Chapter 4. ECA's Institutional Framework for Public Support of Commercial Innovation

In chapter 2 we outlined the rationale for public interventions in creating new knowledge—namely, the public-good character of knowledge—as well as the intrinsic information asymmetries that hinder the funding of innovation. In principle, these arguments do not refer to specific economic circumstances and hence could be applied equally to any country, at any stage of development. Yet, any attempt to draw specific policy recommendations from such arguments should pay close attention to policies and institutions that mediate the impact of innovation and R&D on economic growth.

In this chapter we acknowledge that market failure per se is a necessary but not *sufficient* condition for the success of the support instruments described in chapter 3. Government support aimed at increasing the total amount of resources devoted to R&D, by offering for example R&D subsidies, is predicated on the assumption that there are inventors, entrepreneurs, and companies with valuable innovative projects that are effectively constrained by prohibitively high costs of financing those projects.[14] The assumption is that if the government were only to use policy levers to lower those costs through some subsidies, the entrepreneurs would be forthcoming and the projects undertaken. In developed economies with strong interfaces between science, advanced technology, and commercial R&D; with abundant human capital; and with institutional and legal settings that encourage entrepreneurship, such an assumption is for the most part well grounded. In many transition and developing economies, in which any number of these factors may be lacking, the availability of worthy innovative projects waiting to be supported cannot be taken for granted.

Although it is not a precondition per se that a country already be producing a steady flow of innovations and companies before a government intervenes, there is nonetheless a minimum level—a threshold of macroeconomic stability, infrastructure, human capital, investment climate quality, and trade openness—that represents a prerequisite for starting any intervention in the innovation context. Moreover, the government's capacity to manage such an innovation policy depends on the interaction of these factors in the institutional framework, the so-called national innovation system (NIS). The NIS must be gradually put in place so that at the very least there is the human and institutional potential to generate innovative ideas and the investment climate to allow companies to act on and commercialize those ideas.

In this chapter we use the NIS framework and knowledge assessment methodology (KAM) developed by the World Bank Institute to assess ECA countries' readiness to apply innovation support instruments. This exercise is not meant to provide an absolute standard to dictate to

[14] Of course, these entrepreneurs are not to be associated necessarily with new ventures (start-ups), but could well be (and in most cases will actually be) established firms willing to undertake new R&D projects.

governments whether or not they can implement innovation support instruments. Rather, it is meant to provide a useful guide to governments in deciding on whether to allocate public support for specific innovation interventions, rather than investing in the requisite institutions that support innovation.

This chapter will first describe the NIS framework and our empirical methodology in assessing the "readiness" of ECA countries. It will then provide detail on specific indicators for ECA countries before classifying them in the following categories:

1. Countries that are "ready" for implementing innovation support instruments.
2. Countries without properly functioning innovation systems (e.g., low-quality ICT, no intellectual property rights, low level of human capital).
3. Countries that lack one or more of the elements of an NIS but that should start putting in place the institutions required to implement the instruments identified in chapter 3.

As noted above, this categorization should serve only as a broad guide to governments in thinking about their innovation policies. Furthermore, rather than being a definitive indicator, it should point the direction toward a detailed study of the NIS system and the appropriateness of applying the specific instruments to support innovation. Nonetheless, the categorization provides a clear message to governments that they should "look before they leap" and critically evaluate the returns on investments in innovation instruments given their existing NIS systems. Given EU's Lisbon Agenda and the current vogue for innovation instruments designed for OECD economies (particularly VC funds), this message is especially pertinent for ECA countries at this time.

4.1 The National Innovation System (NIS)

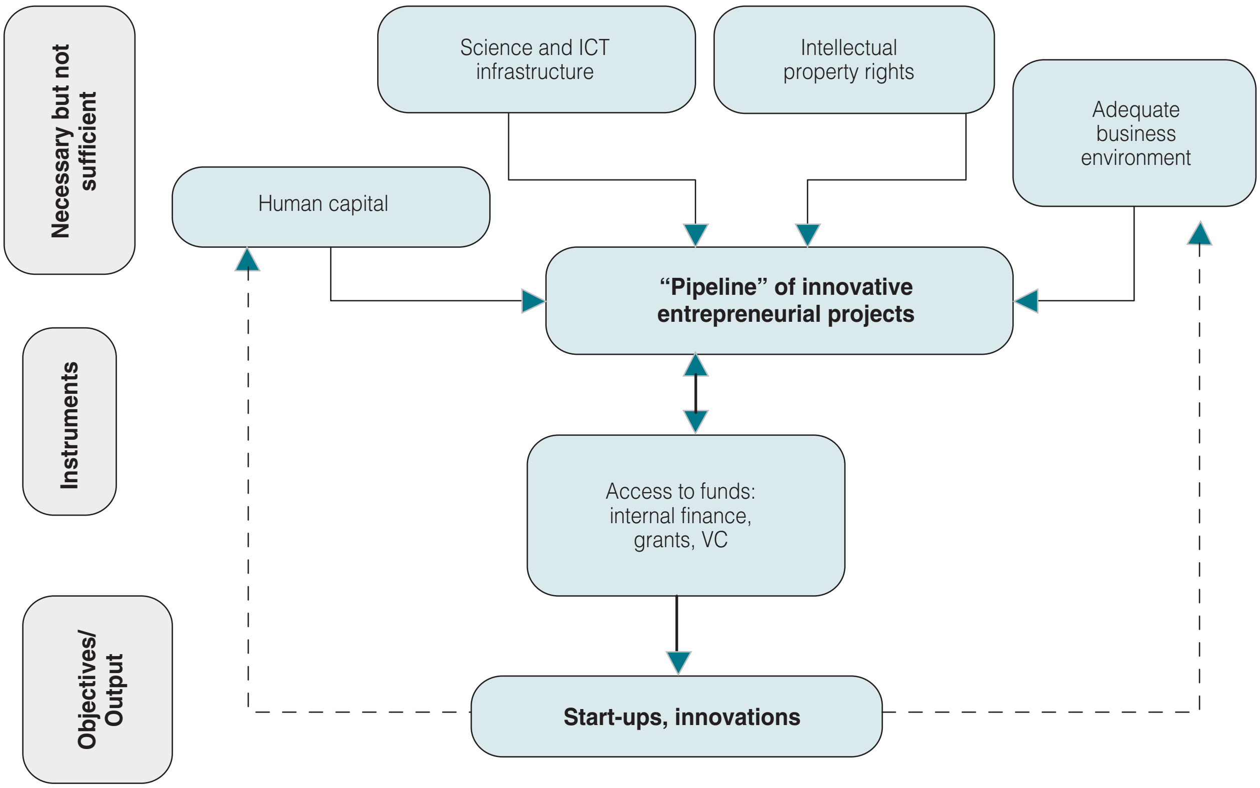
What is the NIS? The realization that individual measures to support R&D are ineffective when poorly coordinated has led to an extensive literature on the concept of a holistic national innovation system (the concept is elaborated in Nelson 1993; OECD 1998 and 2001; Lundvall et al. 2002). The NIS is a system in which those who generate new knowledge are efficiently connected to those who can benefit from its use. This connection is established through a set of instruments, institutional settings, and infrastructure that accelerate knowledge flows and enable innovation. For the system to work efficiently the "links" form effective networks that help overcome market failures caused by coordination and information problems, as discussed in chapter 2.

