

Overview

This edition of *Global Economic Prospects* is being released during a period of increased uncertainty following four years of record growth in developing countries. In addition to examining economic prospects over the near and longer term, it takes an in-depth look at the current level of and recent trends in technological achievement and the main factors that determine the extent to which developing countries succeed in implementing foreign technologies.

Notwithstanding the financial turmoil provoked by a reassessment of risks in the U.S. mortgage market, and despite large losses in some financial markets, exposure to asset-backed securities appears to be broadly based. Losses so far have been manageable, although credit conditions have tightened. For developing economies, sovereign risk premiums have increased but remain low by historical standards. Equity values, exchange rates, and commodity prices have become more volatile, and the vulnerability of countries with large current account deficits or pegged exchange rates has become more visible.

Against this background, global growth slowed modestly in 2007, coming in at 3.6 percent after a strong 3.9 percent in 2006. Most of the slowdown was attributable to weaker growth in high-income countries. Growth in developing economies was a robust 7.4 percent, broadly unchanged from 2006 (figure 1). This strong performance in the developing countries has offset somewhat the slowdown in U.S. domestic demand that started with the unwinding of the housing bubble early in 2006. During 2007, developing

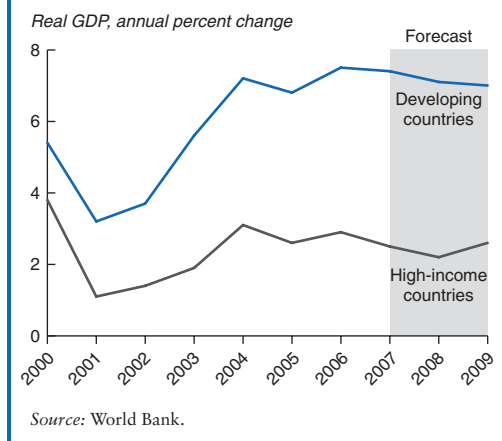
countries accounted for more than half the growth in world imports, contributing—along with the depreciation of the dollar—to strong net exports for the United States and furthering the reduction in global imbalances.

Global growth in 2008 should moderate to 3.3 percent, as the robust expansion in developing countries partly compensates for weaker results in high-income countries. World output should pick up in 2009, expanding by 3.6 percent, as the U.S. economy regains momentum.

Several serious downside risks cast a shadow over this soft landing for the global economy. External demand for the products of developing countries could weaken much more sharply and commodity prices could decline if the faltering U.S. housing market or further financial turmoil were to push the United States into a recession. Alternatively, monetary authorities might overreact to the current climate of uncertainty and overstimulate the economy. This would be particularly dangerous for developing countries if the bulk of the resulting liquidity were to move into rapidly growing developing regions, provoking the same kind of overinvestment conditions that arose in the U.S. housing market.

Prospects for the U.S. dollar represent an additional risk factor. A recession in the United States or an excessive easing of U.S. monetary policy could contribute to further sharp declines in the dollar. A weaker dollar would benefit developing countries with dollar debt, but impose losses on those that hold dollar-denominated assets. It would hurt the competitiveness of firms exporting to the United States

Figure 1 Robust growth among developing countries should cushion the developed country slowdown



(and those producing close substitutes for U.S. imports), while benefiting countries with currencies pegged to the dollar—at least temporarily. However, the main impact of a precipitous decline of the dollar would likely derive from the increased uncertainty and financial-market volatility it would provoke, which would increase trading costs, and spreads on developing-country debt—resulting in weaker export and investment growth throughout the global economy.

Even should such risks not materialize, several developing countries may be quite vulnerable to sudden adjustments in financial markets. Most exposed are those countries that combine large current account deficits with pegged exchange rates and with increasing domestic inflation. Also at risk are countries whose domestic banking sectors have balance sheets characterized by large currency mismatches.

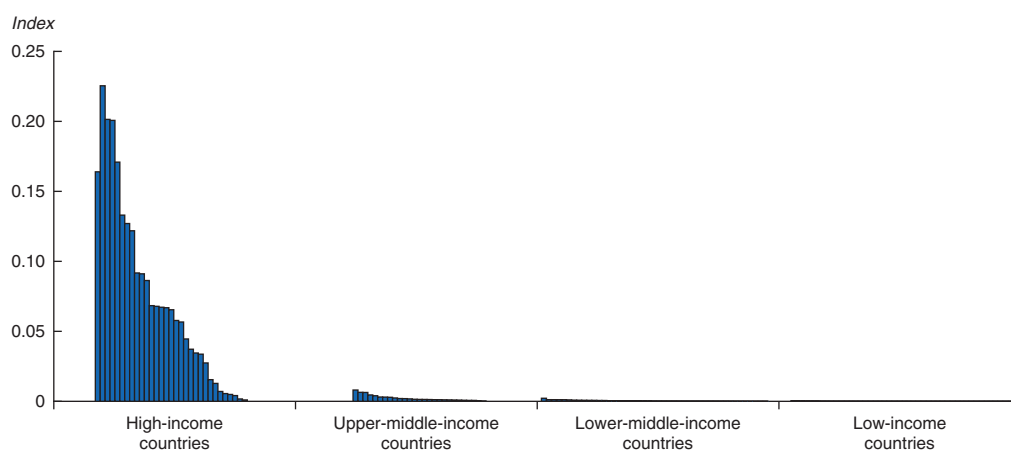
Technological achievement and diffusion in developing countries

The special topic of this edition of *Global Economic Prospects* is technology and its diffusion within the developing world. Much

of the economic and social progress of the past few centuries has been due to technology. Technology has been central to both economic growth and many elements of social welfare that are only partly captured by standard measures of gross domestic product (GDP), including health, education, and gender equality. As measured by total factor productivity, it explains much of the differences in both the level and rate of growth of incomes across countries (Easterly and Levine 2001; Hall and Jones 1999; King and Levine 1994). And, looking forward, it is expected to play a central role in meeting the environmental and climate-change challenges of the remainder of this century.

