recent efforts to enhance their efficiency in several countries.

**Innovation Institutions in a Market Economy**

Innovation results from processes of production, transfer, and use of knowledge that involve multiple interacting organizations. This characterization directs attention to a variety of historical and institutional factors (legal and regulatory regimes, financial markets, labor skills, etc.) that influence the specific pattern of innovative activities in different geographic (national, regional) and economic settings. Efforts at developing a useful taxonomy of the types of knowledge relevant to innovation processes differentiate between tacit and explicit forms of knowledge, or between uncodified (and possibly, uncodifiable) and codified knowledge. The distinction between these different types of knowledge carries over to the character of the processes for transferring or sharing them across individuals or organizations. The view that considers knowledge to be the same as information supports the view that knowledge is a quasi-public good, non-rival in use, and can be reproduced at virtually no cost. On the other hand, knowledge that is not codified or codifiably held tacitly by individuals or organization cannot be transmitted or shared easily, and certainly not without considerable costs. This fact has important implications for the way in which technology can be transferred.

Individual business firms are the principal actors involved in making decisions about what commercial innovations ought to be pursued and how to structure requisite investments. The World Bank Study “Unleashing Prosperity: Productivity Growth in Eastern Europe and the Former Soviet Union shows a significant effect of changes in R&D financed by industry on TFP growth in 2001-2004 in a sample of 40,000 firms in ECA. But the limits to the appropriability of returns from R&D weaken their incentive to invest resources in the pursuit of innovation. Moreover, the pervasiveness of uncertainty combined with the asymmetric information conditions that prevail in the financial markets reduce the ability of would-be innovative firms to tap external sources of finance. Both of these problems point to the need for institutions that strengthen firms’ incentives to direct private resources toward innovative activities.

These incentive problems are addressed partly by the development of a market for new technologies and products operating thanks to an effective system of intellectual property rights (IPRs), whose objective is to strengthen the innovators’ ability to appropriate the value of their creations. But even in countries where IPR systems are well developed and reasonably effective, they are typically complemented by other policies aimed at reducing the cost of innovative activities for firms and thereby stimulate private R&D investment. In some cases, these policies act by subsidizing the cost of R&D activities performed by private sector entities. Thus, firms and other organizations might receive R&D subsidies, matching grants, tax credits, low interest loans, etc.

In other cases, efforts at reducing the cost of innovation for private firms consist of supporting research activities performed at public sector organizations, including national research laboratories, universities, extension services, technology parks, among others. The objective is to promote the conduct of scientific and technological research activities, or the production of technical information and services. These activities are expected then to provide valuable inputs for the innovative efforts of private sector firms. This second type of intervention has been oriented typically to the conduct of research activities whose po-
tential contributions to commercial innovation are highly uncertain, or whose outputs are expected to draw interest from a very broad array of stakeholders.

While these kinds of policies are widely diffused across advanced and developing economies, their specific implementation in each country has produced over time a considerable degree heterogeneity characterizing the types of organizations and the patterns of interactions among them which underpin the performance of innovation systems, whether defined by reference to geographic boundaries or defined by their sectoral and technological specialization. From the viewpoint of the national innovation systems, the origins of the observed institutional heterogeneity can be traced to multiple factors. In general, it can be argued that the institutional arrangements supporting innovation in different countries will depend on the overall level of economic development, the sectoral composition of the national economy, and the varied political circumstances that framed the historical genesis and evolution of crucial aspects of the innovation system. These observations are particularly important in the context of this research project, which focuses on a set of economies whose economic institutions have been forged during decades of socialist rule and whose current innovation capacity is substantially behind that of advanced capitalist economies.

Economic Rationale for Publicly-Supported RDIs

What is the economic rationale for supporting RDIs in a market economy?

Commercial innovation and R&D are key factors driving self-sustained, long-term economic growth and, moreover, these factors are generated from within the economic system (hence the term endogenous economic growth theories), responding to economic incentives. The basic argument for public support of R&D is that innovation is a critical factor for growth, but a well-functioning market economy cannot by itself generate the optimal levels of R&D. There are three main sources of market failure with respect to technology absorption: (1) spillovers, (2) coordination failures and (3) information asymmetries. These failures inhibit private firms from investing enough in innovation and R&D, thus depriving the economy of one of the key levers for sustained growth. Clearly though, it is not enough to spell out such an economic rationale: for it to lead to policy, it must be weighed against the costs of government intervention, namely, the well-known problems of “industrial policy”, capture and corruption, which constitute the so-called government failures.9 We will discuss the governance problems of government owned RDIs in chapter 4.

(1) Spillovers: a basic feature of knowledge creation is that returns from investments are not fully appro-priable by the original investor. Knowledge has significant public good attributes, that is, once created it can be used repeatedly by multiple agents at no or low extra costs (to account for firm specific demands for technology). This characteristic is an extreme form of decreasing marginal costs as the scale of use is increased: while the cost of the first use of new knowledge or information may be large, in that it includes the cost of its generation, further instances of its use impose a negligibly small incremental cost (for a recent discussion of these issues, see Aghion and David, 2008). A broad consensus exists among economists that the production of technological knowledge is generally subject to the presence of spillovers, so that the organizations involved in carrying out the relevant research work are unable to retain exclusive control over the resulting knowledge, or to appropriate the social benefits associated with their research.

At the same time, spillovers are not automatic or costless, since this ignores the costs of training potential users to be able to find and grasp the import of information, or to know what to do with it. While it is correct to recognize that developing the human capability to make use of knowledge and information are processes that entail fixed costs, the existence of the latter does not vitiate the proposition that reuse of the information will neither deplete it nor impose significant further (marginal) costs. A second peculiar property of knowledge or information that should be

9 — This point has been discussed in Goldberg et al (2006)
underscored here is the difficulty and cost entailed in trying to retain exclusive possession while, at the same time, putting them to use. It is of course possible to keep knowledge secret, but the production of visible results that were not otherwise achievable will disclose (at very least) that a method exists for obtaining that effect.

Attempts at innovation create information about which bundles of novel products and business models work and which do not. This information spills over to other players who benefit from it without incurring the innovator’s costs. This decreases the potential incentives to innovate.

Whether the innovator can appropriate all benefits depends largely on the mechanism by which innovation returns are appropriated. When production complexity or knowledge or lead times or secrecy are major mechanisms, this argument does not apply. These spillovers occur because of the inherent difficulties that R&D performs have in keeping information about research results from leaking to other firms. Such information is one of the different joint outputs that can be ascribed to the conduct of research activities, which otherwise include individual and organizational knowledge and skills.

Developed countries mitigate this effect through patent protection and R&D subsidies. In developing countries, the efforts at innovation have less to do with the invention of new products or processes than with the search for products that can be profitably produced in the country given its actual and potential capabilities. Because of these informational spillovers, the market generates too little effort at searching this space.

(2) Coordination failures. In general, production of a particular good requires a combination of general purpose and specific inputs. Looking at this at the global level, if these specific inputs can be imported, they will be. However, if they need to be produced domestically, the decision to invest in producing these inputs is more complicated. Individuals, firms and the government will have no incentives to invest in the creation of these specific inputs unless they can market them to a corresponding industry. In practice, this limits the type of structural transformation that the market can generate: countries move from existing activities to new activities that are “near” the existing ones in the sense that they use similar relatively specific inputs.

A crucial characteristic of technological innovation is the role of uncertainty. Uncertainty is not only a matter of technical feasibility, however important this may be. It also concerns the identification of latent market demands that can plausibly be addressed through the exploitation of specific technical results. The presence of these forms of uncertainty suggests an important reason why interactions among organizations with different technological capabilities and knowledge of market opportunities are a hallmark of an effective innovation system. Facilitating these interactions is then a policy goal of organizing R&D inter alia via RDIs.

(3) Information asymmetry makes it very hard for a creditor or equity investor to predict the returns from a potential investment in innovative ventures, which implies that such funding is not likely to be forthcoming. In the absence of demonstrated cash flows or other collateral, a typical start-up company or individual innovative entrepreneur will not have access to traditional sources of finance—leading to a so-called “funding gap”. At the most basic level, the “funding gap” implies that entrepreneurs face stiff constraints in funding innovation activities and will not be able invest enough in R&D projects that may have high social returns.

In addition to market failures, there are two systemic failures that could justify a public role for RDIs.

- **Capability failures**: inadequacies in companies’ abilities to act in their own best inter-
Chapter 2: The Role of R&D Institutes

Restructuring of Research and Development Institutes in Europe and Central Asia — Draft

Empirical Evidence on the Impact of Public R&D

Cohen, Nelson and Walsh (2002) show that public research (university and government research labs) is generally important across a broad segment of the manufacturing sector. As regards the evidence on developing countries, Lederman and Maloney (2003) find that the perceived quality of research institutions such as universities and public research institutes has a significant positive impact on overall R&D intensity in developed and developing countries, as does the perceived quality of the interaction between these institutions and the private sector. Bosch, Lederman, and Maloney (2005) find that these two factors also have a significant impact on the productivity of R&D in developed and developing countries.

Does public or private R&D contribute more to growth than another? A recent paper by Guellec and Van Pottelsbergh de la Potterie (2004) present estimates of the long-term impact of various sources of knowledge (R&D performed by the business sector, the public sector and foreign firms) on multifactor productivity growth of 16 countries from 1980 to 1998. Their main results are that all three sources of knowledge are significant determinants of long-term productivity growth. Further evidence suggests that several factors determine the extent to which each source of knowledge contributes to productivity growth. These factors are the absorptive capacity, the origin of funding, and the type of public institutions that perform R&D. Crucially for developing countries, the stock of foreign R&D appears to have an impact two to three times as large as domestic business or public R&D, underlining the importance of openness and of the capacity to absorb international knowledge. The authors also find that higher business R&D intensity also raises the impact of foreign R&D stocks on growth, suggesting that domestic business R&D is important in making firms more capable of absorbing foreign knowledge. Significantly, foreign R&D appears to benefit small economies more than it does large ones.

Jaumotte and Pain (2005b) (cited in East Asia report) find that non-business R&D spending has a large and significant impact on growth in business R&D stocks in OECD countries. They also offer evidence for two important features of the impact of public and university R&D that have been discussed in the literature. First, the impact of public and university R&D is likely to depend on the quality of the links between these sectors and the business R&D sector, which uses the results of more basic research to develop commercially valuable innovations and products. Second, a greater volume of public sector R&D may crowd out business R&D by pushing up the wages of scientific and technical staff. The latter may be a particular concern in developing countries where such specialized skills are in scarce supply. At least in OECD countries, the overall impact of non-business R&D on business R&D remains significantly positive, even after taking crowding-out effects into account.

The Role of Public RDIs: Insights from Outside ECA

R&D cooperation between firms and RDIs can correct market failures and increase the rate of technological progress and diffusion of technological knowledge in industry and among research institutes and universities. The rationale for this collaboration rests on the lack of sufficient incentives for individual

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13 — See also the East Asia report. p.153
firms to undertake uncertain and imperfectly appro-
riable research at the socially optimal level.

Some of the market failures impeding investments in
R&D could be considered targets for economic pol-
icy prescriptions, if (and only if) the possible market
failures more than outweigh the expected government
failures. A key feature of effective innovation systems
has been the presence of a collection of research
organizations whose mission can be characterized
as the support of private sector’s innovative efforts
through a mix of activities, including research work
oriented to broad areas of technological research or
to narrowly defined problem-solving tasks, training
of scientific and technical personnel, and provision
of metrology, certification, standardization services.
These RDIs are indeed a typical component of the
scientific and technological infrastructure supporting
innovation. Of course, the mere existence of these or-
ganizations is not sufficient to ensure that innovative

Table 2.1: Functions of state-financed RDIs

<table>
<thead>
<tr>
<th>Function</th>
<th>Examples of Activities</th>
<th>“Public good” Rationale of the RDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental/strategic research</td>
<td>• Fundamental research in particular in areas considered to be of strategic importance, e.g. defense, security, nuclear energy, public health. &lt;br&gt; • Long-term studies</td>
<td>• Improbability that enterprises or universities would undertake the work in sufficient breadth/depth, interdisciplinarity, with sufficient continuity. &lt;br&gt; • Need to combine basic and applied work and to ensure “knowledge integration”, i.e. marrying knowledge from own and other sources (cf mission orientation of RDIs). &lt;br&gt; • Scale of the investment required for critical mass (people facilities, etc.). &lt;br&gt; • Security (in strategic or sensitive areas). &lt;br&gt; • Specialized training and skills (perhaps a benefit rather than a rationale).</td>
</tr>
<tr>
<td>Technological support to economic development/competitiveness</td>
<td>• Contract research services to industry &lt;br&gt; • Long-range technological research &lt;br&gt; • Technology “extension” &lt;br&gt; • Support for SMEs</td>
<td>• Compensate market imperfections related to cost and risk &lt;br&gt; • Accelerate and broaden technology diffusion.</td>
</tr>
<tr>
<td>Supporting public policy</td>
<td>• Fundamental and precautionary research, e.g. environmental policy, public health, food safety, sustainable development &lt;br&gt; • Ex-ante policy design and impact analysis &lt;br&gt; • Ex-post surveillance and monitoring of the implementation of policy, e.g. pollution, seismic survey &lt;br&gt; • Expertise</td>
<td>• Impartiality (including the need to separate monitoring and control functions from advocacy functions) &lt;br&gt; • Requirement for resource-/time-intensive expertise (i.e. more than occasional or one-off expertise) &lt;br&gt; • Responsibility and accountability</td>
</tr>
<tr>
<td>Technical norms, standards</td>
<td>• Pre-normative research &lt;br&gt; • Implementation monitoring, e.g. metrology</td>
<td>• Impartiality &lt;br&gt; • Security based on independence</td>
</tr>
<tr>
<td>Constructing, operating and maintaining key facilities</td>
<td>• Big infrastructure (e.g. accelerators, research reactors, botanical gardens, large computing facilities). &lt;br&gt; • Large, unique, dangerous etc. collections. &lt;br&gt; • Large, long-term data collections &lt;br&gt; • Cost beyond the resources of other players</td>
<td>• Security and safety (physical concentration, accountable management)</td>
</tr>
</tbody>
</table>

Source: Adapted from European Research Advisory Board, 2005.
entrepreneurs will find their services valuable, and more generally to promote greater private sector’s financial commitments to innovative activities. This fact is clearly illustrated by many of the existing RDIs in the ECA countries. The central challenge then is how to promote the effective integration of the RDIs’ activities and private sector innovative efforts.

Table 2.1 provides an overview of the functions of RDIs that have been found to warrant public support. Government support is based on a “public good” rationale that results in underinvestment in a specific R&D-related good or service by the market.

In Some Countries, RDIs Have Played an Important Role in Industrial Development

A prevalent factor among ECA RDIs is that they play a limited role in industrial development. RDIs have had a much more important role in a number of Western European and East Asian economies.

In OECD countries 63 percent of all R&D is funded by industry and 30 percent by Government; while, as we noted above, in ECA countries the proportions in financing are reversed: 30 percent industry and 60 percent government. Public RDIs in Western Europe are argued to play a “crucial role” in helping overcome “market failures” and capability failures. Research associations, which originally tackled common problems within one or more branches of industry and then became institutionalized in the form of institutes (e.g. Mekanförbundet, which eventually established IVF, is a Swedish example.) These public RDIs provide SMEs with independent expert advice that can help bridge the information gap that is at the heart of this market failure. (Arnold et al 2007).

RDIs’ clients often include small firms which lack the capability and market intelligence to identify their own technological, organizational and managerial needs (capability failure). However, supporting this market segment requires specific skills in marketing and business that many universities and research institutes are unlikely to have. Many RDIs, such as Centros Tecnológicos in Spain and HKPC in Hong Kong, are explicitly organized to serve this market. Moreover, the SME market is typically very fragmented and rife with market failures, so even successful market-driven RDIs rely on government programs to support SME demand.

According to Arnold (2007), in most OECD countries, state-owned institutes have been transformed (or were already) into free-standing organizations outside the civil service. In particular, the separation between funding and research performance (or “cus-

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14 — “Technology push” means that a technology is identified in a research laboratory and then a development program is set up in order to transfer the innovative idea from the laboratory to the market. “Market Pull” means identification of a market need and set up of an applied research program to develop a new product, process or service to meet this need.