Specifically, the NIS needs to have the following:

1. *Institutions* such as universities/research institutes that are linked to each other and to a strong private sector, centers of technological innovation, and so forth.
2. *Instruments* such as a public-financing process to elicit the largest possible private sector R&D investment response, fiscal and financial incentives, and so forth.
3. *Incentives* such as a proper intellectual property rights regime and strong competition in product and input markets, as well as the proper linkages among the latter.

Notwithstanding the national scope of the innovation system, a critical element of its success is the ability to take advantage of the stock of knowledge abroad and to absorb and diffuse it locally. This system, including the availability of human capital, science and ICT infrastructure, intellectual property rights (IPR), and a business-friendly environment, is illustrated schematically in figure 6.

Figure 6. National Innovation System



A component of the NIS is the innovation production function, a concept building on Romer's endogenous growth model (1990) (see literature review in chapter 2), which articulates the economic foundations for a sustainable rate of technological progress (A) by introducing an "ideas" sector to the economy. It is assumed that growth follows the national ideas production function:

$$\dot{A}_t = \delta H_{A,t}^{\lambda} A_t^{\phi} \quad (1)$$

According to this structure, the production of new "ideas" is a function of the number of ideas workers (H_A) and the stock of ideas available to these researchers (A_t), making the rate of technological change endogenous in two distinct ways. First, the share of the economy devoted to the ideas sector is a function of the R&D labor market (which determines H_A); allocation of resources to the ideas sector depends on R&D productivity and the private economic return to new ideas. Second, the productivity of new ideas generation is sensitive to the stock of ideas discovered and accumulated from the past.

The literature proposes two approaches to estimating the effects of knowledge and its determinants on growth. One approach is to estimate the effects of the various inputs, including human capital and R&D, directly on growth. Such an approach is followed in Lederman and Maloney (2003) and in Chen and Dahlman (2004). Another approach is to look for a proxy for "ideas" or knowledge: the most prevalent relatively usable and universal measure is the registration of patents in the USPTO and recently in the EU patent office. This approach is followed by Jaffe and Trajtenberg (2002); Furman, Porter, and Stern (2002); and Bosch, Lederman, and Maloney (2005). We will use the second approach to argue that variables that have been found to have a large and significant effect on patents are, to the extent that patents proxy innovation, determinants of innovation and therefore should be used in our analysis of the components of the institutional support for innovation. Clearly, patents are only an imperfect proxy for innovation, given that much innovation takes place without patenting—especially at the lower end of the innovation spectrum. Process innovations normally fall outside the domain of patents and, more important for ECA countries, patenting will normally take place in the countries in which the inventors have commercial interests—local patenting or even EU patents could be more relevant for ECA countries than U.S. patents. In addition, the high costs of applying (and maintaining) a patent may deter many inventors from filing for protection. However, given the extended use of USPTO data in the literature, we will accept the use of patents to proxy for innovation but not without noting the caveats mentioned above.

For example, we look at the evidence from Furman, Porter, and Stern (2002), who estimate an expanded form of equation 1, and find that in addition to the level of inputs used in innovation (R&D resources and human capital), other factors that have an impact include the business environment (proxied by openness to trade and tax breaks), the IPR regime, and the knowledge stock in each country. They also find that the type of industrial organization in the country and its interplay with research institutions (e.g., universities) can also play an important role.

Bosch, Lederman, and Maloney (2005) analyze the elasticity of innovation (proxied by U.S. patents) with respect to inputs (proxied by R&D). They find a very strong relationship in developed countries, but a somewhat weaker one in developing countries. They argue that this difference is due to the different ways in which the national innovation systems function. Some of the variables that they find to have an important bearing on the ability of countries to innovate are education and security of intellectual property rights as well as the quality of the research institutions and the role of the private sector in the system. The implications of their findings are far reaching for countries trying to climb the technology ladder—increasing R&D funds alone will not do the job, the countries will also have to take into account other determinants in their national innovation systems.

