

Introduction

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A key driver of economic growth and industrial development is a country's absorptive capacity, or ability to tap into the world technology pool. Trade flows, foreign direct investment (FDI), and labor mobility and training are among the best conduits for knowledge absorption. But such transfers are not automatic. They also require a favorable investment climate, an educated workforce, and, not infrequently, some research and development (R&D) on the part of the absorbing country. This study provides an analysis of the extent of knowledge and technology absorption by firms in Europe and Central Asia (ECA), based on the statistical analyses of various data sources, including World Bank Enterprise Surveys and the patent databases maintained by the United States and European patent offices, as well as original case studies.

Definition of Innovation and Knowledge Absorption

As a point of departure, we refer to the ideas in Cohen and Levinthal (1989, 1990), and Griffith, Redding, and Van Reenen (2004), which shape the following definition of absorptive capacity at the firm level:

A firm's capacity to assess the value of external knowledge and technology, and to make the necessary investments and organizational changes to absorb and apply this in its productive activities.

Absorption is therefore a costly learning activity that a firm can employ to integrate and commercialize knowledge and technology that is new to the firm, but not new to the world. The development of new-to-the-world knowledge can be considered innovation.

In other words, innovation shifts a notional technological frontier outward, while absorption moves a firm closer to the frontier. Examples of absorption include: adopting new products and manufacturing processes developed elsewhere, upgrading old products and processes, licensing technology, improving organizational efficiency, achieving quality certification, etc.

This study is a follow up to *Public Financial Support of Commercial Innovation* (ECAKE I), which focused on innovation. As indicated in ECAKE I, this followup study provides a more detailed analysis of the complementarities between innovation and absorption, with a focus on absorption. As will be shown in the following chapters, based on the literature (Cohen and Levinthal) and from our empirical findings, R&D, which is a key input into innovation, is also an input into absorption. Indeed, there are important complementarities between innovation and absorptive capacity. Innovation promotes absorptive capacity because the generation of human capital and new ideas, and the associated knowledge spillover effects, help build absorptive capacity. Conversely, the absorption of cutting-edge technology inspires new ideas and innovations.

While recognizing the general importance of policies that would improve the absorptive capacity of firms in ECA, this study's point of departure is that policies need to be designed according to the level of development of countries, and specifically, depending on whether these policies are meant for advanced reformers or for less advanced ones. Consistent with this view, the study, *Productivity Growth, Job Creation, and Demographic Change in Eastern Europe and the Former Soviet Union* (World Bank 2007b), points out that late reformers will need to continue focusing on facilitating the restructuring and the entry and exit of firms, improving access to credit, and accelerating the "behind the border" reform agenda, in order to benefit from trade openness. The emphasis is somewhat different for advanced reformers, which need to focus on how knowledge and private sector-led innovation and R&D can be harnessed to sustain productivity growth within the firm, which is the focus of this study.

Diffusion of Knowledge in Support of Productivity Growth: Literature Review

Ever since the path-breaking research of Robert Solow (1956), economists have known that secular growth is closely connected to technological change, in addition to factor accumulation. A vast array of empirical research during the last half century has shown conclusively that a substantial share of growth in income per capita is associated with the growth of total factor productivity (TFP). Attaching the label of technological change to Solow's famous "residual" (TFP growth), begs the question of what technological change contains exactly, and perhaps, more importantly, how it evolves over time, as well as the nature of the economic forces that determine its course and pace.

One of the challenging aspects for economists who first considered these matters was that the growth of TFP appeared as an impenetrable "black box" that operated outside the realm of economic forces. A long and very fruitful research agenda pioneered by Arrow, Abramovitz, Griliches, Jorgenson, Denison, Rosenberg, and others, sought to open this black box, and to explain the economic drivers of technological change. With the development of the endogenous growth theory in the late 1980s and 1990s (Romer 1986, 1990;

Lucas 1988; Grossman and Helpman 1991; Aghion and Howitt 1995), the economic profession as a whole came to accept the view that innovation, knowledge spillovers, and R&D were indeed key factors driving self-sustained, long-term economic growth. It also became widely accepted that these activities were generated from within the economic system, which was responding to economic incentives.⁶

It is fair to say that the early contributions and endogenous growth literature were, to a large extent, focused on *new-to-the-world* activities. Meanwhile, a separate stream of literature examined the processes of diffusion and absorption of new technologies. This literature owes much to the pioneering contribution by Griliches (1957) about the timing and location of technology adoption, and his paper was based on empirical research on the spread of new hybrid corn varieties in U.S. agricultural regions.