The private sector and the efficient functioning of markets are key to technological progress. At the same time, the efficient delivery of socially relevant technological goods and services depends on the direct contribution of nonmarket actors, including governments, nongovernmental organizations, and international organizations. Of course, policy also supports technological progress by facilitating the smooth operation of markets, by ensuring the acquisition of technological competencies by the general population, and by providing the physical infrastructure that is often a necessary complement to technologically sophisticated activities. Active measures to promote technology diffusion and strengthen the linkages between firms and research and development (R&D) agencies are also vital.

In exploring technological achievement and diffusion, this report adopts a broad definition of technology and technological progress, one that encompasses the techniques (including the way the production process is organized) by which goods and services are produced, marketed, and made available to the public. Understood in this way, technological progress at the national level can occur through scientific innovation and invention; through the adoption and adaptation of pre-existing, but new-to-the-market, technologies; and through the spread of technologies across firms, individuals, and the public sector within the country.

Figure 2 Scientific innovation and invention is almost exclusively a high-income activity

Source: World Bank.

The following discussion traces the structure of the overall report, which in chapter 2 explores the level of—and recent trends in—technological achievement, as well as the process by which technology diffuses between and within countries. Chapter 3 concentrates on the process by which countries absorb foreign technology, both the mechanisms through which they are exposed to foreign technologies and the domestic factors that dictate how successfully they absorb those technologies. Although the chapter identifies a number of important, policy-relevant trends, and it explores their policy implications, it leaves to future work a more normative analysis of the policies that developing countries should follow to maximize the development benefits of technological progress.

Policy needs to actively promote technological adoption and adaptation as well as nurturing domestic innovative capacity

A central finding of the report is that most developing countries lack the ability to generate innovations at the technological frontier. Although the number of patents and scientific journal articles is strongly correlated with GDP per capita for high-income countries,

almost none of this activity is being performed in developing countries (figure 2). The lack of advanced technological competencies in these countries means that technological progress in developing countries occurs through the adoption and adaptation of pre-existing but new-to-the-market or new-to-the-firm technologies. Moreover, relatively thin domestic technology sectors and much better economic and scientific opportunities abroad mean that many nationals of developing countries perform cutting-edge research in high-income countries. For example, 2.5 million of the 21.6 million scientists and engineers working in the United States were born in developing countries (Kannankutty and Burelli 2007).

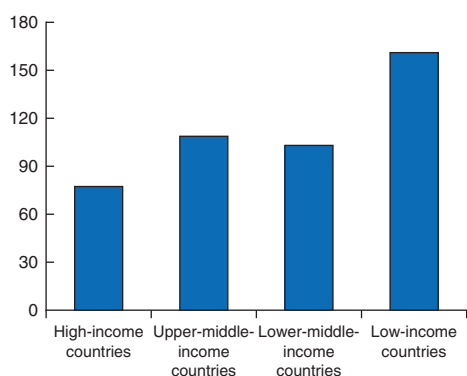
The level of technological achievement in developing countries has converged with that of high-income countries over the past 15 years

A sustained policy of increased openness to foreign trade and foreign direct investment (FDI), plus increased investments in human capital, have contributed to substantial improvements in technological achievement in developing countries over the past 15 years. And despite rapid progress at the technological frontier, technological achievement in both low- and

**Figure 3 Technological achievement:
Converging, but the gap remains large**

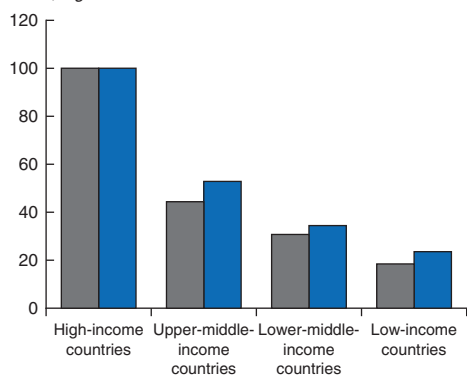
Rapid progress in developing countries...

Percent change in technological achievement, 2000s versus 1990s



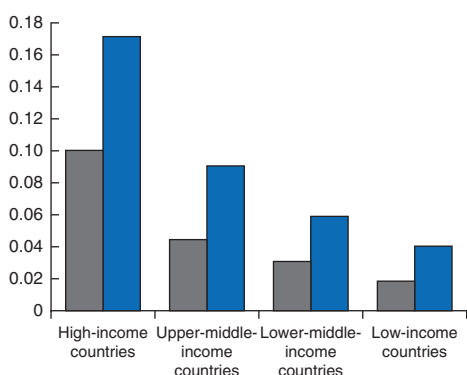
...fueled relative convergence...

Index, high-income countries = 100



...but the gap remains large

Technological achievement index



Source: World Bank.

middle-income countries has increased much more rapidly than in high-income countries. As a result, developing countries have closed the relative gap with high-income countries. However, the gap remains large (figure 3). Moreover, the strong aggregate performance of low-income countries reflects large improvements in technological achievement by some, but much more modest advances by the majority. As a consequence, many are only maintaining pace with, or even losing ground to, high-income countries.

