

Patents as Indicators of Technological Activity in the ECA Region

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Patent Data Provide a View of the Knowledge Absorption Process

Our study takes as its primary focus the absorption of technology by ECA enterprises, rather than the creation of fundamental new technology. The reason for this focus is clear. Many ECA firms and industries lag well behind the global technological frontier, and relatively few ECA firms or industries are so technologically sophisticated that they could expect to play a leading role in the advancement of that frontier, at least in the near term. Given the level of development of the region's economies, it is almost certainly more important for managerial effort and public policy to be more focused on convergence with the global frontier than on support of indigenous attempts at fundamental innovation. Nevertheless, as we have stressed throughout the report, technological absorption is not a passive process that proceeds automatically with no effort on the part of the absorbing firm. Rather, it is often the case that extensive, active efforts are required to take technology pioneered outside the region and adapt it—in large and small ways—to the economic circumstances of ECA countries. Once again, we invoke the Cohen-Levinthal notion of absorptive capacity: a firm must be engaged in an active process of learning about technologies in order to effectively absorb advances in these technologies by other firms. In some instances, the processes of modification and adaptation lead to innovations, often incremental in nature, dramatically increasing the value of the underlying technology in an ECA context.

There are industries, firms, and regions within the ECA countries where the process of technology absorption has proceeded far enough that this kind of incremental innovation is taking place on a reasonably large scale. To a greater extent than is commonly realized, the major patent systems often grant patents that protect even relatively incremental innovations—both in terms of products and processes. These patents, and the wealth of

detailed information they contain, offer a useful window into the ECA technological absorption process that we explore in this chapter.

Almost by definition, successful patenting requires that a firm understand the existing state-of-the-art technology well enough to improve upon it, albeit perhaps in incremental ways. Simply by observing the firms, regions, and industries in which ECA inventors are most active, we can obtain objective, quantitative information on where the technological absorption process is most advanced. We can also observe how the locus of absorption and invention has shifted over time. The significant changes in ECA country patent regimes mean that the patent statistics of the region's countries themselves are unlikely to offer a consistent measure of inventive output over the course of the reform process. For that reason, we rely on data generated by ECA inventors seeking patent protection in the world's two largest patent jurisdictions: the European Patent Office (EPO) and the U.S. Patent and Trademark Office (USPTO). Both organizations provide large quantities of data on ECA-region inventors, obtained through a system whose essential features have remained stable throughout the transition period.

As we have stressed throughout this study, international engagement and connectedness can foster technology absorption and learning. As we will see in our review of patent data, a significant number of ECA-generated patents in Europe and the United States appear to arise out of various forms of R&D collaboration or cooperation with multinational enterprises. A significant fraction of European patents with at least one ECA-based inventor also involve parties from other regions, including Europe's advanced economies. As we will see, Germany plays a particularly prominent role here. Examination of ECA-generated patents in the United States reveals that a significant number of ECA-invented U.S. patents are assigned to American or other foreign multinational firms, a legal arrangement often signifying the existence of an R&D contract or the operation of an R&D subsidiary within the ECA region. These "multinational" patents are generally of higher quality than "indigenous" patents.

Data generated by the U.S. Patent and Trademark Office provide a further unique window into the technology absorption process. Under U.S. patent law, all patent applicants are required to disclose knowledge of the "relevant prior art" on which they are built. These disclosures take the form of citations to earlier inventions and other technical advances that are often the technological antecedents of the invention for which the applicant is seeking patent protection. A large literature has utilized the citations in U.S. patent documents as direct indicators of knowledge spillovers. A recent World Bank Working Paper (Brahmbhatt and Hu 2007) uses patenting in the United States as an index to assess East Asian prowess in generating innovations that advance the global frontier of knowledge. The study looks at patents as an output of innovative activity (number of patents), as well as a measure of patent quality based on the Henderson, Jaffe, and Trajtenberg (1999) approach for measuring the quality of patents, by constructing indexes of patent generality and patent originality that are based on analyses of patent citations.

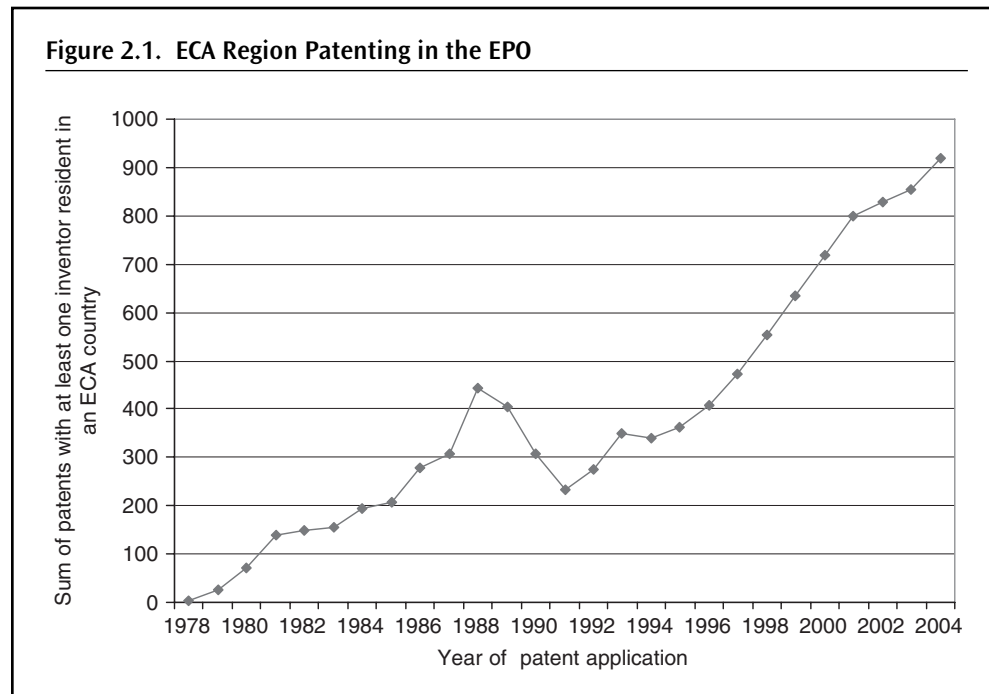
In other words, the citations explicitly trace out the pathways by which inventors absorbed useful knowledge from prior inventions, and used this knowledge to create new inventions. While the more recent literature has clarified important limitations in the degree to which patent citations reflect pure knowledge spillovers, it has also validated the usefulness of citations as a window into the knowledge absorption process. European patents also contain citations to prior inventions, but because European patent law does