The two approaches have recently converged in the Schumpeterian growth theory, which has investigated the factors that determine the absorption of technology by firms that are behind the “technology frontier,” in contrast to the incentives behind radical innovations. An example is Aghion and other (2002), which examines the interplay between competition and innovation, and its impact on growth. For firms that are at similar technological levels (“neck-and-neck” industries), the Aghion model shows that competitive pressures will stimulate the incentives for firms to invest in R&D, with the aim of increasing their competitiveness; and the same reasoning would apply when managers face hard budget constraints. In contrast, when followers are far from the technology frontier, competitive pressures have a weak effect on the R&D incentives of technological leaders, who are so far ahead of the pack, and have no motivation to increase innovation activities. The prediction that absorption incentives are weak in “unleveled” industries—those in which followers are using obsolete machinery and equipment, unskilled workers, etc.—can be argued as applying to certain industries in transition countries, where foreign entrants are much more technologically advanced. Keller (2002) discusses how international technology diffusion relates to other factors affecting economic growth in open economies, and the importance of specific channels of diffusion, particularly trade and foreign direct investment.

In the innovation literature, it is well established that market failures restrict private investment in innovation, justifying public intervention. Several arguments can also be made in favor of government support for technology absorption. For example, Hausman and Rodrik (2003) reason that countries lagging behind the technology frontier will underinvest in technology absorption because of the shortcomings of their intellectual property regime. Unlike innovating companies, which are protected by patents, entrepreneurs who invest funds to discover which technology to adapt to a developing country context do not normally get any protection for the markets they open, no matter how high the associated social return may be.

Underlying the above discussion is the idea that uncertainty and imperfect information serve to obscure and impair the returns from technology absorption. Because of this shortage of information, firms attach such value to the second face of R&D (to paraphrase Cohen and Levinthal, 1989): this relates to the role of R&D in identifying, collecting, and

6. Work on education and technological change by Nelson and Phelps (1966) mentioned that technological progress was the key to growth and highlighted the difference (for growth) between human capital stock and accumulation. However, it was only in the late 1980s that those views were widely shared.

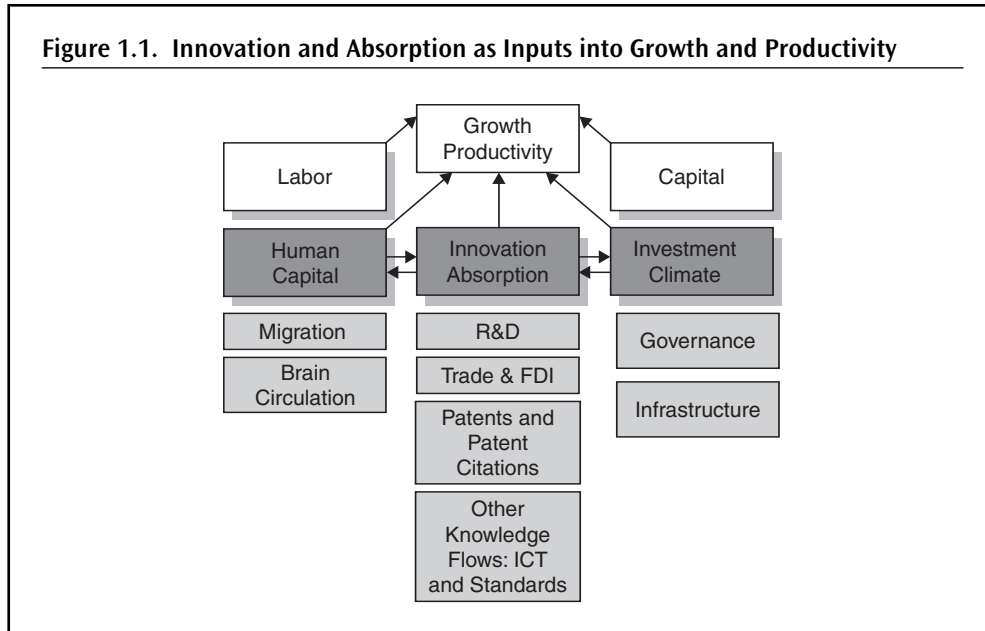
analyzing information regarding the feasibility of technological absorption, as well as support for its implementation. There is evidence from Griffith, Redding, and Van Reenen (2004)—based on a survey of industries across 12 OECD countries—which shows that R&D enhances technology transfer by improving the ability of firms to learn about advances on the technology frontier. Thus, R&D is important both in this catch-up process, as well as in directly stimulating innovation. It is important to mention standards for technical interoperability, quality control, etc., as they have been instrumental in enabling cross-country diffusion of technology.

