

The Links among Knowledge Absorption, Trade, and FDI

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Openness to foreign trade and investment is critical to the process of technological absorption and diffusion, not only for the competitive pressure that it exerts on management and corporate governance, but also for the exposure to global best practices technology and management techniques that such openness provides to local firms. The contribution of international openness to growth has been evident since the first wave of globalization in 1870–1913. In his book, *The Mystery of Economic Growth* (2004), Helpman focuses on four themes:

1. Accumulation of physical and human capital,
2. Productivity growth, as determined particularly by the incentives for knowledge creation, R&D and learning by doing,
3. Knowledge flows across national borders and the impact of foreign trade and investment on incentives to innovate, imitate, and use new technologies,
4. Institutions that affect incentives to accumulate and innovate.

The second and the third themes are at the center of this study in general, and of this chapter in particular. In analyzing the effects of trade and FDI on technology absorption, we control for the effects of human capital and measures of investment climate.

This chapter focuses on the role of international trade (and participation in global supply networks) and FDI as mechanisms for the diffusion and absorption of technology in the ECA region. We consider trade and FDI together because they are two aspects of the singular phenomenon of “international connectedness.” In fact, some of the measures of international connectedness that we employ in our analysis of the impact of international trade are at least as much a reflection of FDI as they are of the engagement in international trade.

We emphasize at the outset that we are interested in the impact of international trade, participation in global supply networks, and FDI as mechanisms to promote the diffusion and absorption of technology. We need to draw a distinction between this phenomenon and the narrower concept of productivity “spillovers,” which has been the focus of much of the earlier literature. A “spillover” is a benefit for which the recipient did not have to pay. Previous researchers in the literature have often presumed that the technology absorption abetted by trade or FDI would show up in the form of faster growth rates of total factor productivity: Through contact with superior foreign technology, indigenous firms would be able to realize large gains in output that are far greater than their investments in new capital or better workers. Our broader concept of technology absorption or technology diffusion accepts the reality that indigenous firms may have to make costly investments to acquire new technical competencies, and their ability to appropriate the gains generated by these new competencies may be limited. In other words, a socially beneficial acquisition of new technological capabilities may take place, even when the conventionally defined “productivity gains” are limited or slow in coming, and it may take place even when the conventional techniques designed to measure “productivity spillovers” suggest limited effects. We will re-emphasize this distinction later in the chapter.

Trade and its Benefits

Imports of manufactured goods, especially from more advanced economies, have been a channel of knowledge flows. By purchasing imported inputs and capital goods, firms in less developed countries acquire use of the technology embodied in these goods, thereby realizing gains in national welfare. Empirical multi-country studies (Coe and Helpman 1995; Keller 2002) show that international trade mediates flows of knowledge, allowing firms and industries to acquire technology that expands their productive capabilities, often in ways that show up in conventional productivity measures. There has long been a belief among experts that trading with countries that have a richer R&D stock or, more broadly, which are able to export more advanced technology goods, can facilitate the acquisition of new technical competencies on the part of importers. Conversely, one may posit that participation in export markets enables firms to become more productive, a phenomenon referred to as “learning through exporting,” although this belief has not always been supported by empirical research at the firm level. In a similar vein, it is widely believed that trading in parts and components with foreign companies that are already well integrated in the global production network can facilitate the acquisition of new technology. Data from surveys of ECA firms provide direct evidence suggesting that the purchase of foreign capital goods is a major source of acquisition of newer, more effective technologies.¹³

Historical accounts of the rise of East Asian export industries, often based heavily on case studies and managerial interviews, stress the role played by advanced country buyers

13. In one question in the BEEPS dataset described below, ECA firms are asked to identify a single source (presumably the most important) of acquisition of new technology. The overwhelming majority cite the purchase of new capital equipment as the source of this new technology.

as conduits of technology and managerial know-how to developing country firms (Pack and Westphal 1986). Similarly, case studies and interviews suggest that the cultivation of manufacturing outsourcing relationships between local firms and multinationals—with or without a local presence in the market—can also serve as a channel of knowledge flows (Pack and Saggi 2001). These channels are likely to play a significant role in the ECA context. Our firm-level data, described below, allow us to measure, in principle, the impact of participation in such global supply networks on measures of the adoption of new-to-the-firm technology.

The significant, positive impact of openness to international trade on conventionally measured productivity growth, which has been found in the aggregate country-level studies mentioned above, has been confirmed at the firm level.¹⁴ A study of trade liberalization and productivity in Chile (Pavcnik 2002), found significant positive effects of liberalization on within-firm productivity growth.¹⁵ Other researchers have found similar effects in other contexts. An opening to trade typically intensifies the degree of market competition faced by local firms along a number of dimensions. Foreign firms are often both more efficient in production and better able to offer high-quality products than are many domestic incumbents. Their entry into the marketplace typically intensifies efforts on the part of domestic firms to improve productive efficiency and to alter the product mix so as to better compete with the new entrants. Efforts along both dimensions improve consumer welfare.

Trade in ECA

As described in the study, *Productivity Growth, Job Creation, and Demographic Change in Eastern Europe and the Former Soviet Union*, merchandise exports and imports as a share of GDP in ECA expanded from just over 15 percent in 1994 to nearly 25 percent in 2003. Services, which were considered to be low priority under central planning, have emerged as a dynamic force in sectors such as telecommunications, transportation, energy services, and banking—and services trade as a share of GDP is 5 percent. These numbers, however, mask significant intra-regional variation: merchandise exports and imports, as a share of GDP, ranged in 2003 from 40 percent for the EU-8 through 15 percent for the low-income Commonwealth of Independent States (CIS). Services trade as a share of GDP ranged from around 4 percent for the CIS countries, where services are heavily burdened by regulation and protected from competition, to over 7 percent for the Southeast European (SEE) countries (World Bank 2007b).

Returning to the question of whether international trade mediates flows of knowledge, thus raising productivity, one might also ask: Does the generally positive

14. Yet, this is by no means a guaranteed result: Often-cited results suggesting the absence of a strong productivity effect in particular national contexts include the results of Harrison (1994) in Côte d'Ivoire and Haddad, De Melo, and Horton (1996) in Morocco.

15. De Loecker (2007) and Bernard, Redding, and Schott (2006) have shown that this general finding of a positive impact of trade liberalization on within-firm productivity growth remains even when one allows, theoretically and empirically, for the possibility of multiproduct firms and firm-specific demand shocks that affect firm-level markups.

view of the role of trade in enhancing the productivity of indigenous firms also hold in the ECA region? A number of recent studies strongly suggest that the answer is “yes.” ECA’s flagship trade study¹⁶ “*of Eastern Europe and Former Soviet Union since the Transition*” argues that country participation in international trade has borne much fruit: significant improvements have been observed in the allocation of domestic resources, enhanced productivity, and more rapid and sustained growth. Earle and Estrin (2003) conclude that there is a strong, positive effect of increased import competition on the labor productivity of Russian firms. Djankov and Hoekman (2000) find that an opening to trade, *per se*, does have an impact on enterprise productivity, but that these effects tend to be concentrated among non exporters who, by virtue of their domestic orientation, have been largely cut off from international competition prior to trade reform. Taken together, these studies suggest that the trade liberalization undertaken by the ECA countries in the 1990s did indeed have a positive impact on productivity.

Yet many countries in ECA still have high average tariff and non-tariff barriers, which would need to be reduced in the medium term in order to gain from international integration. In Russia, in particular, the average tariff increased between 2001 and 2003 from about 11.5 percent to between 13 percent and 14.5 percent, but it held steady in 2004 and 2005 (Shepotylo and Tarr 2007). This places Russia’s tariffs at a level slightly higher than those of other middle-income countries, and considerably higher than the OECD countries. The trade weighted standard deviation of the tariff approximately doubled from 9.5 percent in 2001 to 18 percent in 2003, but then fell to 15.2 percent by 2005. Further, the authors suggest that the Russian tariff structure has become more diverse, implying more highly protected sectors and more sectors with very low tariffs. While Russia implemented a tariff simplification reform in 2000–01, wherein it significantly reduced the number of ad valorem tariff rates employed, there was a movement to a less uniform tariff structure. A diverse tariff structure, as argued by the authors, typically imposes significant inefficiency costs on a country, due to increased incentives for lobbying and rent-seeking behavior, which typically lead to tariff-setting policies that are highly inefficient.

A reduction in the import tariff by 50 percent would produce gains for the Russian economy on two counts. It would improve domestic resource allocation due to a shift in production to sectors where production is valued higher, based on world market prices; and it would increase productivity as a result of Russian businesses’ ability to import modern technologies (Rutherford and Tarr 2006)—which is the more significant impact. Having established that tariff and non-tariff barriers pose obstacles to trade openness, Kee, Nictia, and Olarreaga (2006) compute indicators of trade restrictiveness (Table 3.1) that include measures of tariff and non-tariff barriers for 91 developing and industrial countries. Among the indices that the authors calculate is one that focuses on the trade distortions imposed by each country on imports, and another that focuses on

16. Introduction to “*Trade Record of Eastern Europe and Former Soviet Union since the Transition*,” Part I, page 51.

market access for exports in the rest of the world. Table 3.1 shows these two indices for the manufacturing sector. It is interesting to note that the Trade Restrictiveness Indices (TRI) for imports for Russia and Kazakhstan are lower than those of Brazil and India; they are, however, higher than those of South Africa, China, and the EU. Among the ECA countries for which Kee et al. estimated a TRI, Russia's is the highest—a reflection of the high tariff and non-tariff barriers that the country imposes on its imports. This fact is illustrated in Figure 3.2, where Russia has the highest overall trade restrictive index (OTRI)¹⁷ for tariff and non-tariff barriers. However, it experiences smaller trade distortions