15 — Governing the Knowledge Infrastructure in an Innovation Systems World Erik Arnold April 2007
Box 2.1: The Fraunhofer Society in Germany

Founded in 1949, Fraunhofer has taken the lead in German innovation and is today the largest applied research institution in Europe. Initially it benefited from investments from the German government, with its main focus on research in Bavaria, a region relatively abundant in industry. In 1966, the government decided to support further expansion of the Fraunhofer Institute with a proposal to introduce results-oriented remuneration. The creation and implementation of the “Fraunhofer model” meant that “state funding was to increase in proportion with the Fraunhofer-Society’s success in acquiring contract research work. This meant that research and development work had to be oriented strictly in accordance with the market.”

The main challenge the institute faces in the 80s was to keep the pace of the growth in size of the Fraunhofer with the qualitative growth. Spin-off started to be seen as an effective way of knowledge transfer. The share of defense research significantly decreased over time and Fraunhofer internationalized its activities by setting up its branch laboratories in the US, Switzerland, Singapore, Malaysia and China. In order to close the gap between research institutes and industry, new forms of innovation centers were set up in Germany, organized on the same principles as private industry, in line with the recommendations formulated by the federal government.

Currently, the Fraunhofer incorporates around 80 research units, including 56 Fraunhofer Institutes, at 40 different locations in Germany. The large number of highly qualified institutes provides a platform for pooling ad hoc expertise groups depending on specific needs. An institute can be established within the Fraunhofer only under the condition that it will have sufficient revenues from its projects over next three years. Contract research is the main pillar of the Fraunhofer’s activity.

The active role of the government is a typical feature of the German innovation system. On one side, the public support for innovation is very significant, but on the other, there are active market incentives as well. Thus, the German innovation market is marked by the balanced combination of both, public and private. The active role of the government in the innovation policy does not however mean that the Fraunhofer suffers from restrictions on its competencies or flexibility, and direct government intervention is still considered to be rather small. In terms of funds, one third of the funding of the Fraunhofer comes from the government and the rest is generated by contracts with industry and by publicly financed research projects. One of Fraunhofer’s important strategies to increase the commercialization of its products is that scientists within Fraunhofer’s institutes are obliged to collaborate with the end customer or user, and therefore to strengthen applicability of the research results on the market. Building on this type of collaboration has brought a competitive advantage over university research centers which lack sufficient interactions with the industry representatives.

High decentralization is another specific feature of the Institute. Fraunhofer’s institutes have been given the autonomy in order to reach a higher degree of flexibility on the market. The institutes’ directors are thus allowed to take an individual approach in identifying market opportunities. The institutes’ management is responsible both for human resources and business results. Another distinctive feature is the Fraunhofer Institute’s place on the international and especially European market. The European Commission’s Programs enhance the international approach in applied research. Crossing borders and thinking in global market terms, particularly with reference to the Lisbon Agenda, have been challenges that the Institutes has been undertaking successfully.

Source: Adapted from “Fraunhofer moves towards core role in Euro research”, MPR, November 2003

Although universities and research institutes increasingly need to form tight intellectual partnerships to meet the needs of industry, their roles as service providers remain complementary. RDIs are easier and less risky to collaborate with as they are much more structured than universities and often make use of management processes and norms of confidentiality found in industry. RDI staff is often more experienced and familiar with practical production processes than in universities and can also deliver directly applicable knowledge to industry. Most importantly, providing services to industry is the core business of an RDI, whereas universities often need to balance the tension between teaching and research (Arnold 2007). Universities, on the other hand, are not constrained by the stability and consistency of institutes which provides them with attributes that RDIs do not have: (i) they are constantly regenerating their capabilities, with direct access to the next generation of scientists, and (ii) they are always under pressure to maintain a

competitive edge to secure research grants. With this in mind, firms tend to rely on universities for human resources or for risky projects requiring strong problem-solving skills. While, universities cannot compete with RDIs to deliver short-term practical services to industry, the two must collaborate ever closely to support firms who need to keep up with a fast-moving technological frontier to compete on a global scale.

A Number of Countries Have Adopted Reforms to Increase the Efficiency of RDIs

**European Union**
Reforms in European RDIs are diverse but share many common themes in governance reform: (i) increased role of stakeholders; (ii) professionalization of management; (iii) changes in organization to become more outward-facing; (iv) increased autonomy to define and implement strategy; (v) “contractualization” of relations with founders / customers via various kinds of performance contracts, often accompanied by performance indicator systems; (vi) increased external quality control through the market (Arnold 2007).

**United States National Laboratories**
The most radical reforms in the United States RDI system were initiatives in the 1940’s. In the United States, the Department of Energy Laboratories are government-owned, but are operated by private contractors selected from industry, academia, and university consortia. This government-owned, contractor-operated (GOBO) approach to laboratory management began in the 1940’s to meet pressing wartime needs, and today provides flexibility in the assignment of resources and facilitates quick responses to a wide variety of program needs. This approach enables private sector and university-based R&D management experience to be brought to bear on government work. The GOCO system has offered significant advantages in attracting and retaining world-class scientists and achieving scientific excellence. In recent years, the GOCO system has been the subject of significant concerns regarding administrative and business management issues. At the same time, however, there has been a growing recognition that the GOCO approach utilized by the Department of Energy had resulted in generally superior technical performance than is found at government-owned, government-operated (GOGO) facilities.

Critics of the GOCO approach argue that it overestimates the importance of management incentives and ignores the fact that there is no developed market for management control in ECA. Yet, the “contractor” in GOCO could be an international company or university or a regional one (e.g. Slovenian, Hungarian). Moreover, it could help develop such markets. Some argue that GOCO can’t provide the type of management that is mainly judged through stakeholders’ value rather than whose efficiency is judged via shareholders value.

Jaffe and Lerner (1999) examined the commercialization of publicly funded research in the US national laboratories. Beginning in 1980, a series of legislative initiatives and executive orders in the U.S. have sought to encourage the patenting and the licensing of federally owned technologies, as well as the formation of cooperative arrangements between laboratories and private firms. Jaffe and Lerner study federally funded research and development centers (FRDCs) owned by the U.S. Department of Energy (DOE). These include some of the largest R&D laboratories in the US, such as the Lawrence Livermore, Los Alamos, and Sandia facilities.

Jaffe and Lerner’s results suggest that the organizational structure of the government-owned contractor-operated (GOCO) model used at DOE laboratories may be far more credible than critics have suggested. Their empirical and case study analyses suggest that the policy reforms of the US in the 1980s had a positive effect on technology commercialization with patenting activities sharply increasing and little evidence of degradation in patent quality. These effects appear to be stronger where the danger of bureaucratic interference was lower, such as when there was turnover of contractors. According to the authors, the results are consistent with numerous studies of privatized firms (reviewed in D’Souza and Megginson, 1998) that show transfers from public to private ownership to have a significant impact on performance.
Henderson, Jaffe and Trajtenberg, (1998) show that the 1980 Bayh-Dole reforms gave a great degree of flexibility to universities to license and spin out new technologies. The US national laboratories whose prime contractors were universities may have benefited from this know-how to make their technology transfer activities more effective.

China

RDI Reform in China started since 1999.17 All RDIs (248 central level & 134 central level, respectively) were government-controlled and the emphasis was on military technology. Research and production under central planning were disconnected and there was little innovation in the RDIs.

17 — Shiguo Tang, presentation to the World Bank, May 2008

The objective of the reform was to enhance the development of national innovation system and reinforce the role of enterprises in innovation and facilitate the development of high-tech industries. The method undertaken was as follows: research institutes were integrated into enterprises or corporate groups, or converted into high-tech enterprises or intermediary organizations. By 2001, 300 centrally-owned RDIs and over 7,000 local RDIs were transformed into companies. The essence of the reform was conversion into companies, not closure of RDIs. The Government made transformation into companies mandatory and maintained supportive policies for transformed RDIs: continued subsidies, tax holidays for 5 years and payment of pensions.

The majority of the equity is still held by the Government, but notably some is owned by private share-
The Council of Scientific and Industrial Research (CSIR) was set up in 1942, modeled after the U.K. Department of Scientific and Industrial Research. After India’s independence in 1947, it focused on building up an extensive R&D infrastructure, from metrology to R&D for a wide range of industries—with a focus on supporting emerging industry, especially SMEs. In the pursuit of Indian self-reliance, CSIR concentrated on reverse engineering products and process technology, primarily in pharmaceuticals, chemicals, glass, and other import-substituting industries, and in adding value to technologies using domestic resources such as high-ash coal, small-scale cement plants, and medicinal and aromatic plants.

The process of reform was initiated in 1986 by the Abid Hussain Committee report, and was given additional impetus when India shifted from an inward-oriented to a more outward and market-driven development strategy as a result of the 1991 economic crisis. With the liberalization of trade and industrial policy, firms began facing more international competition. CSIR was criticized for being unwieldy and ineffective at transforming laboratory results to technologies for industrial production, and for spending too much effort “reinventing the wheel” by focusing on known processes. The demands of the crisis led to self-examination and radical change in CSIR’s role—from emphasizing technological self-reliance to viewing R&D as a business and generating world-class industrial R&D. More emphasis was placed on outputs and performance, and on work that was relevant for productive sectors and that could earn income. Each laboratory became a corporate subsidiary, and rewards were introduced for meeting targets. Laboratories were given autonomy in operations based on how well they delivered on committed outputs and deliverables. In addition, there have been continuous efforts to streamline further to improve effectiveness and efficiency.

Although CSIR is still restructuring, the results to date have been quite impressive. They show the kind of impact that a change in the direction and incentive regime of even a very large public research system can have. Between 1997 and 2002, CSIR cut its laboratories from 40 to 38 and staff from 24,000 to 20,000. Technical and scientific publications in internationally recognized journals jumped from 1,576 in 1995 to 2,900 in 2005, and their average impact factor increased from 1.5 to 2.2. Patent filings in India rose from 264 in 1997–98 to 418 in 2004–05. Patent filings abroad quintupled from 94 in 1997–98 to 500 in 2004–05, and CSIR accounted for 50–60 percent of U.S. patents granted to Indian inventors. In addition, CSIR increased earnings from outside income forms 180 core in 1995–96 to Rs. 310 crore in 2005–06 (about $75 million). Today it has 4,700 active scientists and technologists supported by 8,500 scientific and technical personnel. Its government grant budget has roughly doubled since 1997, and is now Rs. 1,500 crore ($365 million), so its earnings are about 20 percent of its grant budget.

Source: Dutz ed. 2007.

The pace of commercialization has been accelerated, financing and investment channels have been enhanced and innovation capacity has been boosted. The number of new employees joining the enterprises is more than that of leaving employees. The quality of new employees is also better than that of leaving employees. Employee income grows steadily. R&D investment has increased, strength of the organizations has been enhanced and innovation capacity has been boosted.
expanded, income from commercialization has increased, and their economic benefits have also improved greatly.

The remaining problems of the RDIs stem from a conflict in the funding system which causes too little attention to long term research. There is a dilemma for RDIs providing public goods: should they become companies providing services or should they become manufacturing plants? Many want to become public once again but the Government wants them to become private companies. They rely on supportive policies for their survival. The dilemma as to whether there should be preferential policies for those RDIs producing public (or high spillovers) goods and services remains a key issue in the debate about the future of R&D.

In 2006, government research institutes only accounted for 18.9 percent of China’s R&D expenses while the share of enterprises rose to 71.1 percent. Chinese enterprises have not only become the most important R&D implementers, but have also become an important sponsor of China’s R&D. In 2006, within China’s R&D expenses, the percentage of enterprise sponsorship reached 69.1 percent. The conversion has facilitated the commercialization of S&T results and the development of high-tech industries.

**Lessons for ECA**

The objective of structural reforms in RDIs is to enhance the development of national innovation system and reinforce the role of enterprises in innovation and facilitate the development of high-tech industries. ECA region RDIs are typically isolated from industry and effective structural reform would require bridging this gap between industry and research.

In order for ECA RDIs to effectively integrate their activities in line with private sector innovative efforts requires the resolution of two crucial problems of institutional design. The first is concerned with aligning the activities performed by the RDIs to the technological demands of existing business enterprises. The second is concerned with the task of facilitating the flows of information and knowledge at the interface between the RDIs and the community of intended users in the business sector. Their resolution will require among other things: (i) a careful evaluation of the extent and modality of public financial support to RDIs; (ii) structures and incentives aimed at facilitating the flow of technical personnel from the RDIs to industry and vice versa; and (iii) a realistic assessment of the role of intellectual property rights in the transfer of technological knowledge from RDIs to industry.

The discussion above of market failures features of innovation processes provides a useful key to understanding the differentiated patterns of governance of knowledge production that characterize contemporary innovation systems. This expression refers to the institutional arrangements determining which scientific and technological research activities are funded, the kinds of organizations that will be involved in carrying out various types of activities, and the types of interactions that will take place in order to promote the diffusion of information and the sharing of knowledge. The next two chapters discuss the results of the survey conducted among RDIs in select ECA countries, their current situation and finally outlining various options for reorganization and restructuring these RDIs.
Chapter 3: The Role of RDIs in ECA’s Transition Towards the Knowledge Economy

Introduction

This chapter draws on case studies of RDIs in several ECA countries to investigate the status of these RDIs today, the role they play in providing R&D services to industry, and the challenges these organizations face. This shows that, two decades into the transition, the RDIs that are still operating as standalone entities have made limited progress in terms of the intensity and quality of their interactions with the overall national innovation system and specifically in the range of services they provide to industry, and it exposes areas that lag far behind such as knowledge management, licensing, incentive structures and staffing.

Although the remaining RDIs are mostly owned or operated by government, two different types of RDIs appear to have emerged in regards to core activities and sources of funding. On one hand there are RDIs that are predominantly funded by public sources and that are rather isolated from knowledge commercialization activities, yet at the same time have not shown sufficient results in regards to publications and training and more generally fulfilling their mission to generate public knowledge with significant productive spillovers. On the other, some RDIs are largely financed through the goods and services they offer the private sector, but these goods and services seem to be at the lower-end of the knowledge value-
Chapter 3: The Role of RDIs in ECA’s Transition Towards the Knowledge Economy

Restructuring of Research and Development Institutes in Europe and Central Asia — Draft

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3

Introduction

Chain and there is a need to engage further in knowledge-intensive R&D activities that are competitive globally.

The foregoing deficiencies seriously reduce the effectiveness of RDIs as a mechanism for cutting-edge knowledge and innovations to be integrated into productive uses. The experiences of comparator RDIs from OECD countries suggest ways to improve this, such as introducing governance and funding models that achieve a better balance between strategic R&D and commercialization activities, reducing inherent tensions in the mission and organization of RDIs and leveraging additional resources. Since the countries covered by this study have made clear their aspiration to become part of the advanced club of knowledge-based economies, in which science, technology and innovation lie at the forefront of productivity growth and competitiveness, there are substantial policy challenges that need to be faced to amplify the benefits of public investments in RDIs.

A Case Study Approach to Examine the Role of RDIs in ECA

Case studies were carried out of 21 RDIs in Russia, Ukraine, Croatia, Serbia, Poland, Lithuania and Turkey. The information was collected through face-to-face interviews and informational material distributed by the RDIs or on their websites. For a sample of RDIs, data was also obtained through questionnaires covering a variety of topics, including missions and activities, scientific and market outputs, governance, management and funding models, and key assets. The authors’ familiarity with the national innovation systems of these countries ensured that contextual information was not lost in the interpretation of the questionnaire and that national factors could be accounted for. Since the sample used in the study is not representative of RDIs in each country or of the ECA region as a whole, prior familiarity with the national and institutional context provided the authors with greater ability to interpret the data. In some cases, the
RDIs in the sample are benchmarked against RDIs in a number of comparator countries in Europe, North America and East Asia, for which data is available through their annual reports, websites or past RDI benchmarking studies (Figure 3.1).