Global Economic Prospects 2008 (World Bank 2008) argues that geography and history appear to be important determinants of technological achievements, and countries in ECA show significantly higher levels of technological achievements than do other countries at similar income levels. It shows that the technology gap between middle-income and high-income countries has narrowed over the past 10 years, and that evidence of catch-up is particularly strong in the Czech Republic, Hungary, and Poland, where the level of technological achievement increased by more than 70 percent during the 1990s. *Global Economic Prospects 2008* develops an aggregate measure of technological achievement using a statistical technique (principal components analysis) that combines some 20 separate indicators of technological achievement along three dimensions—scientific innovation and invention; penetration of older technologies; and penetration of newer technologies—plus an additional dimension, the extent to which countries are exposed to external technologies. Distribution of overall technological achievement across countries, and the change over the past decade, are examined to evaluate both the speed with which technological achievement in countries is advancing, and the dimension along which the change is occurring.

Conceptual Framework: Economic Conditions and Capacities for Knowledge Absorption

In accordance with the literature reviewed above, the conceptual framework that molds our analysis assumes that innovation and the resultant absorption of productive knowledge and technology are central forces behind economic growth; these forces play just as important a role as the accumulation of human capital and physical capital. Key inputs and economic conditions enable and motivate innovation and absorption activities, and these are central to our endogenous production function approach (see Figure 1.1). Human capital availability and a favorable investment climate are two important prerequisites for firms to be able to innovate because it would be very costly to carry out and reap the benefits from innovation and absorption if these necessary conditions were not in place. Our analysis will use different methods to explore how such factors as human capital and investment climate variables, among others, shape absorption decisions at the firm level.

Trade, FDI, R&D, and knowledge flows are “channels of absorption,” by which we mean that they are central conduits for cutting-edge innovations and good practices that are to be diffused to other countries, and then to ultimately percolate into the private sector. Figure 1.1 describes the important channels of absorption at the country, as well as the firm, level. While in and out migrations of the workforce and brain circulation are important channels of innovation and absorption, they are beyond the scope of the analysis in this study. The channels, highlighted in the middle column of Figure 1.1, will constitute



the central focus of the study. Our analysis will primarily investigate how the presence of these channels (the fact that a given firm has received FDI, or invests a certain amount in R&D), affects absorption outcomes. As a secondary question, we will examine the firm-, industry- and country-level conditions that induce firms to activate these channels as part of their overall growth and sales strategies.

Just as the prerequisite conditions and capacities are impacted by governmental policies, so too can properly designed economic policies influence the channels of absorption and the specific decisions for firms to absorb technology. Technology absorption needs a stable and conducive policy framework, and a firm's ability to absorb this technology and knowledge depends on its inherent characteristics, such as resource base, R&D expenditure, and worker skills. Access to knowledge and technology is increasingly linked to FDI and trade. However, extracting benefits from these channels requires dynamic local firms and institutions. Firms' absorptive capacity is thus determined by (i) conditions internal to the firm, such as the presence of foreign investors, foreign trade, and skill endowments; and (ii) conditions external to the firm, such as the costs and incentive structure determined by the wider environment (notably the regulatory framework; openness to knowledge flows, trade and FDI policies; the quality, availability, and cost of infrastructure services; and the ease of access to finance). These aspects of the investment climate are being studied in ECA countries via Investment Climate Assessments (ICA) conducted by the World Bank; thus, in addition to our regional analysis, we rely on the ICAs to provide in-depth national assessments.