Having introduced the concepts of the production function for "ideas" and the role of the NIS and its main components, we now discuss the relationship between the two empirically. We continue using the same framework (the NIS) and try to quantify these concepts to clarify the situation in the ECA countries.

4.2 Key Factors in the Knowledge Economy

As discussed above, recent research allows us to identify which factors affect the innovation capability of a country. That will help us to evaluate whether specific countries should consider innovation interventions and to determine how they should sequence the interventions. It is useful to categorize the key factors that come into play to make it possible for innovative entrepreneurs to emerge in sufficient numbers, and to have a reasonable chance of success. The literature identifies the following key areas, or "pillars," of the knowledge economy[15]:

- Economic incentives and institutional regime
- Education (tertiary in particular)
- Innovation system
- Information infrastructure

[15] According to the Knowledge for Development website of the World Bank, the term Knowledge Economy has been coined to reflect this increased importance of knowledge. A knowledge economy is one where organizations and people acquire, create, disseminate, and use knowledge more effectively for greater economic and social development.

4.2.1 Economic Incentives and Institutional Regime

Typical business environment factors, such as regulatory and taxation burdens on small business, will more generally affect the "deal flow" of businesses capable of absorbing or matching government-supported investments in R&D. The business environment in which potential innovative entrepreneurs operate is crucial for their chance of success in transforming ideas into viable enterprises and commercializing innovations.16 As demonstrated by various investment climate assessments conducted in ECA by the World Bank Doing Business Series, the business environment may present barriers that affect all businesses, but particularly technology-oriented SMEs. The number of procedures and high costs associated with business incorporation, unfavorable tax and labor regulations, the high level of social contributions, and the low efficiency of the bureaucracy and of the judicial infrastructure are major obstacles for innovative entrepreneurs.

The extent to which the economy is open to international trade (with profound implications in regard to the competitive pressures exerted on local markets); the opportunities for expanding in global markets; the access to foreign inputs, capital, technologies, and so forth; as well as the macroeconomic stability of the country will also determine whether businesses are able (and willing) to invest and benefit from existing knowledge.

At a more micro level, the business environment has to do with the structure of specific markets and, in particular, with the extent to which these are competitive. Indeed, the effect of competition on innovation has recently received renewed attention in the context of development: the WDR (World Development Report) 2005 presents the results of an analysis of 27 ECA countries with ICA (Investment Climate Assessment) and BEEPS (Business Environment and Enterprise Performance Survey) II data, which show that the tendency to develop or upgrade new products or use new technologies is higher under stronger competitive pressures. Aghion and Howitt 2005, found that competitive pressures raise innovation in both new and incumbent firms. Entry, exit, and mobility, and not just competition among incumbent firms, are therefore important if risk taking for innovation is to be enhanced to create a business culture that rewards success handsomely but does not stigmatize failure.

It is particularly useful in this context to evaluate the role of SMEs in the process of innovation. The role of SMEs in spearheading innovation may be similar to their role in the initial years of the transition (Mitra and Selowsky 2002). In the early 1990s Polish SMEs, for example, started by taking advantage of remaining price distortions; once they accumulated enough capital they switched to manufacturing taking advantage of pent-up demand and shortages that existed in the postsocialist economies. Yet, there is evidence that these SMEs, although having thus far exhibited significant signs of entrepreneurship, do not know how to start innovating. They realize that the EU accession poses a challenge for their future business and are looking for strategies to restructure once again (Piatkowski 2004).[17]

Goldberg, Radulovic, and Schaffer (2005) find that the effects of ownership on TFP in a sample of 27,000 firms from 50 countries are positive, large, and significant: "The results for new entrants, however, are unambiguous: new private firms in Serbia, like those in the rest of the world, are more productive, more profitable,

[16] The development of SMEs, measured for example by the increase in the number and sales volume (relative to GDP) of active SMEs, is one possible index of the entrepreneurial capacity in a given country, which is a prerequisite for innovation.

[17] For example, Polish farmers have invested a great deal in adjusting to the hygiene requirement of the EU.

and growing more rapidly than state/socially-owned firms." The institutional setting in the country (rule of law, corruption, legal system, etc.) will also have a strong bearing on the ability and willingness of the private sector to invest in R&D and innovation. Special attention in this section should be given to a particular institutional setting: intellectual property rights.

Ideas and inventions are only the first stage: the business environment must encourage entrepreneurial activity in the form of new and existing companies with the resources and skills that allow for a reasonable chance of commercializing the innovation. The degree of protection that intellectual property rights receive allows companies to legitimately own or acquire and profit from specific knowledge, and the degree of protection will specifically affect the likelihood of commercialization of knowledge generated from the knowledge economy.