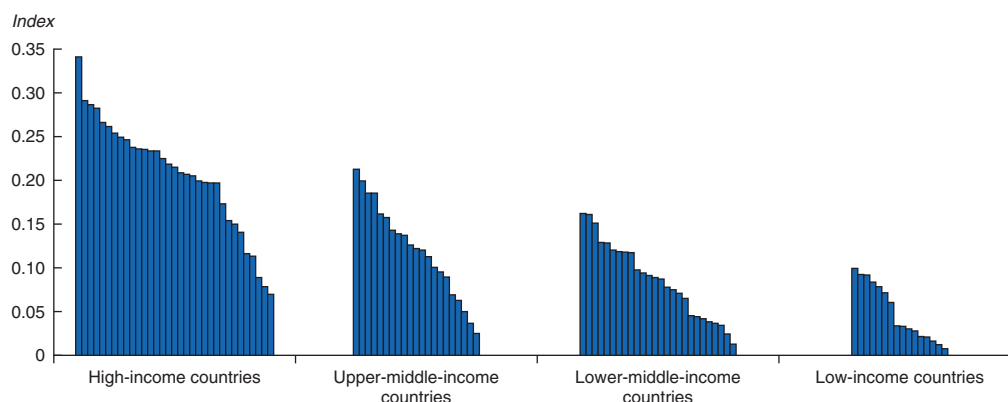
In general, the level of technological achievement observed in a country is positively correlated with income levels. However, considerable variation is apparent within income groups. Among other things, this variation reflects the nature of the technology being observed, the impact of the overall policy framework on the ability of technologically sophisticated firms to grow, and the extent to which governments have given priority to and had success in delivering services with a strong technology component.

The penetration of older technologies, such as fixed-line telephones, electrical power, transportation, and health care services—many of which were originally provided by governments—is only weakly correlated with income. The low-income countries with the highest utilization rates of these older technologies tend to have rates as high as those of the average lower-middle-income country (figure 4). Similarly, the lower-middle-income and upper-middle-income countries with the highest utilization rates tend to have rates that match the average rate of the next highest income group.

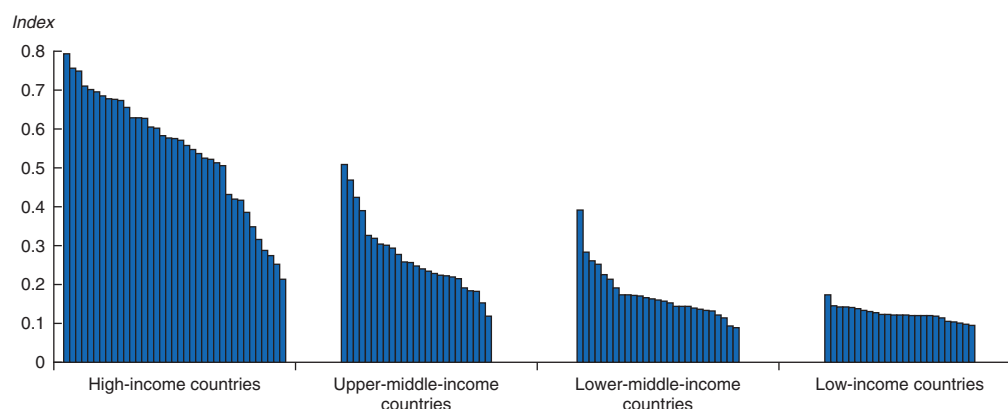
In part, this reflects the nature of the technologies in question, such as electrical networks, road infrastructure, fixed-line telephony, and sanitation networks. Many of these technologies require an infrastructure that is relatively expensive to create and maintain, and which relies on large numbers of individuals with scarce technical skills. In addition, the observed diffusion of older technologies today depends on the intensity and efficiency with which government services have

Figure 4 The penetration of older and more recent technologies depends on more than income

Penetration of older innovations (2000–03)



Penetration of newer innovations (2000–03)



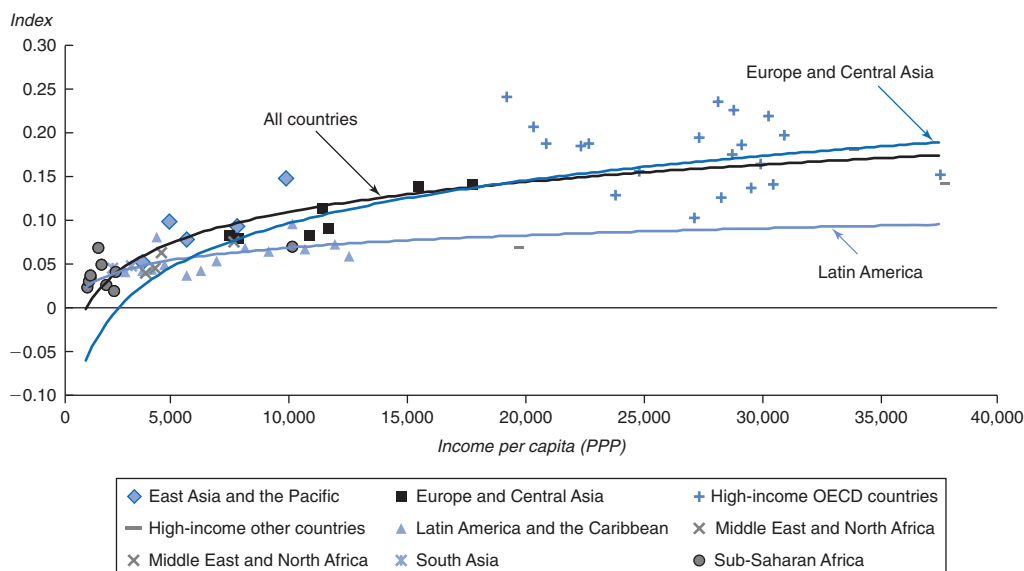
Source: World Bank.

been delivered in the past. Part of the strong technological showing of the countries in the former Soviet bloc is explained by the heavy emphasis that past governments placed on providing basic infrastructure and education to a wide range of the population. Similarly, past governance problems and civil strife help explain the relatively weak penetration of these technologies in many Sub-Saharan African countries, whereas macroeconomic turmoil and a relatively unequal distribution of incomes and skills in Latin America may have contributed to weak outcomes in that region.