Several of the RDIs included in the sample played a central role in their respective national innovation systems prior to the transition period (all but one RDI in the sample were created before the transition) and continue to be among the publicly-funded institutions with a better track record. Arguably, looking at institutions that were originally better funded and closer to the technological frontier helps us to pin down inherent limitations of the incremental strategy chosen to further the goals of these institutions. At the same time, to examine policy options for a broad range of institutional features, special care was taken to also include RDIs spanning various typologies into the sample. In terms of size, 18 out of the 21 RDIs in the sample are mid-sized organizations, with between 100 to 500 staff members and most focus on highly-specialized technical fields. The remaining three have between 1,000 and 2,000 staff. It must be noted that some of the benchmark RDIs from outside of ECA tend to be much larger, SINTEF, VTT, TNO and SRI have between 1,900 and 4,000 staff members, while Arsenal has 180 and the Spanish Technology Centers, which are institutionally independent and are organized around a government agency, FEDIT, have an average of 95 staff (Table 3.1).

The RDIs in the sample differ broadly from one another in their scope and focus of activities. The sample of RDI spanned a wide range of industries. While some RDIs are engaged in fields that draw highly on scientific knowledge, such as biology, others specialized in technical areas that draw on a combination of industrial and scientific knowledge, such as shipbuilding, civil engineering works and production of industrial equipment. Only two RDIs in the sample were engaged in distinct technical areas (Table 3.2). For one RDI, part of this diversification was driven by market pressures to seek revenue in more profitable areas. For the other, different activities were put together to gain economies of scale in the administration of the RDI. It is worth noting that many of the RDIs in the sample do not fit neatly into the OECD notion of an RDI because they engage in production activities that are generally not covered by OECD RDIs.

Table 3.1: Comparator RDIs in the sample

<table>
<thead>
<tr>
<th>RDI Name</th>
<th>Country</th>
<th>Ownership</th>
<th>Number of Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTT Technical Research Center</td>
<td>Finland</td>
<td>Public</td>
<td>2,740</td>
</tr>
<tr>
<td>Sintef</td>
<td>Norway</td>
<td>Public</td>
<td>1,901</td>
</tr>
<tr>
<td>SRI</td>
<td>United States</td>
<td>Private</td>
<td>1,500</td>
</tr>
<tr>
<td>Fraunhofer Society</td>
<td>Germany</td>
<td>Public</td>
<td>239 per institutes on average</td>
</tr>
<tr>
<td>Arsenal Research</td>
<td>Austria</td>
<td>Private</td>
<td>178</td>
</tr>
<tr>
<td>FEDIT Technology Centers</td>
<td>Spain</td>
<td>Public-private</td>
<td>95 per Technology Center on average</td>
</tr>
<tr>
<td>TNO</td>
<td>Netherlands</td>
<td>Public</td>
<td>4,003</td>
</tr>
<tr>
<td>PARC</td>
<td>United States</td>
<td>Private</td>
<td>230</td>
</tr>
</tbody>
</table>

Source: World Bank survey of RDIs; RDI annual reports.
Restructuring of Research and Development Institutes in Europe and Central Asia — Draft

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Chapter 3: The Role of RDIs in ECA’s Transition Towards the Knowledge Economy

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General Characteristics of the Sample

RDIs in the sample face funding constraints that restrict upgrading of laboratories and the development of new R&D areas that respond to evolving industry needs

RDIs in the sample have less financial resources per staff than their OECD counterparts. If the income is adjusted for purchasing power parity (PPP) to account for the fact that salaries are a large share of expenses, the adjusted incomes of several RDIs are comparable to what one would find in OECD RDIs such as Sintef and TNO.

But roughly a third of the RDIs have an income, which even when adjusted, accounts for a fraction of what one would see in OECD RDIs. These RDIs are highly under-resourced, which reduces their capacity to retain and attract skilled personnel, a point we

Table 3.2: Specializations of the RDIs in the ECA sample

<table>
<thead>
<tr>
<th>Technical Area</th>
<th>RDI Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical engineering</td>
<td></td>
</tr>
<tr>
<td>Chemistry</td>
<td></td>
</tr>
<tr>
<td>Civil engineering</td>
<td></td>
</tr>
<tr>
<td>Electrical engineering</td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td></td>
</tr>
<tr>
<td>Environmental engineering</td>
<td></td>
</tr>
<tr>
<td>Environmental science</td>
<td></td>
</tr>
<tr>
<td>Food science</td>
<td></td>
</tr>
<tr>
<td>ICT</td>
<td></td>
</tr>
<tr>
<td>Mechanical machinery</td>
<td></td>
</tr>
<tr>
<td>Nuclear engineering</td>
<td></td>
</tr>
<tr>
<td>Occupational health and safety</td>
<td></td>
</tr>
<tr>
<td>Physics</td>
<td></td>
</tr>
<tr>
<td>Security and defense</td>
<td></td>
</tr>
<tr>
<td>Shipbuilding</td>
<td></td>
</tr>
<tr>
<td>Space</td>
<td></td>
</tr>
</tbody>
</table>

Note: ECA RDIs have fictitious names for confidentiality purposes

In all of figures of this study:

(***): denotes private RDIs.

(***): denotes RDIs for which the state owns less than a 90 percent share and the private sector owns the remaining share.

(*) : denotes RDIs for which the state owns at least a 90 percent of share and the private sector owns the remaining share.
discuss further below. Figure 3.2 presents a depiction of available resources with and without the PPP adjustment.

Besides the issues it poses for human resource development, the lack of adequate funding has significant implications for the quality of infrastructure and the research strategy. Funding for infrastructure, used to acquire new investment in equipment and laboratory facilities, is insufficient and erratic. Rather than being part of a comprehensive and long-term development plan agreed by RDIs with stakeholders and funding entities, the investments are made on an irregular basis as and when additional public funds become available.

This is very worrying as the fast-paced industrial change that ECA countries are experiencing demands flexibility in terms of setting-up new R&D and practice areas, and RDIs are currently not equipped with the level of resources to adapt their structure, staff and infrastructure. In Turkey, the government is attempting to remedy this situation through a Research Infrastructure Projects, operated by the State Planning Organization. The program allocates over US$122 million per year of competitive funding, evaluated through public-private panels, to establish or upgrade new university or RDI facilities.

The sample reflects the absence of fully-private RDIs in ECA

Seventeen out of the 21 RDIs in the sample are state-owned institutions and four are joint-stock companies, owned by both the private and public sector. In the joint-stock companies, the state tends to own an overwhelming majority of the shares, mostly through a Ministry or in some cases through a national acad-

Box 3.1: Legal status of RDIs in Russia

During the early transition period, a special legal status, “Federal Research Center”, was created for a number of RDIs operating as federal unitary public enterprise. This status is awarded by the government and is confirmed, through attestation conducted by the Ministry of Education and Science of the Russian Federation, every two years. This status was awarded to 58 industry R&D organizations during 1993-1995 in order to help them to survive and maintain unique equipment by means of additional government financial support and tax exemptions. In 2005 Federal Research Centers stopped receiving additional non-competitive financing from the federal budget but kept their tax exemptions (land tax; assessed tax).
Chapter 3: The Role of RDIs in ECA’s Transition Towards the Knowledge Economy

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Box 3.2: A socially owned RDI which survived transition in Serbia

The Maize Research Institute (not in the sample) is an R&D organization focused on the development and production of high-yielding, quality maize and sunflower hybrids, soybean and wheat varieties that have been adapted to diverse agro-ecological conditions and growing practices.

Contrary to most other R&D institutes in Serbia, which are state-owned, this institute is 100 percent socially owned and the management is appointed by an assembly of workers, a remnant of the Yugoslav era. By law, as a socially owned enterprise, the Maize Institute is subject to privatization by a given date.

The Maize Institute has 362 employees, out of which 34 have PhD degrees, 13 MSc, and 51 BSc, while the rest include technical support staff, laborers/workers, and administrative support staff. The institutes’ activities are supported with a seed processing plant with an annual capacity of 8,700 tons, six research laboratories, 1,600 hectares of arable land, and a maize breeding station. Over the last three years MRI has invested some EUR 3 million in equipment, and as result their seed processing factory will be fully computerized/automated in a matter of months.

R&D activities are extremely important for the Maize Institute. As a result of their research efforts, the Institute has registered over 550 corn and 13 sunflower hybrids, 6 soybean cultivars and 6 wheat varieties, 25-30 of which registered abroad. Over the course of the last two years it has developed two new species of sunflower and wheat. It has also obtained ISO 9001 quality certification.

Only 2-5 percent of the Institute’s revenue comes from projects awarded by the Ministry of Science, while the rest is from the market. The Institute controls 40 percent of the Serbian market, while some 50 percent of their entire production is exported to some 20 countries, out of which Russia is their largest destination. Part of their seed production is located abroad as well (Romania, Macedonia). Its business model is based on revenue from a fixed amount from each hybrid sales as well as a percentage of the customers’ sales. The Institutes is slowly diversifying its products, adding food for animal and human consumption. It is also facing increasing competition from foreign players who have started growing and producing crops in Serbia due to arable land and favorable climate conditions.

None of the RDIs in the sample operates as a fully-private entity, either for-profit or not-for-profit. Although there are certainly exceptions which were not included in the sample (Box 3.2), this reflects a general trend found in the ECA region, where privatized RDIs, or their R&D activities, were generally not able to survive the pressures of an open, competitive market. This was largely due to industrial restructuring process which left little private sector demand for the RDIs’ services.

By contrast, in OECD countries, private RDIs do exist, but they typically have some specific characteristics. They either (i) conduct work of a very applied nature and are not even designated as “RDIs”, but rather engineering companies or design consultancies in their home countries, (ii) they are part of larger corporate groups or (iii) they operate on a not-for-profit basis:

- Case (i) is mostly a question of terminology. While in ECA, during the socialist period, industrial organizations under line-ministries conducting design, engineering and sometimes even limited production activities were termed R&D “institutes” these types of entities would more likely be categorized as “engineering firms” or “design consultancies” in OECD countries. In OECD countries the term “institute” is generally reserved for an “organization for the promotion of a cause”,18 where the cause is typically a social cause rather than shareholder profit-maximization. Hence, similar organizations do exist in OECD countries, but it is generally acknowledged that their public goods element is not important enough to classify them as “institutes”. For example, the Institute for Field and Vegetable Crops Novi Sad controls

18 — Merriam-Webster dictionary definition
two-thirds of the Serbian seed production market. In OECD countries, seed production is dominated by corporations such as Monsanto and Dupont that can hardly be considered “institutes”.

- In terms of case (ii), when R&D organizations in OECD countries are run on a for-profit basis, they typically operate as part of larger corporate groups with activities going well beyond R&D. In the United States, this is the case of Xerox Palo Alto Research Center (PARC), a subsidiary of Xerox Corporation, and Bell Labs, which is part of Alcatel-Lucent. Several of the ECA RDIs in the sample approach this model as they are part of large engineering holding companies (former state conglomerates), but these are partly state-owned, not fully private.

- As for case (iii), a number of very successful RDIs in OECD countries operate as either stand-alone not-for-profit organizations (SRI International and Research Triangle Institute in the United States) or industry associations (Pera in the United Kingdom, and the hundreds of RDIs organized in the AiF, the German Federation of Industrial Research Associations “Otto von Guericke” in Germany).

Most of the RDIs in the sample do not appear to be very oriented to the market, with the exception of selected joint-stock RDIs

The RDIs in the sample are engaged in a range of activities along the innovation chain. While some are mostly engaged in strategic R&D with no immediate commercial applications (Bio-3), at the other end of the spectrum, some conduct little original R&D but are oriented towards client-work with immediate practical applications (Energy-1 and Elec-2). In the sample, the former category tends to be overwhelmingly fully state-owned, while the latter has a greater representation of joint-stock RDIs. Nonetheless, several fully state-owned RDIs conduct very little strategic research (ICT, Bio-2, Ship-2). This appears to be a trend in many ECA countries, where a number of state-owned RDIs have phased out their strategic research during the transition period. This contrasts with OECD countries, where strategic research is the
core learning and knowledge-generation mechanism that is associated with the types of spillovers of publicly-owned RDIs.

It is most that the RDIs in the sample have very the limited budget allocated to marketing and business development activities (Figure 3.3). In the case of RDIs conducting a high level of strategic research, this can be expected, as in every country they tend to be overwhelmingly funded by public sources. But this underlines fundamental differences in the operation of RDIs in OECD and ECA countries among RDIs that conduct mostly client-work. One possibility is that marketing and business development are done on an informal basis by the upper-management of the RDI and time spent on these activities are not reflected in the RDIs’ budgets. Another is that some of the RDIs still operate in a protected environment, either because they are favored by state procurement practices or rely on funding from the state budget. This second point will be explored at a later point in the chapter.

A number of RDIs in the sample are involved in teaching activities, but their role in bringing teaching and research closer together is often unclear

In ECA, under the central-planning system, there was little overlap between teaching and research, with teaching the exclusive domain of universities and research the exclusive domain of RDIs. One exception was doctoral-level programs offered by RDIs.

An interesting feature of RDIs in the sample is their involvement in educational activities (Figure 3.4). Five mostly public RDIs in the sample offer more than a dozen university-level courses each yearly. Moreover, most RDIs in the sample, both fully state-owned and joint-stock RDIs, have formal or informal ties to educational institutions through their staff. These ties are established through a small number of staff members who also hold faculty positions in universities, and to a greater extent through students who work as part of the staff of the RDIs. In three RDIs of the sample, students account for around 10 percent
of the RDI staff. RDIs in OECD countries sometimes employ university students and faculty in order to extend their knowledge network and stay up to date on latest research trends. Students can also be important assets for RDIs when they are funded by external sources as is the case in some of the RDIs in the sample.

RDIs in some countries have taken steps to formalize their teaching roles. The Bulgarian Academy of Sciences has established a nationally accredited graduate school which allows graduate students to be involved in its extensive research activities. It currently enrolls 554 graduate students and graduates 20 percent of Bulgaria’s PhDs. In Russia, as of January 1, 2008, the integration of research and education is further simplified due to additions to the Federal Law “On Science” according to which RDIs and universities may jointly use material resources and workforce for research and teaching; facilities may be shared free of charge; and RDIs and universities may jointly establish integrated entities — such as educational centers and laboratories.

However, in many cases, ECA RDIs remain far from fulfilling the role of bringing together teaching and research and they have few formal ties with universities. In some countries, such as Bulgaria, ties between RDIs and universities have not been intentional but have occurred because low salaries have pushed RDI staff to seek additional income as faculty members in universities. Whether ECA RDIs could actually take the role of research universities as in OECD remains an unexplored issue.

Research Outputs

Publication activity is not always consistent with the level of strategic research in the RDIs of the sample

In OECD countries, one would expect publishing patterns to be affected by two sets of factors: the first being the degree to which the technical field of research draws from scientific knowledge, which is most pronounced in the case of pharmaceutical and biotechnology sectors where patents refer extensively...
to scientific publications (citation); the second factor reflects the importance of blue-sky or “strategic” R&D, where results are expected to be in the form of knowledge to be published in the public domain through academic and technical journals rather than commercializable forms of technology.

While this pattern can be used to explain the publishing activities of some RDIs in the sample, others clearly deviate from this pattern. For example, Ship-2 operates in an applied field of engineering, shipbuilding, conducts limited strategic R&D and has a very high publishing track record. At the other extreme, Mech-2 conducts a high amount of strategic R&D but publishes very little. In the case of Mech-2, one would expect that its public-service orientation would sharpen the incentives to publish. There could be two explanations for the inconsistent publishing patterns in some RDIs: (i) strategic R&D is not being translated into publishable results, either because of the nature of the research (far from the academic state of the art) or due to the low productivity of the researchers, and (ii) the RDI is generating “tacit” knowledge that is useful internally but that is not being disseminated via publications and thus the RDI is generating weak public knowledge spillovers.

When we look at publications in leading international journals (compiled using the Science Citation Index), the performance of ECA RDIs is very weak, whether this is measured by the frequency of publications or the impact these have on the wider scientific community. The number of publications per RDI worker in a given year, which is a common proxy of the productivity of RDIs in disseminating theoretical knowledge, is either null or very low relative to comparator RDIs located in the OECD (Figure 3.6). Publishing in international peer-reviewed publications is either not valued in most ECA RDIs of the sample or the quality of the research is not high enough.