Table 3.1. Trade Restrictiveness Indices

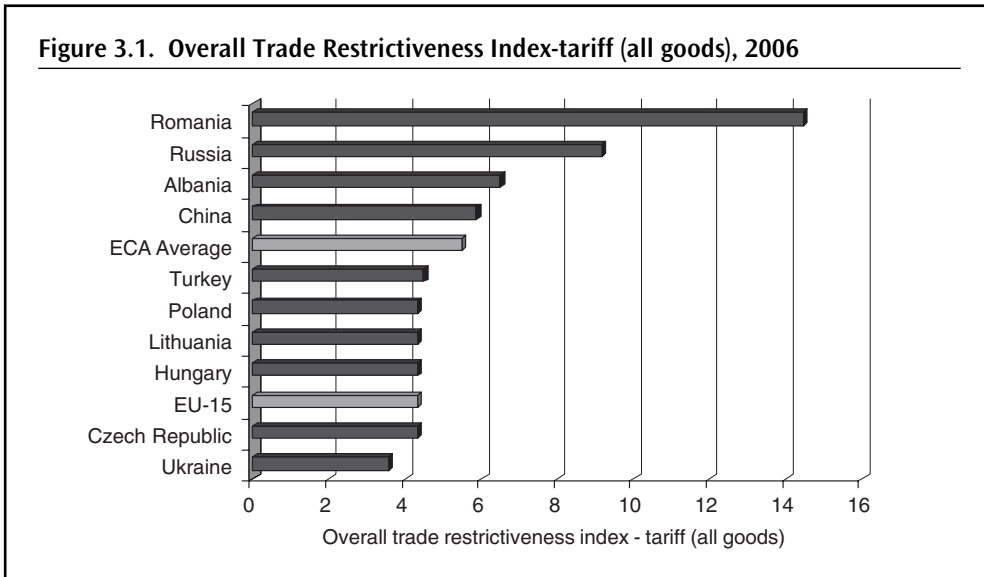
Country	Imports	Exports
Albania	0.07	0.139
Hungary	0.073	0.086
Kazakhstan	0.123	0.115
Kyrgyz Republic	0.033	0.116
Lithuania	0.048	0.161
Latvia	0.067	0.114
Romania	0.16	0.116
Russia	0.19	0.078
Poland	0.07	0.108
Ukraine	0.183	0.106
Brazil	0.217	0.081
China	0.118	0.06
India	0.203	0.131
South Africa	0.066	0.074
EU	0.081	0.085

Source: Kee, Nicita, and Olarreaga 2006.

on its exports from the rest of the world, with China the only country facing a lower level of restrictiveness. Romania has the highest overall trade restrictiveness index for tariffs alone (Figure 3.1), a reflection of the fact that the average Most Favored Nation (MFN) tariff in Romania is the highest in the region, at 11.6 percent, and both agricultural and manufacturing tariff protections are among the highest in Romania (World Bank 2005).¹⁸ Russia imposes the highest non-tariff barriers, making it the most overall trade restrictive country in ECA (Figure 3.2). Early on in the transition, many countries in the region cut tariffs and reduced or eliminated non-tariff barriers. Governments in the region have taken the initiative to ease policy restrictions at their borders to facilitate trade flows. The weighted average applied tariff rate on all goods for all of the region's countries is 5.8 percent (World Bank 2005). These tariff rates compare favorably with

17. OTRI (tariff), displayed for selected countries in Figure 3.1, only summarizes the tariff restrictiveness of a country. It is the uniform equivalent tariff that maintains the aggregate import volume of a country at its current level with heterogeneous tariffs. On the other hand, OTRI (tariff + non-tariff), seen in Figure 3.2, summarizes the trade policy stance of a country. It is the uniform equivalent tariff that maintains the aggregate import volume of a country at its current level with heterogeneous tariff and non-tariff measures.

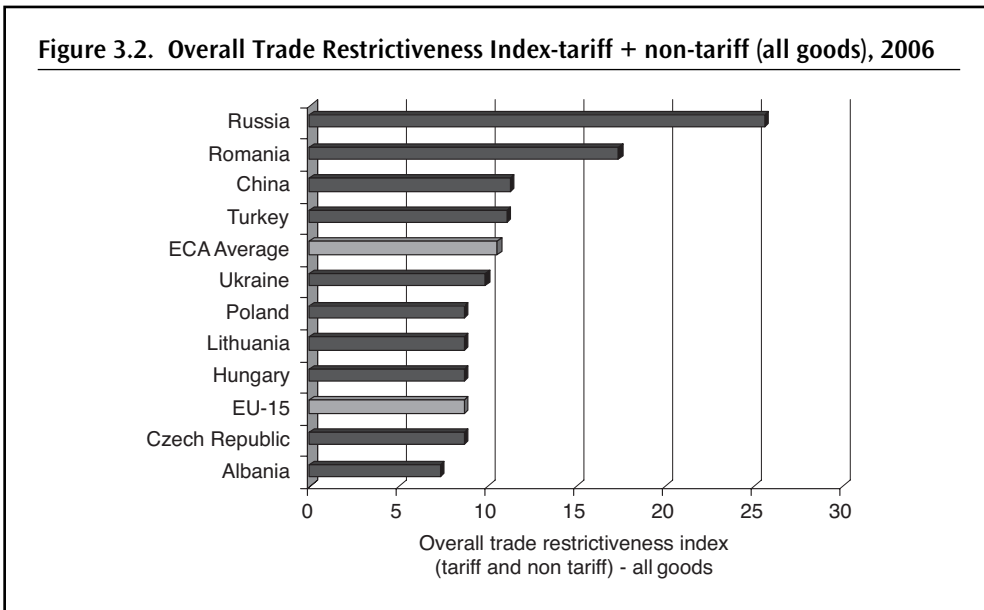
18. Average most favored nation (MFN) tariffs for countries in transition range from a low simple average of 3.3 percent in Armenia to a high of 11.5 percent to 11.6 percent in Belarus and Romania. The highest tariff protection in agriculture is present in Bulgaria and Romania, while the highest tariff protection in manufacturing is in Belarus, Romania, and Uzbekistan (World Bank 2005).



Note: The methodology used is from Kee, Nicita, and Olarreaga (2006).

Source: World Bank trade web site.

those of developing countries at comparable income levels. Nonetheless, some countries in the region still maintain high tariffs and appreciable non-trade barriers. These include some Central Asian republics and others in the CIS, such as Kazakhstan and the Kyrgyz Republic.



Note: The methodology used is from Kee, Nicita, and Olarreaga (2006).

Source: World Bank trade web site.

Research has shown that improved and simplified customs procedures would have a significant positive impact on trade flows, and that the facilitation of cross-border movement of goods would have a positive effect on the ability of a country to attract foreign direct investment and better integrate into international production supply chains. These are the conclusions of the survey by Engman (2005). More specifically, Wilson, Mann, and Otsuki (2003) have shown that enhanced port efficiency has a large and positive effect on trade flows in the Asia-Pacific region and that regulatory barriers deter trade. Improvements in customs and greater use of e-business significantly expand trade, but to a smaller degree than do improvements in ports or regulations. Persson (2007) uses data from the World Bank's Doing Business Database on the time required to export or import, as indicators of cross-border transaction costs. Using a gravity model, she robustly finds that, on average, time delays both on the part of the exporter and the importer, significantly decrease trade flows.

Further, technical barriers to trade (TBTs) also significantly reduce the entry of firms into export markets, substantially reduce trade in some cases, and increase firm start-up and production costs. Chen et al (2006) have shown that testing procedures and lengthy inspection procedures significantly reduce exports and impede exporters' market entry.¹⁹

Because trade and FDI are the key channels for international diffusion of knowledge, poor logistics may impede access to new technology and know-how, and in turn slow the rate of productivity growth (according to the 2007 Logistics Performance Index).²⁰ Cost and efficiency of transport services determine export competitiveness, with higher shipping costs feeding into lower returns to capital in export ventures, and poor logistics increasing inventory costs (Mattoo, Rathindran, and Subramanian 2001). The Logistics Performance Index (LPI),²¹ as shown in Table 3.2, analyzes the performance of key trade logistics processes for 150 countries.

It shows that ECA countries like Russia, Kazakhstan, Albania, and Tajikistan rank low at 99, 133, 139, and 146, respectively. The LPI shows that landlocked countries in Central Asia are typically the most logistically constrained. Further, there appears to be a negative correlation between the LPI and the Trade Restrictive Index (TRI), which would imply that policies to decrease trade logistics costs would also translate into a decrease in the degree of trade restrictiveness. Countries doing fairly well in logistics are also likely to do well in growth and competitiveness, export diversification, and trade expansion. The LPI (2007) shows that developing countries where trade has been an important factor in accelerating

19. They find that firms that outsource components are more challenged by compliance with multiple standards. Wilson and Otsuki (2001) have shown that adopting international guidelines regarding the pesticide aflatoxin would substantially increase world trade of nuts and cereals. Maskus, Otsuki, and Wilson (2005) have shown that standards and technical regulations raise the start-up and production costs of firms in developing countries to an extent that can be substantial for many companies.

20. Connecting to Compete, Trade Logistics in the Global Economy, The Logistics Performance Index and its Indicators, 2007.

21. For details, look at <http://www.gfptt.org/lpi>: The LPI is based on several areas of performance, such as trade procedures, infrastructure, services, and reliability. Based on a 1 to 5 scale (lowest to highest), it aggregates more than 5,000 country evaluations by professionals trading with the country on various dimensions of performance.

Table 3.2. Logistics Performance Indices, 2007

Country	Logistics Performance Index		Country	Logistics Performance Index	
	Rank (Of 150)	Score (Max: 5.00)		Rank (Of 150)	Score (Max: 5.00)
Germany	3	4.1	Lithuania	58	2.78
United Kingdom	9	3.99	Brazil	61	2.75
United States	14	3.84	Croatia	63	2.71
Spain	26	3.52	Ukraine	73	2.55
Portugal	28	3.38	Belarus	74	2.53
China	30	3.32	Bosnia and Herzegovina	88	2.46
Turkey	34	3.15	Macedonia	90	2.43
Hungary	35	3.15	Russia	99	2.37
Slovenia	37	3.14	Kyrgyz Republic	103	2.35
Czech Republic	38	3.13	Azerbaijan	111	2.29
India	39	3.07	Serbia and Montenegro	115	2.28
Poland	40	3.04	Uzbekistan	129	2.16
Estonia	47	2.95	Armenia	131	2.14
Slovak Republic	50	2.92	Kazakhstan	133	2.12
Romania	51	2.91	Albania	139	2.08
Bulgaria	55	3.92	Tajikistan	146	1.93

Source: *Connecting to Compete, Trade Logistics in the Global Economy, 2007*, <http://www.gfptt.org/lpi>, The World Bank.

growth²² also have logistics that are significantly better than in other countries at similar income levels. It also goes on to suggest that in emerging economies, where export-oriented manufacturing has been a major factor in growth, the private sector has been a key proponent of logistics reforms.