The penetration rates of newer technologies have risen relatively rapidly and are more directly correlated with income than is the case for older technologies. The infrastructure for newer technologies such as mobile phones, computers, and the Internet is generally less expensive to create and requires fewer (though more skilled) workers to maintain. Moreover, in many countries, regulatory reform has meant that the private sector now offers these services in a competitive environment as compared with the state-owned, monopolistic environments of the past. As a result, supply of

Figure 5 Technological achievement tends to level off at different income levels in different regions

Technological achievement versus per capita income by region



Source: World Bank.

these new technologies has been more responsive to market demand and less restrained by the budget constraints of governments or state-owned-enterprises. Furthermore, demand for these products has been boosted by low end-user costs as a result of competitive pricing strategies and because some of these newer technologies lend themselves more easily to sharing than do some older technologies.

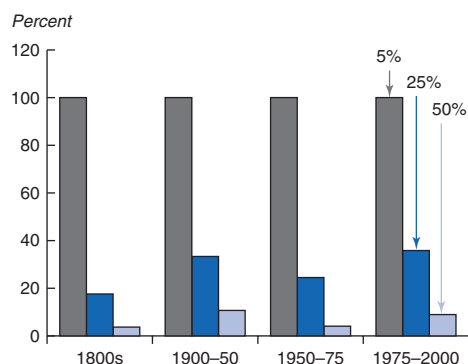
Overall, although technological achievement tends to rise with incomes, this relationship is nonlinear and shows a tendency to level off. Moreover, it is not uniform across regions. Thus countries in Europe and Central Asia tend to have somewhat higher levels of achievement than would be expected on the basis of income alone, but the overall relationship between technological achievement and income in the region tracks relatively well that of all countries (figure 5). In contrast, technological achievement in Latin America tends to be lower than what would be expected given incomes, and the overall relationship suggests

that other factors appear to be restraining achievement even as incomes progress. These results are consistent with the view that policy choices over the long term (such as those that generated the uneven distribution of income and educational opportunities in Latin America and the region's history of weak links between R&D communities and the business world) are important determinants of absorptive capacity and technological progress.

The level of technology in developing countries reflects the pace at which technology diffuses within countries

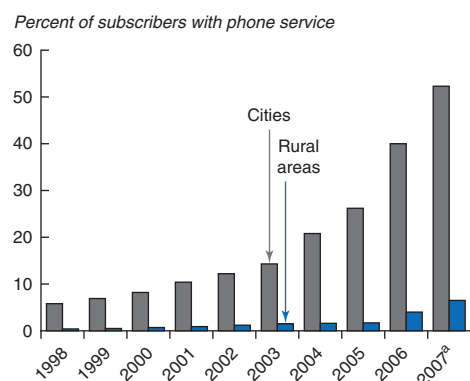
Although it can take time for a technology to gain a foothold in developing countries, the more serious impediment to technological achievement is the speed with which technologies spread within these countries. On average, the time it takes before official statistics in a developing country record significant exploitation of a new technology has declined from almost 100 years for innovations

Figure 6 Most technologies fail to penetrate deeply into developing economies



Source: World Bank calculations using data from Comin and Hobijn 2004.

Figure 7 The urban–rural gap in telephone access in India is huge



Source: Telecommunications Regulatory Authority of India.
a = estimated.

discovered in the 1800s to about 20 years today.¹ However, technological progress also depends on how rapidly the technology spreads within the country. Here the story is less encouraging. For technologies discovered during 1950–75, only a quarter of the developing countries that have achieved at least a 5 percent penetration level have gone on to reach the 25 percent threshold, and all of these are upper-middle-income countries (figure 6).

The story is somewhat better for newer technologies. Not only have these technologies spread more quickly between countries, but also the share of countries that have achieved the 25 percent threshold is higher, at 33 percent. Indeed, developing countries have now reached the same average level of penetration of mobile phones as was observed in high-income countries in 1995.