The citation indicator (shown in Figure 3.7), which summarizes the number of citations per RDI publication, is also significantly lower in ECA RDIs. It is

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19 — The data set in the Science Citation Index tracks the citations of all major publications and leading science journals. Arguably, this Index is skewed toward the more prestigious and well-know publications, thus omitting the citations in less-regarded local sources. Yet, because this index represents the forefront of international scientific efforts and is comparable to a greater degree between institutions, it provides a more realistic picture of the relative distance to the knowledge frontier.

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Figure 3.6: Number of annual publications per RDI staff

![Graph showing number of annual publications per RDI staff](https://example.com/graph.png)

*Note: Fraunhofer, Mixed and Space based on 2008 data; all others based on 2003-2007 averages.*

*Source: Authors’ calculations using Science Citation Index.*
useful to compare this indicator to the citations per publication in (i) the same field of specialization and the same country and to (ii) that in the EU10. The comparison indicates that RDI publications tend to have a slightly weaker impact than the scientific community as a whole and much lower impact than new accession countries as a whole. The room to improve is substantial, as RDIs in OECD countries tend to have comparable impact to the country in which they operate. The smaller impact of ECA RDI publications could be either a result of lower publication quality or fewer opportunities to disseminate the results.

*While a number of the RDIs in the sample are involved in patenting, virtually none of their patents lead to licensing revenue.*

**Figure 3.7: Citations of international RDI publications**

![Bar chart showing citations of international RDI publications](Note: based on 2003-2007 averages. Source: Authors’ calculations made with Science Citation Index data.)

**Figure 3.8: Average number of patents granted per staff**

![Bar chart showing average number of patents granted per staff](Note: patents include national and international patents; Fraunhofer based on 2008 data; FEDIT based on 2007 data; Mixed based on 2003-2008 average; all others based on 2002-2007 averages.)
Chapter 3: The Role of RDIs in ECA’s Transition Towards the Knowledge Economy

Restructuring of Research and Development Institutes in Europe and Central Asia — Draft

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Figure 3.8 shows the average number of national and international patents obtained on a yearly basis between 2002 and 2007. There is no indication that RDIs in the sample are patenting uniformly less than their OECD counterparts. While some are extremely successful at patenting, others perform poorly. In general, there does not seem to be a clear relationship between the ownership, technical field of the RDI or even commercial orientation and patenting. Some of the RDIs in the sample are engaged in providing services, which, although they rely on R&D, result in incremental improvements and adaptation of existing technologies, and patenting does not fit in their business model. This is also the case of some industrially-oriented RDIs in OECD countries.

Licensing does not play an important role among the RDIs in the sample and most have not licensed any technology in the past five years (Figure 3.9). Only one RDI had generated any substantial licensing revenue during that period. This is surprising for those RDIs involved in technical fields in which licensing traditionally is a strategic mechanism for transferring technology to the private sector, such as the biological and medical sciences. Of the three RDIs in the sample involved in those areas (Bio-1, Bio-2 and Bio-3), none had developed any non-negligible licensing activities in the past five years or generated any licensing revenue in 2007.

Figure 3.9 shows that all three of these RDIs were relatively successful at publishing their results, thus indicating that the absence of licensing is not the result of low research quality, but rather of deficient knowledge management, poor linkages with the private sector or simply poor demand for their technological outputs. In one case (Chem) the RDI had an explicit policy of not licensing technology. Interviews with ECA RDIs often show that they avoid cooperating with businesses and licensing technologies because legislation concerning intellectual property rights (IPR) is not transparent. This is often compounded by unclear internal policies regarding the distribution of royalties between the researcher and the RDI.

Further development of quality-related services by RDIs could help to diversify funding sources and move up the knowledge-value chain

An examination of sources of revenues by activity indicates that several RDIs in the sample derive a substantial share (20-30 percent) of their income from testing, certification and measurement services (Figure 3.10). These are the types of very practical commercial services that many RDIs found in OECD countries focused on before they developed their science-intensive activities. Although not very scientifically rewarding for researchers, and not always recog-
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The joint-stock RDIs in the sample are generally more successful at forming business ties with the private sector, but SMEs are generally absent from the picture.

The sample shows that the joint-stock RDIs in ECA are generally able to generate more income from industry than their public counterparts (Figure 3.9). The best performing RDI is Elec-1. However, it is worth noting that a large share of Elec-1’s services are sold to other firms of its holding group, with which it benefits from long business and ownership relationships, much like the relationship between Xerox and its PARC laboratory.

What is of particular interest for two other top ECA performers in the sample, namely Elec-2 and Ship-1, is that state-owned enterprises account for the vast majority of their industrial income (Figure 3.10). Their clients are typically large national infrastructure companies with complex projects. These RDIs typically benefit from historic linkages with these SOEs, and their geographic proximity make them well-suited candidates for procurement. It is worth noting that large infrastructure projects typically do not require research at the technology frontier and these RDIs are likely competing on the basis of price and prior knowledge of the domestic infrastructure sector rather than on technological leadership.

In sum, some of the ECA RDIs in the sample are as successful as their Western European counterparts Sintef, Arsenal and VTT in generating industry revenue, but the top performing RDIs appear to be performing services that are better described as engineering than R&D (Figure 3.11). At the other extreme, two RDIs in the sample engaged in biological sciences have no revenue from industry. This could be a symptom of low productivity of the RDI, lack of marketing efforts or lack of relevance of their research to industrial applications. Importantly, the RDIs in the sample obtain a negligible share of their income from international businesses, even for those RDIs operat-
ing in small markets. The amount of business RDIs are able to win from international firms is an important measure of competitiveness in ECA countries. International business ties implies that the RDIs are not protected by national procurement preferences or by a national monopoly position but are competing on an equal footing with RDIs in other countries on the basis of price and quality. Only Nuclear-3 obtains an important share of its revenue from abroad (Figure 3.12). To a lesser extent Ship-1, Elec-1 and

Figure 3.11: Industry revenue per researcher

Figure 3.12: Sources of industry revenue
Elec-2 are able to obtain foreign contracts. The absence of any international contracts in some RDIs suggests that they either have no incentives in seeking business abroad or they are unsuccessful at winning foreign contracts due to their lack of competitiveness or to other barriers such as language. Both scenarios imply that the RDIs may be operating in shielded environments in their home countries where they do not have pressure to compete with foreign RDIs for their sustainability.

One aspect of the RDI sample that stands out is that few are being tapped for their technological capabilities by SMEs. Only one of the RDIs in the sample has SMEs as a principal source of industrial revenue (Figure 3.13). In most cases SMEs account for less than 20 percent of revenues. This is as expected since, as a general rule, SMEs and particularly in ECA, invest less in R&D than larger firms. Nonetheless, while RDIs in OECD countries increasingly offer specialized services to SMEs, this is still a relatively uncommon phenomenon in ECA. In most cases, when SMEs collaborate with RDIs or universities in OECD countries they are supported by publicly-financed grants programs destined to support industry-research linkages, and often targeted specifically at SMEs (Table 3.3). Since these types of programs are designed to overcome a dual market failure, namely underinvestment in R&D in the private sector and lack of collaboration in the national innovation sys-

![Figure 3.13: Share of revenues from SMEs](image)

Table 3.3: Collaborative applied R&D matching grant programs for SMEs & RDIs

<table>
<thead>
<tr>
<th>Country</th>
<th>Ireland</th>
<th>France</th>
<th>Hungary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organization</strong></td>
<td>Enterprise Ireland</td>
<td>OSEO</td>
<td>National Technology Program</td>
</tr>
<tr>
<td><strong>Individual projects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>45%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>Cap</td>
<td>€650,000</td>
<td>€10mln</td>
<td>€3.8mln</td>
</tr>
<tr>
<td><strong>Collaborative projects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max</td>
<td>80%</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>Cap</td>
<td>None</td>
<td>€10mln</td>
<td>€3.8mln</td>
</tr>
</tbody>
</table>

Source: websites of the different funding programs, accessed on Feb 6, 2009.
tem, their funding instruments are usually designed to be more attractive to participating firms than single-objective programs. In the EU they provide up to 80 percent of the R&D project through matching grants and offer relatively high caps on co-financing. In ECA countries there are few programs aimed at improving ties between SMEs and research institutions. In the sample, only five RDIs reported having a very minor share of their client SMEs benefiting from special government support.

**Funding and Governance**

The structure of governments funding plays a key role in an RDI’s market-orientation

An RDI’s funding model is intimately connected to its overall research and business strategy. When funding is provided as a subsidy with no strings attached, it can be used to pursue R&D objectives motivated by scientific curiosity, theoretically free of any commercial or political considerations and can help build the long term R&D capabilities of an RDI. The RDI is likely to use this “core” or “strategic” funding to adopt a “technology-push approach” where resource allocations are mostly motivated by internal scientific interest and capabilities. When this model is not accompanied by external performance evaluation it can result in a lack of accountability of the RDI, poor performance, and lack of relevance with the needs of the economy.

When, at the other extreme, no income is available from the government, the RDI’s survival will be based on offering services of value to the private sector. In this case, the RDI is forced to adopt a “market-pull” approach (Figure 3.14), where its activities are solely determined by client contracts. A drawback of this latter approach is that in order to remain financially viable, the RDI will shift its focused away from R&D towards services for which its clients can fully and immediately appropriate payoffs. While still economically relevant, the RDI will lose its social role as a disseminator of public knowledge and in conducting research with high spillovers.

Since innovation is not a linear process, the technology-push/market-pull dichotomy is in fact a simplification of the dominant R&D strategy approach. In reality, innovation in RDIs is likely to be a much more complex process involving technological trajectories, learning and feedback processes from multiple sources. For strictly illustrative purposes, Table 3.4 provides some of the characteristics likely to emanate from following pure “technology push” or “market pull” strategies.

*Figure 3.14: Schematic representation of the influence of funding source on R&D strategy*
Governments can create incentives for RDIs to become more market-oriented through their research funding strategies. The first strategy they can implement is to restrict the amount of unconditional core funding allocated to the RDI, so that the RDI must seek revenue from the market to remain financially sustainable. Another strategy is to introduce earmarked core funding. What this means is that government funding is still granted unconditionally but is allocated ex ante to specific activities, equipment or infrastructure within the RDI, which ensure that the RDIs activities are relevant to private sector needs. Although this does provide the government with closer oversight of the RDI’s activities, it further centralizes research funding decision-making by displacing the resource allocation challenge from the RDI’s management to the government's bureaucratic apparatus. This is only useful if the government’s resource allocation strategy genuinely reflects the country’s industrial needs. However, this strategy does not provide incentives for increasing the efficiency of the institution.

Another public funding strategy which can address both research quality and research strategy issues is competitive (or “grant”) project funding. In this case, funding is allocated on a competitive basis to research groups for particular projects, and for particular outcomes. In theory, this ensures that funding is allocated on the basis of research quality and efficiency and introduces accountability, since unsatisfactory outcomes for one grant will hinder a research group’s chances of obtaining a second one. In OECD countries, competitive funding typically constitutes the largest share of government funding. Governments have focused on decreasing the ratio of institutional funding to competitive project-based funding to allow for better monitoring of results and accountability of public sources of funding (OECD 2003). A survey of large European research institutions showed that they tended to receive roughly one-third of their funding as core funding, another third as competitive public funding, and another third from contract research (EARTO, 2005).

However, competitive funding has its limitations as well, particularly in countries with limited research infrastructure. In such countries, there is often a single predominant RDI focusing on a particular technical field, which implies there will be little or no real competition for government grant funding. Given the critical mass of equipment and researchers, and the lumpiness and learning curve of research, it is going to be nearly impossible for new entrant RDIs to displace incumbents or for existing RDIs to encroach in each others’ technical areas unless there is a provision for international consortia to that can leverage the strengths of domestic and foreign partners to compete for these funds. The latter is not always politically feasible in a context of limited resources, as this involves a transfer of subsidies abroad. Another limitation has to do with the peer-review process that allocated grant funding, as this takes time to develop and must be designed to operate in a transparent and

<table>
<thead>
<tr>
<th>Table 3.4: A comparison of the main general characteristics of “technology push” and “market pull”</th>
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<tbody>
<tr>
<td><strong>Technology push</strong> (Top down)</td>
</tr>
<tr>
<td>Origin of the project</td>
</tr>
<tr>
<td>Main barrier</td>
</tr>
<tr>
<td>Technological sophistication</td>
</tr>
<tr>
<td>Market</td>
</tr>
<tr>
<td>Level of risk</td>
</tr>
<tr>
<td>Return on investment*</td>
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*when successful
Source: Gilbert Nicolaon, Background paper on “RDI restructuring”, 2008.
independent way for grants to go to the best projects. The result is that competitive funding in certain countries often has the similar effect as direct earmarked subsidies.

In ECA, RDI funding policies are often not conducive to effective market-oriented R&D

The RDIs in the sample are associated with a variety of funding models (Figure 3.15). At one end of the spectrum, some institutions draw the quasi totality of their funding from government subsidies (e.g. Nuclear-2, Bio-3, Occup and Energy). In one case, a joint-stock company receives almost 80 percent of its funding from government subsidies (Energy-1). This is rather surprising as the introduction of private ownership in an RDI has typically been justified on the grounds of reducing dependence on the public sector. Two of the RDIs in the sample receive the vast majority of their funding from core funding, with very little from competitive funding. This is a pattern repeated in many ECA countries. In Bulgaria, competitive funding only accounted for 20 percent of government funding for research in 2007. However, some EU accession countries have moved in the direction of OECD countries. By 2006, only 13 percent of Slovenia’s national research budget was allocated through institutional transfers, the rest being competitive funding mostly through the Slovenian Research Agency.

At the other end of the spectrum, some RDIs in the sample derive almost all of their income from industry. These include the remaining private or joint-stock companies of the sample. This conforms with the idea that private ownership exerts pressure on the RDI to increase its revenues by responding to market demand. Five RDIs in the sample derive more than 70 percent of their income from industry. These RDIs may have become focused on fields of work with limited spillovers for the rest of the economy, and hence have decreased their research intensity. It is surprising that two of these five RDIs are still fully owned by the government. They are either (i) provid-

Figure 3.15: Source of financing of the budget
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Box 3.3: Russia’s evaluation of public RDIs

Most of the RDIs in Russia are subject to quasi-independent evaluation every 5 years. For FRCs, this procedure is obligatory every two years if the RDI wanted to keep its special status. The evaluation is conducted by the Ministry of Education and Science of the Russian Federation and is based on a set of formal criteria, such as:

1. Number of publications, contracts, patents,
2. Number of defended theses,
3. Share of R&D in total RDI budget,
4. Honors and rewards granted to RDI staff

The evaluation does not affect the schemes according to which FRCs receive their financing. Currently all the RDIs have managed to renew their status. Public organizations also undergo evaluations conducted by government officials. Performance indicators are similar to those for FRCs and include:

5. Number of publications, contracts, patents,
6. Level of international cooperation, grants received,
7. Average age of researchers, number of graduate students,
8. Number of thesis defended, number of presentations at the conferences. However, the size of unearmarked government financing does not change after the evaluation: implying that these evaluations have no bearing on the financing provided to RDIs.

ing services that have a limited public goods element, or (ii) active in providing high spillover services on the basis of strategic assets acquired through prior government funding. In case (i), the logic of public ownership is not justified, in case (ii), the absence of government funding cannot be justified if the RDI is to maintain its existing function without seeing all of its equipment and knowledge become obsolete.

Other RDIs in the sample depend on a mix of public and private funding. As can be seen by the funding sources of the four Western European RDIs included in Figure 14, namely VTT, Sintef, Fraunhofer and Arsenal Research, the trend in Western European RDIs is to depend on a mix of income from unearmarked core funding sources, competitive funding sources and industry sources. The unearmarked core funding allows the RDI to invest in generating new capabilities and remain at the forefront of certain technical areas in the long run, while the competitive and industry funding ensure that the RDI remains efficient and accountable. None of the RDIs in the ECA sample display this mix of funding. Funding systems in ECA are still largely homogeneous and have not moved much towards diversified forms of funding: institutional, programs, project funding and individual grants. Yet, the situation in EU accession countries has changed or is changing significantly when compared to the CIS.

