

Technology & Development



Findings from a World Bank Report
Global Economic Prospects 2008: Technology Diffusion in the Developing World

Trends | Data | Benefits | Policy Advice

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Photos

Cover: dreamstime.com and Tran Thi Hoa (old lady with cell phone); Zoran Mrdja (three boys); Arne Hoel (boy drinking water); Curt Carnemark (women in field); Dreamstime.com and Julio Pantoja (good road, mud road); Dominic Sansoni (rural home with electricity); Eric Miller (man with cell phone); Dominic Sansoni (port); Ami Vitale (student).



Technological Progress and Development

Technological progress is about improvements in the ways that goods and services are produced, marketed, and made available to the public. This plays a central role in spurring income growth and reducing poverty.

In fact, technology is at the very heart of human progress and development. It accounts for much of the economic and social progress of the past few centuries. And it will help meet the environmental challenges of the twenty-first century.

Technology and poverty reduction

To a significant degree, technological progress is what makes the difference between fast-growing developing economies and slow-growing ones. In the graph below, the main difference between regions where GDP per capita has been growing quickly since the early 1990s (East Asia, South Asia, and developing countries in Europe) and those where growth has been weaker (Latin America, the Middle East, and Africa) has been the rate at which technology has progressed.

Rapid GDP per capita growth translates into rising incomes. In this way, technological progress has helped reduce the share



of people living in absolute poverty in developing countries from 29 percent in 1990 to 18 percent in 2004.

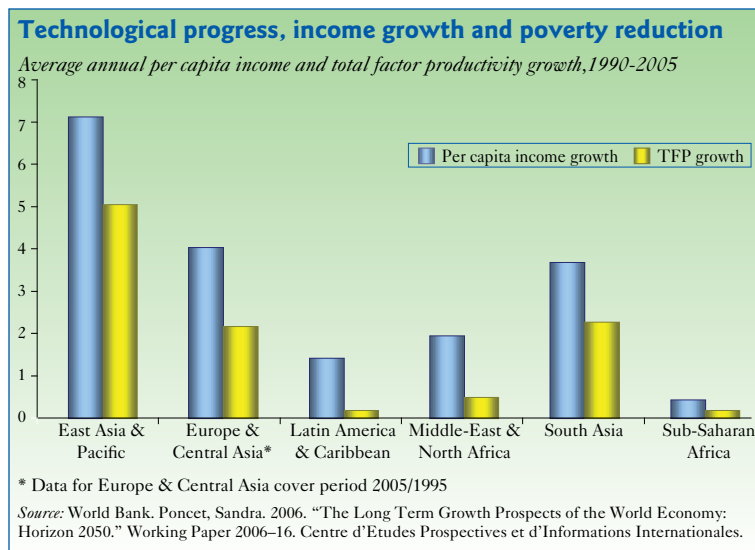
Measuring technological progress

A common measure of technological progress (the one used in this graph) is growth in total factor productivity (TFP). This is the relative efficiency with which an economy produces goods and services given a certain quantity of labor and capital.

TFP is an indirect measure because it attributes to technology all income growth that cannot be explained by investment and increases in labor supply. It is commonly used because measuring technology directly is difficult. Unlike pencils and pens, technology cannot be easily counted in physical terms.

A World Bank report, *Global Economic Prospects 2008: Technology Diffusion in the Developing World*, goes beyond the common TFP measure to assess technological progress more directly—by measuring the quantity and quality of inputs and outputs.

The World Bank's new summary index of technology described in this report is based on *direct* measures of a wide range of indicators.



It measures technological achievement by how intensively different technologies are used or generated in a country. These intensities are measured along four dimensions:

- The extent of scientific invention and innovation
- The spread of older technologies
- The spread of newer technologies
- The use of foreign technologies in domestic production

By these measures, technological progress in developing countries between the 1990s and 2000s has been very strong, though the “technology gap” between rich and poor countries remains large.

Far-reaching benefits

Technology and technological progress are relevant to a wide range of economic activities, and not just, as often assumed, to manufacturing and computers.