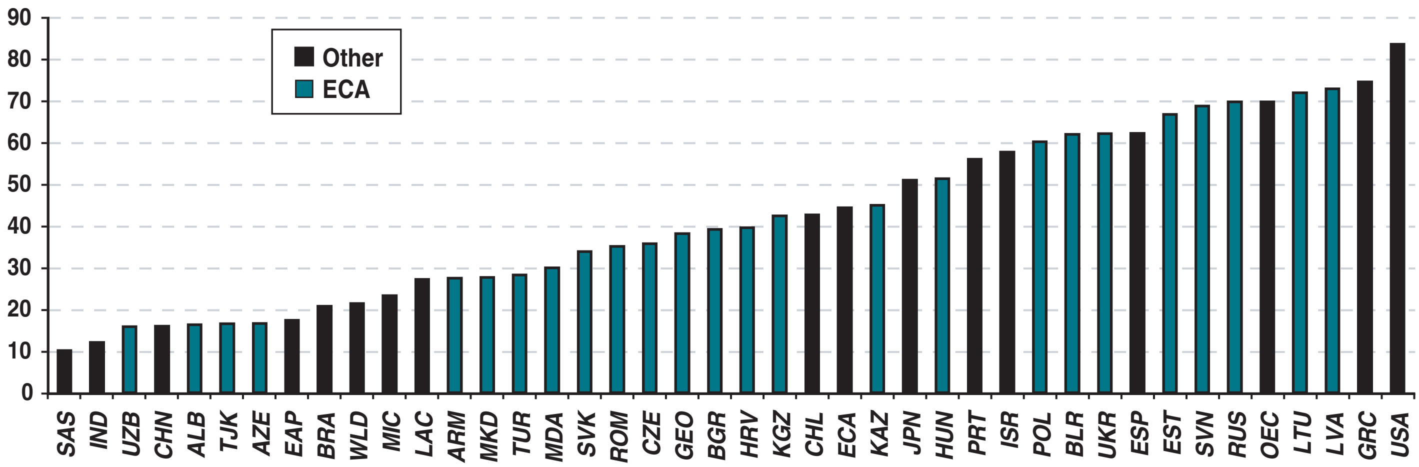
Intellectual property rights (IPR) developed in many countries as a response to the market failure that the public-good character of knowledge represents. By granting, for a predetermined period of time, monopoly rights to the knowledge creators, IPR allow creators to recover the costs of creating the knowledge, and in this way solving the problem of the "partial appropriability" of knowledge. Empirical analysis (Mansfield 1994, 1995; Smarzy_ska 2005) of the relationship of FDI, training, and licensing with IPR has shown their importance in developing the innovation potential of the ECA countries. In broad terms, the conclusion of this line of research was that IPR regimes that fail to provide effective patent protection are a drag on investment in innovative activity. These researchers found that in four technology-intensive industries—pharmaceuticals, chemicals, and the machine and electrical equipment industries—potential investors are very sensitive to IPR regimes.

However, IPR also imply costs (lost rents, costs of enforcing IPR, monopoly prices, etc.) that have to be taken into account when designing an IPR regime. These have to be weighted against the benefits of IPR (and, more important, the costs of an inappropriate IPR regime). Inventors, entrepreneurs, and investors will react to government signals on the IPR issue. They need to be sure that they will be able to capture the benefits of their investment in R&D. In regard to the IPR regime that ECA countries would want to follow, much will be determined by the *acquis communitaire* for the EU-8 and those in accession talks. Other ECA countries will have more leverage. Regardless of their EU accession status, countries will still be able to tailor much of their IPR regime to their needs and a proper understanding of its working—the way it incentivizes knowledge creation by assigning ownership of knowledge is important. Similarly, IPR might be an adequate protection instrument for certain forms of codified knowledge—while they are not for others (trade secrets, process innovations). It is important that countries find ways to promote those other types of knowledge also.

4.2.2 Education

A creative knowledge economy is reflected in the human capital of engineers, scientists, and entrepreneurs that are technically and creatively capable of engaging in knowledge creation and invention. A country rich in human capital will also be more able to absorb and disseminate knowledge and new technologies, enabling it to benefit more from sources of technology diffusion such as FDI or trade. These abundant scientific and technological skills intertwined with entrepreneurial capabilities are clearly the primordial ingredient for innovation to emerge. Education at all levels, of course, is one of the crucial levers for policy action. Basic education is necessary to increase people's capacity to learn, but university, technical, and business training, especially in the engineering and scientific areas, can most directly affect the innovation potential. Historically, ECA countries have benefited from

Figure 7. School enrollment (tertiary education), 2002



Source: World Development Indicators

high levels of investment in education, which enables them to tap into a pool of highly skilled individuals. Figure 7 illustrates that fact by comparing ECA countries with a number of other countries and regional averages in regard to their school enrollment in tertiary education.

Figure 8 shows that when tertiary education is plotted against GDP per capita for a worldwide sample, many ECA countries show a higher level of human capital than would be expected by their GDP per capita. Abbreviation explanations to this and other figures can be found in annex F.

Human capital, or education, has an important part to play in the relationship between innovation and growth. High levels of education as available in ECA are an advantage, but that does not translate automatically to innovation successes and even less so to commercial innovation if adequate incentives structures and institutions are not in place. The historical dissociation between the private sector and universities and research institutions has prevented the private sector from benefiting in full from such high levels of human capital. The education system as well as the surrounding institutions and structures have to be reformed to reverse that trend.