Furthermore, core funding in many ECA countries is not distributed in a way that ensures that it is being used efficiently. Most ECA RDIs, including in Turkey, receive their core funding on the basis of their number of employees and operational costs. This is in stark contrast with the situation in high-income countries where core funding is increasingly tied to independent evaluations. Independent evaluations ensure that public funding for research and innovation is spent on effective projects, programs and institutions. In Germany, the individual institutes of the Max Planck Society undergo scientific evaluations by independent Scientific Advisory Boards every two years. At a higher level, the German Government requests international commissions to conduct system evaluations of the Max Planck Society. In Russia, RDIs are subject to evaluations, but these are not completely independent and the results do not affect their funding (Box 3.3). In some ECA countries, it may be difficult to negotiate a strategic or performance–based mechanism for core funding since the RDI receives its budget directly to the Ministry of Finance, not to a body responsible for research and innovation policy. This is the case of the Bulgarian Academy of Sciences. In Germany, the Federal Ministry of Education and Research is responsible for allocating institutional funding to the national research institutes, including the Max Planck Society and the Fraunhofer Society.

Moreover, while core funding is increasingly committed on a multi-year basis in OECD countries, only one subsidized RDI in the sample had a multi-year commitment. Multi-year mechanisms have the
advantages of ensuring a stable and predictable income stream, important for long-term planning of research, and ensuring the practical relevance of the institute’s activities (Arnold 2007).

In ECA, the private sector generally does not play a role in the governance of state-owned RDIs

RDI governance plays a critical role because it influences the overall strategy of the institution, as well as how budgets are allocated and how staff is hired. The composition of the Board of Directors, also referred to as the “Supervisory Board” in ECA, provides a good indication of the level of influence of various stakeholders on the governance of the institution. In the ECA RDI sample, only one state-owned RDI has any private sector involvement in its strategic decision-making (Bio-1). In OECD countries, successful public RDIs aim to have a broad range of stakeholders represented on the Board. This is the case of VTT in Finland, which although a public entity, only draws 14 percent of its Board from the public sector, the rest consisting of representatives of the private sectors or of various associations. The Board of the Dutch public RDI TNO does not include a single government representative (Figure 3.16). Including the private sector in the governance of a public RDI allows the RDI to be more closely guided by the needs of the private sector and integrates the RDI in business networks. This provides it with additional commercial opportunities.

Limited autonomy from the government could hinder the performance of some of the RDIs in the sample

In almost half of the cases, the state-owned RDIs are not empowered to determine their own budgets. Further, a few extreme cases can be observed where the RDIs are tightly controlled by the state administration. For example, Bio-2 and Bio-3 both require state approval to set salaries and service fees, as well as to set their strategic or business priorities or to offer new services. This lack of flexibility prevents the RDIs from efficiently responding market needs, including in terms of their research and staffing needs. It is not surprising that both of these institutions rely on government funding for virtually all of their income.
Regardless of the level of institutional autonomy of the RDI, in all but one state-owned RDI the executive director is appointed by the state administration. There are no RDIs in which the director is selected by a board of directors with external, non-state representatives. The major drawback here is that the appointment of the director may be politicized when it is carried out by the government and may result in the establishment of a management structure with insufficient skills and experience. In the United States, the issue of management quality has been addressed by outsourcing the management of some of the national RDIs to private organizations. This is the case of all the RDIs under the responsibility of the United States Department of Energy. In some cases they are managed by private non-profit RDIs such as RTI, private corporations such as Lockheed Martin and in others by universities. The government-owned/contractor-operated approach is not very common outside of the United States, let alone in ECA.

Few of the RDIs in the sample incorporate institutional mechanisms to provide incentives for the commercialization of knowledge

Box 3.4 Human resources management can be a bottleneck for productivity

One of institutes in the sample is currently undergoing restructuring. Recent reports for this institute confirm that the restructuring process is very slow, particularly in the area of organizational change and human resources. The Institute’s most recent human resources (HR) analysis, sent revealed a number of outstanding issues. The HR analysis report identified a number of factors linked to low employee performance and high turnover. Notably, minimum base pay at the Institute is not market competitive, not transparent and that the variable pay is not based on individual performance, due partly to the absence of a sound performance management system. Moreover, employees in the production areas have no clear career development plan. A background study for the HR analysis found that without a clear career development plan and a transparent remuneration system none of the 50 interviewed engineers planned to stay at the Institute. The HR analysis also pointed out to a high ratio of production to services staff and identified a group of employees who were deemed to be unsuccessful or have no potential career development.

The Institute has made limited use of severance packages available for restructuring purposes. Overhead costs remain high and technical staff productivity remains low due to the absence of an appropriate internal incentive structure and the absence of performance evaluation processes. Fundamental changes in human resource management and business management process would constitute critical first-steps to ensuring the long-term financial sustainability and economic relevance of the Institute.
It is striking that the publishing track record continues to be the most common yardstick to provide incentives for personnel in the state-owned RDIs of the sample, even for those engaged in market-oriented activities. Figure 3.17 shows that less than 40 percent of RDIs in the sample provide staff salary- and promotion-linked incentives for patenting and generating new contracts. Surprisingly, some RDIs in the sample which derive the majority of their budgets from industry, such as Ship-2, do not provide any incentives to their staff to commercialize their knowledge. Moreover, many ECA RDIs do not have modern human resource management practices with where researchers have clear career paths and salaries based on transparent performance evaluations (Box 3.4).

Half of the RDIs in the sample employ few or no sales, marketing or technology transfer staff (Figure 3.18). Even some of the RDIs that derive important shares of their revenues from the market, such as Ship-1 and Ship-2, have very few commercial staff. This is particularly problematic for RDIs where there are limited incentives for researchers to engage in business development. In three cases, the state-owned RDIs have no dedicated commercial staff. Figure 3.18 also suggests that joint-stock RDIs and RDIs that do not obtain any core funding from the government employ more commercial staff. This is in line with the theory that government ownership and unconditional government funding shield RDIs from the competitive pressures that would lead them to adopt more effective organizational and managerial structures.

The limited commercial orientation of the management model for state-owned RDIs is further reflected by the fact that several of them have no marketing strategy (Figure 3.19). A marketing strategy can be seen as a basic first step to commercialize knowledge or at least an ‘intent’ to sell services to the market. All of the RDIs in the sample without a marketing strategy are fully owned by the state. Few of the RDIs in the sample collaborate with external technology...
commercialization organizations (Figure 3.20). Only roughly a quarter of the RDIs in the sample cooperate with either an incubator or external technology transfer office (TTOs). In some cases, such as Russia, the lack of collaboration with TTOs can be partly explained by the legal obstacles prohibiting public RDIs to have shares in spinoffs. This is in sharp contrast with successful RDIs such as VTT and Sintef that often become shareholders of their spinoffs. Nonetheless, the trend is slowly changing and some ECA RDIs have started to establish TTOs (Box 3.5).

**ECA’s RDIs often have trouble attracting a high-quality workforce**

The most critical asset of an RDI is its personnel. It is the research staff that accumulates the knowledge that can generate new discoveries and inventions or be commercialized. Formal education and training provides the fundamental building blocks for this knowledge, but arguably the most valuable knowledge is accumulated by conducting R&D through learning-by-doing and learning by interacting with clients and with other sources of knowledge. Universities, particularly in the United States and Western Europe, typically act as national repositories of advanced technical knowledge. For this reason, RDIs in these economies find it useful to forge ties with universities through collaborative project, graduate student researchers and faculty. Figure 3.4 already showed that most RDIs in the sample had some ties with universities, by employing students or faculty members. However, the RDI sample confirms the widespread belief that ECA’s RDIs are unattractive...
workplaces for ECA’s younger generation of researchers. As seen in Figure 3.21, the average age of the research staff in the sample is quite high, at times approaching the late fifties, and mostly between 40 and 50.

The ageing of the RDI personnel could be caused by a number of factors. One possible factor is that in many ECA countries the number of science and engineering graduates has declined over the years and this is creating supply-side constraints. At the same time, personnel in many of ECA’s state-owned RDIs are considered to be civil-servants, and inflexible firing rules can make it difficult to replace older researchers. RDIs in Turk are addressing this issue by hiring an increasing number of project-based staff and placing a freeze on the number of permanent positions. Although this strategy increases the RDI’s flexibility, it also makes it more difficult to attract high-quality staff. Moreover, salaries in ECA’s state-owned RDIs tend to be significantly lower than in the private sector, as illustrated by the RDIs in the sample (Figure 3.22), which make them an unattractive option to young graduates. In some ECA RDI such as Bio-2, Ship-2 and Nuclear-2, the RDI salary is less than a third of the private sector salary.

If the performance of an RDI is largely determined by the quality of its workforce, it is worth noting that a number of RDIs in the sample employ few staff with doctoral or even masters degrees (Figure 3.23). This contrasts with surveys of knowledge-intensive enterprises in ECA countries by Radosevic and Sav-
which suggests that these enterprises are able to attract higher-shares of skilled personnel with graduate degrees. The authors’ sample of 304 firms in six countries (Hungary, Croatia, Czech Republic, Lithuania, Poland and Romania had 41 percent of the firms’ CEOs with Masters degrees, 17 percent with PhDs and 36 percent with a Bachelor’s degree. The core staff had a larger proportion of PhD graduates (22 percent) and 23 percent with a masters degree and 42 percent with a bachelor’s degree.

A rather surprising finding from the sample is that this is even the case for RDIs conducting work in very science-intensive fields such as biology and nuclear engineering (e.g. RU-FRC-3, Nuclear-3), or for those where the high share of self-initiated R&D would imply that their mission is tied to pushing the technological frontier (Mech-2, RU-FRC-3). In those RDIs, there appears to be a mismatch between the staffing structure, the funding structure and the mission of the institution.

**Challenges Ahead**

The case studies highlight a number of obstacles hampering industry-research collaboration

The results suggest there is a large performance gap that needs to be breached for RDIs to fully meet spe-
specific technological needs of local firms and complement the national system of innovation by playing a bridge role between pure research-performing organizations and the productive sector. Among the barriers that exist, some can be attributed to external factors.

- Mechanisms to finance industry-oriented R&D are underdeveloped. There are few public grant programs to fund collaborative research between RDIs and industry; there are often no business angels or venture capital markets to transfer research coming out of RDIs into early-stage startups.

- In some ECA countries, poor investment climates reduce the demand for innovation in the private sector by making it difficult to establish new innovative enterprises or increasing the risk of innovation.

- There are legal barriers for collaboration due to unclear IPR legislation or inability of state-RDIs to establish spinoff firms.

- There is an increasing shortage of researchers.

- Government funding models based are often biased towards institutional funding instead of competitive funding, thus decreasing competitive pressures to operate efficiently.

- There is little accountability for institutional funding.

A number of internal factors relate to the governance of the RDIs:

- Many RDIs do not have the institutional autonomy to operate efficiently.

- The private sector is not involved in the strategic decision-making process of the RDIs.

- There are few institutional mechanisms to facilitate the commercialization of knowledge and knowledge-management is therefore not effective.

- Modern human resource management practices are sometimes lacking.

- In some dimensions, like publishing and licensing, the measured outputs of RDIs are very weak.

Chapter 4 explores strategies to tackle some of these issues in ECA’s RDIs.
Introduction

Reform of RDIs in ECA countries has been uneven. In many cases RDIs sought to modernize and improve their performance through various reorganizations but little was done to fundamentally change the mission of the RDIs to bring them closer to industrial market demand, to improve their governance, renew management, or attract new sources of funding.

For example, in the Russian RDIs included in this study, it is clear that developing linkages with business was not a central objective, in part because they were historically involved in defense R&D. Internal reorganizations were aimed at improving R&D performance but barely related to the idea of strengthening science-industry collaboration (Box 9). Workforce problems persist, and attempts to attract young researchers by offering salaries several times higher than average has led to growing tensions within RDIs and stimulated further departure of experienced and qualified scholars to other institutes or abroad.

Another example is Turkey, where RDIs underwent a first round of restructuring starting in the late 1990s. Their cooperation with industry increased and Turkey’s largest RDI, TUBITAK-MAM, more than doubled its industry revenues over the 2003-2007 period, and provided as much as 52,000 industrial testing and analysis services in 2008. Turkish RDIs
Box 4.1: Reforms undertaken in several Russian RDIs

While the Russian RDIs in the study have undertaken steps to improve their performance within the constraints of the existing legal framework, none has been associated with true reform:

**FRC-1:** 1. Changes in organizational structure of RDI — departments are created instead of laboratories. 2. Attraction of young researchers to the RDI. 3. Purchasing of new equipment (about 1 piece per year, during last 3 years, at a cost of $45,000 per piece). 4. Entrance to foreign markets with novel R&D results.

**FRC-2:** 1. Young researchers are employed with salary that noticeably exceeds RDI average. 2. Establishment of new departments and laboratories and managing retirements of older researchers.

**FRC-3:** 1. Recruitment of young researchers.

**Public:** 1. Renewal of research equipment. 2. Reorganization of the laboratories. More multi-disciplinary research profile. 3. Opening of a patent office.

**Private:** 1. Educating and training of the staff. 2. Purchasing new equipment. 3. Certification of the institution according to ISO 9001.

Figure 4.1: Chain of events leading to ineffective RDIs

1. **Public:**
   - Poor governance
   - Inadequate external funding structure
   - Insufficient demand from the private sector
   - Public resources spread thin between too many RDIs
   - Unclear IPR legislation

2. **Private:**
   - Limited incentives to collaborate with industry
   - Limited incentives to improve RDI management

3. **Public:**
   - Poor human resources management
   - Staff incentives not aligned with the mission of the RDI
   - Low staff quality
   - High staff turnover and ageing of researchers
   - Top-down management and inflexible organization
   - Low salaries
   - Limited investments in new equipment and infrastructure
   - Mismatch between RDI capabilities and economy

4. **Private:**
   - Poor quality or irrelevant outputs
   - Limited revenues from industry

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ing the 2004-2006 period, only 6.4 percent had any type of cooperation with RDIs in Turkey.

Many reforms aimed at improving RDI performance in ECA are solely focused on the proximate causes shown in panel 3 of Figure 4.1, without consideration for the more fundamental factors included in panel 1, such as governance, funding incentives and market demand. As a result, reforms have a mostly superficial impact on RDI performance.

**Diagnostics — Prerequisites for a Reform Strategy**

In this chapter we build on the evidence from the RDI statistics and case studies in chapter 1 and 3 to propose a strategy for reform of RDIs based on their relevance to national priorities, their expected role as providers of public versus private goods, their performance levels and their relation to relevant markets and users. A first question that ECA governments must ask as they evaluate strategies for reform of RDIs, concerns their very role in the economy, including the technical specialization and the services offered. The specialization area of the RDIs should be guided by national research priorities and by current or future prospective industry needs. In some cases, policy-makers may decide to concentrate fiscal resources in a limited number of technical fields of strategic relevance to the economy. As discussed in chapter 2, RDIs can offer a range of services, some of which have the characteristics of public goods including conducting basic research, supporting industrial development, supporting public policy, supporting standardization and maintaining key facilities (EURAB 2005), and other RDIs — mostly located in ECA countries — which produce private goods such as engineering services for mature technologies or manufacturing of finished products.

When deciding on what ownership and management structure can provide the right incentives for RDIs, governments need to make a distinction between RDIs that provide mainly public goods vis-à-vis RDIs already selling or with the potential to sell mainly private goods and services. There is a continuum of possibilities, and any classification of RDIs must take into account that RDIs often produce public and private goods, both at the institution-level and within individual teams and projects. If an RDI is not assessed to be performing well, another essential distinction is between RDIs whose products and ser-
services are developed responding to concrete demands in the market ("market pull") and those RDIs whose R&D is self-initiated, leveraging a core capability to come up with a technology ("technology push"). This latter dimension is of particular interest to ECA RDIs because it strongly differentiates them from OECD RDIs, which tend to be more demand-driven (Arnold 1998).