Sometimes, apparently low-tech products such as corn or flowers can result from high-tech production processes. And in some countries, seemingly high-tech products like computers are produced by relatively low-tech assembly activities.

Technological progress contributes to development by:

- Lowering costs, improving quality, creating new products, and helping reach new markets.
- Using relatively simple skills to generate substantial improvements in living conditions.

For example, the simple skills needed to build rainwater collection systems can greatly improve access to clean drinking water and reduce the incidence of diarrhea, a major cause of infant mortality.

While technological progress can bring great benefits, it can also be disruptive when these benefits are not evenly distributed. Technological progress may benefit some classes of workers over others. It can also mean significant short-term losses for competitors who are still using older technologies.

But disruptions caused by technological progress can benefit economies by spurring domestic competition. For example, the introduction of mobile phone technology in several developing countries has brought in significant competition and lower prices not only in the telecommunications sector but also in banking and other information-sensitive sectors.

Asia's Green Revolution



Asia's Green Revolution is a good example of how modest technological advances can have a dramatic impact on development.

Between 1970 and 1995, better agricultural technologies doubled Asia's cereal production while increasing the land area devoted to growing cereal crops by just 4 percent.

These technologies included pesticides, irrigation, synthetic nitrogen fertilizer, and development of high-yield varieties of maize, wheat, and rice.

By the late 1990s it was clear that, on the positive side, poor people had benefited from higher incomes, cheaper food, and more demand for their labor.

Lessons from the Green Revolution also caution us that technological progress can have unintended effects, including in this case water pollution from excessive agrochemical use.



The Technology Gap

Technological progress in developing countries between the 1990s and 2000s has been very strong. It has outpaced progress in developed countries by more than 100 percent in some cases. But the technology gap between rich and poor countries is still very wide.

Rich and poor countries

While the level of technology used in all countries has increased rapidly, it has done so quicker in developing countries and quickest in low-income countries. (Of course, the initial level of technology in lower-income countries was much lower to begin with.)

There is strong evidence that some middle-income countries are catching up with high-income countries. In Chile, Hungary, and Poland, the overall level of technological achievement increased by more than 125 percent during the 1990s.

Despite rapid technological progress, developing countries still have a long way to go. Low-income countries currently employ only a quarter of the level of technology in developed countries.

The pace at which technology has spread *among* countries has increased dramatically over the past two centuries. In the 1800s, a new technology took an average of 84 years to reach all developing countries. By the 1950s this had fallen to 26 years and by 1975 to 18 years.

But technology does not spread as quickly *within* countries. Not surprisingly, richer countries use technology more extensively than poor countries, partly because they can afford it and partly because more of their people and firms have the necessary skills to use technology.

What distinguishes good technology performers? At a given income level, it is differences in the extent to which older rather than newer technologies are exploited. (Many older technologies first began spreading when developing-country governments' ability to deliver them was hampered by civil strife, macroeconomic instability, budgetary difficulties, and other governance problems.)

Encouragingly, years of constructive policy reforms and reduced political turmoil mean that these technology deficits are now being made up in several countries.

Technological progress in developing countries has outpaced high-income countries

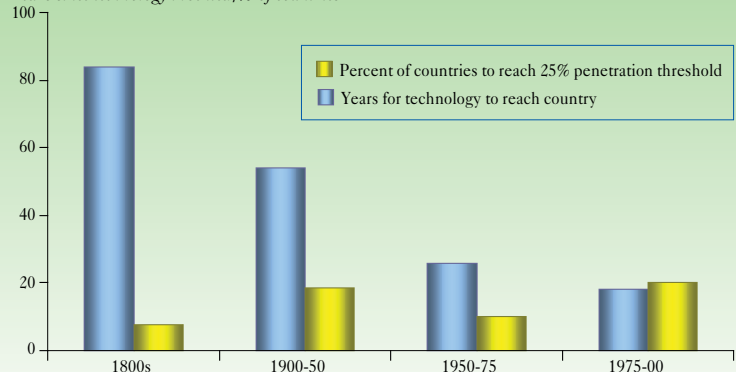
Percent change in technological achievement, 2000s vs 1990s



Source: World Bank

Diffusion across countries has accelerated but penetration within countries remains weak

Years since technology invented/% of countries



Source: World Bank calculations using CHAT database. Comin, Diego, and Bart Hobijn. 2004. "Cross-Country Technology Adoption: Making the Theories Face the Facts." *Journal of Monetary Economics* 51 (1): 39-83.