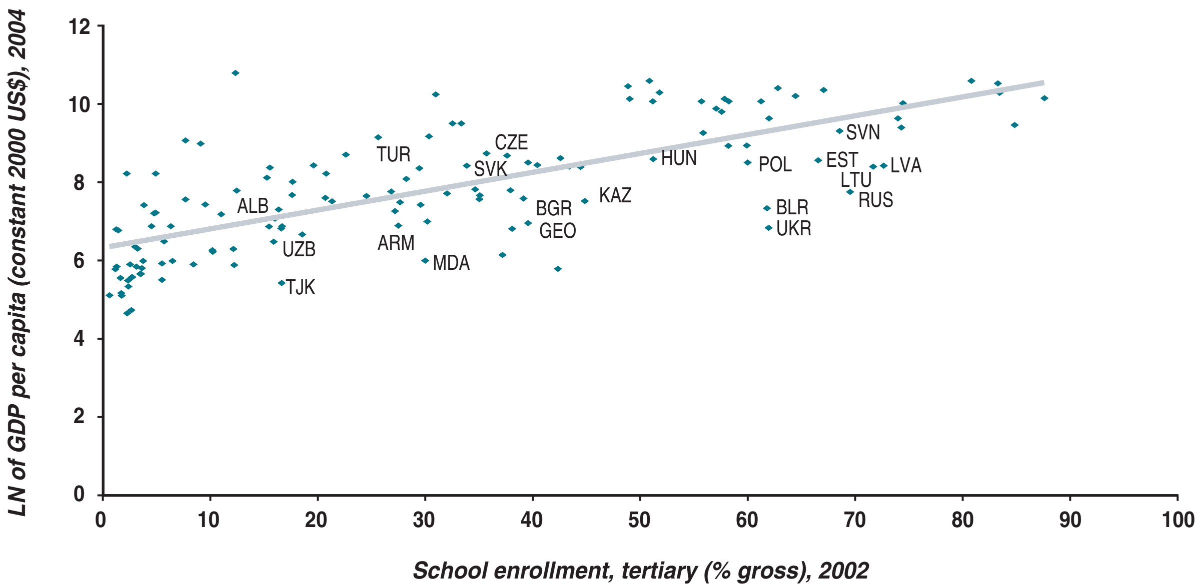
4.2.3 Effective Innovation System

Human capital needs to operate in an institutional setting that supports creative endeavors. Indeed, the institutional setting of research may profoundly affect the supply of "scientific entrepreneurs." Heavily research focused science institutions without links to industry can severely limit the commercial applicability of R&D.

The innovation system refers to the institutional setting (rules, linkages, governance) that determines the way in which countries create and disseminate knowledge (domestically or, more important for developing countries, from abroad). It determines the way in which universities, government, research institutes, and the private sector liaise with each other. In addition to the existence of effective communication channels and coordination mechanisms, the innovation system has to provide the right set of incentives for all players involved.

One of the most prevalent indicators of investment in innovation is the ratio of R&D to GDP. This has long been used as a key measure of inputs into the innovation system by enterprises and governments. Many ECA clients are driven in this respect by the Lisbon Agenda (in particular, the EU-8 and the accession coun-

Figure 8. GDP per capita in relation to schooling



Source: World Development Indicators

tries), which set a target of achieving a 3 percent R&D-to-GDP ratio by 2010. Currently, however, all ECA countries are significantly below that benchmark (see figure 1 in chapter 1) and, as mentioned in chapter 1, the average for the region is significantly lower, at 0.9 percent of GDP. Of the 28 ECA countries, only 6 countries had an R&D-to-GDP ratio of 1 percent or more. That highlights the differing paths that ECA countries underwent during the transition, in which countries that reformed earlier, deeply, and consistently have advanced beyond the others on all fronts, including those pertaining to the knowledge economy.

Another important measure of knowledge inputs available to the economy is the number of researchers per one million people in the population. The ECA region has a long-standing and rich tradition of building up a strong science and technology sector, dating back to Soviet times. A significant investment was made by the state in the former Soviet Union to support research and development across a number of different industries, ranging from aerospace to defense, chemical, and machine building.

As mentioned in chapter 1, researchers remain in relative abundance in the ECA region, with an average of nearly 2,000 R&D researchers per million (see figure 2 in chapter 1). Some common characteristics of the problems encountered in the R&D systems of many countries inherited from the Soviet era are the reliance (almost exclusively) on government support, which has resulted in concentrating on basic rather than applied research, and the lack of cooperation between research institutes and the private sector, calling into question the financial viability of innovations undertaken. In addition, this reliance has also meant that given budgetary constraints suffered in most ECA countries during the past 15 years and the need to prioritize, many R&D innovation systems have seen small and decreasing budget allocations. That has resulted in many institutes losing their best people and facing a lack of resources for investment and R&D.

In light of the above, and bearing in mind that this is a generalization, we could say about innovation systems in ECA countries that the two basic motives of research are hardly served by the system: new knowledge does not diffuse as it should through teaching, and it does not respond to market signals. A vast restructuring of the existing system is necessary to free the human capital that could become innovative entrepreneurs and to make sure that more is generated by the reformed system.

4.2.4 Information Infrastructure

An appropriate scientific and information and communications technology (ICT) infrastructure is a key element of the knowledge economy. Innovating in most sectors, especially in technically advanced sectors, requires an infrastructure comprising testing equipment, fast communications, and scientific consulting that substantially increases productivity. In the economy as a whole, the information infrastructure can be measured by the availability of reliable computers, phones, and other communication media. The World Bank includes in its definition of ICT both the hardware and the software to facilitate communication.

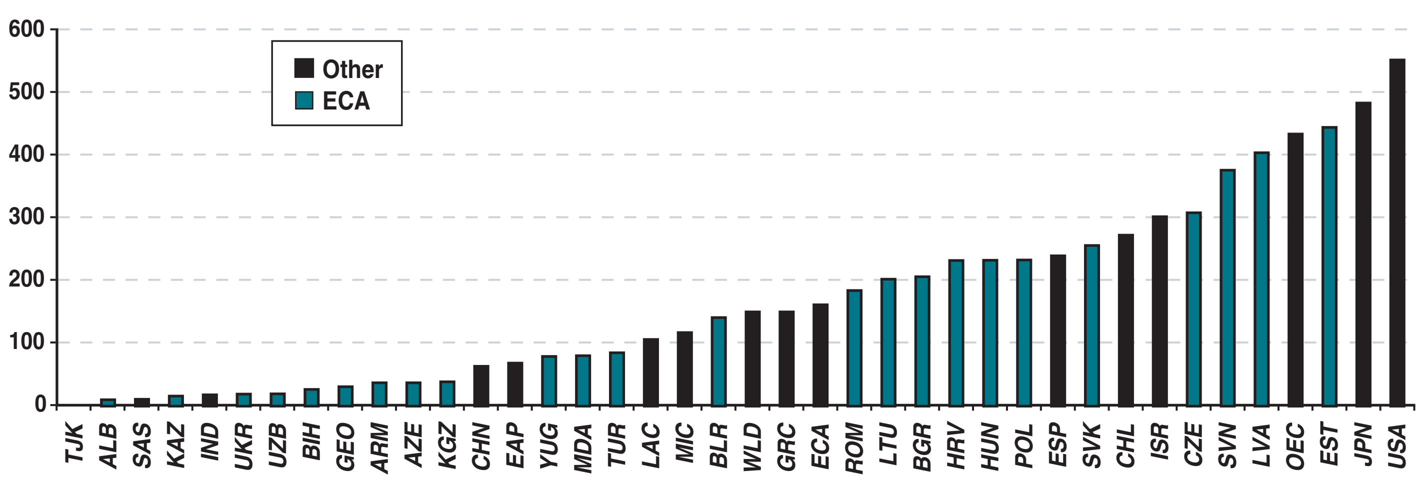
There is an increasing trend to view a country's ICT infrastructure as a key to economic growth and sustainable development. This has been empirically tested, and various studies have found that ICT production and, more important, use has led to economic growth (Pilat and Lee 2001; Van Ark and Piatkowski 2004; Schreyer 2000). In addition, governments are also turning to a heavier use of ICT to improve and expedite the delivery of services (e-government). A proxy for the use of ICT infrastructure in a country could be the Internet penetration rate. Figure 9 shows Internet use in ECA and a few benchmark countries.

