



A regular series of notes highlighting recent lessons emerging from the operational and analytical program of the World Bank's Latin America and Caribbean Region

CLOSING THE GAP IN EDUCATION AND TECHNOLOGY

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Rapid skill based technological change and its implications for growth

Over the last fifty years, the income gap between rich and poor countries has grown. Between 1950 and 2000, annual per capita income in OECD countries tripled from US\$7,300 to US\$23,000, while income in Latin America only doubled, from US\$3,000 in 1950 to US\$6,200 in 2000. This is largely due to widening gaps in knowledge and technology. The North has continued to generate new technologies that statistical studies suggest drive at least half of economic growth; most of the South has been unable to take full advantage of them.

The newly industrializing countries (NICs) of Asia, and other countries such as Finland that are closer to LAC in resource endowments, were able to achieve dramatic technology driven increases in living standards. Their national innovative capacity and ability to learn from abroad sets apart the successful resource abundant countries- Australia, Canada, Scandinavia- from the disappointing LAC experience. Early on, the successful countries recognized the need for an explicit, efficient and sustained policy to move the private sector to the technological frontier. Second, they engaged in one of the most rapid and dramatic build ups of national human capital in human history.

“Closing the Gap in Education and Technology”, (de Ferranti, Perry, Gill, Maloney, Guasch, Schady and Sanchez-Paramo; World Bank, 2002) looks carefully at what it takes for countries and firms to learn how to learn. Education is vital, for at least two reasons. First, it has always been a critical complement to technological advance. Emerging evidence suggests that the knowledge transfer benefits of FDI and trade liberalization, for example, are enhanced by

higher stocks of human capital. As late as 1950, the United States was perhaps the only country where the median school-leaver was a high school graduate. By the time countries in Europe—seeing the rapid rise of the United States as an economic powerhouse—learned their lesson, the United States had expanded its lead in tertiary education, and most European countries have only recently begun closing this gap. Many East Asian countries were quick to see the importance of investing in education: Korea, for example, has secondary and tertiary education indicators that are already better than many European countries. But in much of Latin America, this recognition has come more slowly.



Second, technological change in the twentieth century has been increasingly biased in favor of skilled workers and appears to be the strongest force driving the increasing skilled/unskilled wage differential in industrialized countries. There is some evidence that this is partly a result of the information and communication technology (ICT) “revolution”.

Productivity, educational and technology gaps in Latin America and the Caribbean

The report focuses on Latin America's gaps in education and technology. The central premise is that skills upgrading, technological change and interactions between the two are major factors behind total factor productivity (TFP) growth, and that TFP is a key determinant of long term growth. Skill-based technological change is being transferred faster today to LAC countries that are more open to trade and foreign direct investment (FDI) flows and have increased the education level of their work force. The report presents empirical evidence that technological change has been complementary with skill in Latin America in the last two decades, as in more

developed countries. As a result, firms have substantially increased the demand for educated workers, especially workers with tertiary education, and this rise in the demand for educated workers has bid up their relative wages.

This process creates challenges and opportunities. Demand for higher skills, and in particular for workers with tertiary education is rising faster than demand for less skilled workers in most of the region. Hence the challenge: inequality in wages tends to increase as long as major inequalities in access to education remain, and lack of skills may become a real constraint on fast and efficient technology transfer, and thus on potential growth. The opportunity lies in the possibility of accelerating productivity growth in the economy if increased demand for education helps close the educational and technological gaps between Latin America and other countries. Policy must respond swiftly so that the potential demand for higher and better education is translated into higher and better educational levels of the work force and higher productivity at the firm level.

Productivity differences between countries and between firms within countries are profoundly affected by differences in skills and technology.¹ It is therefore no surprise that countries with well-above-average rates of TFP growth (the East Asian tigers and some of the suc-

cessful natural resource based economies) also outperform Latin America in technology and skills. The best-performing country in Latin America, Chile, concurrently had positive increases in productivity, substantial skill upgrading, and increases in all indicators associated with technology transfer and innovation.

Despite progress in the region, educational gaps have increased and are particularly wide at secondary level, with a few exceptions (Chile, Argentina and the English-speaking Caribbean). This is linked to the way that educational transition has taken place and the way in which resources are allocated in the education sector in Latin America. A very large share of resources go to public universities, frequently of low quality, leaving little funding for secondary education. These policies have constrained tertiary education expansion, and led to large gaps in secondary education. This causes inefficiency and inequity: talented, poor students do

not access or benefit from the large university subsidies, and tertiary students are drawn from a narrow talent pool.