How Technology has Progressed in Developing Countries

The rapid technological progress seen in developing countries between the 1990s and 2000s almost entirely involved the increasing use of pre-existing technologies rather than cutting-edge inventions.

Scientific invention and innovation, which can be measured by the number of patents and journal articles attributable to a country, plays virtually no role in explaining the level of technological achievement in developing countries. The graph below shows that developing countries are scarcely active at the global technological frontier. This is mainly because many developing countries lack the critical mass of technological competencies necessary to participate at the global technology frontier.

Owing to relatively thin domestic technology sectors and better opportunities abroad, many people from developing countries perform their cutting-edge research in high-income countries. However, the Europe and Central Asia region is an exception in this regard, reflecting a history of advanced scientific and engineering work in a number of former Soviet bloc countries. Also, because of their overall size, some developing countries do play an important role. China now



contributes a larger share of global patent applications—10 percent in 2004, up from 1.5 percent in the late 1980s.

Diffusion of technology

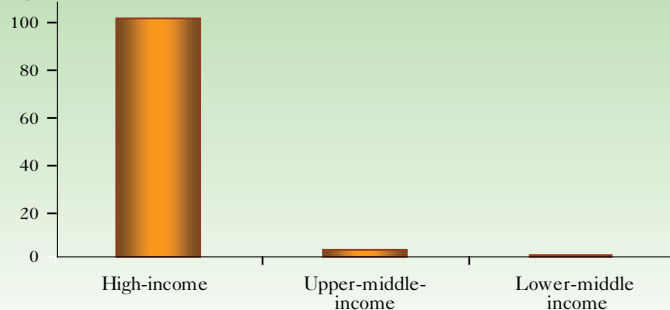
How have various pre-existing technologies spread in developing countries? The picture is somewhat different for older technologies than it is for newer ones.

The major innovations of the past 200 years—such as steam power, electricity, and telephones—exist to some degree in virtually every country. But access to these *older technologies* varies widely between countries, depending on both the country's capacity to absorb technology and whether the technology is affordable. While countries of the former Soviet bloc enjoy near-universal access to electricity, only 8 percent of the rural population in Sub-Saharan Africa has access to electricity, and just over half the urban population.

Economies usually rely on governments to provide infrastructure services such as electricity, roads and railways, and fixed-line telephones. But especially in the past high cost and excessive indebtedness have limited the extent of investments in these technologies in many countries.

Developing countries are scarcely active at the the global technology frontier

Intensity of imported technologies summary index (2000s),
high-income countries=100



Source: World Bank, Global Economic Prospects, 2008.

Also, in many low- and middle-income countries, weak institutions and lack of capacity to maintain infrastructure systems has made it even more difficult for such technologies to spread.

Older technologies have spread quicker in some sectors than in others. Technology diffusion has contributed strongly to rapid growth in agriculture in many developing countries. But medical technologies have diffused slowly in many low-income countries, with South Asia and Sub-Saharan Africa averaging immunization rates of just 59 to 63 percent in 2003. And well over half the populations of China and India still live without improved sanitation.

Some *newer technologies* have penetrated developing countries much faster than older technologies.

- Rapid expansion of mobile phone ownership in low-income countries is of great use to poor people in rural areas with poor infrastructure.
- Internet bandwidth consumption and the number of broadband subscribers have more than doubled from 1999 to 2004 in developing countries.