Several countries (some of the EU-8 countries) have Internet penetration rates that are higher than in the benchmark countries. This can also be taken as a signal of the readiness and the effort that some of these countries are putting in place to become knowledge economies.

4.3 Knowledge Assessment Methodology (KAM)

We now use the knowledge assessment methodology (KAM) developed by the World Bank Institute's Knowledge for Development (K4D) Program to group countries in ECA according to the KAM indicators and assess which countries in ECA are ready for public support of commercial innovation. There are an increasing

Figure 9. Internet Usage per 1,000 (2003)



Source: World Development Indicators

number of indexes developed for similar purposes that could have been used instead of the KAM indicators. The EU has developed a similar methodology called the European Innovation Scoreboard to assess and compare the innovation performance of its member countries. UNDP, UNIDO, the United Nations Conference on Trade and Development (UNCTAD), and WEF have all constructed indexes that assess the innovation capacity of a country. A brief description of these indexes is included in annex B. For our purposes, the KEI is preferred because our focus is on commercialization and the KEI has more information on economic incentives and the investment climate. In addition, the KEI has data for most countries in ECA, whereas some of the other indexes do not cover all ECA countries. For comparability's sake, we have added five benchmark countries—three of the less-developed EU15 countries (Spain, Portugal, and Greece) and two small open economies that have been successful in climbing the technology ladder (Finland and Israel).

The KEI summarizes the performance of a country in relation to the four pillars of the NIS. It produces a composite index that combines 12 variables (3 for each pillar). The KEI is available for all ECA countries except for Azerbaijan, Macedonia, and Turkmenistan. The countries, variables used, as well as scores in the KEI and pillar indicators are shown in annex A and figure A1.

We also attempt grouping according to a "median country" approach rather than according to average KEI: we find that the KEI of half of the ECA countries is higher than Ukraine's and the KEI of the other half is lower. The median is to a certain extent a more appropriate measure than the average because it is less sensitive to extreme scores than is the average. The median analysis also allows us to visualize the groupings based on the concrete example of the median country (Ukraine). This analysis does not change our rankings: countries with the most (least) developed NIS, have the highest (lowest) KEI scores. Yet, it does allow us to ask interesting questions about the countries in the middle of the distribution (around the threshold). Is Ukraine, as the threshold country, ready for the instruments we are proposing? If so, are the countries just above and below it equally ready? In fact, the World Bank is already engaged in a knowledge economy project in Romania, which is just above Ukraine in the ranking. We present this analysis in annex E.

In computing the average KEI for a country, we weigh the indicators equally. Obviously, that practice is debatable: Is education as important as Internet use as an indication of the innovative capacity of a country or the quality of its NIS? In annex C we look at the impact of the weights. First, we compare the rankings of the ECA countries according to the aggregate KEI with the rankings according to the separate four indicators: incentives, education, innovation, and ICT. Although there are some differences in the rankings, the ranking according to the KEI is not very dissimilar to the ranking according to the four individual pillars. Second, we change the weighting of the individual pillars, attributing a weight of 50 percent to each pillar at a time and the other three sharing the remaining 50 percent equally. Although scores change using different weightings, the rankings of the countries remain fairly consistent, which means that the use of equal weights does not distort the results significantly.[18]

In determining whether to engage in innovation interventions, it will be useful to review the scores in the individual pillar indexes to identify and prioritize interventions targeted at specific *bottlenecks* and to identify particular

[18] A recent exercise by the European Commission on the use of different indicators (Sajeva et al. 2005) to assess the innovation capacity of its member countries (including the new countries) showed that using different weighting methodologies, when the indicators were properly chosen, did not significantly change the ranking and scores that countries achieved.

institutional strengths that might enhance the potential for success. [19] It might well be that a country has a fairly high education level and a fairly well developed information infrastructure but its economic incentives regime is so weak that it presents a severe bottleneck to the commercialization of research. In that case, the country might consider aggressively addressing the bottleneck before engaging in innovation interventions.[20] The KEI indicator tool when combined with a review of bottlenecks and institutional strengths, allows countries around the threshold level to critically evaluate whether they are ready to consider innovation interventions and how best to implement them.[21] For example, a weak economic incentives regime might represent a bottleneck for government intervention even though the other three scores—education, innovation and ICT—are higher and thus the KEI is relatively high. Thus countries with an imperfect economic incentives regime (such as Russia) might need to take a closer look at the elements that form this weak pillar, comparing their performance with that of other countries. Tables D3 through D7 in the annex present the scores for each of the four pillars.