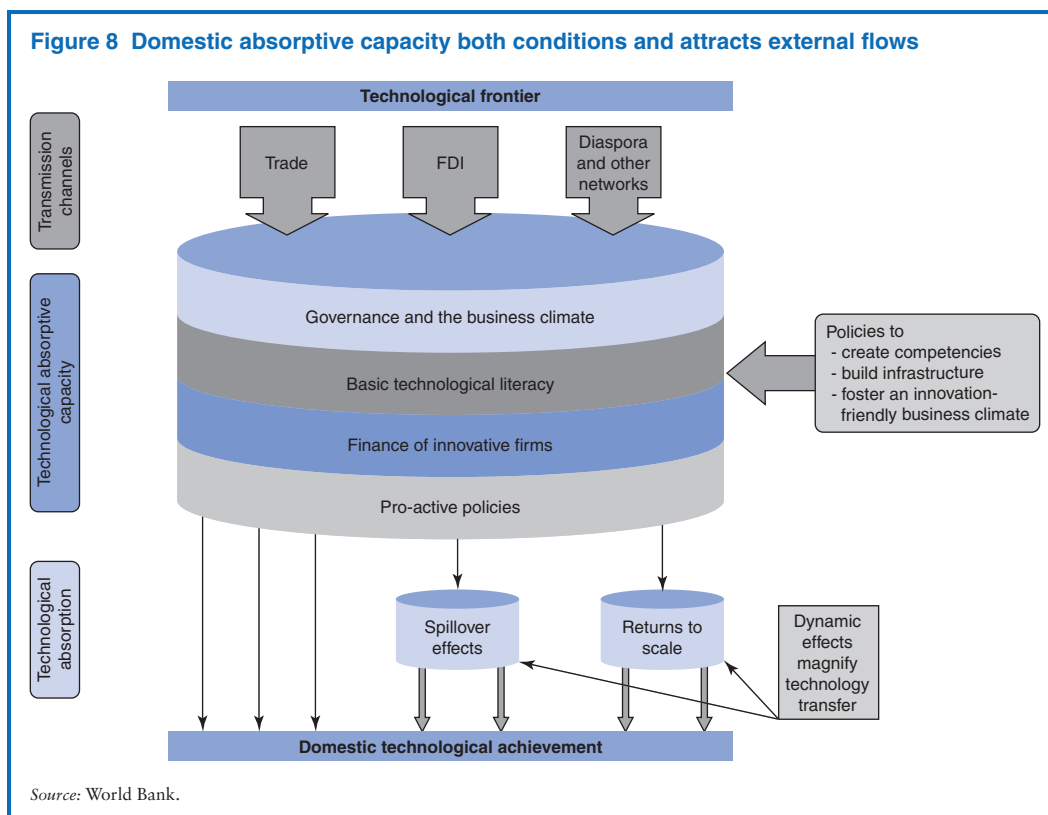
The unevenness of technological diffusion across countries is often mirrored within countries, especially large countries. Although technology spreads relatively rapidly among elites living in major cities, it takes much longer for it to find its way to the rest of the population or from top-performing companies to the average firm. Specific sectors in advanced urban centers in China and India, for

example, use world-class levels of technology, but the incidence of these technologies elsewhere in the country, and in rural areas in particular, remains low (figure 7). Even within sectors, technology may diffuse only slowly. In Brazil and India, for example, the most sophisticated firms use technologies and achieve levels of productivity that rival world leaders, but the vast majority of firms operate at levels of productivity that are less than one-fifth those of the top performers.

A framework for understanding the diffusion of technology within developing countries

The bulk of technological progress in developing countries has been achieved through the absorption and adaptation of preexisting and new-to-the-market or new-to-the-firm technologies, rather than the invention of entirely new technologies. Given the still wide technology gap, this is likely to remain the case for the vast majority of developing countries.

A developing country's ability to absorb and adopt foreign technologies depends on two main factors: the extent to which it is exposed to foreign technologies (the pace at

Figure 8 Domestic absorptive capacity both conditions and attracts external flows

which technologies diffuse across countries) and its ability to absorb and adapt those technologies to which it is exposed (the pace at which technology diffuses within the country). Figure 8 presents a stylized description of how a developing country absorbs technology. As a first step, an economy is exposed to higher-tech business processes, products, and services through foreign trade; foreign direct investment; and contacts with its diaspora and other communications channels, including academia and international organizations (the large arrows at the top of the figure). The larger these flows, the greater the exposure of the economy to the global technological frontier.

However, exposure to new ideas and techniques is not sufficient to ensure that the technology diffuses throughout the economy. Successful absorption of foreign technology

depends on the technological absorptive capacity of the economy (represented by the multiple-ringed drum). Absorptive capacity depends on the overall macroeconomic and governance environment, which influences the willingness of entrepreneurs to take risks on new and new-to-the-market technologies; and the level of basic technological literacy and advanced skills in the population, which determines a country's capacity to undertake the research necessary to understand, implement, and adapt them. In addition, because firms are the basic mechanism by which technology spreads within an economy's private sector, the extent to which financing for innovative firms is available—through the banking system, remittances, or government support schemes—also influence the extent to and speed with which technologies are absorbed.

Government policy also has a crucial role to play. Governments are often the primary channel through which certain technologies, such as electricity, fixed-line telephones, transportation infrastructure, and medical and educational services, are delivered. Moreover, government policy is largely responsible for creating a business environment that facilitates easy firm entry and exit and that is not hostile to the profits to be made from exploiting new technologies. Too often, rules and/or specific features of the domestic market prevent firms from making money by exploiting a new technology, and, as a result, the technology does not spread within the country. Policy should also ensure that R&D and dissemination efforts give priority to creating and introducing products for which a market (domestic or foreign) exists and to helping firms exploit those opportunities.

The overall process is, of course, much more complicated and much less mechanistic than is depicted in Figure 8. Technological flows and technological absorptive capacity influence each other. How well technology diffuses depends on various market imperfections, including increasing returns to scale and technological spillovers (the smaller light blue rings toward the bottom of the figure). Here the existence of a financial sector that intermediates between savers and innovators may be necessary to overcome the initial cost of some new technologies. In particular, access to finance may be essential if innovative firms are to achieve the necessary scale to unleash a potential virtuous circle, so that the additional income garnered by the successful exploitation of one new technology permits the acquisition of another, thus resulting in further gains.