Is There Learning by Exporting?

In the reviewed literature, the concept of “learning by exporting” has been seen as a process in which exporting increases productivity by exposing producers to new technologies, or by upgrading product quality. Exporting is another channel through which firms based in open economies can acquire foreign knowledge about technologies and products.

22. The study uses multivariate regressions and shows that there exists significant association between LPI and outcomes such as medium-term growth from 1992–2005 and trade expansion, defined as the overall annual change in trade openness over the same period.

Both case studies and empirical evidence support this view, showing that exporting firms are more efficient than non exporting firms (Pack 1993).

Because import protection can also restrict the growth of exporting firms and industries, trade liberalization (reducing tariffs and removing non-tariff barriers) is often also associated with export growth. The importance of exports for absorption has been long debated in the literature. Some empirical studies have found evidence of “learning by exporting”—that domestic firms are able to improve their technology of production through exports to more advanced markets (Van Biesebroeck 2005; Kraay, Soloaga, and Tybout 2002). However, this has not proven to be a robust finding. The apparent absence of learning-by-exporting effects documented in many contexts has led many economists to question their importance and has, to some extent, undermined the policy case for pro-trade reform. Even well-cited papers such as Pavcnik (2002), which do find evidence of productivity gains from trade liberalization, tend to find most of these gains arising through increased import competition, and have found no evidence of learning by exporting. This would seem to suggest a limited relationship between trade liberalization and the increased absorption of advanced technology by exporting firms.

Our study strongly suggests that the conventional methodology employed by virtually all previous researchers to estimate learning-by-exporting effects may be biased against finding a linkage between exports and increased technology absorption, even when such a relationship exists. This bias exists, in part, because the conventional methodology uses changes in total factor productivity (TFP) as a proxy for technology absorption and diffusion. We will demonstrate below how this methodology might fail to find evidence of efficiency-enhancing technology absorption, even when it does exist. As the reader will see, a similar critique may apply to previous attempts to estimate the impact of foreign direct investment on technology absorption.

Foreign Direct Investment

The close connection between foreign direct investment and trade must be stressed. ECA’s flagship trade study *From Disintegration to Reintegration: Eastern Europe and Former Soviet Union in International Trade* (World Bank 2005) emphasizes this connection and places it in a theoretical and global context. The benefits of international exposure to best practice technologies often come directly or indirectly through the intermediation of foreign firms. The strength of this connection arises out of well-noted revolutionary changes in logistics, information technology, and manufacturing in recent decades, which allow firms to disaggregate the total production process of a good or service into separate stages, and to locate each of these stages in an environment where local factor endowments enable efficient production. This process, referred to as the slicing up of the value chain, or the fragmentation of production (Krugman 1995; Jones, Kierzkowski, and Lurong 2004), enables a broad range of countries to participate in various stages of the production chain—even if they do not possess intangible assets or a service infrastructure sufficient to provide them with a comparative advantage in the production of final goods. Multinationals have played an important role in driving this process—estimates suggest that about two-thirds of world trade by the latter half of the 1990s involved multinational corporations.

Multinationals have played particularly significant roles in expanding the international trade in some of the most successful developing countries. China clearly stands out over the course of the past decade, in terms of the speed with which its exports of manufactured goods have expanded and diversified across a broad range of product categories. China is now the third-largest trading economy, as measured by conventional trade statistics, and it has recently emerged as the largest single supplier of IT hardware to the U.S. market. Most of the expansion of Chinese trade in the 1990s has been driven by foreign firms, and this is especially true of “high-tech” production. Today, foreign firms are responsible for nearly 60 percent of China’s total exports. By 2003, foreign firms accounted for 92 percent of China’s export of computers, computer components, and peripheral devices.²³

China is not alone in Asia in terms of its reliance on foreign firms to mediate exports of technologically intensive goods. In fact, China can be viewed as merely the latest manifestation of a phenomenon that is common throughout Southeast Asia. Athukorala (2006) presents an interesting view of Asian industrial history, in which he contrasts the industrialization of Japan and the East Asian Newly Industrialized Economies (NIEs), which were primarily based on the growth of indigenous firms, with the experience of “latecomer countries”—the Southeast Asian nations and China. He argues that a long period of import substitution in the latecomer countries undermined the development of indigenous entrepreneurship and cut off local managerial elites from international markets. In this context, it was simply more efficient for the latecomer countries to join a preexisting international production chain, rather than try to create one from scratch through the efforts of indigenous firms alone. Using official data from Asian countries to document the sizable expansion in the share of international trade mediated by multinationals in all of these countries, he concludes that the entry of multinationals is virtually essential for the export success of latecomers.

In ECA, seven countries—the Czech Republic, Estonia, Hungary, Poland, the Slovak Republic, Slovenia, as well as Turkey—started off by participating in network trade in clothing—a sector activity intensive in unskilled labor and embedded in so-called “buyer-driven” production chains, wherein global buyers create a supply base upon which production and distribution systems are built, without direct ownership. However, prompted by rising wages, these countries were able to move into sectors such as automotive and information technology (IT)—which are intensive in skilled labor and capital and, in the case of IT, intensive in knowledge as well—by using foreign capital and know-how and the so-called “producer-driven” production chains. The latter networks divide the value chain into smaller components and move them to countries where production costs are lower. Production fragmentation in vertically integrated sectors (drives) producer-driven network trade. Such a transition to producer-driven networks has, however, not taken place for CIS countries such as the Kyrgyz Republic, Moldova, and Turkmenistan, which are involved in the buyer-driven production chains of the clothing trade. Nor has it happened in Belarus, Russia, and Ukraine which, together with the Kyrgyz Republic and Moldova, have been active in the furniture network; though buyer driven, the furniture network is

23. See Branstetter and Lardy (2007) for an overview of Chinese trade and FDI reform, and which stresses the role of foreign firms in China’s export dynamism.

more diversified and complex, requiring a larger input of skills and investment in capital assets and thereby creating more opportunities for knowledge transfer and productivity spillovers compared to the clothing network.

Proximity to Western Europe has evidently been a major advantage with regard to countries' participation in networks. Indeed, the EU-15 accounts for three-quarters of the producer-driven network trade of the transition countries and Turkey as a whole. Notwithstanding the disadvantages of geography, reform of the investment climate, which is within the control of country authorities, is important in order to attract the FDI necessary to permit participation in such trade. The three most important obstacles to doing business are reported to be: (i) the macroeconomic environment, (ii) regulation, especially customs and trade regulations, and (iii) the judiciary and corruption in institutions. Hence, reform in these areas is a high priority for policy reform in the low-income countries of the region. We will come back to this point in the last chapter on the role of government (World Bank (2007b)).

FDI and Technology Absorption

We now return to the question of how and to what extent FDI has contributed to technological absorption—both in general and in the ECA region in particular. Empirical studies²⁴ generally find strong, robust effects of foreign ownership on the productivity of wholly or partially owned foreign subsidiaries. In other words, firms with some level of foreign ownership are more productive and technology intensive than are purely domestic firms. What is rarer is evidence of productivity spillovers to indigenous domestic firms. A number of studies have found evidence of such spillovers in industrialized countries, but they have proven harder to find in developing-country contexts. In fact, a number of well-regarded studies have even found evidence of negative TFP spillovers, suggesting that the presence of foreign firms actually triggers a *decline* in the productive efficiency of local firms. Studies of the Czech Republic, Bulgaria, Romania, and Poland could not find evidence of positive spillovers to indigenous firms (Djankov and Hoekman 2000; Konings 2000). Javorcik (2004) has suggested that spillovers from FDI will only flow to a particular subset of indigenous firms. She notes that multinationals have little incentive to transfer technology to local rivals, and can often take steps to limit the extent to which their technology leaks out. However, they do have an incentive to share technology with local suppliers—and Javorcik finds evidence of inter-industry (or “vertical”) spillovers from foreign firms through supply chain relationships to their local suppliers in Lithuania. Garrick Blalock (2002) finds similar evidence of spillovers through so-called backward linkages in Indonesia.²⁵

24. This literature has taken a production function-based approach to estimate the impact of FDI on the productivity of both foreign subsidiaries and indigenous firms. Output levels or growth rates of output at the firm level are regressed on measures of inputs (or neoclassical assumptions are imposed on data to subtract cost share weighted measures of input growth from output growth), allowing the computation of a residual, which is interpreted as total factor productivity. The presence of FDI spillovers are inferred from the positive correlation, if any, between measures of multinational presence in the industry or related industry, and the productivity residuals of local firms.

25. Yet, recent research for China fails to find strong evidence for spillovers through vertical linkages (Girma and Gong 2007).

Box 3.1: Measuring the Impact of Trade and FDI on Technology Absorption

The conventional methodology estimating the effect of FDI on productivity cannot fully capture the impact of FDI on technology absorption by local firms, especially among firms within the same industry. Nor does it capture the full benefits from learning by exporting. This is because the methodology does not distinguish effectively between changes in profits and changes in the technical efficiency of production. When foreign firms arrive, or when firms are first exposed to international competition through trade liberalization, it is likely that this change will diminish the market power of the indigenous incumbents, driving down profits—at least in the short run. At the same time, the incumbents may learn useful production techniques and technologies from their foreign rivals or foreign customers, allowing them to reduce their costs and produce goods and services much more efficiently. The decline in profits arising from this learning could overshadow the increase in productivity in the data, even when the latter effect is quite large. The analysis below provides a graphical illustration of this problem.

Most econometric studies cannot track changes in the prices charged by individual firms. Instead, the output of all firms in an industry is deflated by a common price index. As a consequence, the decline in profits following the entry of foreign firms through exports or direct investment, evident in Figures 3.3 and 3.4 (see Box 3.2), shows up as a decline in total factor productivity under the conventional methodology. This can be true even in cases, such as the one we have illustrated, where real learning by domestic firms takes place, resulting in quite substantial reductions in marginal cost. It may be that a decade of applied research has systematically underestimated the effects of FDI and openness on the technology absorption of local indigenous firms.

The potentially serious shortcomings of the conventional approach point to the need for an alternative, and we provide one in the following section. By employing survey data, we can more directly measure the technology absorption of ECA firms. We find a strong empirical connection between technology absorption and the exposure of ECA firms to foreign markets and foreign competitors through trade and FDI. These results considerably strengthen the case for trade and FDI openness.