The increasing returns to tertiary education suggest that the technological transition will require more workers of this skill level. One option is for public policy and resources to focus on increasing secondary places, while facilitating private expansion of tertiary education. The high *potential* demand for university education signaled by the high returns does not necessarily translate into high *effective* demand because of liquidity constraints and information asymmetries. More information about the quality of private tertiary education providers (through state exams for graduates, labor market observatories and sound accreditation programs) and less uncertainty should facilitate better choices by households and increase effective demand.

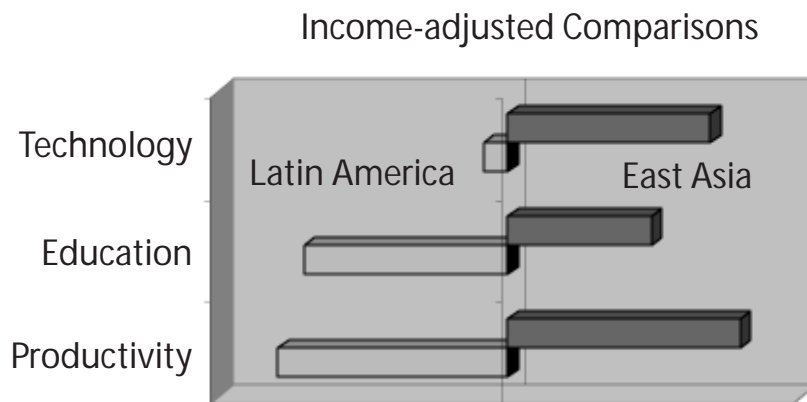
Second, the report argues that development of the ICT sector is an essential complementary instrument to develop technological capability. Yet the region's technological gap relative to East Asia more than tripled during the 1990s.

Third, the report compares domestic spending on research and development (R&D) and payments for licensing, to countries of similar income levels and to the superstars like Finland, Korea, Israel or Ireland. Despite extraordinary returns to innovation in-

vestments, R&D by firms in Latin America is strikingly low. This is partly due to weak credit markets, ICT infrastructure or explicit government policy toward encouraging innovation. Also, until the recent opening of LAC economies to competition and foreign ideas, firms had neither the motivation nor the ability to look outside for relevant technologies. For historical reasons and to compensate for the low private sector effort, governments have tended to provide a disproportionately large part of financing and implementation of R&D (much of the latter being concentrated in public Universities).

LAC countries have not given innovation and science and technology a central role in their development strategies until recently. So although their technology absorption and innovation have increased, these countries have fallen behind more aggressive economies like the Asian Tigers, Israel, Ireland and Finland. The opening of the LAC

LAC Deficits in Technology and Education Relative to East Asia are Reflected in Slower Rates of Productivity Growth



Technology: Capital Stock of domestic private R & D per worker (1995 US\$)
Education: Mean years of education: population 25+
Productivity: TFP growth per year (1990-99)

countries has given them greater access to various technologies developed abroad. However, access to technology is not enough for rapid sustainable growth. Countries also need capabilities and institutions to use technologies efficiently and eventually to steer themselves onto a path of innovation-based development, which allows for sustainable long-term growth.

The complementarity between education and technical change

Empirical experience suggests that countries that attempt to close education and technology gaps in an unsynchronized manner suffer low or erratic economic growth. The reason is the strong complementarity between technology and skills, explained by three facts. First, skilled workers are needed to implement new technologies because they are better at dealing with change. Second, the availability of more skilled workers creates incentives for firms to develop new technologies that are more skill intensive (so-called “directed” technological change). Directed technical change requires even faster upgrading of education systems in developing countries, to support continued skill-biased technological change. Third, skilled workers, engineers and scientists are required to produce significant adaptations of existing technologies and even more to create new ones. Even adoption and diffusion of existing technologies require a minimum level of education of the work force (at least some secondary education) and of training and R&D in firms.

Thus, countries with low education levels remain in a trap of technological stagnation, low growth and low demand for education. If countries strongly subsidize tertiary education, but do not open to trade and FDI, and firms are not subject to competitive pressures that stimulate technological progress and hence demand for education, then a high proportion of educated people will emigrate, and effective demand for education will be weak. Similarly, low R&D by firms may limit adoption of new technologies and innovation and undermine growth of demand for education; and efforts by Government to subsidize R&D may fail to achieve their goals when low levels of education prevail and/or economies are not open to trade and FDI and firms face no competitive pressures to innovate.

Synchronized elimination of the education and technology gaps

The implication is that countries can close skill and technology gaps more easily and with stronger effects on productivity and economic growth, if policies in these two areas are *synchronized*. Phases in the educational transition—from low basic and secondary education levels and quality to high levels of secondary and tertiary education—and the technological transition—from reliance on adopting simple foreign technology to major adaptations and creation of new tech-

nologies—should keep step. There is no “one size fits all” recommendation; policy priorities should depend on each country’s progress in the educational and technological transitions from “knowledge absorbing” towards “knowledge creating” societies, and should correct imbalances in progress in these areas.