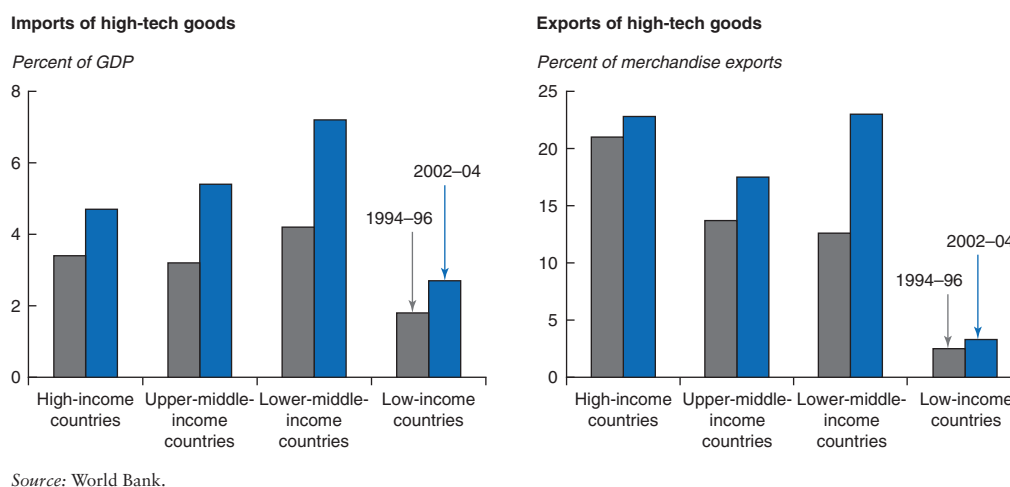
Increased openness to trade, FDI, and diaspora contacts have boosted technological diffusion

The dismantling of trade barriers in many developing countries over the past two decades has dramatically increased developing countries' exposure to foreign technologies. Their

imports of capital and intermediate goods (which permit the production of technologically sophisticated goods and services) now represent between 6 and 14 percent of their GDP, an increase of more than 80 percent since 1994. The ratio of high-tech imports to GDP more than doubled during the same period. Partly as a result, developing-country exports of high-tech goods have also increased, rising from 11 percent of total exports in the mid-1990s to 19 percent in 2002–04 (figure 9). In the case of lower-middle-income countries, high-tech goods represent broadly the same 23 percent share in total exports as in high-income countries (15 percent if China is excluded).

The easing of restrictions on FDI also has contributed to technology diffusion within developing countries. FDI is a major source of process technology and learning by doing opportunities for individuals in developing countries. Over the past 15 years, FDI inflows to developing countries have almost doubled as a percentage of GDP. In addition, foreign firms are making important contributions to the technological capacity of host countries, performing more than 40 percent of the total R&D in some countries. At the same time, the competition, standards and knowledge of foreign markets that foreign firms bring to the domestic market can have important spillover effects. Finally, many firms in developing countries have increased their access to cutting-edge technology by purchasing technologically sophisticated firms domiciled in high-income countries.

In addition to dismantling barriers to foreign investment, some middle-income countries have encouraged greater FDI flows by implementing stronger regimes governing intellectual property rights (evidence suggests that stronger intellectual property rights are associated with a rise in knowledge flows to affiliates and in inward FDI flows toward middle-income and large developing countries, but not in poor countries). A few countries have encouraged joint ventures rather than FDI to maximize technology transfers to

Figure 9 Developing countries' trade in technology goods has risen

local firms. However, this strategy seems to work only for countries with substantial market power. In particular, fear of losing control over cutting-edge technologies sometimes causes multinational firms forced into joint ventures to reserve their best technologies for the domestic market and transfer only older less efficient ones.

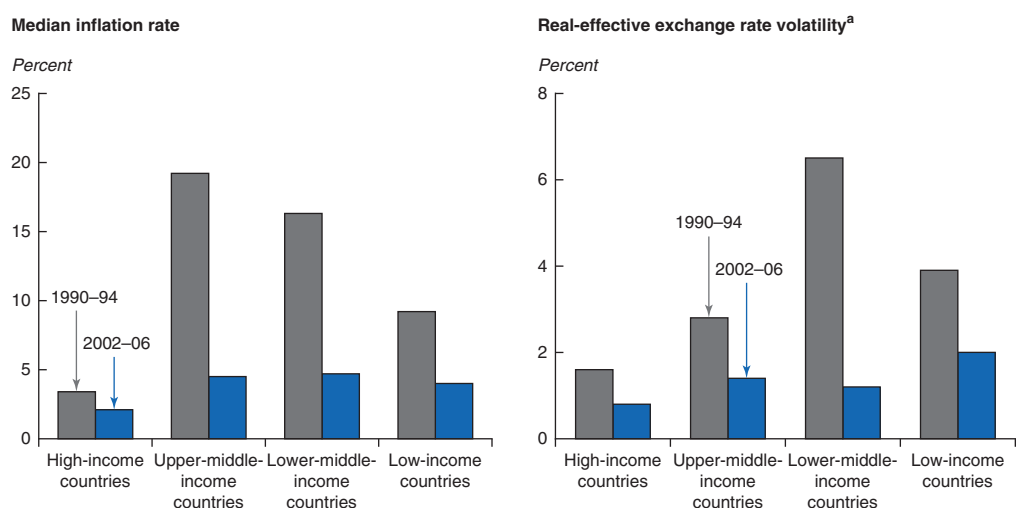
Substantial technology transfers are also associated with international migration and the diasporas of developing countries. Not all of these are positive. Even though 93 percent of university-educated individuals from developing countries return to or remain in their country of origin (Docquier and Marfouk 2004), the brain drain is a serious problem for a number of mostly small countries. However, the existence of a well-educated diaspora (more highly-skilled individuals migrate than lower-skilled individuals) constitutes an important technological resource for the home country—a brain bank, as it were. This is especially the case when weak employment prospects in the home country reduce the economic benefits initially forgone by the individual's departure.

For most countries, high-skilled out-migration remains at manageable levels and these technologically savvy diasporas contribute to technological transfers by strengthening trade

and investment linkages with more advanced economies through networks that provide access to technology and capital and through remittances. Remittances not only contribute to domestic entrepreneurship and investment, but also, along with the introduction of mobile phone services, have greatly expanded the provision of banking and other arm's-length financial services within developing countries—themselves a critical enabling process technology. Finally, returning migrants can provide important resources, such as entrepreneurship, technology, marketing knowledge, and investment capital. The effect of a single returning émigré armed with skills acquired in a developed economy can have (and has had) large economic and technological effects on the country of origin.