4.4 Results of the Analysis: Categorizing ECA Countries

In Figure 10, we plot the (natural logarithm of) GDP per capita (GDP per capita in 2004 based on actual exchange rates) against the KEI. In this graph we can identify a relationship between innovation and per capita GDP. We can group together countries that have similar KEI scores for a similar development level (GDP per capita). For example, Turkey, with a GDP per capita similar to that of Lithuania or the Slovak Republic, seems to be in a different grouping because of its much lower KEI score.

The KEI scores in Figure 10 show that eight ECA countries (Estonia, Slovenia, Czech Republic, Latvia, Lithuania, Hungary, Poland, and the Slovak Republic) have a KEI above, say, 6.5. Assuming a threshold of 6.5 on the KEI score (on a scale of 1 to 10), we hypothesize that countries above this threshold are more likely to have an incipient NIS that is sufficient to start an innovation support program. Interestingly, few of the countries mentioned above do score higher than some of the EU15 benchmark countries, Portugal, Spain, and Greece (see table A1 in the annex). We check whether or not any of the individual pillars represents a bottleneck in this group. Based on Table 1, we find that none of the scores for the four pillars are lower

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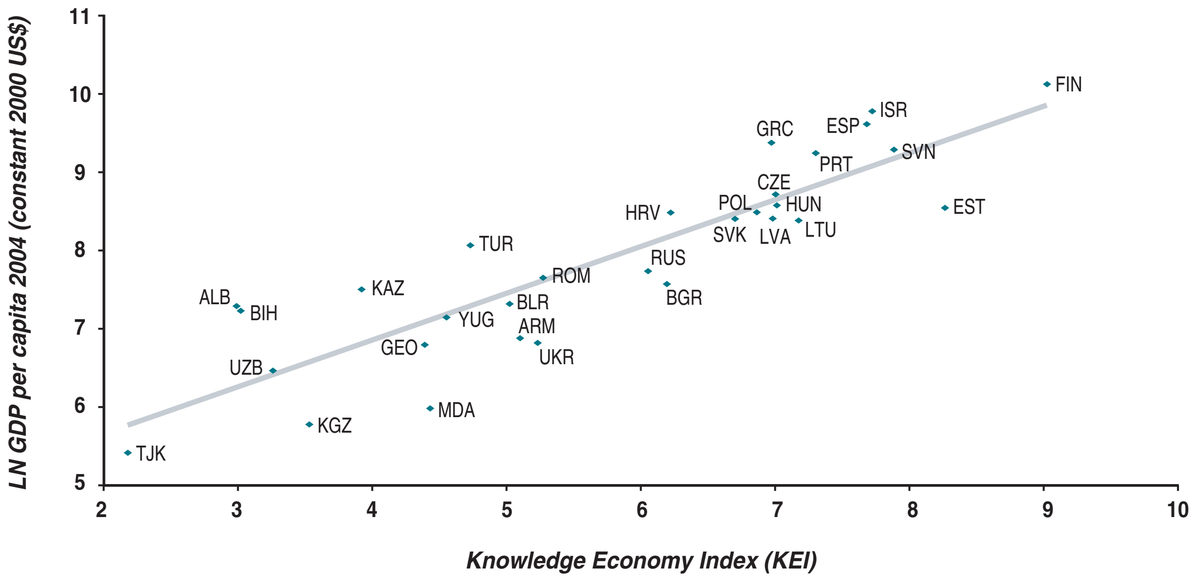
19 We have included a table that illustrates the bottlenecks in the KEI and pillar indicators (table D1 in the annex). It provides an empirical support for the discussion here. It should be noted, however, that the bottleneck evaluation needs to be driven by an understanding of the specific context of the country and the types of innovation instruments that the country will be applying. It is therefore inherently a qualitative and policy design–oriented analysis.

20 This approach is analogous to the "growth diagnostics" that Hausmann, Rodrik, and Velasco (2005) advise as a tool for identifying growth strategies for countries. They argue that "the key step is to develop a better understanding of how the binding constraints on economic activity differ from setting to setting. This understanding can then be used to derive policy priorities in a way that uses efficiently the scarce political capital of reformers." The key words in this statement are both "binding constraints," meaning that there might be a policy area that is halting progress as a whole (in our case the bottleneck), and "priorities." Given scarce resources (and political capital), it might not be feasible to argue for reform in all areas, so that priorities have to be identified.

21 Table D2 in the annex highlights the weakest pillar indicator for those countries that have KEI scores low enough that they may want to consider addressing necessary reforms in their NIS as they introduce these types of instruments. In addition, we highlight cases that do not necessarily show low KEI or pillar scores but in which the country appears to score significantly worse in comparison with the other ECA countries (e.g., Croatia and Romania in education).

Figure 10. Relationship between GDP per capita and KEI



Source: World Development Indicators

than, say, 5 in any of the pillars. Thus none of these pillars seem to be a binding constraint *in this group of countries*.

Countries with lower KEI scores, (e.g. below 6.5 and above 4) are included in the second grouping: Croatia, Russia, Bulgaria, Serbia, Romania, Belarus, Armenia, Ukraine, Turkey, and Moldova. However, these countries might face problems in one or more of the pillars of the knowledge economy creating a bottleneck for government intervention in support of innovation. For example, Turkey scores low in education and Serbia scores low on the Economic Incentives Regime. Belarus with a score of 1.4 in the economic incentives regime (third from the bottom in the whole group) might consider targeting a reform of its economic incentives regime rather than the design of an innovation finance program because given the severe limitations of its business environment, innovations are likely to fail to commercialize despite Belarus' relatively high level of education. Countries may also want to look at the composition of the individual pillars (tables D3-D7 in the annex). For example, in the innovation system pillar, Armenia appears to have a problem particularly on total expenditure on R&D and the collaboration between universities and the private sector. This approach of looking at more information under the different pillars of the NIS is a further step in the bottleneck analysis, but it by no means precludes a more in-depth country-by-country analysis.