RDIs can be classified in terms of optimal management and ownership structure using two sets of characteristics. Figure 4.2 shows the continuum between private and public goods production on the vertical axis, and on the horizontal axis we classify RDIs by their relation to their relevant markets/users. Within this continuum we make a classification of RDIs that can serve as a basis for governments to decide which RDI should remain government owned and government operated (Quadrant I), government owned but operated by contractors or organized as autonomous non-governmental entities (Quadrant II), restructured or closed (Quadrant III) or privatized to insiders or to outsiders (Quadrant IV).

This classification of RDIs according to R&D outputs and organizational characteristics is also a good starting point for discussing the advantages of different public funding instruments. If RDIs are producing a large share of public goods (Quadrants I and II), then public support through institutional / strategic funding (e.g., “block grants”) is probably needed to partially subsidize recurrent expenditures such as salaries of researchers and strategic assets. RDIs mostly producing private goods (Quadrant IV) should not have access to such funding streams. At the same time, competitive funding allocated based on peer review and public procurement can help to top-up the budgets of RDIs for high-quality projects in more experimental areas; in the case of RDIs in Quadrant IV. This should preferably be through matching grants that provide incentives for collaboration with industry from early on.

Two more characteristics are necessary to guide a restructuring strategy, namely the performance of the RDI and the existence of a market for its services. For RDIs offering public goods, a performance evaluation will identify strengths and weaknesses and provide insight on whether or how to proceed with reforms. High-performing RDIs are not likely to re-
quire deep reforms. For RDIs offering private goods, the existence of a market will determine whether to privatize or close the RDI. Figure 4.3 summarizes the questions that ECA policy-makers need to address for each RDI.

The rest of this chapter discusses: (i) diagnostics that could be used to operationalize the classification of RDIs using readily available data about their activities and outputs, as an initial screening device for policymakers; (ii) RDI governance reform options in more length, reviewing advantages and drawbacks found when applying these in RDIs globally as well as in the ECA enterprise sector; (iii) public funding options that should be put in place to support RDI governance reform, as well as other policy levers to improve the overall performance of the R&D sector and increase the impact on competitiveness.

Diagnostic Tools to Guide RDI Reform

In order to apply the above classification of RDIs and in particular to spell out its implications for restructuring of a specific RDI, we require diagnostics. The following decision-making guidelines are numbered according to the decision tree in Figure 4.3.

1. **Is the RDI providing a public good?**

   Following the economic literature, a public good was defined in chapter 2 as a good that is non-rival and non-excludable. This means, respectively, that consumption of the good by one individual does not reduce availability of the good for consumption by others; and that no one can be effectively excluded from using the good. Applying this concept to RDIs, based on the different functions reported in Table 2 of chapter 2, there are several activities that can be classified as public goods:
   - Fundamental / strategic research, including defense-related
   - Infrastructure and technological support to economic development / competitiveness
   - Technical norms, standards
   - Advanced training such as PhD programs
   - Supporting public policy

A key methodological issue facing governments is how to avoid identifying all upstream research (basic and applied research) as being “public good” research and all downstream (development and engineering) with private goods production by an RDI. As the example of SEMATECH (SEmiconductor MAnufacturing TECHNOlogy), a non-profit consortium that performs basic research into semiconductor manufacturing, shows, RDIs can grow to be complex entities with upstream “technology push” but also downstream “market pull” projects and in terms of supply it combines public and private knowledge production.

In contrast, an indication that an RDI is offering private goods is that it derives a substantial portion of its revenues from production activities, or mainly sells technical services to large established clients in mature industry sectors.

2. **Does the RDI fulfill a strategic mission and is it performing well?**

   **Strategic mission**: There is no clear-cut answer to the first half of the above question. Determining whether an RDI that is producing public goods should be supported by government depends on policy choices and is best addressed through national consensus-building exercises. The type of RDI to sustain depends on the national needs, level of technological development and innovation strategy of a given economy. For example, decisions on investments in national defense, energy and food research often reflect security concerns and priorities. Decisions for hosting a specific RDI also need to consider tradeoffs with procuring R&D from alternate sources such as universities, the private sector and foreign countries, and by considering fiscal constraints. An increasing trend in OECD countries to ensure that RDIs stay relevant to national priorities is to organize them to

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24 — Radosevic, S., Background paper.
focus on specific problems rather than on academic fields of science. Turkey has adopted this approach.

**Performance**: Once it has been established that an RDI is relevant to an economy, its performance can be evaluated. While it is difficult to compare the performance of RDIs, since each has its own mission associated with a particular measure of success, a combination of indicators can be used to provide an initial snapshot of the quality and quantity of their research outputs. Table 4.1 presents a set of indicators that are relatively straightforward to measure for the RDI functions presented in Table 2.1 of chapter 2. The indicators do not strictly focus on the level of scientific and technological capacity of the RDIs, but whether they are effectively performing their public functions.

The most readily-available indicator to measure the performance of RDIs engaged in **fundamental / strategic research** is the quantity and quality of publications (Box 4.2). Another benchmark indicator for basic research performance is the level of international funding the RDI is able to raise from sources such as the EU’s FP7 or foreign clients. International research funding usually implies that an RDI is internationally competitive. Chapter 3 showed that although some RDIs in the sample produced numerous publications, few of these were in international journals, thus questioning the quality of some of them.

### Table 4.1: Performance indicators according to RDI function

<table>
<thead>
<tr>
<th>RDI’s Function</th>
<th>Performance indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental / strategic research</td>
<td>Publications, international funding</td>
</tr>
<tr>
<td>Technological support to economic development / competitiveness</td>
<td>Patents and licenses, industry funding and spin-offs, international clients</td>
</tr>
<tr>
<td>Supporting public policy</td>
<td>Government contracts, publications</td>
</tr>
<tr>
<td>Technical norms, standards</td>
<td>Standards developed and technical services provided, conformity to international guidelines</td>
</tr>
<tr>
<td>Constructing, operating and maintaining key facilities</td>
<td>Publications, international funding, industry funding</td>
</tr>
<tr>
<td>Advanced training</td>
<td>PhD programs, mobility programs with universities</td>
</tr>
</tbody>
</table>

**Box 4.2: Publications as a measure of public goods**

Government research evaluation systems (RES) have been developed in a number of countries in the context of new public management practices, scarce public funds and increasing accountability requests (Georghiou, 1995), and the allocation of resources for organizations and programs has become more and more connected to the evaluation of research.

We propose to use publications as a measure of “public goods” production. Two measures which we already employed in our discussion of ECA RDIs in chapter 3 are (i) the number of publications per RDI employee, which can be refined by weighting the publications according to the scientific prestige of the journals and publishing houses; (ii) the impact of an average publication of the RDI on the wider scientific community, using the number of citations as a proxy. These indicators can be calculated with information from publication citation databases, the most comprehensive ones being the Science Citation Index owned by Thomson Reuters and Scopus.

In countries behind the “knowledge frontier”, publications and citations in peer-reviewed international scientific journals may be a better indicator of the impact on the international research community than of the public nature of knowledge produced. To address this, it is useful to consider a broader measure: (iii) the number of publications per RDI employee in papers, books, conference presentations and papers in proceedings, in peer-reviewed domestic journals, working paper series in top universities, and other dissemination channels. This drawback of this measure is that it is not really comparable across institutions, unlike the measures using standard publication citation databases.
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Europe and Central Asia Knowledge Economy Study No. 3

these publications. Chapter 3 also showed that few ECA RDIs were able to secure grants from foreign organizations, even those in the EU, implying a lack of international competitiveness.

RDIs with a mission of technological support to economic development and competitiveness should be assessed according to a more comprehensive list of indicators, to reflect the various channels of knowledge transfer to industry. Possible indicators include patents, licenses, share of industry funding, collaborative projects and spin-offs. Patents are a good measure of the output of the RDI, with more demanding international patents being a demonstration of even better performance. However, patents only show commercial potential and not actual economic impact, unless they protect products or processes that are used commercially by the RDI, IP that is licensed to external firms, or technology used by enterprise spin-offs. The number of licenses, licensing revenue, number of spin-offs and the contracts the spin-offs generate are indicators of commercialization. In all cases, performance indicators based on IP should be used to benchmark RDIs that are in technology and service areas where patenting play similar roles. For example, patents are much more important to protect innovations of RDIs conducting research in the pharmaceutical sector than for RDIs involved in providing technological services to small firms in the wood industry.

Because patents and licensing are mostly relevant in economies operating at the technological frontier, it is likely that technology commercialization in ECA countries will occur through alternate channels such as contract research, use of facilities, testing, certification and training. Industry revenue per worker and ratio of market-based funding to institutional funding are good indicators that should be considered together. These indicators measure how much the RDI is collaborating with industry, although they do not necessarily measure the quality of its work. Revenues from privately-owned clients are a good measure of quality, since they are likely to be more demanding than state-owned enterprises in the services they receive. An indicator of even better quality regards the number of contracts with international clients, since it indicates a capacity to develop services for more competitive markets.

The sample of ECA RDIs analyzed in chapter 3 performs poorly compared to OECD benchmarks in terms of patenting, licensing and spinoffs. However, as a whole, they do not lag as far behind in terms of industry revenue indicators.

It is more difficult to assess RDIs’ performance in supporting public policy. Two possible indicators are the size and share of government contracts and the number of publications. Government contracts may not be a reliable indicator of the quality competitiveness of RDIs since government procurement preferences for national RDIs. In the case of Turkey, a research funding program subsidizes the procurement of RDI services by state entities. Publications statistics can be used as complementary indicators.

Developing technical norms and standards tends to be the function of specialized RDIs such as national standardization bodies and national metrology institutes. Since these types of institutions were not included in the sample of ECA RDIs it is not possible to evaluate their performance. These specialized institutions are the subject in a forthcoming regional study of the national quality infrastructure in ECA.

Finally the performance indicators for RDIs whose role is to construct, operate and maintain critical R&D infrastructure that could be used by different public and private R&D teams depend on the exact purpose of the RDI. Although publications and level of international and industry funding can be used as proxies of the outputs from these R&D facilities, often such an RDI will also have some of the functions mentioned earlier and can be evaluated against those functions.

3 & 4 Is there sufficient market-pull?

Measuring the degree of market-pull relies on both quantitative and qualitative indicators. The obvious indication of market-pull is whether there is demand in the market for the technology provided by the RDI as measured by sales and orders. At the same time,
market-pull is mostly a function of an RDI’s management model: the existence of an RDI marketing strategy, full-time staff dedicated to marketing, business development and technology commercialization efforts. It also relies on internal processes that ensure that R&D is mostly initiated by a demand from a customer. Many OECD RDIs now have technology transfer offices. RDIs such as Finland’s VTT, Norway’s SINTEF and Germany’s Fraunhofer- Society’s all have programs to spin-off technologies by forming new companies (Box 4.3).

The sample of RDIs in chapter 3 reveals that technology-push is the dominant strategy in ECA, rather than market-pull. Few ECA RDIs have technology transfer offices or programs. Turkey’s extensive RDI network run by TUBITAK has yet to actively spin-off a single company through processes that transfer intellectual property to the private sector. Spinning off new ventures is further hampered as there is no way for RDIs to create and own independent legal entities without an approval from the Council of Ministers. In Serbia, the Institute of Physics has spun-off three firms, but although it officially retains 51 percent of their ownership, there is no official guideline at the state level on how to transfer the remaining ownership of intellectual or physical assets. One recent example of a technology transfer office in ECA is Rudjer Innovations Ltd., owned by the Rudjer Boskovic Institute in Croatia.

**Box 4.3: Promoting spin-offs at the Fraunhofer-Society**

Promoting technology transfer from research to industry is one of the Fraunhofer- Society’s major objectives. In 2007, the Fraunhofer Venture Group provided support to 34 new spin-off projects. So far, a total of eight companies have been created with the assistance of the venture group. The Fraunhofer- Society holds a share in the capital stock or ordinary stock of seven companies. A typical example of a successful spin-off from the Fraunhofer-Society is Concentrix Solar GmbH, an offshoot of the Fraunhofer Institute for Solar Energy Systems ISE in Freiburg created in 2007. The company won the German Industry Innovation Award for the development and implementation of its novel concentrator photovoltaics technology.

Since the Fraunhofer- Society launched its support program for spinoffs in 2005, known as “FFE – Fraunhofer Promotes Spin-offs”, more than 40 researchers have received help with setting up their own companies. In 2007, funds totaling EUR1.4 million were granted to 13 new projects. In September 2007, the venture group initiated a new project, “FFM – Fraunhofer Promotes Management”, to strengthen the management skills of the new entrepreneurs and guide them through the highly critical early phase of their business. The German federal ministry of education and research (BMBF) is providing funding of EUR2.3 million for this program over the next three years.

**Can the RDI be restructured to increase public good or market pull?**

In some cases, policy-makers need to make restructuring decisions based on the potential for an RDI to fulfill a certain public role. The potential for institutional reforms is more difficult to evaluate and is covered in greater length in the next section. A number of approaches to assessing the technological potential have been developed for both public and private sector organizations. It is measured by the gap between an institution’s existing technological assets and the technological capabilities it requires to fulfill a new function. A technology audit is a possible approach to evaluating this potential. The outcome of a technology audit can provide policy-makers with a good understanding of the additional investments necessary to upgrade the equipment, skills and know-how of RDIs.

**Options for Restructuring RDIs**

We identify five restructuring options, presented in Table 8 together with their characteristics.

**Option 1 — Corporatization and increased autonomy of Government RDIs**

Under this option, the government maintains its ownership and management of RDIs but tries to increase their effectiveness by granting them more autonomy.
Governments are interested in this option for RDIs producing public goods with strategic implications such as defense, nuclear, standards, etc. that have no private or commercial, current or prospective clients. Increased autonomy is meant to allow government-owned RDIs more freedom in terms of the direction of their innovation activities, including their establishment of small companies that can commercialize applications and patenting-licensing activities. Under this option, RDIs should be allowed to conduct some types of activities which at the present time are not legally determined — such as technical assistance and consulting. In the Russian RDIs discussed by in Box 11 above, the reform would allow RDIs to be not only co-founders of private enterprises but also own and sell founder shares, or commercialize intellectual property in these new enterprises.

Governments that maintain the ownership and operation of their RDIs have tried to improve their efficiency by introducing changes to the internal organization or management approach and by introducing different incentive structures. Examples include adding directors from the private sector to the RDIs’ boards of directors, introducing technology audits by outsiders, changing the structure of funding (institutional funding based on independent evaluations, more competitive funding vs. institutional). In Germany, the Fraunhofer- Society’s Senate contains 18 elected members representing science and the private sector, and only 7 members designated by government institutions. Moreover, individual institutes of the Fraunhofer- Society have Governing Boards composed of representatives of the scientific and private sectors. Another path followed by governments is a change in the legal status of incorporation: conversion of RDIs from a government unit into an autonomous public body, into a joint-stock company owned 100 percent by the government or an NGO. (OECD, Governance of Innovation Systems, 2005).

Additionally, as discussed in chapter 3, the staffing of RDIs and incentive structures need to be strengthened to improve the quality of personnel. The staff needs to be empowered to shift to R&D areas with high spillovers to the productive sector and be given incentives that induce the commercialization of results. Currently, recruitment of young researchers and technical workforce is weak due to the lower salaries that RDIs can offer, whether because of funding constraints or the contractual restrictions imposed by civil service rules. The development of knowledge-intensive services for industry will require a commensurate investment in human capital. RDIs need a more flexible organizational model that opens the doors to creating new R&D practice groups in response to changing industrial demand. Reforming institutional incentive structures, especially salary — and promotion-linked incentives, to reward patenting, licensing and other commercialization ef-

<table>
<thead>
<tr>
<th>Option</th>
<th>Relevance to public goods RDIs</th>
<th>Effect on market-pull of RDIs</th>
<th>Effect on RDI governance incentives</th>
<th>Political feasibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Corporatization / autonomy Government-owned</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>++</td>
</tr>
<tr>
<td>2. Insider restructuring, Government-owned</td>
<td>+</td>
<td>±</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>3. Government-owned, contractor operated (GOCO)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>4. Non-profit Foundation</td>
<td>+</td>
<td>-</td>
<td>±</td>
<td>++</td>
</tr>
<tr>
<td>5. Insider privatization</td>
<td>-</td>
<td>±</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>6. Outsider privatization</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>7. Liquidation/closure</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>--</td>
</tr>
</tbody>
</table>
forts has been essential in OECD RDIs as a way to align the individual interests and public objectives. Importantly, RDI contractual rules and employment contracts should be flexible enough to allow private funding for specific R&D projects, consulting activities and temporary mobility. IPR ownership typically needs to be clarified to facilitate commercialization of knowledge.