not require disclosure by the applicant, the vast majority of European patent citations are added *ex post* by patent examiners, and may or may not reflect inventions that were a source of inspiration to—or even known by—the actual inventor. Interestingly, detailed examination of the citation patterns in indigenous ECA patents reveals significant contrasts between ECA patents and those of other developing regions. Indigenous ECA patents tend to be systematically less well connected to high-quality prior research than do patents from the more dynamic parts of the developing and developed world. This appears to validate the widely held view that ECA inventors, while highly skilled and well educated, are insufficiently connected to centers of technological excellence outside the region to reach their potential levels of research productivity.

General Trends in ECA Patenting

First, it is clear that the transition process of the early to mid-1990s disrupted inventive activity in the short run. Both U.S. and European patents reveal a striking downturn in inventive output during these years. By the mid-1990s, however, measures of inventive output were trending upward, and this generally positive trend has been maintained up to the most recent years for which data are available. Graphical evidence of this is provided from two very different samples of the patent data.

Figure 2.1 gives a long-run perspective on ECA patenting by tracking all patent applications (including those later withdrawn or denied) for all EPO patents with at least one inventor based in the ECA region. The figure shows a substantial increase in patent activity,

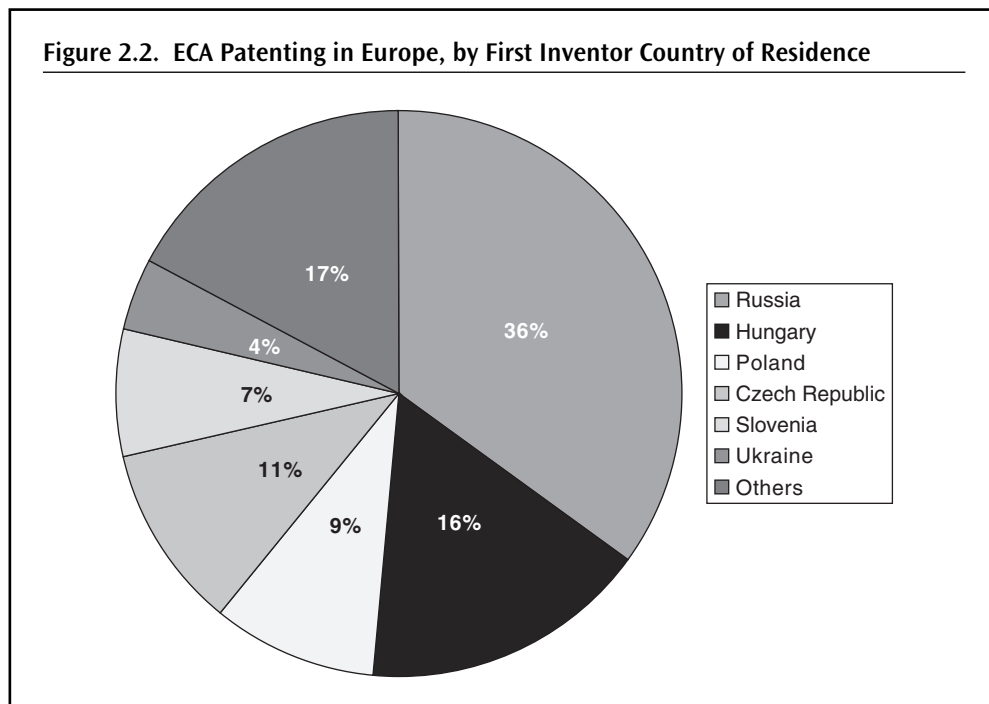


Source: Authors' calculations based on data provided by the European Patent Office, 2006.