Internet services have not spread uniformly across the developing world. Although Internet penetration has risen by 41 percent in Sub-Saharan Africa from 1999 to 2005, the region still has the lowest penetration of any developing region in the world. This partly reflects a lack of infrastructure, which makes such technologies prohibitively expensive. In Kenya, call centers connected by satellite pay \$7,000 per MB of bandwidth compared with \$500 for those connected by fiber-optic cable in India. Prospects for the Internet in Africa are expected to improve after a fiber-optic backbone is completed along the eastern coast of the continent in 2008.

Personal computers, which are more expensive than shared Internet connections, have spread more slowly. Three-quarters of low-income countries have 15 or fewer personal computers per 1,000 people, and a quarter have fewer than five. But some low-income countries do much better. Mongolia, for example, has 133 PCs per 1,000 people.

Widening Africa's Financial Services Network



Efficient savings and payments systems are often beyond the reach of poor households, because they are not available in rural areas or the minimum balance requirements of traditional banks are too high. Technology has helped banks in Sub-Saharan Africa bring these services to low-income customers innovatively.

- Kenya's Equity Bank operates vans with laptops and telecom facilities as mobile banking units. It offers flexible savings mechanisms with access to emergency loans.
- South Africa's Teba Bank has developed a smart card that uses mobile phone technology to provide low-cost electronic banking services. Card values can be topped up or card purchases made at simple wireless terminals in shops frequented by poor people.
- In the Democratic Republic of Congo and in Zambia, a system developed by Celpay allows clients to use their mobile phones to pay bills by texting requests to CelPay, which then transfers money to the merchant's account.

Surveys by Bankable Frontier Associates (2007)* found that the potential for this type of service is increasing with rising penetration of mobile phones in countries like Botswana, Kenya, Namibia, South Africa, Tanzania, Uganda, and Zambia, where between 7 and 41 percent of the unbanked population has access to a mobile phone.

*"Financial Service Access and Usage in Southern and East Africa: What Do FINSCOPE™ Surveys Tell Us?" Bankable Frontier Associates. <http://www.bankablefrontier.com>. Accessed October 2007.

Globalization & Technological Progress

The level of technology in a developing country depends on both the extent to which it is exposed to foreign technologies as well as the capacity of the domestic economy to absorb these technologies.

The high-tech business processes, products and services that flow into a country through *foreign trade*, *foreign direct investment (FDI)*, and *contact with migrant populations* living abroad offer the critical exposure required to jumpstart technological diffusion.

Trade, FDI, and migrant influences

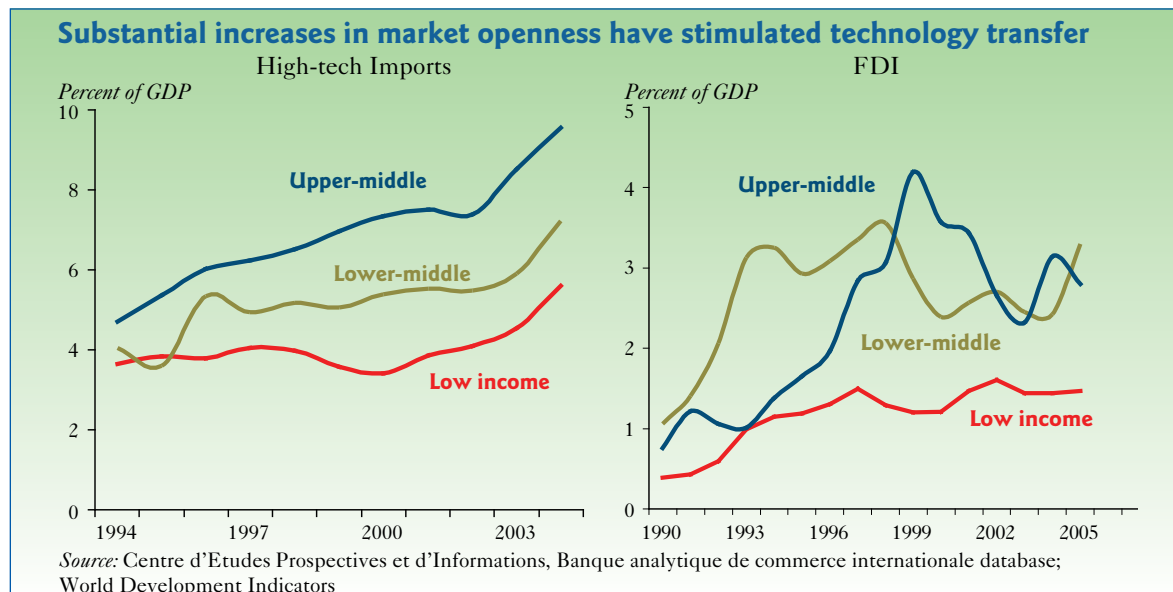
The dismantling of trade barriers in many developing countries over the past 20 years has dramatically increased their exposure to foreign technologies. The ratio of high-tech imports to GDP in developing countries has more than doubled since 1994.