Empirical Analysis: Linking Trade, FDI, and Human Capital with Technology Absorption

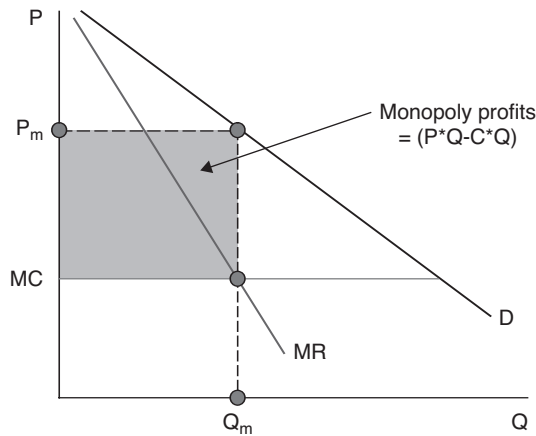
Having extracted significant lessons for the ECA region from the existing literature, we go on to use original data analysis to quantitatively assess their relevance in the ECA context. The BEEPS datasets contain a number of variables describing outcomes closely related to technology absorption, each of which is obtained from detailed surveys of managers of ECA-region firms. In these surveys, firm managers are asked specifically whether their firm recently introduced a new (to the firm) product, upgraded an existing product, acquired a new production technology, signed a new product licensing agreement, or acquired a new quality certification. Each of these potentially represents a dimension of the kind of technology absorption process that we believe is fostered through exposure to international best practices. In our empirical work, we use these variables, individually and together, to attempt a systematic assessment of the degree to which ECA-area firms really are absorbing technology through their connections to the global economy specified in the academic literature.

We are able to measure this connection because the BEEPS data also contain information on the extent of international “connectedness” of the individual firms. These data include information on exports, the level of foreign ownership, whether or not the firm is

Box 3.2: New Foreign Competition: Lowering Profits and Raising Efficiency

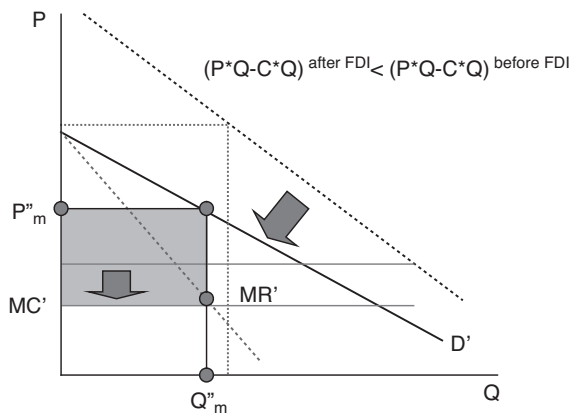
This point is important enough that it deserves some elaboration, and a graphical illustration may be useful to underscore the idea. Imagine a local firm with a substantial degree of *de facto* monopoly power, perhaps held as a consequence of an only partly reformed trade and FDI regime. This firm's *ex ante* position is illustrated in Figure 3.3. The monopoly power of the local firm is represented by the relatively inelastic downward-sloping demand curve it faces. Responding optimally to this market power, the firm keeps output levels low and output prices high, charging the optimal monopoly price.

Figure 3.3



Now, thanks to trade and FDI reform, a foreign entrant comes into the market—an entrant with superior technology, higher quality, a more powerful brand name, or perhaps all three attributes. The local firm finds that its demand curve has both shifted in and become more elastic—that is, flatter. This is illustrated in Figure 3.4. The opportunity cost of foregone income at all price points is now higher. The local firm reacts rationally, lowering price and output below the *ex ante* monopoly levels.

Figure 3.4



(continued)

Box 3.2: New Foreign Competition: Lowering Profits and Raising Efficiency (*continued*)

With the passage of time, the local firm is able to learn elements of the foreign competitor's technology, thereby realizing substantial declines in marginal cost. This allows the local firm to expand output and increase profits, relative to its situation immediately after the foreign firm's entry. Nevertheless, the profits of this firm remain lower than they were under the prior *de facto* monopoly. As emphasized in the text, the conventional methodology will often interpret these lower profits as indicating a decline in technical efficiency, even though the cost of production is now much lower.

a supplier to a multinational, how much it sells to multinationals, and whether the firm engages in joint venture partnerships with multinationals. It is thus possible, at least in principle, to measure the impact of international connectedness along various dimensions on the likelihood of technology absorption, measured in different ways.

To be concrete, we will consider regressions of the following form:

$$\begin{aligned}
 Upgrade_{it} = & \beta_0 + \beta_1 \left(\frac{K_{it}}{L_{it}} \right) + \beta_2 International_{it} + \beta_3 Human_Capital \\
 & + \beta_4 Investment_Environment_{it} + \theta_j + \gamma_c + \lambda_t + \varepsilon_{it}
 \end{aligned} \tag{1}$$

Where various measures of technology upgrading or technology acquisition are regressed on firm-specific (and sometimes time-varying) measures of capital intensity, the various measures of international connectedness described above, industry dummies (indexed by *j*), country dummies (indexed by *c*), and time dummies (indexed by *t*). Based on prior World Bank research, we know that the level of human capital within the firm and the institutional features of the home market that reward or penalize investment will also impact technology upgrading and technology acquisition. We will include these variables in some specifications to ensure that our key findings are robust.

The BEEPS datasets are cross-sectional surveys, and the most complete of these surveys is the most recent one, conducted in 2005. For this reason, much of our empirical work will focus on the data contained in this survey. However, an obvious identification problem arises in the context of cross-sectional data. Measures of international connectedness and measures of technology absorption both reflect choices by the firm, and both could be driven by some unmeasured or poorly measured third factor. In particular, we worry that firms with better managers will tend to be more proactive in terms of their adoption of technology; a cross-sectional regression is unable to determine whether positive correlations observed between these variables are driven by a causal relationship. If we had a good instrument that was highly correlated with firm-specific measures of international connectedness, but was not itself subject to similar endogeneity critiques, we could employ such an instrument. However, as is often the case, such an instrument does not appear to exist. In the absence of a good instrument, we will utilize panel data

techniques to address these issues of causality, and we will further specify our approach below.²⁶

Our contribution lies in establishing a direct connection between the exposure to international technical best practices, through trade and supply networks, and specific, discrete processes of technical improvement at the firm level. The prior literature has been unable to make much progress on this front, in part because of the difficulty of tracking technological absorption through the usual sorts of data available to researchers. The unique resources of the BEEPS surveys provide an unusual, if limited, ability to peer inside the “black box” of technology absorption, and those resources are exploited in this chapter.

The qualitative and subjective nature of the data on technology absorption present challenges to our empirical analysis. The notion of exactly what constitutes a “new” technology or a “new” product will clearly vary across countries, industries, and even individual firms within an industry. It seems evident from related work using these data that the typical respondents frame their answers about “new” products, processes, and technology with respect to the experience of the surveyed firm, rather than global best practices.²⁷ Thus, these variables are not capturing innovation, *per se*, as much as technology absorption; as such they are actually well-suited to our purposes. Because the frames of reference of multinational subsidiaries with regard to new technology may be quite different from that of indigenous firms, we need to be careful in our interpretation of results that compare majority or wholly owned foreign subsidiaries with other kinds of enterprises. In some contexts, the use of country, industry, and firm effects will help us get around the measurement challenges posed by the subjective nature of our data.

For all of their flaws, these data offer, at least in principle, one significant advantage—the directness with which they may be able to measure technology absorption. Most studies of technology transfer have tended to use firm-level productivity measures as the outcome variable. Such studies have had to contend with the reality that conventional productivity measures reflect not only the firm’s mastery of more efficient methods of production, but also the ability of the firm to appropriate at least some of the benefits of that efficiency increase in the form of higher profits. However, as we have already emphasized, one can easily imagine that the entry of multinationals into local markets or trade liberalization might raise the intensity of market competition, forcing local firms to reduce markups and pass most or all of the benefits arising from increased productive efficiency on to downstream customers. Under such conditions, real productivity increases could be

26. Panel data (that is, data sets incorporating repeated observations on the same firms) can often, be used to determine whether a statistical relationship has a causal interpretation. When several years worth of observations are available for the same set of firms, a firm-fixed effect can be incorporated into the regression, and GMM-based regression techniques can be employed to control for the plausible endogeneity of certain key explanatory variables. These usual econometric fixes are not available to us because of the absence of a sufficiently rich panel, requiring caution to be exercised when making inferences based on regression equations such as those described above. However, we do have something of a panel dimension, in that nearly 2,000 firms appearing in the 2005 BEEPS survey also participated in the 2002 survey. We can link these firms into a short panel, and then utilize the limited panel dimension of our data to obtain some leverage around issues of causal interpretation.

27. See related work by Almeida and Fernandes (2007) for a discussion of this issue.

taking place, but their effects could be masked in the data by changes in appropriability conditions.

Going further, one could even point out circumstances in which technology absorption can create social gains, even though the cost of this acquisition of a new technical competence is so high for the acquiring firms that “productivity” benefits (that is, expansion in output that exceeds the cost of the expansion in inputs) may be slow to emerge. Technology absorption can facilitate the diversification of the economy, expand the range of diversified intermediate inputs available to local producers; raise the return to investment in sophisticated physical capital and raise the return to investment in human capital. All of these changes enhance the economic growth process, and this shows further how a narrow focus on firm-level TFP residuals can fail to fully account for the social gains generated by technology absorption, both empirically and conceptually.

The indicator variables mentioned above are more direct measures of technology transfer or technology absorption than are changes in productivity. While the measures have the disadvantage of reflecting the self-assessment of a firm’s representative, they have the important advantage of not being obscured by changes in the firm’s market environment that are coincident with the absorption of the new technology. Each of these outcomes could be used separately in a regression analysis; they could also be combined into an aggregate measure of technology/quality upgrading. Fortunately for us, the BEEPS data sets *also* include data on output and input measures, allowing for the computation of simple productivity measures that could also be employed in a manner more directly comparable with the previous literature.²⁸

We describe below the results of regression analyses using data drawn from BEEPS surveys conducted in 2002 and 2005. Given the relationship between R&D expenditure and technology absorption emphasized by Cohen and Levinthal (1989), we believe it is important to control for R&D investment when such data are available. We will also present some results from a panel of firms that were included in both the 2002 and 2005 surveys.