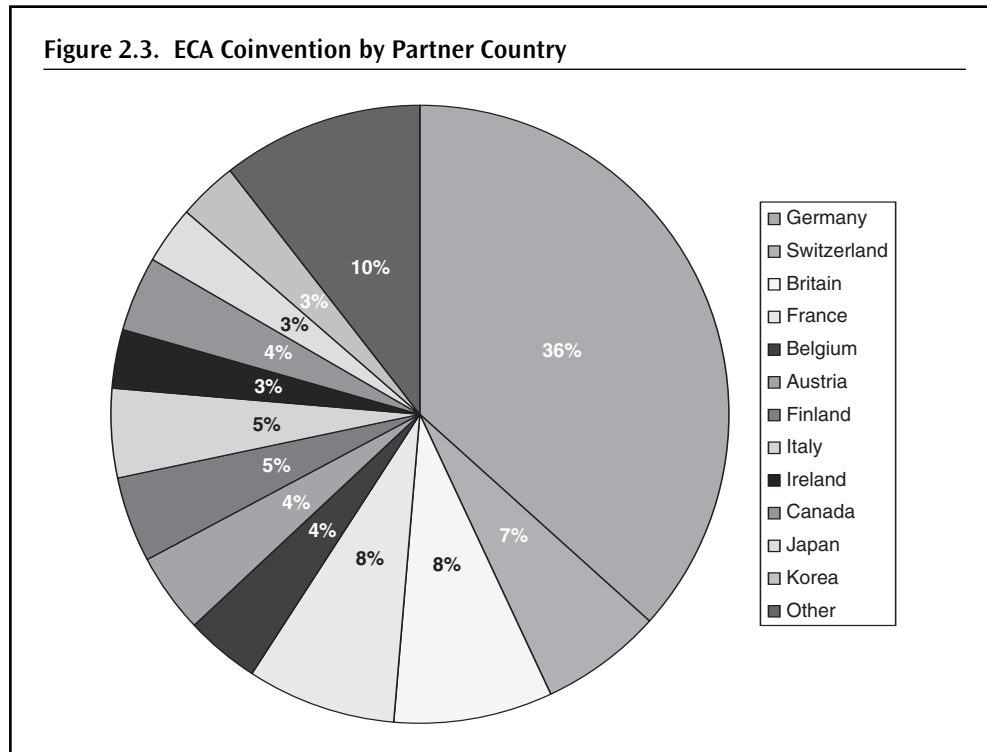
peaking in the late 1980s, followed by an equally impressive decline. While levels of patenting outside the region continued to climb, inventive activity within the region did not re-attain its late 1980s level until the late 1990s. Since then, there has been robust growth. This pattern for the region as a whole is replicated in similar charts one could produce for individual ECA countries, such as Hungary or Russia/the former Soviet Union. One sees a similar pattern in data on ECA-generated patents registered with the U.S. Patent and Trademark Office. It is clear that the transition process massively disrupted inventive activity.

Second, measures of inventive activity suggest a disproportionate concentration of that activity in the relatively more advanced ECA economies. Perhaps not surprisingly, Hungary and the Czech Republic are clear standouts in terms of inventive performance. Russia is a large patent generator in aggregate terms, but it is less significant than one might expect given its size and Cold War era scientific strength. Figure 2.2 provides a breakdown based on EPO patent applications with at least one ECA inventor, registered between 1992 and 2005.

Third, various forms of international R&D cooperation appear to be quite important in ECA inventive activity. A large fraction of ECA patents taken out in the EPO are coinvented with inventors in Western economies, of which Germany plays a particularly important role. Figure 2.3 provides a breakdown based on EPO patent applications taken out from 1992 through 2005. We designate a coinvention as a patent in which at least one named inventor is located in the ECA region and at least one inventor is located outside the region. Coinventions are quite common. Most regional specialists would not be surprised to see the prominence of German inventors in these coinventions.



Source: Author's calculations based on data from the European Patent Office, 2006.

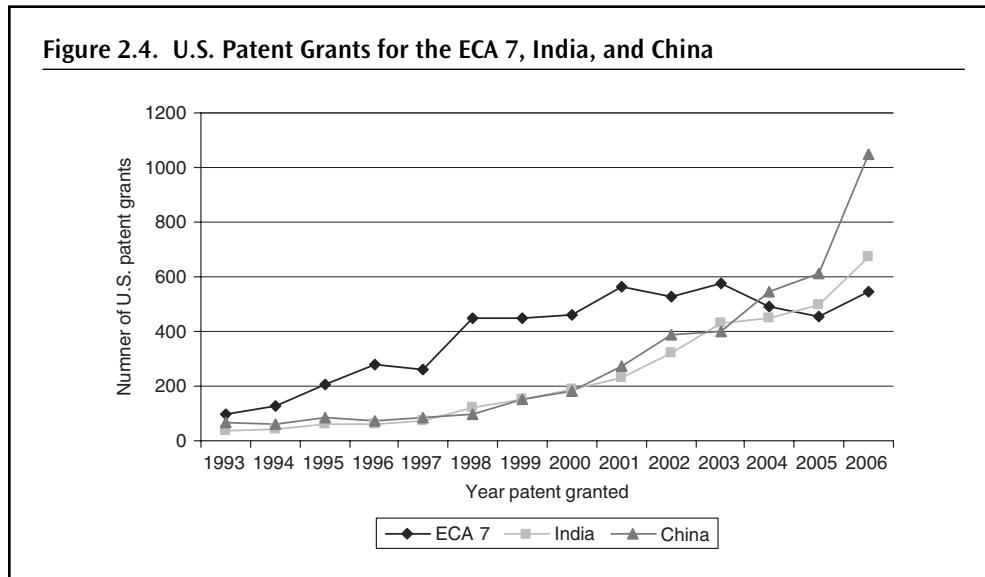


Source: Author's calculations based on data from the European Patent Office, 2006.