Better macroeconomic and educational policies have improved absorptive capacity in developing countries...

Although increases in the flows of the principal international transmitters of technology have been marked, improvement in the factors that determine the capacity of developing countries to absorb and effectively use that technology has been much more gradual. On the positive side, most developing countries

Figure 10 Macroeconomic stability has improved since the early 1990s

Source: World Bank.

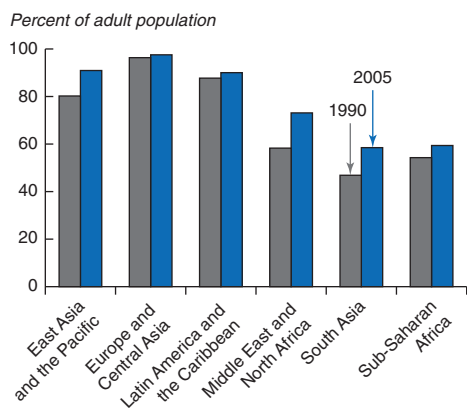
a = average absolute value of the monthly change in the real-effective exchange rate.

have improved their investment climates. Their macroeconomic and political environments have become more stable over the past 15 years. The number of international conflicts has fallen by more than 50 percent since the 1990s, median inflation has dropped from about 20 percent in the early 1990s to less than 5 percent, and exchange rate volatility has fallen by more than 50 percent in every developing region (figure 10). All these changes reduce risk and increase the likelihood that entrepreneurs will take a chance and introduce a new technology within a country. These same changes have contributed to improved per capita GDP and a significant decline in the number of people living in absolute poverty, which has eased the constraints on the ability of poor countries to generate resources for investment, and has increased the willingness of firms and individuals to take risks.

Improvements in the quality of human capital in most developing countries have increased the countries' capacity to adopt and adapt technologies. Poor health is receding as a factor that impedes technological progress. Life expectancy in middle-income countries

has reached 70 years and continues to rise. In low-income countries outside of Sub-Saharan Africa, life expectancy is up from 59 years in 1990 to 64 years in 2005 (in Sub-Saharan Africa, extremely low incomes and the HIV/AIDS epidemic have led to a drop in life expectancy since 1990). The labor force in most developing countries has also become better educated. Adult literacy rates have increased in every developing region over the past 15 years (figure 11). The share of children graduating from primary school has also increased in all regions except East Asia and the Pacific (where it stood at 98 percent in 2005). Meanwhile, secondary school and college enrollment rates are up across the board. Increased school enrollment has raised youth literacy rates to close to 100 percent in all the predominantly middle-income regions. According to official statistics, almost 75 percent of 15- to 24-year-olds in Sub-Saharan Africa can read and write. That rate compares favorably with an adult literacy rate of 60 percent and suggests that over time, the technological literacy of the population will rise. Although policies to promote literacy and extend school

Figure 11 Literacy rates have increased in all regions



Source: World Bank.

attendance are critical, in too many cases, the quality of the education delivered in many developing countries remains low. Large proportions of students officially classified as literate fail to pass international standardized tests of literacy and numeracy.

Technological progress requires additional improvements in the quality of the labor force beyond strengthening educational systems. Training can make an important contribution to both the productivity of private firms and the efficiency of public services. For example, the dissemination of the simple skills required to build rainwater collection systems can improve access to clean drinking water and to reduce the incidence of disease. And investing in the domestic skills required to support high-skill and high-value-added industries can help maximize the technology spillovers from FDI.

...but improvements in the business climate and governance lags

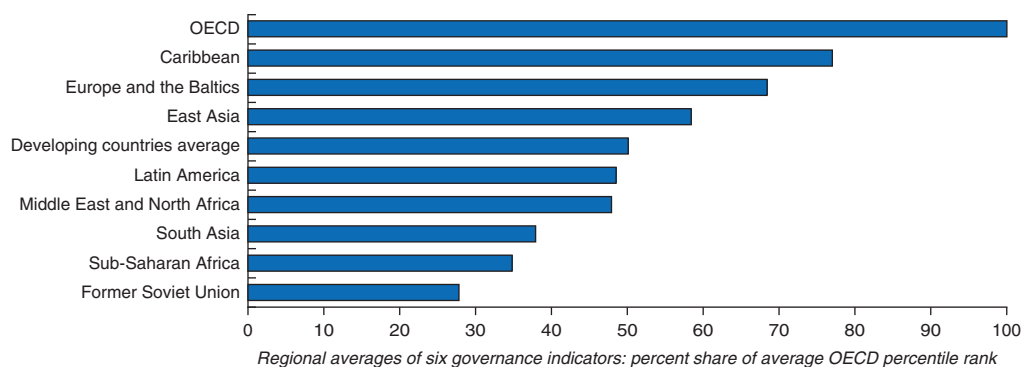
In contrast to improvements in the quality of human capital, business climate and governance indicators have shown little improvement, on average, over the past decade. Governance in several countries has improved, notably in Central Europe and the Baltic countries, proving that motivated

political leadership can make a difference. But, in many other countries, the quality of governance has declined or remained stable.

Progress in the dismantling of regulatory barriers that impede technology diffusion has also been slow. Restrictions on labor mobility that constrain firms' ability to reallocate workers within the firm can be important barriers to the adoption of new technologies, and restrictions on firm entry and exit tend to prop up inefficient firms and limit the expansion and creation of innovative ones. Overall, the time and cost involved in starting a business, the efficiency of contract enforcement, the time required to resolve insolvencies, the average amount recovered, and the degree of corruption in developing countries generates an overall investment climate that is much less conducive to innovation than that observed in the industrial countries (figure 12).