Results from Regression Analysis

Table 3.3 presents results from a version of equation (1) in which the dependent variable is a binary response variable indicating whether or not the firm has introduced a new product or process. We regress this on several measures of international connectedness, including: 1) a dummy variable indicating whether or not the firm has exported at all, 2) a variable measuring the fraction of sales exported, 3) a variable indicating whether the firm is majority owned by a foreign enterprise, 4) a variable measuring the fraction of sales to multinational corporations (as a proxy for participation in global supply chains), and 5) a dummy variable indicating the existence of a joint venture with a multinational. As control variables, we include the firm size, age of the firm, the log of

28. Preliminary empirical work confirms a positive, statistically significant connection between the discrete measures of technological absorption tracked in this study and simple measures of firm-level labor productivity.

Table 3.3. Regression Results for New Product Introductions as Dependent Variable

Dependent Variable: New Product						
Exporter dummy	0.065 [0.014]***					0.055 [0.014]***
Exports as a percentage of sales		0.001 [0.000]**				
Majority foreign owned			0.009 [0.017]			-0.002 [0.018]
Percentage sales to MNCs				0.001 [0.000]		0 [0.000]
Joint ventures with MNCs					0.24 [0.023]***	0.23 [0.024]***
Size	0.009 [0.008]	0.011 [0.008]	0.013 [0.008]*	0.008 [0.008]	0.01 [0.008]	0.002 [0.008]
Age	-0.001 [0.000]***	-0.001 [0.000]***	-0.001 [0.000]***	-0.001 [0.000]***	-0.001 [0.000]***	-0.001 [0.000]***
State ownership	-0.052 [0.021]**	-0.054 [0.021]**	-0.053 [0.021]**	-0.043 [0.022]**	-0.049 [0.021]**	-0.038 [0.021]*
R&D expenditures	0.027 [0.004]***	0.029 [0.004]***	0.029 [0.004]***	0.03 [0.004]***	0.028 [0.004]***	0.027 [0.004]***
Foreign ownership	0 [0.000]	0 [0.000]		0 [0.000]	0 [0.000]	
Web use	0.061 [0.012]***	0.064 [0.012]***	0.066 [0.012]***	0.066 [0.012]***	0.062 [0.012]***	0.058 [0.012]***
ISO certification	0.154 [0.016]***	0.158 [0.016]***	0.158 [0.016]***	0.155 [0.016]***	0.133 [0.016]***	0.129 [0.016]***
Training	0.074 [0.011]***	0.076 [0.011]***	0.076 [0.011]***	0.078 [0.011]***	0.072 [0.011]***	0.071 [0.011]***
Skilled workforce	0.001 [0.000]**	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***
University graduates	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***
Infrastructure index	0.021 [0.011]*	0.02 [0.011]*	0.021 [0.011]*	0.019 [0.011]*	0.018 [0.011]	0.016 [0.011]
Governance index	0.08 [0.033]**	0.082 [0.033]**	0.083 [0.033]**	0.089 [0.033]***	0.084 [0.033]***	0.086 [0.033]***
Use of a loan	0.074 [0.010]***	0.076 [0.010]***	0.076 [0.010]***	0.077 [0.010]***	0.074 [0.010]***	0.074 [0.010]***
Observations	7964	7960	7986	7819	7986	7799
R-squared	0.16	0.16	0.16	0.16	0.17	0.17
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes

Note: Logit Regressions; Marginal effects at mean values from logit regressions shown. Dependent variable is response to question: Have you introduced a new product or process?

R&D is measured in logs in this and subsequent tables. We do not present another set of regressions that included K/L as a dependent variable, since its inclusion leads to the loss of a number of observations. Qualitatively, the results are similar to those shown below.

Source: Authors' Calculations, BEEPS 2002, 2005.

reported R&D expenditure, industry dummy variables, and country-of-origin dummy variables. To probe the robustness of these results and to examine the role of human capital in the absorption process, we also include controls that measure the levels of education and skill within the workforce and the existence of training programs. In most regressions, we are especially concerned about the impact of openness on local firms that are not foreign owned, and, therefore, we include an additional regressor, which measures the level of foreign ownership in the firm. We also include measures of whether firms absorb modern knowledge as those that (i) *have obtained ISO 9000 certification (a proxy for a firm's adoption of international standards and technical regulations)*, or (ii) *use the Internet for their business operations*. Finally, we also incorporate measures of infrastructure and governance into our regressions. The governance index²⁹ is the first principal component derived from factor analysis based on measures of the quality of contract enforcement, the predictability of government regulations, and the bureaucratic burden felt by firms. The infrastructure index³⁰ is the first principal component derived from the factor analysis based on infrastructure measures of power and telecom. For the most part, inclusion of this rather extensive group of additional controls did not qualitatively alter the empirical results. Where there were important changes, these will be noted explicitly in the text. Given the dichotomous nature of the dependent variable, we employed a logit specification. The nonlinear nature of the regression procedure requires us to take some care in interpreting the regression coefficients, which show the marginal effects at mean values for these regressions. The variables used in the regressions are defined in Table B.1.

Controlling for firm size, age, and ownership, one finds that larger, as well younger firms, are introducing new products and technologies. Further, state ownership decreases the likelihood of firms absorbing new technologies and processes. Our focus, however, is on the importance of various measures of international connectedness in this process of technology diffusion.

Column 1 of Table 3.3 provides the results obtained when we measure international connectedness with the export dummy variable. The coefficient is quantitatively large and statistically significant, suggesting a strong association between exporting activity and new product or process introductions. The logit regression coefficient does not have an elasticity interpretation, but evaluated at the mean values of the data, the regression coefficient implies that being an exporter, compared to being a non exporter, is associated with a higher likelihood of the introduction of new products or processes of about 6.5 percent, and this value is also highly statistically significant.

29. Governance Index is the first principal component based on the factor analysis of: trust in the legal system; average percentage of firms indicating that they think government regulations are predictable; (1 minus average percentage of firms indicating that it is common for firms in the industry to pay bribes to get things done); (100 minus average percentage of time managers spend dealing with regulations and inspections), by region.

30. Infrastructure Index is the first principal component based on the following variables: energy outages and telecom outages.

Column 2 gives results obtained when we measure international connectedness by employing measures of the fraction of sales that are exported. Evaluated at the means of the data, the regression coefficient implies that an increase in the export sales ratio implies an increase in the likelihood of the firm introducing a new product or process. With the full controls for investment climate and foreign ownership, the coefficient is significant at the 5 percent level. Viewed together, these first two columns appear to suggest that there is a strong association between the engagement of a firm in export activity and measures of technology absorption, but that the exact level of export activity is a weaker predictor of technology absorption.

Column 3 suggests that majority-owned foreign affiliates are more likely to introduce a new product or process, but these results are not statistically significant at conventional levels. We will later argue that this is consistent with a systematic difference in the way managers at foreign-owned firms and managers at indigenous firms interpret questions about the introduction of “new” products. It may also reflect differences in the degree to which foreign-owned firms had converged to international best practices, relative to indigenous firms, by the beginning of the current decade.

Column 5 gives the results obtained when we use a dummy variable measuring the existence of a joint venture (JV) with a multinational firm. Again, the results suggest a statistically significant positive association. Evaluated at the means of the data, the regression coefficient implies that a JV is associated with a higher likelihood of new product or process innovation of more than 100 percent.

Column 6 gives the results obtained when we include export, majority foreign ownership, sales to multinational corporations (MNCs) and JVs with MNCs, all together. The results suggest that our results are robust: The effects of all these variables remain the same as before, the only difference being that the “vertical FDI” measure is now statistically insignificant, though only marginally. Everything else is the same, which is reassuring.

We see a similar pattern when we adopt an alternative measure of technology absorption: the upgrading of an existing product or process. The results are provided in Table 3.4, which has a column format similar to that of Table 3.3.

As the reader can see, all but one of our measures of international connectedness are positively associated with technology upgrading, and each of the positive relationships is statistically significant at conventional levels, even in our most complete regression specification (except for the percentage of sales to MNCs). In keeping with the pattern established in Table 3.3, the coefficients on the export and multinational JV dummy variables are particularly large. In this table, the logit regression coefficients imply a 5 percent increase in the likelihood of product or process upgrading, as one moves from non exporter to exporter status, and a nearly 20 percent increase in the likelihood of product or process upgrading as one moves from the absence to the presence of a multinational JV.

However, the dummy variable signifying majority foreign ownership is not statistically significant at conventional levels, and this is a pattern that we see repeated in many of the regression tables that follow. Does this suggest a more limited technology transfer to wholly owned or majority owned subsidiaries? Is majority ownership by foreign firms a handicap in the technology absorption process? That interpretation would be

Table 3.4. Regression Results for Product Upgrades as Dependent Variable						
Dependent Variable: Product Upgrade						
Exporter dummy	0.054 [0.015]***					0.043 [0.016]***
Exports as a percentage of sales		0.001 [0.000]**				
Majority foreign owned			-0.021 [0.019]			-0.003 [0.020]
Percentage sales to MNCs				0.001 [0.000]*		0.001 [0.000]
Joint ventures with MNCs					0.206 [0.025]***	0.195 [0.026]***
Size	0.002 [0.008]	0.003 [0.008]	0.003 [0.008]	-0.002 [0.008]	0 [0.008]	-0.006 [0.008]
Age	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]
State ownership	-0.1 [0.023]***	-0.102 [0.023]***	-0.101 [0.023]***	-0.091 [0.023]***	-0.098 [0.023]***	-0.088 [0.023]***
R&D expenditures	0.025 [0.004]***	0.026 [0.004]***	0.027 [0.004]***	0.028 [0.004]***	0.026 [0.004]***	0.025 [0.004]***
Foreign ownership	0 [0.000]	0 [0.000]		0 [0.000]	0 [0.000]	
Web use	0.1 [0.013]***	0.103 [0.013]***	0.105 [0.013]***	0.103 [0.013]***	0.101 [0.013]***	0.098 [0.013]***
ISO certification	0.141 [0.017]***	0.145 [0.017]***	0.146 [0.017]***	0.142 [0.017]***	0.124 [0.017]***	0.119 [0.017]***
Training	0.113 [0.012]***	0.114 [0.012]***	0.116 [0.012]***	0.113 [0.012]***	0.112 [0.012]***	0.107 [0.012]***
Skilled workforce	0.001 [0.000]**	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***	0.001 [0.000]***
University graduates	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]
Infrastructure index	-0.015 [0.012]	-0.015 [0.012]	-0.014 [0.012]	-0.014 [0.012]	-0.017 [0.012]	-0.018 [0.012]
Governance index	0.153 [0.035]***	0.155 [0.035]***	0.155 [0.035]***	0.157 [0.036]***	0.156 [0.035]***	0.156 [0.036]***
Use of a loan	0.07 [0.011]***	0.072 [0.011]***	0.072 [0.011]***	0.074 [0.011]***	0.071 [0.011]***	0.071 [0.011]***
Observations	7964	7960	7986	7819	7986	7799
R-squared	0.17	0.17	0.17	0.16	0.17	0.17
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%.