The Role of International Coinvention in the ECA Region

U.S. patent data confirm the importance of international coinvention as shown in the EPO data, both for the region as a whole and for individual countries. To place this in context, it is useful to compare recent invention trends for the ECA region to those of India and China. Figure 2.4 compares trends in U.S. patent grants for seven ECA countries, India, and China. The rationale for comparing ECA patenting activities to those of India and China is that the large ECA middle-income countries such as Russia, Ukraine, and to some extent Poland and Kazakhstan, are looking to India and China as benchmarks. Countries that have been through a transition—from central planning in China and a semi-socialist economy in India—are seen as interesting examples of overcoming the traditions of socialism. We show that just a few decades ago, ECA had more patents than India and China, but this has been changing in recent years.

The seven ECA countries compared are Russia, Hungary, the Czech Republic, Poland, Slovenia, Bulgaria, and Ukraine. The numbers are taken from the Cassis CD-ROM published by the U.S. Patent and Trademark Office at the end of 2006; the database incorporates data on U.S. patents granted up to the end of that year. Patent grants are attributed to the ECA region, India, or China, if any of the first 10 inventors listed on the patent reside in one of those countries, and these patent counts include patents granted to individuals, government agencies, and academic institutes, as well as firms.



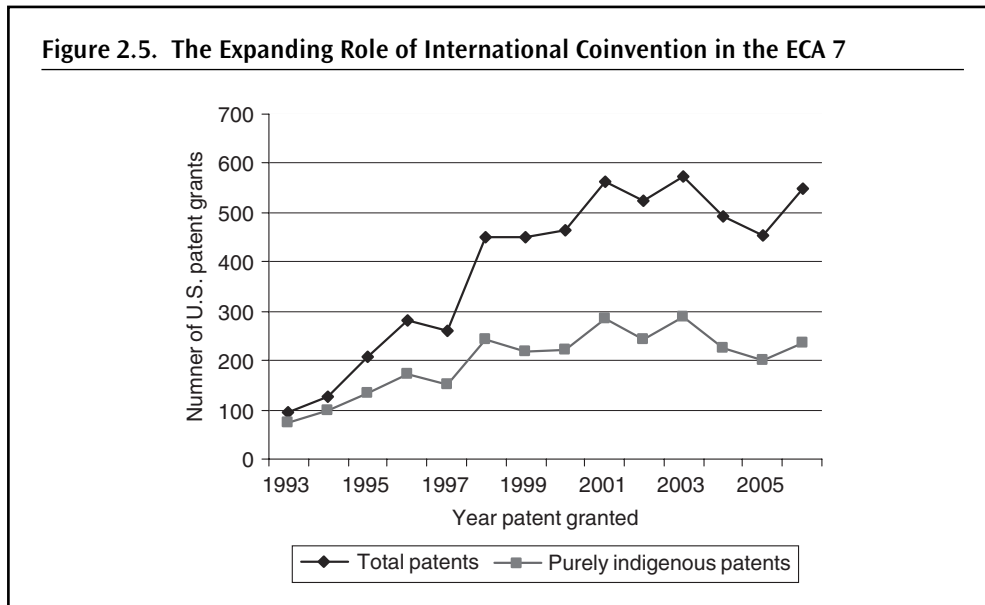
Note: The graph compares counts of patents in which at least one inventor is based in one of seven ECA countries, India, or China. The ECA-7 are Russia, Hungary, Poland, Slovenia, the Czech Republic, Bulgaria, and Ukraine.

Source: Authors' calculations based on the U.S. Patent and Trademark Office Cassis CD-ROM, December 2006 version.

Despite the impact of the transition period in the 1990s, inventors based in the seven ECA countries consistently received more U.S. patent grants than did inventors in India and China until the most recent years. If one sums up cumulative patent grants from 1993 through the end of 2006, the ECA 7 countries obtained 5,489 patent grants, whereas India-based inventors obtained only 3,331, and China-based inventors obtained 4,063. Clearly, when we normalize by population, the performance of the seven ECA countries has been much better on a per-capita basis. However, there is a clear acceleration in India- and China-based patenting in the most recent years, which is not evident in ECA patenting. Aggregate ECA patenting was slightly lower in 2006 than it had been five years earlier, but levels of patenting have been relatively stable. This contrasts sharply with the almost exponential growth in China-based inventive activity.

Figure 2.5 disaggregates ECA patent grants into those generated by international teams of inventors and those generated solely through the efforts of inventors based within a particular ECA country.

It is immediately apparent that international coinvention is *extremely* important—in recent years, more than half of total patent grants were generated from teams of inventors based in more than one country. While we do see some inventive collaboration between ECA countries, the patterns of coinvention are dominated by collaboration with inventors in more advanced countries. Germany, the United States, the other major European economies, Japan, and South Korea all tend to play more important roles than do other ECA countries. We also see significant and growing international collaboration in the U.S. patent grants of India and China, but it is much less prevalent than in the ECA countries.



Note: The graph tracks total counts of patents in which at least one inventor is based in one of seven ECA countries: Russia, Hungary, Poland, Slovenia, the Czech Republic, Bulgaria, and Ukraine. “Purely indigenous patents” are those generated by a team whose members are all based in a single ECA country.
Source: Authors’ calculations based on the U.S. Patent and Trademark Office Cassis CD-ROM, December 2006 version.