Even in economies where most enterprises are stagnating in terms of technology, some firms will create important adaptations and even significant technological innovations. This is more probable in sectors where the country has held a comparative advantage for a long time. It is important that government policies support these leadership initiatives. Natural resource-based sectors are especially important, as technology transfers normally require significant adaptations to the characteristics of indigenous natural resources and their particular environmental conditions. Major examples are successful development of fresh fruits and salmon in Chile and cut flowers in Colombia. Moreover, there is little R&D in tropical agriculture in OECD countries for obvious reasons; this puts the onus on Latin American countries themselves or productivity growth will stagnate.

Successful countries have consistently taken an active approach to integration in the world economy through upgrading the learning and training capacity of firms, selectively financing private R&D, encouraging licensing of foreign technologies and protecting intellectual property rights, stimulating development and access to ICTs and progressively deepening and tuning up their National Innovation Systems rather than passively waiting for multinational corporations or imports to transfer technology.

In all the higher performing countries, increasing the technological absorptive capacity of firms has required a supportive set of policies and institutions ranging from well-designed fiscal incentives and subsidies to the active promotion of incubators, technology parks and clusters, and creation and coordination of industrial consortia that share the costs and risks of R&D and skill upgrading, act as learning laboratories for the less advanced firms and help identify ideas from abroad.

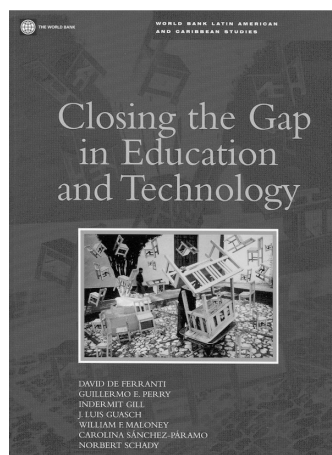
An integrated approach and a coordinating, even leading, role by government is needed. In highly successful countries, governments have not been shy about financing and undertaking R&D that has broad spillovers. At a minimum, the state needs to ensure a consistent and coherent set of incentives. An active and efficient “innovation policy” is required. This offers a challenging policy agenda.

¹ Of course, differences in skills and “technology” do not explain all differences in productivity levels. Many other factors contribute, including differences in quality of institutions, depth of financial sectors, and macro/fiscal performance.

Table 1. The Gaps that matter most...

	Observed LAC mean	Income-adjusted deficit in LAC	Observed East Asian "tiger" mean	Income-adjusted surplus in East Asian "tigers"	Observed NRA country mean	Income-adjusted surplus in NRA countries
Productivity						
TFP growth per year (1990-99)	0.45	-0.21	1.42	0.76	0.78	0.12
Educación						
Mean years of education, population aged 25+	5.8	-1.4	9.7	1.0	11.1	1.4
Net secondary enrollment rate (percent)	46.7	-18.7	93.3	17.8	93.2	6.0
Gross tertiary enrollment rate (percent)	20.0	-10.0	47.3	5.1	67.0	14.0
TIMSS score (points)	387	-81.2	584	86.3	524	+ (n.s.)
Tecnología						
Capital goods imports as a fraction of GDP, 1999 (percent)	7.7	-3.6	29.5	18.1	12.6	2.0
Domestic R&D expenditures per worker (1995 US \$)	35.6	-26.4	329.5	116.5	725.4	152.5
Patents registered in the US, 1996-2000 average (per million)	0.8	-1.5	54.4	48.3	114.8	80.9
Mean number of computers per 1,000 workers	37.7	- (n.s.)	172.0	+ (n.s.)	404.2	+ (n.s.)

Source: Data on TFP from Loayza et al (2002); data on educational attainment of adults from Barro and Lee (2002); data on enrollment rates from UNESCO; data on TIMSS scores from TIMSS; data on imports, imports of capital goods, GDP, GDP per capita, and population from World Bank data bases; data on R&D and patent registration from Lederman and Saenz (2002).



World Bank Latin American and Caribbean Studies Closing the Gap in Education and Technology

Investing in education, opening up to new technologies through foreign trade and investment, and encouraging private sector research and development (R&D) are the keys to unlocking the potential of technology to speed up economic growth in Latin America and the Caribbean (LAC).

In *Closing the Gap in Education and Technology*, principal authors David de Ferranti and Guillermo E. Perry advise Latin American and Caribbean governments to address the region's deficits in skills and technology, and thereby boost productivity, which is essential to improving growth prospects. Visit <http://www.worldbank.org/lac> to download

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