Along with eliminating unnecessary requirements, technological progress often requires the strengthening of regulatory initiatives. For example, improvements in the effectiveness of public-sector institutions have contributed to more efficient logistics services, a key determinant of trade competitiveness. Strengthening contract enforcement, the efficiency of court operations, the security of property rights (including the reliability and timely update of property registries), and the effective regulation of financial markets can be critical to ensuring an adequate return to investments in technology. Governments also can play a key role in boosting technological progress through the definition and promotion of product standards, and in helping firms comply with them.

Despite the limited amount of at-the-frontier scientific innovation performed in developing countries, technological progress depends on R&D and especially technology dissemination activities. In most developing countries and sectors, R&D should focus on the adoption and adaptation of preexisting technologies, not on efforts to expand the global technological frontier. For low-income countries, policy should focus on strengthening

Figure 12 Developing regions have much poorer governance than do OECD countries

Source: Kaufman, Kraay, and Mastruzzi 2007.

Note: OECD = Organisation for Economic Co-operation and Development.

the infrastructure necessary for the successful diffusion and implementation of technologies, on facilitating the diffusion of already existing technologies, and on developing domestic competencies. More technologically advanced middle-income countries should emphasize the same points but should strengthen their R&D and technical competencies in order to increasingly compete at the global technological frontier. In both low- and middle-income countries, policy should place special emphasis on incentives and on maintaining strong ties to private-sector firms.

Some policy directions

This review of the level of and trends in technological achievement in developing countries, of the major transmitters of technological knowledge, and of the determinants of countries' ability to absorb them suggests a number of empirical conclusions (box 1). This report does not offer a comprehensive explanation of why technological progress occurs, nor does it include an in-depth analysis of the policies that governments can adopt to increase the rate of technological progress. Nevertheless, the preceding analysis makes clear that some combination of openness to foreign technology, strong domestic

technological competencies, a motivated public sector, and a well-financed private sector are key ingredients for success. In addition, several general policy directions suggest themselves.

First, much of the technological progress in developing countries over the past 15 years has been associated with the increase in openness that occurred during the same period. This openness has increased developing countries' exposure to foreign technologies, but their capacity to absorb them has improved much less. To the extent that technological absorptive capacity limits the level of technological achievement that an economy can reach (as suggested by the tendency for technological achievement in Latin America to level off), the relatively weak improvement in absorptive capacity may result in a future slowing of the rate of technological progress in some countries unless they take significant steps to raise the quality of domestic human capital, improve the regulatory environment, and increase the efficiency with which they deliver government services. This risk may be most marked for those countries such as Indonesia and Mexico that have taken advantage of globalization in a relatively passive manner, exploiting their low-wage comparative advantage without taking strong steps to improve domestic competencies.

Box 1 Summary of empirical results

First, on most fronts, developing countries have progressed markedly over the past 15 years. As a result, technological achievement in all income groups and in every region has advanced more quickly than in high-income countries.

Second, the technological frontier has advanced as high-income countries (and some developing countries) continue to innovate at a rapid rate. Thus the technology gap between developed and developing countries remains large, particularly for low-income countries.

Third, to a large extent the convergence in technological achievement reflects a substantial increase in the openness of developing countries to foreign

trade, foreign direct investment, and international migration, which has dramatically increased both the exposure of developing countries to new technologies and the opportunities to use foreign markets to exploit increasing returns to scale.

Fourth, progress has also been made in increasing countries' absorptive capacity through improved literacy, enhanced educational attainment, and better macroeconomic stability. However, progress in improving the business climate and governance indicators has been much more mixed. As a result, technological absorptive capacity has advanced much less quickly than technological achievement.

Second, because of the complementarity of technologies and infrastructure, countries where older technologies have yet to penetrate particularly deeply may also face limits to the extent to which other technologies are able to diffuse. Therefore, the authorities should focus on ensuring that publicly supplied technological services are available as widely, reliably, and economically as possible, whether they are delivered directly by the state or by private firms.

Third, a main remaining challenge is to ensure that technologies diffuse throughout the country, not just to major centers or top-performing firms. This does not mean trying to create research centers everywhere, but it does require reinforcing absorptive capacity at the subnational level. Moreover, it means paying attention to dissemination channels within countries, including domestic transportation infrastructure, and the essential role to be played by the outreach, testing, marketing, and dissemination activities of applied R&D agencies.

Fourth, notwithstanding the relatively strong improvement in technological achievement by some low-income countries, many others have improved only marginally or not at all. In particular, improvements in technological absorptive capacity have been limited.

Efforts to concentrate on increasing the quality of human capital must continue, not only by ensuring that more students stay in school longer, but also by raising standards, which in too many cases are too low.

Fifth, given the importance of market failures (for example, increasing returns to scale, the potential for coordination failures, the difficulties in appropriating the full returns to innovation owing to imitators, and capital-market imperfections), governments may need to intervene directly to encourage the rapid diffusion of technology and the growth of a vibrant domestic culture of technology adaptation and new-to-the-market innovation. Policies that have been tried include, among others, support for industry-specific research, subsidies for specific products, barriers to trade that favor technology-intensive activities, and directed credit programs. Such policies have been associated with economic miracles, particularly in several East Asian countries. However, they have also been associated with significant failures, notably in some Latin American and Sub-Saharan African countries. In those cases where direct interventions have been successful, they have tended to make support conditional on performance and have maintained high-quality government monitoring programs

that have avoided being “captured” by industrial interests.

Note

1. Significant is defined here to be a penetration rate that is at least 5 percent of the average level in countries with the highest rate of exploitation.

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