Notes: Logit Regressions; Dependent variable is response to question: Have you upgraded an existing product line/service? Marginal effects at mean values from logit regressions shown.

Source: Authors' Calculations, BEEPS 2002, 2005.

inconsistent with one of the most well-established empirical regularities in the micro TFP spillovers literature: the finding that wholly or partially owned foreign firms tend to be more productive than other firms in the industry. In fact, when we construct simple measures of labor productivity using the BEEPS data, we find similar evidence of a positive relationship between being majority owned by foreign firms and having higher productivity.

We interpret these results in a different way: affiliates of multinationals are likely to acquire a high *level* of technology soon after acquisition; hence, they are less likely to have to upgrade. This is consistent with the studies that find that foreign affiliates are more productive—that they have a higher *level* of technology and productivity.³¹

This particular aspect of the general pattern of our results should be quite reassuring for those who might be concerned that the benefits of trade and FDI openness are largely restricted to enterprises that are controlled by foreign investors. We seem to be finding just the opposite—majority foreign ownership does *not* appear to be strongly associated with our measures of technology absorption. Rather, it appears that firms controlled by *local* owners, engaged in exports, or participants in FDI-mediated supplier networks are the primary beneficiaries.

A further alternative perspective on this phenomenon is provided by Table 3.5, which measures whether the firm in question has acquired a new production technology.

The pattern of regression coefficients is similar to that in the previous tables: All measures of international connectedness, except majority foreign ownership, are found to be positively correlated with the acquisition of new technology. All of the positive correlations are statistically significant at the 10 percent level, even in the most complete specifications, and the impact of exports and multinational JVs is especially large and significant at the 1 percent level.

A final examination of the correlation in the cross-section comes from Table 3.6. Here, we construct a dependent variable, “technology upgrading,” from a composite of dummy variables measuring firms’ introduction of new products or processes, upgrading of existing products or processes, achievement of new quality certifications, and acquisition of technology licensing agreements from other firms. We simply sum up responses by firm, producing a limited dependent variable that lies between 0 and 4. We apply ordinary least squares regression analysis, controlling for country and industry fixed effects. The results of these regressions parallel our earlier results. Once again, all measures of international connectedness, except majority foreign ownership, are positively and significantly associated

31. An alternative interpretation of this result is that majority foreign-owned firms may apply a different set of criteria in determining whether a particular technology is “new,” and in determining whether a particular process or product is being upgraded. It is quite likely that the managers of foreign firms will either be foreigners themselves, or they will be indigenous managers with a very deep understanding of technological best practices as it exists in the global economy beyond the ECA region. Such individuals are less likely to flag a process or technology as “new” when it only brings the ECA enterprise up to standard practice elsewhere, whereas an indigenous enterprise manager might be much more likely to view adoption of the identical process or technology as “new.” To the extent that our interpretation is correct, it suggests that empirical results regarding the impact of majority foreign ownership have to be viewed with care and a certain degree of skepticism.

Table 3.5. Regression Results for Introduction of New Technology as Dependent Variable

Dependent Variable: New Technology						
Exporter dummy	0.053 [0.014]***					0.051 [0.015]***
Exports as a percentage of sales		0.001 [0.000]*				
Majority foreign owned			-0.065 [0.018]***			-0.076 [0.018]***
Percentage sales to MNCs				0 [0.000]		0 [0.000]
Joint ventures with MNCs					0.088 [0.024]***	0.082 [0.024]***
Size	0.016 [0.008]**	0.017 [0.008]**	0.019 [0.008]**	0.015 [0.008]**	0.017 [0.008]**	0.012 [0.008]**
Age	-0.001 [0.000]***	-0.001 [0.000]***	-0.001 [0.000]***	-0.001 [0.000]***	-0.001 [0.000]***	-0.001 [0.000]***
State ownership	-0.039 [0.021]*	-0.04 [0.021]*	-0.04 [0.021]*	-0.037 [0.022]*	-0.038 [0.021]*	-0.037 [0.022]*
R&D expenditures	0.032 [0.004]***	0.033 [0.004]***	0.034 [0.004]***	0.034 [0.004]***	0.034 [0.004]***	0.032 [0.004]***
Foreign ownership	-0.001 [0.000]***	-0.001 [0.000]***		-0.001 [0.000]***	-0.001 [0.000]***	
Web use	0.068 [0.012]***	0.071 [0.012]***	0.073 [0.012]***	0.073 [0.012]***	0.071 [0.012]***	0.068 [0.012]***
ISO certification	0.141 [0.016]***	0.143 [0.016]***	0.144 [0.016]***	0.145 [0.016]***	0.135 [0.016]***	0.133 [0.016]***
Training	0.088 [0.011]***	0.089 [0.011]***	0.09 [0.011]***	0.09 [0.011]***	0.088 [0.011]***	0.086 [0.011]***
Skilled workforce	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]
University graduates	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]	0 [0.000]
Infrastructure index	-0.023 [0.011]**	-0.023 [0.011]**	-0.023 [0.011]**	-0.022 [0.011]**	-0.024 [0.011]**	-0.024 [0.011]**
Governance index	0.007 [0.033]	0.01 [0.033]	0.011 [0.033]	0.009 [0.033]	0.011 [0.033]	0.006 [0.033]
Use of a loan	0.06 [0.010]***	0.062 [0.010]***	0.062 [0.010]***	0.063 [0.010]***	0.062 [0.010]***	0.061 [0.010]***
Observations	7901	7897	7920	7754	7920	7736
R-squared	0.15	0.15	0.15	0.15	0.15	0.15
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%.

Note: Logit regressions with dependent variable being response to question: Have you acquired a new production technology?*Source:* Authors' Calculations, BEEPS 2002, 2005.

with technology upgrading, as measured by this composite dependent variable. The statistical significance holds at the 1 percent level for all positive relationships, even in the most complete specifications.

Another empirical regularity that merits comment is the robustly positive relationship that exists between measures of human capital at the firm level and technology absorption. We incorporate three variables to measure human capital: a dummy variable indicating the existence of an in-house training program; a ratio of the number of professionals to total employees; and a ratio of the number of university graduates to total employees. The inherent ambiguity of the definition of a “professional,” and imperfect information on the part of the survey respondent concerning the educational attainment of employees, likely leads to significant measurement error in the latter two variables. Nevertheless, in nearly all regressions, the estimated coefficients for at least two of these three variables are positive and statistically significant. The results for training suggest particularly strong relationships between this variable and our outcome measures. Evaluated at the mean of the data, the coefficients for training imply that the existence of a program raises the probability of technology absorption by 40 percent or more.

The regression analysis also controls for the impact of information and communication technology (ICT) and quality standards on technology absorption. ICT is considered the preeminent “general purpose technology” of the past 20 years, as it has driven economy wide growth over a range of sectors by prompting them to innovate and upgrade further, with technological progress in these sectors in turn creating incentives for further advances in the ICT sector, thus setting up a positive, self-sustained virtuous cycle (Bresnahan and Trajtenberg 1995; Helpman and Trajtenberg 1996). Similarly, there is strong evidence across a range of sectors that the adoption of industry standards and technical regulations are among the most important forms of introducing product and process technology upgrades and increasing productivity for firms (Corbett, Montes-Sancho, and Kirsch 2005). Standards thus play a particularly central role in diffusing knowledge in those industries where products and processes supplied by various providers must interact with one another.

The regression results show that both Internet use and ISO certification are positively and significantly related at the 1 percent level to all the measures of technology absorption. Depending on its international connectedness, a firm in ECA that uses the Internet is between 9.8 percent and 10.5 percent more likely to have upgraded a product or process, and between 5.8 percent and 6.6 percent more likely to have introduced a new product. The coefficients for ISO certification suggest that a firm that is ISO certified is between 11.9 percent and 14.6 percent more likely to have undertaken the upgrading of a product or process, and the probability of it having introduced a new product is between 12.9 percent and 15.8 percent higher. Further, a firm that uses the Internet is between 6.8 percent and 7.3 percent more likely to have purchased new technology in the last three years, while an ISO-certified firm is between 13.3 percent and 14.5 percent more likely to have done so than a firm that isn’t certified. Finally, the likelihood of a firm in ECA having upgraded its technology, as measured by this composite dependent variable, increases by between 30 percent and 34 percent if the firm uses the Internet. Appendix D analyzes the determinants of ISO certification and Internet use by firms in ECA countries using the 2002 and 2005 World Bank BEEPS. We outline a framework that highlights three types of