The disadvantages of this option in terms of governance must be kept in mind. Increased autonomy of government-owned RDIs contains a high scope for rent seeking and leaves unresolved the issue of interaction between private and public stakeholders. The form of public/state-owned R&D institutes may not be conducive to science-industry collaboration unless certain preconditions in terms of RDI governance are in place and sweeteners are made available in the form of public subsidies. We discuss public funding instruments to induce collaboration such as matching grants in the last section of this chapter.

**Option 2 — Insider restructuring of Government-owned RDIs**

Under this option, the government restructures the RDIs with the help of its current management by spinning off non-core activities, but maintains its ownership. A restructuring plan specifies which activities will be core activities, which activities will be integrated to other organizations or ‘spun-off’ and which will be liquidated. A full description of the option proposed by Radosevic (2008) can be found in Appendix A26.

Gradual restructuring of R&D institutes is a voluntary management-driven activity that is funded and facilitated by a government program for supporting restructuring of R&D institutes. It is gradual as it is based on bottom-up initiatives by the management of R&D institutes and their financial participation. Ownership after restructuring under this option will remain in the hands of the government while control will remain in the hands of the current management. It is not clear, however, who will be the residual claimant, if there are any profits, which might be the case in the more commercial RDIs. In practice one can assume that it will be management and the workers/researchers collectively, similarly to the Yugoslav social ownership model.

We envisage three possible types of future organization:

- **Type 1:** Institute restructured into dominant-ly production (service) enterprise
- **Type 2:** Institute restructured into dominant-ly public institute
- **Type 3:** Institute restructured into R&D enter-prise or R&D centre

Radosevic (2008) proposes that RDIs be selected for this government sponsored restructuring-exercise based on their willingness, in collaboration with a business enterprise, to co-finance the restructuring. Scientific excellence and research and technological competencies based on an audit and evaluation reports would be required. Finally, the quality of the restructuring proposal and the commitment of top management should be an important selection criterion.

The critique of this option is that neither governments nor insider managers, who are responsible for the status quo, can be entrusted with the implementation of genuine restructuring. Moreover, there are potential transparency risks in the spinning-off process: often the real ownership of the spin-offs and the amount paid by managers for their shares is not transparent. However, provided that these costs can be minimized, the final outcomes should lead to more effective organizations in the NIS.

In cases where an RDI produces both public and private goods but whose access to markets is limited and chances to survive as a private company are low, giving ownership of the RDI to management may not be a practical or desirable solution. The likely outcome is that the institute would shift entirely to

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26 — Slavo Radosevic, ‘Active And Gradualist’ Model For Supporting Restructuring Of R&D Institutes In ECA
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Quadrant III of Figure 21 — i.e. the RDI would go downstream and government would gradually cease to bear any responsibility for public knowledge elements. We need to bear in mind that there is a close link between mode of provision and the underlying knowledge base of an RDI. As a consequence, a mode of ownership should depend on what profile is desirable. One way out of this quandary is spinning-off entirely commercial activities and transferring entirely public good (basic science) to a university. This would therefore require simultaneous adoption of restructuring Types 1 and 2.

However, if a public-private profile is desirable, then the ownership will need to reflect this. It is very difficult to know the optimal profile in advance due to very specific nature of different areas. For example, in biotechnology scientific papers may be quite closely related to commercial issues while in other areas that may be completely unrelated. A careful assessment is needed to prescribe which ownership form would ensure a coherent organizational profile, and be flexible about the restructuring options depending on particular local context. But in all cases it is critical to ensure the quality of the restructuring process — i.e., to ensure its transparency, clarity of strategic objectives, and fair representation of interests of different stakeholders.

We find it useful to review the lessons from manufacturing enterprise restructuring in ECA to assess the RDI restructuring proposal. Pro-active enterprise restructuring has a long history in transition economies. An early approach was termed “Isolation” programs; these were implemented in seven transition economies — Albania, Armenia, Bulgaria, Kazakhstan, the Kyrgyz Republic, Macedonia, and Romania. All these experiences of restructuring enterprises in ECA in the 1990’s have been negative.27

Yet, under certain circumstances, Goldberg and Nellis (2008) argue that modest and temporary public intervention might be warranted to make firms sellable by reducing the baggage of the past — through write-offs of old debts at the time of sale, public funding of severance pay, and the imposition of hard budget constraints to induce recalcitrant insiders to participate in the process. Restructuring measures should be tightly and exclusively connected to privatization; restructuring is not synonymous with bailing out the firm so that it may continue to operate indefinitely as a loss-making state-owned or socially-owned company. Does this logic apply to RDIs? We will discuss RDI privatization below.

Option 3 — Government-owned, Contractor-operated (GOCO)

Under this option the government contracts out the management of the RDI to an outside contractor but maintains government ownership. The contractor may be a university or university consortium, a for-profit corporation, a not-for-profit organization, or a professional and external management team or CEO. The logic of this option is that government ownership addresses the objective of public good provision and the contractor management facilitates meeting market demand and ensures improvements in internal governance and management.

GOCO contracts were designed to be insulated from political pressures, and to be better able to attract and retain talented personnel because they did not have to conform to civil service rules. With management contracts, responsibility for managing, operating, and developing an entity is transferred to a contractor or investor from the private sector for a period of time who is paid for these services and simultaneously the level of public funding for operating and investment expenses are agreed upon28. GOCO is usually used in cases that require high levels of specialized experience in management, operation, and marketing, or when the government has a large investment in the project’s assets and prefers to keep the investment rather than sell it; that is, ownership of the assets is not transferred to the private sector.

27 — See Goldberg and Nellis, (2008)

28 — In the US for example the national lab NREL is managed for DOE by Midwest Research Institute and Battelle. See also on the Lawrence Livermore Lab in http://www.lbl.gov/LBL-PID/Galvin-Report/v2a.html).
As mentioned in chapter 1, Jaffe and Lerner (1999) examined the effect of the GOCO solution in the US national labs. Their paper challenges many of the earlier assessments of national laboratories. The striking improvement in the measures of commercial activities at the laboratories, especially when compared to the experience of the universities, stands in contrast to the negative tone in many discussions such as the "Galvin Report" [Task Force, 1995]. The apparent importance of limiting the distortionary effects of political interference, while in keeping with the academic works on privatization, has not been emphasized in many of the government studies.

Critics of the suitability of the GOCO approach for ECA argue that it overestimates the importance of management incentives and ignores the fact that there is no developed market for management control — let alone for RDIs — in ECA. The critique also questions that management talent, qualified to manage RDIs, is available in the private sector. Yet, in our view the “contractor” in GOCO could be a regional private university (e.g. NES in Moscow, KSE in Kiev, CEU in Budapest, CERGE-EI in Prague), an international company or university (e.g. RTI or Battelle) or a regional one (e.g. Slovenian, Hungarian). Moreover, we believe that the process of development of a R&D management market could only be facilitated by the governments’ use of GOCO for RDIs and other R&D facilities.

According to our interviews with RDI managers, their primary concern regarding outright privatization is that an outsider will be far more interested in controlling or disposing of the organizations’ valuable real estate than in nurturing and redirecting the R&D mission to enhance the effectiveness of the institutes. GOCO addresses this concern as assets remain in state hands. There is still however a possibility of the contractor misusing the project assets, because management contracts, in the majority of cases, stipulate payment of a fixed sum to the contractor in exchange for specific services, which is sometimes not a sufficient incentive for the contractor to maintain the assets in a good condition and improve performance.

Beyond operational efficiency issues, it is essential that the GOCO management has the ability and incentives to develop RDIs. Why would contracted management be at all interested in strategically developing these organizations? Drawing on evidence of management contracting in enterprises suggests that contractors selected for this task should have ample prior experience in related industries and performing R&D activities, and in the case of organizations — in contrast to individuals or consulting companies — should also have a similar mission to the RDI in question. These strategic similarities are one way to ensure that there will be a good synergy between contractor and RDI workforce and that the contractor will have on a long-term horizon and focus on developing R&D core capabilities.

In terms of Figure 4.2, RDIs in Quadrant III combining private good and a technology push approach, could reorient to market pull approach, could reorient to market pull under GOCO because new management can provide sharper incentives for commercialization and marketing of R&D outputs. If this “mismatch” quadrant is not empty, as it should be, it must be because governments still fund them in spite of their private-clients oriented R&D and in spite their unwillingness or inability to identify private clients.

For SOEs, the Performance Evaluation System (PES) in Korea had the following elements: (i) Independent evaluation committee, (ii) measuring performance in three management categories: general management, policy (business) goals, and resource allocation, and (iii) Incentive schemes: 200-600 percent bonus + department / individual performance linked. Kim (2008) argues that PES have had a positive effect on the SOEs’ organizational competence: (1) a strong impact on curbing labor increases, (2) a moderate impact on containing labor costs, sales costs, and financial costs, and (3) little impact on the ratio of debt to asset. Kim also found that PES have had a positive effect on the SOEs’ organizational productivity: (1) a strong impact on labor productivity, and (2) a moderate impact on fixed-capital productivity, and (3) a moderate impact on profitability measures.
Box 4.4: Dealing with the practical difficulties of an RDI restructuring process

1. **Before starting the program, establish a well-defined financial “base line”**. Past accounting methods were not fully reliable, and as RDIs were managed with little concern about efficiency and profitability, it is difficult to have a precise analysis of their financial and managerial situation before embarking on a restructuring program. This generates numerous questions later on. Although it is difficult to obtain a reliable financial picture according to western accounting standards, it is important to require some data, provided and fully approved by management, which will later on be used as a “baseline”.

2. **Audit the available technologies by external recognized experts in the field**. The quality and competitiveness of existing technologies should be assessed carefully with the help of some fully independent external experts having a good understanding not only of the technologies but also of the market. This requires time, but is important because, unless done professionally, it will be very difficult to measure progress later on.

3. **Appoint a dynamic team in charge of managing the restructuring program**. The team in charge of managing the program is a very important component of the whole process. It should be “young,” as employees who have several decades of professional activity ahead of them will be more motivated to prepare the medium and long range future; be given enough authority to manage the restructuring process not just the technical component; and be committed to report according to a precise format and schedule.

4. **Set up goals which are not too ambitious**. It is now quite well established that such restructuring programs face serious challenges. If they have very ambitious goals it is unlikely that the goals can be reached and this will demotivate employees even more. For these reasons, it is best to err on the side of caution and establish a small number of achievable goals at the beginning of the program. All the components of the program should be strongly focused on these few important goals. Additionally, it is unrealistic to expect significant results in the short term and a program over at least four or five years will typically be necessary.

5. **Agree upon a well-defined monitoring and reporting process**. Reporting is not very popular among scientists, particularly when they have not been used to transmit regular information on progress according to a well defined format and schedule. This generated difficulties in the past and should be precisely agreed upon before approving the loan. The content and the format of the various reports should be indicated together with a precise schedule concerning the delivery of such documents.

6. **Communicate positively about the program**. Although an increase in external financial support can provide a unique opportunity to transform an RDI, it appeared that these programs are not well accepted by all the scientists and engineers working for the concerned RDIs. Some are not favorable to accept a financial support, even if it is badly needed for the institute, in order not to face the various associated conditions.

*Source: Gilbert Nicolaon, Background paper on “RDI restructuring”, 2008*

such as the net income and the value-added output. Also, he found significant differences in SOEs’ overall performance in comparison to the control group (eight local SOEs without PES) and ex-post and motivational performance management through systematic evaluation system in SOE sector can be more conducive to the organizational performance

**Option 4 — Non-profit Foundation**

In EU countries there are many examples of non-profit foundations that have been set-up to carry out applied R&D activities. The reasons that foundations have been used rather than for-profit companies are that this type of organization: allows public funds to be channeled in spite of existing EC rules on State Aid; they can be a good vehicle for charitable donations to be given; and provide tax-related advantages.

Arguably, a foundation is also a good way of bringing in a mix of stakeholders to supervise the governance of RDIs.

In this report we do not consider de novo organizations but rather the transformation of long-established RDIs, and therefore it is important to discuss whether a nonprofit foundation is well suited to accomplish the multiple restructuring needs identified. One justification for turning a public RDI into a foundation is that this can avoid the asset-stripping problem mentioned before, in which new owners take over an RDI in order to dispose of valuable assets for commercial gain and layoff the RDI staff. The foundation can be entrusted the RDI’s property and other assets with the proviso that they be used to carry out its central mission. However, in ECA the potential for corruption in a Foundation maybe higher than
in a for-profit corporate structure, in which a controlling shareholder (e.g., corporation) have a clear interest to supervise the RDI management. On the other hand, a foundation would not normally have recourse to a larger external entity — whether this is the government, a company, an industry association, or a university — that is financially solvent and can pay for operating expenditures and investments as and when needed, and therefore it leaves open the question of how the RDI will be able to generate sufficient revenue, obtain grants or other external resources to fund its operations.

One possibility to deal with this dilemma is for government to provide seed capital when setting-up the foundation to cover initial restructuring costs and recurring expenditures for a defined period of time. During this period, the RDI would need to become self-financing by expanding its services to firms, or access resources from public or private sources that can make up for any revenue shortfall.

**Options 5 and 6 — Insider or outsider privatization and/or closure**

The privatization and/or closure option is relevant to Quadrants III and IV, where private knowledge-based goods and services provide a revenue stream to run an RDI on a purely or mostly commercial basis. Methods of privatization for public enterprises include sale through public subscription, sale of shares to employees or sale to a strategic investor. The lessons from privatization of enterprises in the transition economies in the first 20 years show the critical importance of selecting the right method. The method of privatization needs to be chosen in accordance with the specified objectives being the best means to be achieved.

We define insider privatization as a sale of the company’s shares to its managers and workers; and outsider privatization as a sale to an investor who is an outsider, i.e. neither as manager or a worker of the company (Box 4.6).

As mentioned previously, the 1990’s privatization of RDIs in ECA is considered to have negative outcomes. In Russia, privatization that took place in the mid-90’s led to acquisitions by investors interested in the valuable real estate possessed by the centrally located RDIs. The investors then typically disbanded the RDI and used the real state to develop malls and other commercial urban uses. From a social point of view, closure by privatization may be the right solution to allow reallocation of resources from less to more productive uses, but it leaves open the possibility that valuable human capital and marketable research results will be lost in the process, and it is important to put in place mechanisms to minimize these.

For state-owned enterprises (SOEs), the experience of practitioners dealing with the restructuring during the transition is clear in its verdict that SOEs that persistently run losses, that the state either does not wish to or can no longer afford to subsidize, and that attract no buyers when put up for sale, should be closed; and their assets sold piecemeal or otherwise disposed of. RDIs, producing both private and public goods, pose a conceptual challenge: chapter 2 argues that the production of public goods should be subsi-

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**Box 4.5: The Spanish Technology Centers**

In Spain, the non-profit Technology Centers, under joint ownership of enterprises, public sector and banks, play an important role in regional development. The Technology Centers perform a twin role: first, they generate knowledge in terms of technological development; and second, they collaborate with the business sector in applying this knowledge by raising awareness, dissemination and training, carrying out R&D projects, and providing technological services. According to Fedit, the private voluntary federation representing Technology Centers, its 67 Technology Centers have an average of roughly 100 employees each providing services for around 30,000 companies a year, and with average revenues of 7.8 million euros in 2007. More than half of Center revenues are from private sector contracts, with a another third from government contracts and less than 10 percent from public subsidies.


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dized, R&D yielding private goods should not. Splitting the public and private production operations of an RDI may or may not be a solution because of the strong synergies between the two.\(^\text{32}\)

Another way to deal with the concern about assets is insider privatization: selling the shares of the enterprise to its researchers. We are again looking to the literature on enterprise privatization for clues about the efficacy of insider versus outsider privatization. The finding that privatization to outsiders, especially strategic investors, investment funds, foreigners, and other block-holders is associated with more restructuring than privatization to insiders (managers and workers) has been confirmed in many studies (e.g. Djankov and Murrell, 2002).