The easing of restrictions on FDI has also contributed to technology diffusion within developing countries. FDI is a major source of process technology and “learning by doing”



opportunities. Over the past 15 years, FDI inflows to developing countries have nearly doubled as a percentage of GDP.

FDI can also have significant spillover effects on domestically-owned enterprises. For example, leading call center companies from France and Spain have paved the way for domestically-owned and export-oriented call centers in Morocco and Tunisia.



Substantial technology transfers also occur through contact with well-educated migrant populations living abroad.

These populations are an important resource for the home country—a “brain bank”—that contributes to technology transfers in many ways:

- By strengthening trade and investment links with more advanced economies through networks that provide access to technology and capital.
- By sending home money that contributes to domestic entrepreneurship and investment and to the expansion of banking and other financial services.
- By providing (on return to the home country) resources such as entrepreneurship, technology, marketing know-how, and investment capital.

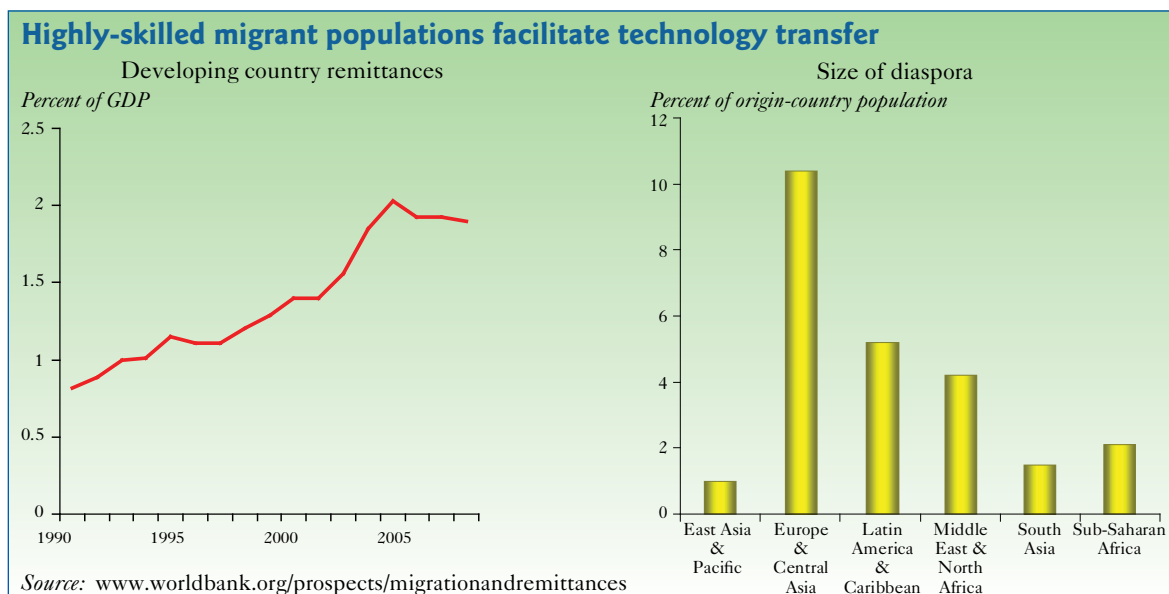
A good example of a returning migrant facilitating an important technology transfer is that of a Bangladeshi national working in the financial sector in the United States who returned home to help create the Grameen Phone network and make mobile phones available to poor people in remote villages. Through its successful Village Phone Program, the network has provided business opportunities to about 260,000 operators, mostly poor rural women.