Dependent Variable: Composite Measure “Upgrade”						
Exporter dummy	0.252 [0.038]***					0.186 [0.038]***
Exports as a percentage of sales		0.002 [0.001]***				
Majority foreign owned			-0.084 [0.048]*			-0.129 [0.048]***
Percentage sales to MNCs				0.004 [0.001]***		0.003 [0.001]***
Joint ventures with MNCs					1.137 [0.062]***	1.099 [0.064]***
Size	0.091 [0.021]***	0.099 [0.021]***	0.105 [0.021]***	0.091 [0.021]***	0.083 [0.021]***	0.065 [0.021]***
Age	-0.003 [0.001]***	-0.002 [0.001]**	-0.002 [0.001]**	-0.002 [0.001]**	-0.002 [0.001]**	-0.002 [0.001]***
State ownership	-0.188 [0.058]***	-0.194 [0.058]***	-0.195 [0.058]***	-0.167 [0.059]***	-0.177 [0.057]***	-0.154 [0.058]***
R&D expenditures	0.15 [0.011]***	0.158 [0.011]***	0.16 [0.011]***	0.16 [0.011]***	0.15 [0.011]***	0.143 [0.011]***
Foreign ownership	-0.001 [0.001]**	-0.001 [0.001]*		-0.001 [0.001]	-0.001 [0.001]*	
Web use	0.32 [0.032]***	0.338 [0.032]***	0.344 [0.032]***	0.338 [0.032]***	0.316 [0.031]***	0.301 [0.032]***
Training	0.46 [0.029]***	0.468 [0.029]***	0.472 [0.029]***	0.469 [0.030]***	0.441 [0.029]***	0.431 [0.029]***
Skilled workforce	0.003 [0.001]***	0.004 [0.001]***	0.004 [0.001]***	0.004 [0.001]***	0.003 [0.001]***	0.003 [0.001]***
University graduates	0.001 [0.001]*	0.001 [0.001]**	0.001 [0.001]**	0.001 [0.001]**	0.001 [0.001]*	0.001 [0.001]
Infrastructure index	-0.016 [0.030]	-0.016 [0.030]	-0.016 [0.030]	-0.021 [0.031]	-0.03 [0.030]	-0.035 [0.030]
Governance index	0.381 [0.089]***	0.391 [0.089]***	0.393 [0.089]***	0.41 [0.090]***	0.392 [0.087]***	0.396 [0.088]***
Use of a loan	0.246 [0.028]***	0.256 [0.028]***	0.255 [0.027]***	0.256 [0.028]***	0.245 [0.027]***	0.24 [0.027]***
Observations	7901	7897	7920	7754	7920	7736
R-squared	0.26	0.25	0.25	0.26	0.28	0.29
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%.

Note: The dependent variable “upgrade” is the sum of firm responses to questions on: 1) introduction of a new product or process, 2) upgrading of existing product or process, 3) achievement of new quality certification, and 4) new technology licensing agreement. We ran an ordered logit regression for the same specification and got the same results qualitatively confirming the robustness of the relationship.

Source: Authors’ Calculations, BEEPS 2002, 2005.

factors—input markets, market incentives, and access to international knowledge—that may be associated with ISO certification and Internet use.³²

We also incorporate measures of infrastructure and institutional quality into our regressions in Tables 3.3 to 3.6. While we think it is important to incorporate these variables as controls, it is difficult to come to general conclusions regarding the estimated coefficients on these variables. Access to finance, which is proxied by a firm's use of a loan,³³ has a strong positive and statistically significant relation to the technology absorption variables. This would seem intuitive, since financially constrained firms would find it harder to invest in technology upgrading processes and methods.³⁴ The governance index that is a combination of measures of corruption, trust in the legal system and institutional regime, has a positive effect on new product innovations and upgrades, as well as on the composite upgrade variable. It does not, however, have an effect on the introduction of a new technology. The infrastructure index that captures the quality of the communications network is only positively associated with the introduction of a new product. This would seem to suggest that some of the impact of this variable may, in fact, be already captured by one of the other control variables.

More generally, we view the robustness of these results as encouraging. The consistency in the pattern of results that we observe across these four sets of regressions suggests that the underlying economic relationships are real. But are they causal in nature? Within the confines of these data, it is difficult to address this question definitively.³⁵ Nevertheless, we can exploit the panel structure of our data to obtain some degree of clarity around these

32. Specifically, we find that firms that have the appropriate *complementary inputs*, namely managerial capacity, higher shares of skilled labor, access to finance (and to a lesser extent access to good infrastructure), and *access to international knowledge*, either from foreign investors or by exporting, *are more likely to be ISO certified and use the Internet*. Our results suggest that the relationship between market incentives and Internet use or ISO certification is more nuanced. While pressures from consumers generate demand for ECA firms to upgrade their technology, pressures from competitors do not, which may seem counterintuitive in a developed economy setting, but is consistent with previous literature that argues that most firms in ECA face very substantial resource constraints (particularly financial resources), and thus only those with rents are able to finance activities related to knowledge absorption. Accordingly, we find that large and medium-sized firms are significantly more likely to be ISO certified, and particularly, to use the Internet. Our findings also suggest that privatized firms exhibit better ISO certification and Internet use only when there is a clear private owner with a profit incentive, who is empowered to make changes. Together with the above-mentioned finding that in environments with severe credit constraints the firms with substantial rents are more likely to absorb knowledge, this underscores the importance of improving market *incentives in conjunction with efforts to improve access to knowledge and to critical complementary inputs*.

33. The use of a loan is a dummy = 1 if the firm has a loan.

34. We also estimated the equation with access to finance being proxied for by “the perception of firms that feel access to finance was a major obstacle.” Using this variable, however, produced counterintuitive results, with firms that expressed a greater difficulty in accessing financial services showing a greater probability of absorbing new technologies and introducing new products.

35. The unavailability of a reliable IV made it difficult to implement the instrumental variables approach to deal with the issue of endogeneity. Attempts were made in the direction, but were unsuccessful. We experimented with the location of firms as an exogenous and predetermined indicator of international connectedness, reasoning that the locations of firms in business prior to the transition were not determined by market forces. On the other hand, firms more proximate to Western markets might be more likely to establish relatively higher degrees of international connectedness. These attempts did not yield informative results.

issues. Table 3.7 presents the results of a panel regression in which we present results based on the roughly 1,700 firms that were surveyed in BEEPS in both 2002 and 2005.

We run a fixed-effects regression on these data. A natural concern in this context is that firms with “better” management will seek both international connectedness and technology

Dependent Variable: Composite Measure “Upgrade”					
Exporter dummy	0.388 [0.115]***				0.274 [0.120]**
Exports as a percentage of sales		0.004 [0.002]*			
Percentage sales to MNCs			0 [0.003]		-0.001 [0.003]
Joint ventures with MNCs				0.392 [0.130]***	0.372 [0.137]***
Size	0.156 [0.068]**	0.164 [0.068]**	0.17 [0.072]**	0.173 [0.068]**	0.158 [0.071]**
Age	-0.001 [0.007]	-0.001 [0.007]	0 [0.007]	-0.001 [0.006]	-0.001 [0.007]
State ownership	-0.618 [0.244]**	-0.596 [0.243]**	-0.518 [0.252]**	-0.6 [0.244]**	-0.52 [0.250]**
Foreign ownership	-0.002 [0.002]	-0.001 [0.002]	-0.002 [0.002]	-0.002 [0.002]	
Web use	0.108 [0.084]	0.129 [0.085]	0.118 [0.086]	0.1 [0.084]	0.121 [0.086]
Training	0.253 [0.070]***	0.26 [0.070]***	0.263 [0.071]***	0.257 [0.070]***	0.277 [0.071]***
Skilled workforce	0.001 [0.002]	0.001 [0.002]	0.001 [0.002]	0.001 [0.002]	0 [0.002]
Infrastructure index	0.146 [0.138]	0.136 [0.138]	0.083 [0.141]	0.138 [0.138]	0.113 [0.140]
Governance index	0.125 [0.185]	0.126 [0.185]	0.073 [0.187]	0.115 [0.185]	0.025 [0.187]
Use of a loan	0.112 [0.080]	0.091 [0.081]	0.094 [0.081]	0.096 [0.080]	0.113 [0.082]
Observations	2366	2355	2308	2377	2296
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
R-squared	0.04	0.03	0.03	0.04	0.04

Standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Notes: Linear regressions based on “composite” measure of absorption, as above. Dependent variable is the sum of firm responses to four questions: 1) Have you introduced a new product or process?

2) Have you upgraded an existing product or process? 3) Have you acquired a new quality certification?

4) Have you entered into a new product or technology licensing agreement?

Source: Authors’ Calculations, BEEPS 2002, 2005.

absorption, and that the positive associations in the cross-section merely reflect the mutual impact of superior management on both of these variables. By running a fixed-effects regression, we effectively extract the impact of all firm-specific variables that do not vary over time. One might logically think that superior management would be exactly this kind of variable, assuming that the management did not change in the firm over the period analyzed. The cost of this fixed-effects approach is that the cross-sectional dimension of variance is largely extracted from the data; one is left with inference based on changes within firms over time. If variables are measured with error, the fixed-effects approach can significantly worsen the measurement bias, leading to an attenuation of measured effects (Hausman and Griliches 1986). Measurement error is likely to be particularly severe in data sets like ours. In addition, two key variables—the level of R&D spending reported by the firm, and the fraction of employees who are university graduates—are not available in the earlier survey year. We are thus not able to estimate coefficients for these variables. Nevertheless, we proceed to regress our composite measure of technology upgrading on our five measures of international connectedness, using a linear fixed-effects approach.

Larger firms continue to be more likely to absorb new technologies. The coefficient on the dummy variable indicating majority foreign ownership could not be estimated, because almost no firms in our sample changed their majority foreign ownership status between the 2002 and 2005 sample years. As a consequence, we omit this variable from consideration. However, the coefficients on our export and multinational JV dummies continue to indicate economically and statistically significant associations between these measures of connection to the global economy and to technology absorption. The coefficients on the fraction of sales going to multinationals are no longer significant at conventional levels. In this fixed-effects context, our coefficient estimates are driven entirely by firms that *change* their exporting status (or multinational JV status) over time. Firms that move from non-exporting to exporting, achieve an expansion in our composite technology upgrading measure of 39 percent. Firms that move from no JV to a multinational JV achieve gains of nearly 39 percent. While we cannot rule out other interpretations, these results lend themselves much more readily to a causal, or at least a partly causal, interpretation. The training coefficient is also positive and statistically significant at conventional levels. The coefficient implies that the transition from no training to a training program increases technology absorption by 25 percent to 28 percent.

Discussion of Results with Implications for Policy

Exporting Leads to Technological Improvements among ECA Firms

We believe that these results are useful, in part, because of the light that they cast on the debate over the existence of a “learning-by-exporting” effect. A long, well-cited series of case studies has documented the importance of the process by which firms in East Asia learned to improve their manufactured products and manufacturing processes through their efforts to export to more advanced foreign markets (Pack and Westphal 1986). However, most attempts to identify positive TFP growth effects from learning by exporting in firm-level or plant-level data, have rejected the hypothesis that a transition of firms into

exporting is associated with an increase in TFP growth. Researchers have effectively concluded that learning-by-exporting effects do not exist (Bernard and Jensen 1997; Clerides, Lach, and Tybout 1996). In an ECA context, Commander and Svejnar (2007) have suggested that, controlling for foreign ownership, there is no independent effect of exporting on firm productivity.