Our data reveal a much greater degree of international coinvention than do earlier analyses. In part, this is because much earlier work has been based on the National Bureau of Economic Research (NBER) Patent Citation Database, which ascribes the nationality of the patent to the location of the first inventor listed on the patent document. While incomplete, this method of assigning nationality generally “works” for patents generated in large, R&D-intensive economies like the United States or Japan. The overwhelming majority of U.S. and Japanese patents are produced by teams of inventors based entirely in the United States and Japan, respectively. However, the usual method of assignment is much less appropriate for smaller, less R&D-intensive economies; the method misses the striking increase in the importance of international teams of inventors, including those based in these smaller economies.

The work of other researchers using very different data also point to the strong role of multinationals in ECA-area invention. Violina Ratcheva, of the University of Sheffield in the United Kingdom, has utilized a data source called Locomonitor to track media announcements of R&D-oriented FDI in multiple regions, including the ECA.⁷ In published papers and unpublished preliminary research, she finds evidence of strong concentrations of foreign R&D activity in the region. It is clear that the evidence of extensive

7. Locomonitor is a database of FDI projects maintained by OCO Consulting, a firm spun off from international accounting and consulting giant Price Waterhouse Coopers in 2001. Data are based on media and trade press reports.



Note: The graph tracks total counts of patents in which at least one inventor is based in Russia. “Purely indigenous patents” are those generated by a team whose members are all based in a single ECA country.

Source: Authors’ calculations based on the U.S. Patent and Trademark Office Cassis CD-ROM, December 2006 version.

international coinvention that we document in this study is not some artifact of patent data but, instead, points to an economically significant real phenomenon.⁸

The high prevalence of international R&D collaboration evident in ECA patenting is likely to be a positive influence on the extent and nature of national inventive activity. Through collaboration with inventors based in more advanced industrial economies, ECA inventors are likely to achieve a greater understanding of recent technological trends and developments than would be possible through autarkic R&D effort. In the next section, we will view preliminary evidence based on U.S. patent citations consistent with this hypothesis. In fact, we believe our data support the tentative conclusion that the quantity and quality of ECA invention would be significantly lower in the absence of this collaboration.

Before turning to the patent citation analysis, we take one more look at international R&D collaboration within the biggest ECA economy: Russia. Figure 2.6 shows that the ECA regional trends hold for its single largest member state. A majority of Russia’s U.S. patent grants are generated by cross-national inventor teams, and many of these patents are assigned to U.S. and other foreign multinationals. In fact, U.S.-based firms and other organizations generate about as many patents in Russia as do inventor teams composed solely of Russians.

8. For examples of recent research employing the Locomonitor database, see Demirbag, Ratcheva, and Huggins (2006) and Huggins, Demirbag, and Ratcheva (2007).

Table 2.1. Top 10 Russian Generators of U.S. Patents

Rank	Name	Nationality	Number of U.S. Patents
1	LSI Corp.	United States	111
2	Samsung Electronics	South Korea	71
3	General Electric Co.	United States	37
4	Elbrus International	Russia	36
4	Sun Microsystems	United States	36
5	Ceram Optec Industries	Germany	28
6	Nippon Mektron	Japan	26
7	Ajinomoto Co.	Japan	25
8	Otkrytoe Aktsionernoje Obschestvo	Russia	20
9	Procter & Gamble	United States	19
9	Ramtech	United States	19
10	Advanced Renal Technologies	United States	16
10	Corning Inc.	United States	16
10	Nortel Networks	Canada/United States	16

Note: The graph tracks total counts of patents in which at least one inventor is based in Russia.

Source: Authors' calculations based on the U.S. Patent and Trademark Office Cassis CD-ROM, December 2006 version.

Table 2.1 lists the top 10 creators of Russia-based U.S. patents. U.S. and Japanese multinationals figure prominently in this list. This top 10 list is somewhat misleading, however. There are a large number of German firms that collectively account for a large number of patents, even though each individual firm has registered relatively few.

Patterns of ECA Knowledge Absorption as Revealed by ECA Patent Citations

We now turn to the use of patent citations as a window into the knowledge absorption process. Examination of the citations in indigenous patents from ECA countries taken out with the USPTO reveals some striking contrasts with those from other technologically successful regions. Indigenous patents typically make fewer citations to the preceding literature; they tend to cite older technologies, less fundamental prior inventions, and patents that are less frequently cited. All of this is suggestive of the notion that ECA inventors are insufficiently grounded in the recent technical state of the art. They are not sufficiently well-versed in recent technical developments outside of their region to build on those developments with maximum effectiveness. Case- and interview-based studies of R&D and productivity in the region have long criticized the tendency for centers of ECA scientific activity to be insufficiently connected to centers of technical excellence outside the region. Our data analyses, drawing upon data from thousands of individual patent grants from across the region, document citation patterns consistent with these criticisms.