In this context, it is useful to recap the experience of Chinese RDIs. In this case corporatization was mandatory but the majority of the equity was still to be held by the government. Some equity is owned by private shareholders or even listed on the stock exchange. A survey of ten listed companies shows that only six have good R&D capabilities, but in general R&D capabilities of (ex-RDI) companies are still poor. When shares were listed, the government's stake was diluted and shares/options were given to employees (Tang, 2008).

Professor Lan Xue of Tsinghua University argues that even if the government maintains a majority stake, listing on the exchange and outsider business participation on the board imposes better governance and financial discipline on RDI management.

**Option 7 — Liquidation/Closure**

If the government as owner of an RDI comes to the conclusion that neither of the other options mentioned in Table 4.2 can resolve the problems of an RDI, the last resort is closure. Obviously, politically this is the most difficult option, represented in the Table with a “double minus”. To the extent that this RDI produces public goods the effect of closure on the economy is negative but the extent that the state-owned RDI sells private goods, the effect of closure is positive: the “crowding out” effect disappears because of the leveling of the playing field vis-à-vis private companies (usually SMEs) producing similar products. Finally, if all options fail, i.e. the RDI cannot be transformed into a form of organization that would improve its governance, closure is positive. Note that

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\(^{32}\) In theory the RDI could be offered for sale with a commitment by the government to subsidize the public production, which could motivate the investor to maintain its production. This solution is complex because of the need to estimate the magnitude of the subsidy in advance.
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Box 4.7: Summary of recommendations for RDI governance reform

- For RDIs producing mainly public goods, option (3), GOCO is the most appropriate solution. It offers the best chance of taking advantage of market pull and the continued government ownership ensures the production of public goods. A second best solution is option (2), insider restructuring: it offers lesser governance incentives and thus less likely to take advantage of market pull.

- For RDIs producing private goods, outsider privatization is most appropriate when the RDIs has access to markets and can be transformed to a fully commercial company.

- For RDIs producing both public and private goods but whose access to markets is limited and chances to survive as a private company are low, a foundation or outsider privatization may be a second best solution instead of closure.

- For RDIs which needs to be eventually closed, outsider privatization could be used as “market test”.

Source: Munari, Roberts and Sobrero (2002)

in Table 4.2, the effects of this option are all in the opposite direction from those in Option 1, continuation of state ownership.

Sustaining RDI Restructuring Through Reform of Public Funding for R&D

RDIs restructuring needs to be carried out in concert with public funding reforms for R&D. Public funding should be based on the classification of RDIs in Figure 4.2 and Figure 4.3: In principle, only RDIs in Quadrant I of Figure 4.2 i.e. those which produce public goods and there is little demand in the markets for their outputs — should be eligible for long-term public funding. Most of these are government owned and government operated and thus government funding is required and justified. RDIs in Quadrant III — private goods and no market — which are candidates for closure or restructuring, should get no public funding, except possibly, short term support for severance pay for departing researchers. The same logic applies to Quadrant IV — private good with market demand — which may need help in the transition. The funding approach to RDIs in Quadrant III is mixed: Government owned government operated (GOCO) RDIs may have both private and public projects. The government should pay a full price for its projects so there is no need for public funding. In practice, in the National Laboratories, the United States Government covers the overhead.

A recent assessment of the potential “Reorganization of the Chilean Public Technological Institutes” by Advansys Oy, a Finnish research and consulting company, presents the issues that RDI restructuring pose for public R&D funding. We agree with the general principle that “institutes have to have a certain proportion of basic government funding for self-initiated R&D” (p. 93) but that determining this is difficult and that it is useful to look at the rules of countries that strengthened their knowledge economies. In the case of Finland, more “institutional funding” is available to RDIs that produce public goods or provide services for the public sector, or are oriented towards technology-push. Competitive R&D financing is a complementary mechanism that encourages competition among RDIs, universities, and private sector as well as the development of internal targets.

In parallel to governance reforms of RDIs regarding ownership and management, Governments should establish a more transparent basis for allocating R&D funding to the public RDIs in quadrant I, indicating the necessary conditions for RDIs to receive some “institutional funding” tied to observable and measurable goalposts about public good performance. The allocation system should provide incentives for substitution of public R&D funds for private funds — or at least crowding-in of fresh private resources — whenever possible. In Korea, the introduction of performance-based institutional funding mechanisms in 1999 appears to have increased the performance state-funded RDIs (Box 15).

34 — A market test — a tender or an auction — can discover whether the company’s asset value plus the social cost of its crowding out more efficient new entrants exceeds that market price so that exit is welfare enhancing. Another rationale for this sequenced approach — restructuring, market test, and bankruptcy — is that politically it is easier to place in bankruptcy a com
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Box 4.7: The role of performance-evaluation for funding RDIs in Korea

In 1997, as a result of the Asian financial crisis, the Korean government started exploring options to reform the governance system of central government-sponsored research institutes. It was believed that R&D performance and efficiency of RDIs was low because ministries intervened in research activities. In 1999, RDIs were separated from their subordinated ministries and were attached to five research councils under the Prime Minister’s Office. Member institutes now report their research and management plans to their research councils on a yearly basis. Research councils set evaluation criteria on which they can guide overall management of member institutes including R&D performance. The budget allocation of the Ministry of Planning and Budget to each research institute is established on the basis of the evaluation. RDIs are ranked against one another and receive budget increases accordingly. The reforms of 1999 have led to important improvements in R&D performance of the RDIs as competition for funding among RDIs has intensified. Number of publications has increased, as well patenting activity and royalty income.

Source: Lee, Kong-rae (2008)

One way to ensure market-pull research is to move away from “block grants” or “institutional funding” towards public procurement. Public procurement should preferably be done through international tenders, to ensure that RDIs build and retain their competitiveness.

Another way is to offer public resources through matching grants that require co-financing from a private enterprise (see chapter 3 for examples). A critical component of matching grants is the potential they have to create and foster linkages between the private sector and universities and research institutes by favoring consortia of an enterprise and an RDI. Cooperative schemes between the private and public sector have been at the heart of many programs in OECD countries. Given the dissociation between the private and public sector, it is important that these instruments be used to promote schemes between the two. The MAGNET Program Israel, for example, involves pre-competitive R&D within a consortium that includes a number of commercial companies together with research personnel from at least one academic or research institution. The R&D focuses on new generic technologies that will lead to new generation advanced products. The industrial partners enjoy a grant amounting to 66 percent of approved R&D costs, whereas the academic partner will receive 80 percent of said costs.33

The competitive funding needs to be structured very carefully. In countries with few research organizations, there may be no effective competition. Marking funding for a specific industry or technological area is also likely to lessen competition and therefore the quality of the projects that are selected. More importantly, the peer review system has to be sufficiently independent and experienced to ensure that selection is made on the basis of the quality of the projects and that there is adequate monitoring of results and audits. The size of the funds is also critical in terms of encouraging participation, and it’s necessary to balance “critical mass” considerations that would lead to concentration of resources and attract larger companies and R&D organizations vs. the objectives of openness and capacity-building in smaller entities.

We discussed the issues of rent-seeking in the context of RDI ownership, and it can also arise in the case of competitive funding when institutions lack experience or autonomy. How to address this potential problem? Several methods that have tried to deal with this including: setting-up international peer review committees that may be less subject to “capture” by domestic RDIs; opening the funding to external (foreign) entities, which is more feasible when pooling resources among several countries as in the EU; requiring applying RDIs to form consortia with entities from other countries or with enterprises, which has the benefit of encouraging international/public-private collaboration.

Given the institutional and governance situation and the identification of corruption as one of the main constraints to the business environment in many ECA countries, it is of the utmost importance

33 — http://magnet.consortia.org.il/
to protect projects from corruption and misappropriation by the state. The second, related principle is neutrality: to minimize distortions, governments should avoid sector and company targeting (“picking winners”). The design of new instruments needs to account for the existing institutional environment. Many ECA countries, especially the new EU member states and accession candidates, already operate variations of innovation support schemes. To avoid government capture and failure, instruments should be designed to be as neutral and transparent as possible. Most critically, the decision-making (selection) processes about funding allocations need to ensure that the quality of selection is driven by true innovative and commercial potential. The funding instruments are likely to attract rent-seeking behavior if the institutional design cannot immunize the funding allocation from interference by political actors and other interest groups.

The design of instruments is crucially dependent on the capacity of public servants to administer them and insulate their decision-making promises from capture and rent seeking. As the Korean case study in Box 15 shows, some of the most successful innovation support systems in the world rely heavily on the analytical and managerial skills of public servants to take good economic decisions. The instrument design in ECA therefore needs to enhance the decision-making processes with sufficient checks and balances through a wide representation of private sector, academia, civil society, and foreign expertise to protect the decision-making process from rent-seeking behavior and capture by interest groups.
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R&D institutes have inherited organizational profile from the past which makes them unsuitable to market economy conditions. They were mainly R&D institutes working *for* industry but producing services and products as if they were R&D institutes *in* industry. They inherited too much diversified portfolio of activities from the past which makes them nonviable in market conditions without significant restructuring. During 15 years of transition their profile has changed through a variety of bottom-up survival strategies coupled with unsystematic attempts by governments to restructure them. However, the final outcome is that they are still organizations which “crowd out” resources from business R&D to state funded R&D. This situation calls for reconsideration of different approaches to their restructuring.

We envisage three possible approaches to this issue:

1. **Ensuring autonomy of R&D institutes**
2. **Privatization of R&D institutes**
3. **Active and gradual restructuring of R&D institutes**

1. **The first approach** is ensuring autonomy of public / state owned R&D institutes which would allow them much more freedom in innovation activity, including establishment of small companies and patenting-licensing activity. Rationale for this approach lies in the fact that form of public / state owned R&D institutes is not conducive for science-industry collaboration. In addition, argument is that privatization did not have the desired outcome since it did not take into account the specific features of the research institutes. Within this approach RDIs should be allowed to conduct some types of activities which at the present time are not legally determined — such as technical assistance and consulting. RDI should be allowed to be not only co-founders of private enterprises but also possess founder shares, or intellectual property in these new enterprises.

2. **Privatization solution** highlights the difficulty of providing high-powered incentives to and intensive monitoring of managers in state-owned firms. Within this approach there are two options for restructuring RDIs in ECA:
   - Government-owned, Government-operated (GOGO)
   - Government-owned, Contractor-operated (GOCO)

3. “Active and gradual restructuring” of R&D institutes is voluntary activity supported and facilitated by public program for supporting restructuring of R&D institutes. Similar to other two approaches the objective is to develop a new profile of R&D institutes but in this approach this is undertaken in a way which may ensure comprehensive restructuring and clear profile of new organizations.

   This is activist approach in the sense that government through its agency facilitates restructuring of R&D institutes on individual basis. It is gradual as it is based on bottom-up initiatives of R&D institutes, their financial participation and requires involvement of other stakeholders.

   Unlike immediate privatization option this approach recognizes that R&D institutes are not ordinary enterprises as they operate in between
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Each individual cases and may involve pure public, pure private or different mixed forms in dependence of specificity of resources and private/public knowledge profile of the R&D institutes. See below for outline of this model.

Restructuring of R&D institutes in ECA: an overview of active gradualist approach

We propose establishing the scheme to financially support the design and implementation of restructuring activities of R&D institutes. Its objectives are:

- to establish organization with a coherent set of activities (commercial or public S&T activities) which makes it viable in a medium term.
- to maintain and develop competencies of organization in its core areas;
- to facilitate labour mobility and thus ease social costs of adjustment.

Restructuring should be undertaken in three phases:

1. Institute diagnostics and strategic concept development

The first step requires external and internal review of R&D institutes activities (research/development/services/production), their viability as independent/combined activities and liquidation/integration or spin-off plan. At the end of this step the plan should be developed which would specify which activities will be core activities, which activities will be integrated to other organization or ‘spin-off’ and which will be liquidated.

2. Restructuring plan development

The objective of this step is to determine the dominant character of new organization and how this will be achieved through separation of core from non-core activities. We envisage three possible types of future organization:

Relevant sources:

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- Option 1: Institute restructured into dominantly production (service) enterprise
- Option 2: Institute restructured into dominantly public institute
- Option 3: Institute restructured into R&D enterprise or R&D centre

Option 1: Institute restructured into dominantly production (service) enterprise

If more than 70% of future revenue should be earned through production (service) activities institute is transformed into production (service) enterprise. This would imply that some of research, applied development and prototype or service activities will be liquidated or integrated into other organization or be separated as independent activities.

Option 2: Institute restructured into dominantly public institute

If more than 70% of future revenue should be earned from publicly funded projects institute is restructured into public institute. This would imply that plan should be developed how most of production and services will be either liquidated or integrated into other organization or separated as independent activities.

Option 3: Institute restructured into R&D enterprise or R&D centre

If institute retains a mixture of several activities like research, applied development, prototype development, services and production or any combination of these and if it is financed from public and private sources than it is considered as R&D enterprise (when profit making) or R&D centre (when non-profit making). These organizations may be financed partly from R&D contracts and/or public research funds and/or membership fees, if financed by consortium of enterprises (for example, sectoral R&D centres).

In each of these options will be developed how now the non-core activities are likely to be separated. A core of the restructuring plan development is solution on how to achieve a clear strategic profile of a new organization.

In all three options the organizational requirements specific to each of them should be specified. The future organizational profile should be derived from strategy as developed in the first phase. The organizational elements to be specified in this phase are for example: structural organization; reporting/controling systems; hierarchical layers; business units/legal entities; departmental split.

3. Implementation

In order to implement the new organizational structure it is necessary to develop a detailed action plan, to ensure management participation and qualification, and to actually perform the divestment of the non-core business as identified before and to address investment opportunities.

A master action plan and action plans for individual activities need to be developed to identify and coordinate the necessary steps for the implementation of the restructuring process. To ensure success of restructuring the management should receive training to actually carry out activities as specified in the detailed implementation plan. Finally, investment and divestment opportunities need to be identified (selling of equipment and buildings or renting as a source of revenue for investing according to restructuring plan).

The essential part of scheme is selection of institutes. The selection has to be transparent as much as possible. Every institute participating to it has to be fully informed about the criteria adopted, the composition of the evaluation committee, the procedure followed and the results of the application (through a letter communicating whether the application has been accepted or not and if not, why.). In preparation of restructuring proposals the top management of institutes will be helped by the staff from Agency which will provide guidance to applicants.
Criteria for selection should be the following:

- Criteria referring to strategic interest of other organizations (R&D institutes, industrial and other enterprises, universities, academies of sciences) through their interest in co-financing minimum of 10% of restructuring activities. Involvement of industrial enterprise in financing restructuring will be given special advantage.

- Criteria referring to the current status of the institute. They include, among others, financial data as well as status of ownership, number of employees, turn-over, range of activities (research, development, service, production). Advantage should be given to bigger institutes with diversity of activities and with greater restructuring needs.

- Criteria referring to the restructuring potential of the institute including willingness and capability of management, S&T excellence, as well as external factors such as research and technological competencies. Institute must be among leading in the country in respective area. Audit and evaluation reports should be used in assessment.

- Quality of restructuring proposal and commitment of top management.

- Quality restructuring proposals are essential to concentrate efforts, to obtain results. They require committed management.

- Criteria reflecting the capabilities of the R&D institute to serve as clear and implementable model for other restructuring projects in country

Eligible expenditures to be supported via this scheme are:

- the income of persons working on managing restructuring plan;

- the costs of preparing, operating and managing restructuring activities;

- costs of training when specified as a part of restructuring plan;

- costs of legal services for implementing restructuring activities;

- cost of consultancy activities when needed for improvements in operational efficiency and if specified by restructuring plan;

- the income of engineering personnel which has to be relocated to industrial partner as a part of restructuring plan for a limited period of time (up to 6 months);

No equipment costs should be financed through this program.

The funding should be subject to the ceiling of a maximum of 50% of total costs of agreed restructuring activities or maximum per R&D institute to be decided by the scheme.

Basis for selection of R&D institutes to be given support for restructuring are:

- Audit report of institute or own strategic analysis with the outline of restructuring plan.

- Project application form

- Interview with the management