Lastly, there is a third group of countries with fairly low KEI scores. If we set a threshold of 4, below which countries are assumed to have a NIS that is not conducive to commercial innovation, most CIS (Commonwealth of Independent States) and several Balkan countries would fall in this third group, showing serious shortcomings in one or several of the pillars. Countries with a KEI score below 4 should likely, for the time being, concentrate on reforming other areas of their NIS, and only after significant advances have been made in that sphere should they consider public support programs to foster commercial innovation. That does not preclude countries with a dysfunctional NIS from fos-

Table 1 Comparison of Rankings of Countries according to KEI and the Four NIS Pillars

Country	KEI	Rank KEI	Econ. Inc. Regime	Rank Econ	Innovation	Rank Inn	Education	Rank Edu	Inf. Infrast.	Rank Inf. Inf.
Albania	2.99	29	2.66	23	1.65	28	4.81	28	2.82	27
Armenia	5.10	19	4.90	15	5.72	20	6.00	22	3.77	24
Belarus	5.02	20	1.40	29	5.83	18	7.64	11	5.20	19
Bosnia and Herzegovina	3.02	28	2.62	24	1.02	30	4.00	30	4.45	21
Bulgaria	6.19	15	6.05	12	5.94	17	6.73	17	6.03	15
Croatia	6.22	14	4.31	18	7.12	7	6.55	19	6.91	12
Czech Republic	7.00	9	6.01	13	6.92	10	7.10	15	7.96	5
Estonia	8.26	2	8.77	1	7.29	6	8.14	5	8.83	2
Finland	9.02	1	8.44	2	9.73	1	9.21	1	8.71	3
Georgia	4.39	24	1.75	26	6.07	16	6.43	21	3.30	25
Greece	6.97	11	6.75	7	6.73	11	7.61	12	6.77	13
Hungary	7.01	8	6.42	10	7.00	9	7.65	10	6.98	11
Israel	7.72	4	6.70	8	8.37	2	6.93	16	8.90	1
Kazakhstan	3.92	25	1.47	28	4.07	25	7.11	14	3.05	26
Kyrgyz Rep.	3.53	26	3.09	20	1.79	27	6.53	20	2.70	28
Latvia	6.98	10	6.65	9	6.12	15	8.11	6	7.02	9
Lithuania	7.17	7	6.91	6	6.46	13	8.32	3	7.01	10
Moldova	4.43	23	3.91	19	4.43	24	5.40	26	3.97	23
Poland	6.86	12	6.36	11	6.15	14	8.32	4	6.60	14
Portugal	7.30	6	7.35	3	7.07	8	7.37	13	7.42	8
Romania	5.27	17	4.37	17	5.20	21	5.60	25	5.93	16
Russia	6.05	16	3.01	21	7.47	5	7.85	9	5.88	17
Serbia and Montenegro	4.55	22	2.15	25	5.17	22	5.93	23	4.94	20
Slovak Republic	6.70	13	5.96	14	6.70	12	6.65	18	7.47	7
Slovenia	7.88	3	7.01	5	7.91	3	8.58	2	8.00	4
Spain	7.68	5	7.30	4	7.65	4	8.10	7	7.68	6
Tajikistan	2.18	30	1.71	27	1.22	29	5.36	27	0.43	30
Turkey	4.73	21	4.50	16	4.89	23	4.19	29	5.35	18
Ukraine	5.23	18	2.83	22	5.82	19	7.98	8	4.31	22
Uzbekistan	3.26	27	1.40	30	3.77	26	5.64	24	2.23	29

tering innovation and R&D, also within their private sectors. A whole array of public interventions are suitable—but the particular nature of the instruments we are proposing and the objectives they have make their implementation more difficult and therefore not suitable for certain economic and policy environments. Aubert (2005) provides a rich discussion on the types of innovation systems available in countries at different development levels.

In sum, it should be stressed that countries with low to average KEI scores are most in need of detailed and critical analysis of their NIS before embarking on innovation interventions. Following the bottleneck analysis in this report, a more detailed analysis conducted by the World Bank as a knowledge economy assessment (KEA) can help decide whether to invest public funds in innovation interventions or allocate those funds and efforts, at least initially, toward strengthening the institutional framework of the NIS. That approach can also help countries address some of the bottlenecks as part of program design.

4.5 Conclusion

A country should not decide whether or not to engage in financing a public support program for innovation on the basis of this KEI indicator analysis. A more in-depth analysis of the country and its circumstances is advisable. The analysis above shows the following:

1. ECA countries differ widely in their national innovation capacity, economic incentive regime, and ICT, but less so in education.
2. Sequencing is critical. Some countries might be better advised to invest first in the necessary reforms of other NIS components before—or in some special cases, in parallel with—engaging in a public support program for innovations.
3. On the basis of an analysis of their NIS, countries should invest in solving bottlenecks that hamper innovation (tables D1 and D2 in the annex might serve as a first indication of where the problem areas may lie).

Government funds are scarce and should be used where returns are greatest. If a country lacks the institutional framework described in this chapter and the innovation infrastructure or if it lacks the appropriate set of economic policies, incentives, and institutions, funds used in supporting R&D and innovation might be wasted or will bring lower returns than investments in other areas (such as improving human capital or the economic and business environment).