This section of our research requires extensive data on patent citations, and the USPTO Cassis database does not contain citation mapping that links patents to the previously granted patents they cite. Therefore, we had to turn to other data sources. Professor Bronwyn Hall of the University of California, Berkeley, has undertaken a partial update of the well-known NBER patent citation database that is current for patents granted through 2002. In keeping with past conventions, nationality is assigned to patents on the basis of the address of the first inventor. We already know that this practice is imperfect for analyzing ECA patenting, but our use of the Hall database constrains us to use it in the analysis that follows. However, if it is the case that the first inventor is also the most important contributor, this convention would make this less of a limitation, as by this definition it would then capture patents in which ECA citizens have a greater contribution.

We are also constrained in the time dimension: The Hall update is only complete for patents granted through 2002. We therefore began our analyses by first identifying all U.S. patent grants over the 1990–2002 period for which the first inventor listed an address in one of the ECA countries. This produced slightly more than 3,000 granted patents. In order to compare ECA inventive activity with activity in other regions, we also sought to obtain a roughly equivalent number of patents from the following countries/regions: Emerging Asia (India and China), Advanced Asia (South Korea and Taiwan), Latin America (Brazil and Mexico), the European Periphery (Spain, Portugal, Finland, and Israel), and the European Core (Germany). As it turns out, the Latin American and Emerging Asian countries included in our comparator set did not generate quite as many patents as the ECA countries did. The other countries or regions generated far more. To maximize the comparability of these samples, we sought to match each ECA patent with another patent drawn from each of these five other regions that had the same primary patent class and grant year as the ECA patent. This was done to ensure that our comparisons primarily reflected differences in inventor nationality rather than citation differences across different technological fields. So we began our analyses with approximately 3,000 patents from four of the six regions, and fewer drawn from Emerging Asia and Latin America.

The next stage was to obtain detailed information on the patents cited by these sample patents. Some of our initial sample patents lacked usable citation data and were therefore dropped from subsequent analyses. The vast majority of patents could be connected to Bronwyn Hall's patent citation mapping, allowing us to examine and compare the backward citations patterns therein.

The next stage was to draw a meaningful distinction between “purely indigenous” inventive activity and multinational inventive activity. Recall our constraint—the Hall data update does not contain complete information on the locations of all inventors. We will thus be unable to distinguish adequately between teams of inventors that are all based in an ECA country and teams of inventors that include members based in advanced economies. However, as we have already noted, a relatively large fraction of patents with ECA inventors are assigned to U.S. firms or to large non-U.S. multinationals based outside the region. Some of these patents are created by the ECA-based subsidiaries of U.S. firms. Others are generated by nominally independent ECA firms undertaking research for U.S. clients under terms that assign the intellectual property rights to the U.S. client. When we include these multinational patents in our ECA sample, ECA patents do not appear to be that different from patents generated in other regions. However, when we omit these multinational patents from consideration, focusing on the “indigenous” patents and comparing

them to indigenous patents in other regions, we find some striking differences between ECA-generated patents and those generated elsewhere.

In many cases, indigenous ECA patents make *fewer patent citations*, and the differences are often quite significant at traditional levels of statistical significance. While the presence of a large number of citations is sometimes viewed as evidence that the citing patent is less innovative, we believe that we are correct in seeing the low levels of ECA citations as indicative of an insufficient grasp of global best practices and recent advances in the state of the art. This interpretation is strengthened by the existence of another empirical regularity: indigenous ECA patents typically cite older patents than do patents generated in other regions. It is hard to explain this on the basis of the age of the patent or technology class, but we started with a sample essentially matched in both aspects. We also see that indigenous ECA patents tend to cite patents with a less broad technological impact than those in other countries. Hall, Jaffe, and Trajtenberg have developed a measure of the generality of a patent's impact by looking at the distribution of citations received by that patent across different technology classes. Most patents are cited largely by other patents in the same or closely related patent classes. Only "fundamental" inventions tend to receive citations from a wide variety of patent classes. Patents cited by indigenous ECA patents tend to be systematically less "general" than other patents. They also tend to receive fewer citations over time. Because one would naturally think that older patents receive more citations, this difference is all the more striking. ECA citation patents only look "good" in comparison to those of the Latin American economies. That in itself is a rather striking statement about what these data show.

Statistical tests require us to measure the mean characteristics of patents cited by indigenous ECA patents with the mean characteristics of other groups. Once we focus solely on indigenous patents, the groups tend to be of different sizes, and we do not want to impose the assumption of a normal distribution for characteristics that tend to be highly skewed.⁹ Brahmabhatt and Hu (2007) find similar results for patents in East Asia.¹⁰ Trends in East Asia signal the growing intraregional dimension in East Asian knowledge flows.

9. We therefore conduct Mann-Whitney tests of equality (also known as the two-sample Wilcoxon rank-sum test), using STATA. We show the sample means (table A.1) and the p-value for the hypothesis that they are the same (table A.2). While small in absolute terms, the differences in means are not small in percentage terms, and imply test statistics well beyond the critical values in many cases. In 14 of 20 cases, the statistical test of equality is resoundingly rejected. At the 10 percent level, one can reject equality in 16 of 20 cases.