Our results suggest a different conclusion, and one that may apply far beyond the ECA context. In our panel data, *transition* to exporting is positively and significantly correlated with *increases* in measured technology upgrading. We find this to be true even when we control for foreign ownership, human capital, and environmental factors affecting export climate. This is consistent with the hypothesis that exposure to foreign markets fosters learning, and our results suggest that this learning effect is not limited to foreign-owned firms. It is, of course, not inconsistent with the view that firms, as they seek to transition to exporting, will invest in upgrading their technology to make themselves more competitive in foreign markets. In other words, technology upgrading could also increase exports—but, to the extent that the technology upgrading was motivated in the first instance by the desire to compete in a foreign market, it still reinforces the policy implications we stress.

This finding could be reconciled with the absence of TFP growth effects in a number of ways. First, it is likely that the implementation of the learning obtained through export experience does not come for free—upgrading products and processes requires expenditures on foreign technology licenses, consultants, worker training, and new capital goods. Second, active competition with other new entrants (from the same developing country) into the first world export market could limit the ability of any one producer to appropriate the gains from learning by exporting. It would clearly be in the interests of the downstream customers of these suppliers to encourage such competition. In the absence of firm-specific output prices and cost measures, this increased competitive intensity could, as we argued earlier, squeeze measured TFP effects to something close to zero. Third, part of the gains from successful entry into foreign markets could accrue not to the firms, but to the (initially) small number of talented managers within the local managerial labor markets capable of managing world-class production operations. Regardless of which of these theories, if any, is correct, the essential policy implication is the same. This strengthens the case for further movement toward an open trade regime and to the elimination of policies that penalize or undermine exporters. ECA governments seeking to promote technology absorption should eliminate export disincentives and pursue a policy regime that provides appropriate support for export activity.

FDI's Contribution to Technological Development of Local Firms

The positive relationships between local firms and multinationals, and our measures of technology absorption, suggest that vertical FDI does promote learning by local firms, and it identifies some explicit channels through which the learning occurs. ECA governments seeking to encourage technology absorption should continue to open themselves to FDI, and should critically examine informal barriers to foreign firm expansion that might impede this channel of technology diffusion.

Reduction of the remaining barriers to FDI in ECA could increase FDI and, given the positive association of absorption and FDI, facilitate absorption. For example, Russia fares

worse than other countries in the region, attracting one of the lowest levels of FDI inflows. Related World Bank-supported research has pointed to key shortcomings in the Russian business environment. Many of these shortcomings are a function of government policies that limit FDI inflows and foreign firm operations, especially in the service sector (Desai and Goldberg 2008). The reduction in barriers to FDI in service sectors would allow all multinationals to obtain greater post-tax benefits on their investments, encouraging them to increase FDI to supply the Russian market. This, in turn, would lead to an increase in technology absorption, as implied by the positive association of FDI and absorption.

Removing barriers to trade in services in a particular sector is likely to lead to lower prices, improved quality, and greater variety. Efficient services would be vital intermediate inputs into the productive sector, and the telecom sector would be particularly crucial to the diffusion of knowledge. Technology transfer accompanying this service liberalization—either embodied in foreign direct investment, or disembodied, would have a stronger effect on growth.³⁶ Among the key restrictions on foreign service providers in Russia, for example, are the monopoly of Rostelecom on fixed-line telephone service, the prohibition of affiliate branches of foreign banks, and the restricted quota on the share of multinationals in the insurance sector. The case of Russian accession to the World Trade Organization provides substantial and robust evidence that various measures of regulation in the product market, particularly entry barriers, are negatively related to investment. The implications of our analyses are clear: regulatory reforms, especially those that liberalize entry, are very likely to spur investment (Jensen, Shepotylo, and Tarr 2007; Alesina and others 2005).

Another example of the remaining reform agenda in ECA is Kazakhstan, which has done more to lower its tariffs on goods than it has to liberalize its barriers to FDI in the service sectors (Jensen and Tarr 2007). In telecommunications, there is strong restriction on entry in some areas of service; incumbent operators have excessively long exclusivity rights in areas such as long-distance and international telephone services, and with respect to interconnection for mobile operators; foreign ownership of a company cannot exceed 49 percent; and competition is limited due to cross-ownership among the incumbents. The costs of long-distance telephone services and broadband Internet access are three to six times the costs of comparator countries such as Russia, selected EU countries, and Australia. In banking, up to the end of 2005, branches of foreign banks were prohibited, and banks with foreign participation were limited to a maximum of 50 percent of the aggregate authorized capital of the sector. In transportation services, railroad tariffs differentiate among import, export, and domestic freight destinations. Existing railroad service is quite slow, contributing to very long delivery times for external trade. In air transportation services, domestic route licensing is rather restrictive. These factors, in turn, would explain why Kazakhstan ranks low in the Logistics Performance Index.

36. Mattoo (2005) argues that since many services are inputs into production, the inefficient supply of such services acts as a tax on production, and prevents the realization of significant gains in productivity. As countries reduce tariffs and other barriers to trade, effective rates of protection for manufacturing industries may become negative if they continue to be confronted with input prices that are higher than they would be if services markets were competitive, making it imperative to have policies to liberalize trade in services and attract FDI in key service sectors like telecommunications and financial services.

Although technology is making it easier to trade in services, often FDI plays a vital role in selling services (Eschenbach and Hoekman 2005). Given the lack of a service sector under central planning, FDI can be expected to play a particularly important role, more so than in countries where incumbent competition confronts foreign providers. Overall, services account for some 62 percent of the stock of FDI in 12 selected ECA countries, with finance, transport, communications, and distribution services accounting for the largest share of this FDI. While the share of the service sector in GDP, employment, output per worker, trade, and FDI in Central and Eastern European countries shows substantial convergence toward that of Western European countries, it also shows a distinct difference between Central European/Baltic states and Central Asian and CIS economies. Reforms in policies regarding financial and infrastructure services, including telecommunications, power, and transport, are highly correlated with inward FDI (Eschenbach and Hoekman 2005).

Firm-level investments in human capital and the skill level of the workforce are strongly associated with technology absorption. In every regression, the presence of a worker training program was strongly associated with technology absorption, and measures of the skill level of the labor force often had significant effects on absorption. In the panel regressions, the introduction of a training program is positively associated with increases in technology absorption. The Serbia case studies, discussed in the next chapter, also highlight the importance of worker training in cases of successful technology absorption.

The relationship between training and skills on the one hand, and successful technology absorption on the other, is complex, with causality almost surely running in both directions. Training and knowledge absorption are complementary, in the sense that a firm's capacity to absorb new knowledge, and to benefit from absorption, depends on the skills and training of the workforce. Higher levels of training and skills typically lead to a firm identifying new technologies that need to be mastered in order to increase competitiveness. Yet the decision of the firm to acquire a certain technical competency often necessitates training and changes in the skill composition of the workforce. For example, training in Russian enterprises is also highly correlated with indicators of innovativeness—such as R&D or licensing of patents and know-how, introduction of new production technologies, and high technology exports (Tan and others 2007).

These findings have implications for both firm strategy and public policy in the ECA region. While all countries struggle to align the output of their formal public educational systems with the changing needs of their industries, the challenge has been particularly acute in the ECA region. The legacy of socialism included a number of significant educational achievements, but many features of the pre-reform system were not well-suited to the needs of an open, competitive economy. Despite the substantial progress that has occurred since transition, more work remains to be done. Again, in Russia, in spite of the high and rising demand for educated and skilled workers, there exist skills shortages in enterprises. The reasons for this shortage include an educational and training system that is under funded below the tertiary level and that faces numerous challenges; an industrial sector with high labor turnover (which inhibits training); and the inability of some non-competitive firms to pay competitive wages to attract and retain needed skills.

The issue of worker training also deserves consideration. In an economic environment with labor mobility, firms may be reluctant to invest in the skills of workers who might simply leave the firm and take those skills to a rival for slightly more pay. This is especially

the case when firms face financial or other constraints that may limit their ability to engage in other necessary investments. While full consideration of this issue would take us beyond the scope of this study, one may be able to make a case for public-private co-investment in worker training. In essence, governments subsidize worker training in firms, but firms will always bear part of the cost themselves, ensuring that government resources are generally directed to training programs that bring real benefits. With a view to remedy this under-investment in training, Tan and others (2007), suggest that the Russian government should consider putting in place employer-targeted training policies. ECA countries can learn from drawing on the experiences³⁷ of many other countries, both industrial and developing, that have used payroll-levy training funds, tax incentives for employer-sponsored training, and matching grants. They suggest that policies should be designed to increase competition in training provision from all providers, both public and private, including the employer. Further, they also cite the use of matching grants, which can help to develop a training culture. The most successful schemes are demand driven, implemented by the private sector, and intended to sustain the markets for training services. With a view to generate training capacity in enterprises and increase the propensity for workers to undertake training, grants in ECA should aim at strengthening and diversifying the supply of training and stimulating demand.

The cost is only one barrier to effective worker training. Indigenous firms behind the technology frontier are often not knowledgeable about the kinds of training programs that could effectively equip their workers to manage new technology in an efficient manner. The Serbia case studies describe intensive training efforts conducted by foreign owners to bring the acquired firms to the technical frontier. In some cases, this included bringing assembly line workers and a shop foreman into established plants in other countries, so that front-line workers could receive direct advice and instruction from their peers in the parent company. Training manuals and training procedures used in contexts like this can often be considered strategic assets of a foreign firm; there may be a natural reluctance to share such knowledge with unaffiliated indigenous firms.

Yet, there are other circumstances in which such knowledge sharing may be in the mutual interest of local and foreign firms. As documented in East Asia, foreign buyers are often willing to share detailed technical knowledge with local suppliers, enhancing the worker training process. Foreign manufacturing firms located in ECA have strong incentives to ensure that direct and indirect suppliers meet quality and efficiency standards, and there will be incentives for knowledge sharing in those contexts as well. ECA governments and firms should make the most of the opportunities that this confluence of interests creates. And, of course, this line of thinking again underscores how important it is for the region's countries to continue to embrace trade and FDI openness.

37. Such as those cited with regard to training levies in Middleton, Ziderman, and Adams (1993) and Gill, Fluitman, and Dar (2000).