In India, the Center for Development of Telematics (founded by Sam Pitroda, a global entrepreneur who divides his time between India and the United States) developed relatively low-cost rural automatic telephone exchanges and introduced shared public call offices all over the country. This innovation expanded access to cheap and reliable domestic and international calling, and the technology has been exported to several other developing countries.

However, exposure to new ideas and techniques is not enough. To ensure that technology diffuses throughout the economy, developing countries also need to have a strong capacity to absorb these ideas and techniques.

In fact, weak internal diffusion of technology holds back overall technological achievement in many countries.

While major centers and leading firms in Brazil, India and China may operate close to the global technological frontier, most firms in these countries operate at less than a fifth of the top productivity level. Given that technology spreads slowly across firms, there are wide differences in the technological sophistication of production, even within the same sector in the same country.



What slows the spread of technology?

Political and macroeconomic stability in recent years has helped countries to exploit technology. Over the past 15 years, the number of countries involved in international conflict or domestic conflict (as measured by the International Crisis Behavior Project) has fallen significantly.

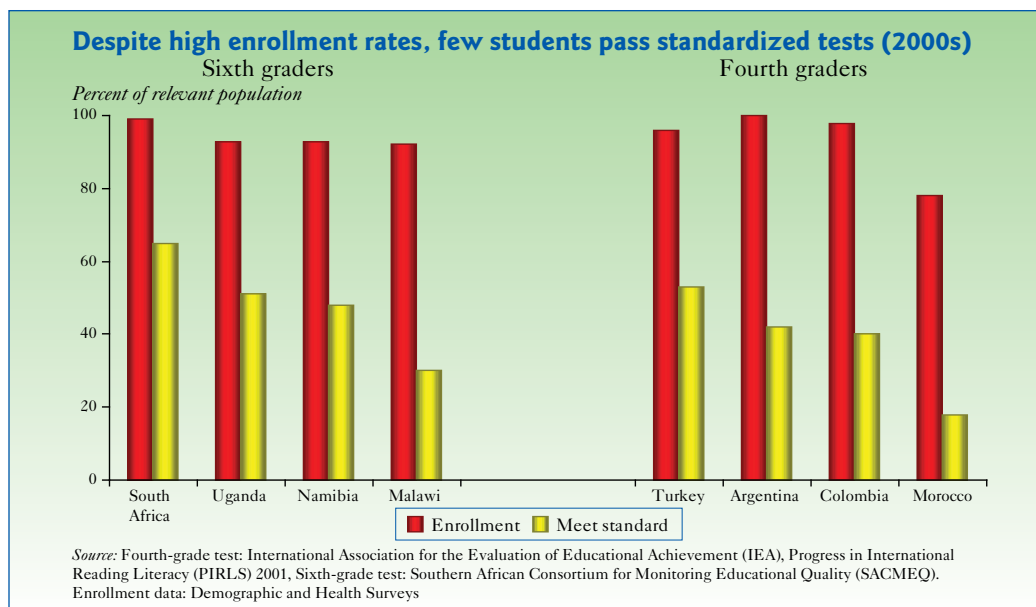
The decline has been greatest in Sub-Saharan Africa, where the number of countries in conflict has declined since 1998. The end of conflict can provide a much better environment for public and private technology investments.

However, surveys suggest that developing countries lag behind high-income countries on a wide range of governance indicators. For example, government effectiveness and regulatory quality are typically considered to be at half of OECD levels, with indicators for corruption, rule of law, and voice and accountability being even lower.