10. The United States is by far the largest source of citations for East Asian innovators, providing close to 60 percent of the total. Japan is the second-largest source, contributing close to 20 percent, on average. Further, they find that there is a rise of intraregional and compatriot knowledge flows (the share of citations by inventors in one East Asian economy to other patents in the same economy) for individual East Asian economies, indicating that the share of citations to other East Asian economies (typically to patents of Korea and Taiwan [China]) is highest—around 7 percent to 8 percent—in China, Hong Kong (China), Malaysia, and Singapore. On the other hand, the share of own or compatriot patents is highest in Korea (around 6 percent) and Taiwan (China), where it is over 10 percent. In other East Asian economies, Singapore shows an exceptionally high citation frequency to patents in Taiwan (China) and Korea, both of which significantly exceed (also high) citation frequencies to patents in Japan and the United States. Citation frequencies to Korea and Taiwan (China) in China and Malaysia also exceed those to Japan and the United States.

Summary of Key Learnings

This section shows that much can be learned about potential pathways of knowledge absorption in the ECA region through the analysis of patent data. We see that the transition period of the early 1990s severely disrupted inventive activity and the kind of absorption of existing trends in the technological state of the art necessary for invention. As patent growth resumed, we see that international R&D collaboration became quite prevalent in the ECA region; this is evident in both EPO and USPTO patents. International coinvention has contributed significantly to the magnitude of ECA inventive activity.

Evidence drawn from USPTO patent citations suggests that international R&D collaboration has also contributed significantly to ECA invention quality. First, the longstanding criticism of “indigenous” ECA science and inventions as being insufficiently connected to the global technological mainstream appears to be largely correct. We see significant differences in ECA citation activity that are completely consistent with this view. Second, international R&D collaboration of various forms has allowed the ECA region to partially sidestep the handicap to its own R&D productivity imposed by its insufficient grounding in the global technological mainstream and by recent advances in the state of the art. When we factor back in the patents generated through this cooperation, the ECA citation patterns appear to be less distinctive. R&D cooperation helps to remedy shortcomings in ECA inventors’ knowledge of global best practices.

Implications for Policy

The National Innovation Systems of CIS Countries Require Further Reform

The persisting effects of the legacy of Soviet R&D policies have been discussed widely, and the recent World Bank report *The Path to Prosperity: Productivity Growth in Eastern Europe and the Former Soviet Union* (2007a) outlines some of the remaining inefficiencies:

Currently, many of the S&T (science and technology) resources are isolated both bureaucratically (in the sense that they are deployed in the rigid hierarchical system devised in the 1920s to mobilize resources for rapid state-planned industrial development and national defense), functionally (in the sense that there are few links between the supply of S&T output by research institutes and the demand for S&T by Russian or foreign enterprises), and geographically (in the sense that many assets are located in formerly closed cities or isolated science/atomic cities).

A disproportionate share of total R&D resources remains locked up in specialized state research institutes, in which there are no strong incentives to transfer commercially useful technology developed within the institutes to private entities in the ECA economies, which could put the technology to productive use.

Our results support these criticisms. Let us start by reviewing Table 2.1, listing the top 10 Russia-based organizations that have obtained patent grants in the United States, the world’s largest and most important single patent jurisdiction. This list is dominated by the local research operations of foreign firms. Despite their absorption of a large share of Russia’s total R&D expenditures, the state-led research institutes produce fewer patents than commercial companies. Surely, these research institutes and private commercial

enterprises are not strictly comparable, as the type of research they do is very different. However, this does not detract from the main message (and even reinforces it), that resources going to these research institutes could be put to much more productive use by supporting R&D in the private sector. In Russia, the share of researchers in the population, and the aggregate outlays of R&D in GDP, are comparable to those of Germany and Korea, and are far ahead of those of Brazil, China, and India. But these high levels of inputs do not translate into high value added per capita, with Russia lagging behind the OECD, as well as other large middle-income countries in R&D outputs, along with a relatively low number of patents and scientific publications per capita (Schaffer and Kuznetsov in Desai and Goldberg 2008).

What is true in Russia appears to be true more generally throughout the CIS countries, but less so in Eastern Europe. The traditional institutions conducting research have been criticized for their isolation from international technological trends. We find statistical evidence of this relative isolation in the citation patterns of U.S. patents generated by indigenous inventors, when they are compared to comparable inventions of comparable vintage generated in other parts of the world. These indigenous patents generally make fewer citations to the existing state of the art, and they cite narrower inventions. The traditional institutions have been characterized by the poor quality of their inventions. We see evidence of the limitations of indigenous inventions in the relatively small number of citations that these patents receive from patents granted subsequently. Moreover, the number of indigenous patents is low relative to the level of R&D investment, and the number of patents is not sharply increasing, as they have been in countries such as India and China. All of these findings reaffirm the need for continued efforts to reform ECA R&D systems, and to complete the transition from the socialist-era model to a system modeled on global best practices that is more internationally integrated and market driven.

Foreign Firms are Making Significant Contributions to ECA Inventive Activity

The research described above has documented the significant contribution that foreign firms have made and are making to ECA-region inventive activity. Foreign firms' local R&D operations, and their sponsorship of local inventors, collectively generate a large fraction of the total patents emerging from ECA countries. Not only does this process of international coinvention contribute to the quantity of ECA patents, but also raises the quality of ECA inventive effort. Whereas indigenous ECA patents lag behind other regions in terms of the degree to which they build on prior invention and extend it, the ECA patents created through multinational sponsorship are more effectively connected to global R&D trends and generally represent inventions of higher quality. Through collaboration with foreign scientists and engineers based in the world's innovation centers, ECA inventors are able to ground their efforts more solidly in the current technological state of the art, and to benefit from knowledge of recent, relevant technical developments outside the region. The multinationals—unlike the state institutes—have both the incentives for and structure to promote the translation of the ECA research effort into formal intellectual property that can then be deployed both inside and outside the region.