Developing countries also typically bear a heavier regulatory burden than OECD countries. Regulatory restrictions that impair the economy's flexibility may slow down the absorption of technology.



In the developing world, savings have not been channeled into the private sector (by the banking system, equity markets, or private sector bond markets) to the same extent as they have in rich countries. Financial intermediation by banks—which play an important role in relaying private savings toward investors—occurs in middle-income countries at half the level of rich countries, and almost not at all in low-income countries.



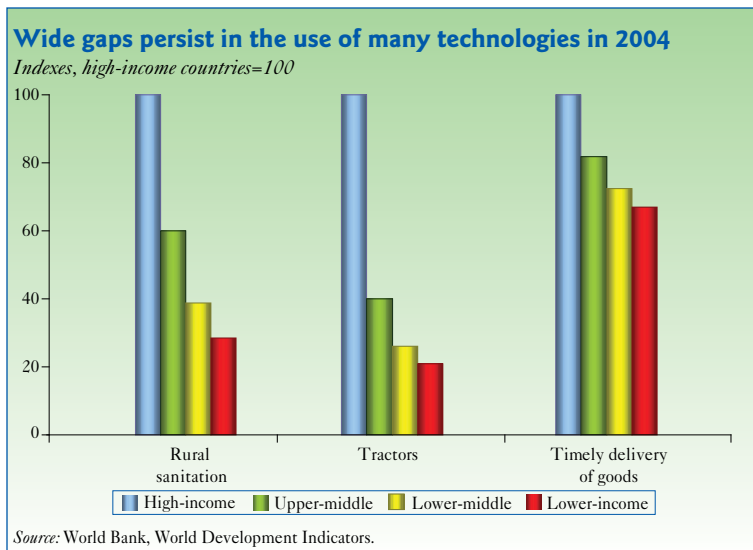
As a result, firms that want to try out untested techniques or problems face serious challenges in developing countries. They are less likely to obtain financing and are more likely to bear higher capital costs.

Developing countries' capacity to absorb technology is further weakened by *low technical literacy*, the *uneven spread of older technologies* such as electricity and telephones, and *low penetration of technologies in rural areas*.

Low technical literacy

There has been significant progress in developing countries in health, incomes, and literacy rates over the past 15 years. Since more children are enrolled in school, literacy rates have increased in low-income countries from less than 50 percent in 1990 to more than 62 percent today, and more than 74 percent among youth.

However, the quality of schooling still suffers. Despite high enrollment rates in both low- and middle-income countries, large proportions of students fail to pass standardized tests of literacy and numeracy. In Sub-Saharan Africa, where enrollment rates approach 100 percent, fewer than half of grade six students in some countries are deemed literate.

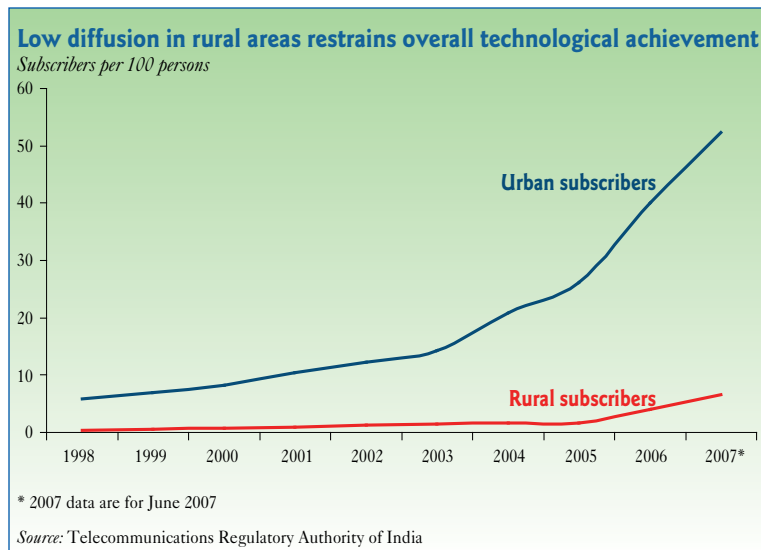


Uneven spread of older technologies

Improvements in the spread of older technologies has contributed significantly to faster technological progress in low-income countries. But the use of the most effective technologies tends to be limited to urban areas and the most productive firms. For example, India's IT-enabled services sector employs world-class technologies, but less than 10 percent of the country's rural households had telephone access as of 2007.

Within sectors, the most productive firms tend to be five times more productive than the average firm. If their technologies were adopted by other firms (and their workforce had adequate skills), GDP could be increased by between four and five times.

While many countries have improved technological achievement, relatively few countries have improved their technological absorptive capacity by more than 10 percent between 1990 and 2000. Weak domestic absorptive capacity will probably hinder future technological progress. Unless developing countries raise basic competencies and invest in local technology dissemination networks, many may not be able to master anything but the simplest of future technologies.



What governments can do to support technology

Governments can play a critical role in supporting technological progress. In fact, countries that have achieved sustained and quick technological progress have usually had the benefit of committed national leadership. Broad policy directions include:

- Maintaining openness to trade, foreign direct investment, and participation of migrant populations.
- Further improving the investment climate so as to allow innovative firms to grow and flourish.
- Strengthening basic infrastructure (roads, electricity, telephony).
- Raising the quality and quantity of education throughout the economy.
- Reinforcing dissemination systems and the market orientation of R&D programs.

Technology in 2020

A recent report by the RAND Corporation (Silbergilt & others, 2006) evaluates 16 important emerging technologies expected to be commercially available by 2020. As the table below shows, all high-income countries will be able to exploit these technologies, and many developing countries may use some of the simpler ones, but a wide range of countries will lose out because they lack the necessary infrastructure, technical literacy and technological capacity.

Technological adaptive capacity may restrict the diffusion of future technologies

Technology application	Most of Africa, Middle East, Oceania	Latin America, South Africa, Turkey, Indonesia	China, India, Russia, Eastern Europe	Industrial countries
	Technologies likely to be mastered by 2020 (✓)			
Cheap solar energy	✓	✓	✓	✓
Rural wireless communication	✓	✓	✓	✓
Genetically modified crops	✓	✓	✓	✓
Filters and catalysts	✓	✓	✓	✓
Cheap autonomous housing	✓	✓	✓	✓
Rapid bioassays		✓	✓	✓
Green manufacturing		✓	✓	✓
Ubiquitous RFID tagging		✓	✓	✓
Hybrid vehicles		✓	✓	✓
Targeted drug delivery			✓	✓
Improved diagnostic and surgical techniques			✓	✓
Quantum cryptography			✓	✓
Ubiquitous information access				✓
Tissue engineering				✓
Pervasive sensors				✓
Wearable computers				✓

Requires increased technological sophistication

Source: Silbergilt, Richard, Philip S. Anton, David R. Howell, and Anny Wong. 2006. *The Global Technology Revolution 2020*. Santa Monica, CA: RAND Corporation, National Security Research Division.

Note: RFID = radio-frequency identification.

Global Economic Prospects 2008: Technology Diffusion in the Developing World

This World Bank report includes chapters on:

- Economic Prospects for Developing Countries
- Technology and Technological Diffusion in Developing Countries
- Determinants of Technological Progress: Recent Trends and Prospects

The report can be purchased online or downloaded free of cost at:

<http://www.worldbank.org/gep2008>

“Rapid technological progress in developing countries has been key to the reduction of poverty in recent decades. While the integration of global markets has played and will continue to play a vital role in this, future success will increasingly depend on strengthening technical competencies and the business environment for innovative firms in developing countries.”

—Graeme Wheeler
Managing Director
The World Bank

This brochure is a short summary of the World Bank report
“Global Economic Prospects 2008: Technology Diffusion in the Developing World”



The complete report can be downloaded at

<http://www.worldbank.org/gep2008>

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