Interestingly, the large role of international coinvention is a feature of regional inventive activity that the ECA countries share with India and, especially, with China. As with the production of goods, it appears that ECA, India, and China all have the opportunity to

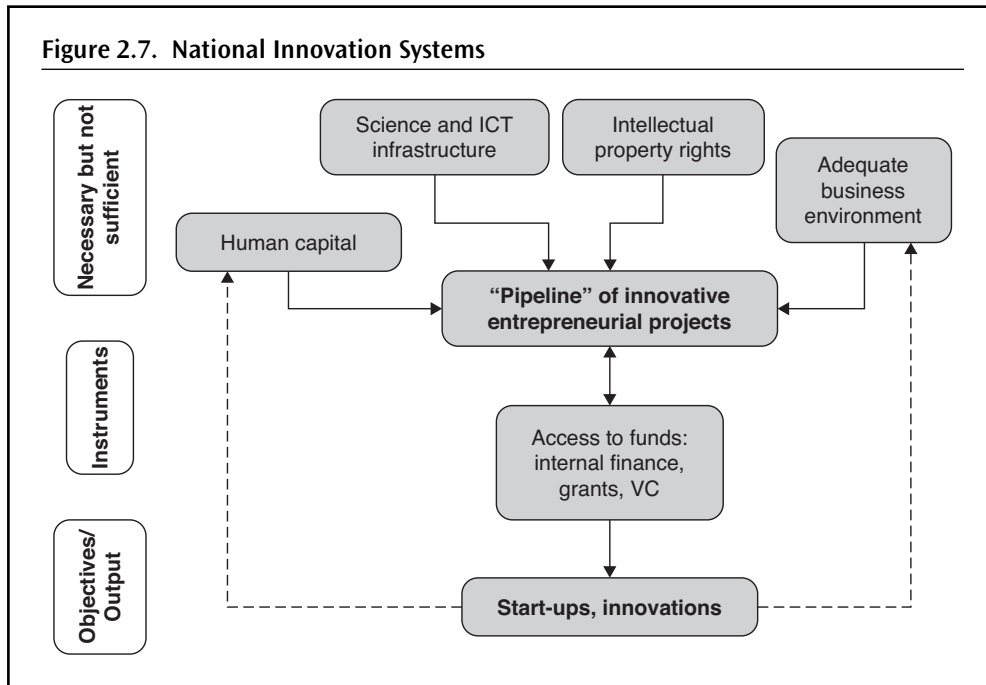
benefit from participation in an emerging international division of inventive labor, in which local inventors become part of a “production chain” of knowledge.

The rapid growth of patenting in India and China presents a contrast to the lack of growth in the ECA region. A complete discussion of trends in R&D in India and China is well beyond the scope of this study, but we would like to point the reader’s attention to one important similarity existing between these two countries and the ECA, as well as to one important difference.¹¹ Like the ECA countries, India and China have seen rapid growth in the share of their total patenting developed as a result of local R&D operations of multinational companies, or by international coinvention more generally. This is particularly true for China, where nearly half of U.S. patents granted to Chinese inventors were created by international teams of inventors, and only a part of these teams was actually based in China at the time of the patent application. The share of international coinvention in China’s total U.S. patents is rising more rapidly than total patents, implying that international R&D collaboration has disproportionately contributed to the impressive growth in China’s inventive output. The fraction of Indian patents developed as a result of international coinvention is lower, but is also experiencing rapid growth. As in the ECA countries, inventors in India and China are apparently able to overcome some of the weaknesses of their own evolving national innovation systems (NIS),¹² by participating in an international division of inventive labor that links them directly with centers of innovative excellence in Europe, Japan, and, especially, North America. Yet there is a very significant difference between ECA, on the one hand, and India and China on the other, and this is pointed out clearly in Figure 2.4 above. In recent years, ECA patenting in the United States has not grown significantly, while India and China have surged ahead. These differences reflect the following trends: extremely rapid economic growth in India and China; substantial public and private investment in higher education, and a large increase in the number of university-educated engineers and scientists; the much larger populations of the two giant Asian nations; and an increasing desire on the part of the world’s leading firms to position themselves in these large consumer markets.

In a globalizing world, multinationals always have a choice among countries when it comes to locating R&D activity. ECA governments should encourage foreign R&D investment and international R&D collaboration. However, as shown in the literature review in ECAKE I, measures to support R&D are ineffective when these are poorly coordinated with other measures. An extensive literature has developed on the concept of a holistic national innovation system (the concept is elaborated in Nelson 1993; OECD 1998 and 2001; Lundvall and others 2002). The National Innovation System 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 infrastructures that accelerate knowledge flow 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. This system, including the availability of

11. See Branstetter and Foley (2007) for a review of U.S. FDI in China, which includes a focus on the R&D activities of U.S. affiliates in that country.

12. See a discussion of the NIS in the last paragraph below and Figure 2.6.



Source: Public Financial Support for Commercial Innovation, ECAKE I, Page 38.

human capital, science and ICT infrastructure, intellectual property rights (IPR), and a business-friendly environment, is illustrated schematically in Figure 2.7 which is reproduced from ECAKE I, page 38.