1
The Knowledge Economy and the Changing Needs of the Labor Market

Knowledge is our most powerful engine of production.  
Alfred Marshall, 1890

All agree that the single most important key to development and to poverty alleviation is education. This must start with universal primary education for girls and boys equally, as well as an open and competitive system of secondary and tertiary education . . . . Adult education, literacy, and lifelong learning must be combined with the fundamental recognition that education of women and girls is central to the process of development.

James D. Wolfensohn, President of the World Bank, 1999

A knowledge-based economy relies primarily on the use of ideas rather than physical abilities and on the application of technology rather than the transformation of raw materials or the exploitation of cheap labor. It is an economy in which knowledge is created, acquired, transmitted, and used more effectively by individuals, enterprises, organizations, and communities to promote economic and social development (World Bank Institute 2001c; World Bank 1998d). Knowledge can either be codified and written down or tacit and in people’s heads.

The knowledge economy is transforming the demands of the labor market in economies throughout the world. In industrial countries, where knowledge-based industries are expanding rapidly, labor market demands are changing accordingly. Where new technologies have been introduced, demand for high-skilled workers, particularly high-skilled information and communication technology (ICT) workers, has increased. At the same time, demand for lower-skilled workers has declined (OECD 2001f).
Four features of the knowledge economy have far-ranging implications for education and training:

- **Knowledge is being developed and applied in new ways.** The information revolution has expanded networks and provided new opportunities for access to information. It has also created new opportunities for generating and transferring information. Knowledge networks and sharing of information have expedited innovation and adaptation capacity. Changes in ICT have revolutionized the transmission of information. Semiconductors are getting faster, computer memories are expanding, and ICT prices are falling. Data transmission costs have fallen dramatically and continue to fall, bandwidth is growing, and Internet hosts are expanding and multiplying. Cellular phone usage is growing worldwide, adding to the pace of and capacity for change and innovation.

- **Product cycles are shorter and the need for innovation greater.** In 1990 it took six years to go from concept to production in the automobile industry; today that process takes just two years. The number of patent applications is growing, and more and more international and multiple applications are being filed. Industrial countries filed 82,846 patent applications at the European Patent Office in 1997, a 37 percent increase over 1990 (OECD 2001f).

- **Trade is increasing worldwide, increasing competitive demands on producers.** Countries that are able to integrate into the world economy may be able to achieve higher economic growth and improve health and education outcomes (World Bank 2002e).

- **Small and medium-size enterprises in the service sector have become increasingly important players, in terms of both economic growth and employment.**

A knowledge economy rests on four pillars (World Bank Institute 2001c):

- A supportive economic and institutional regime to provide incentives for the efficient use of existing and new knowledge and the flourishing of entrepreneurship.

- An educated and skilled population to create, share, and use knowledge.

- A dynamic information infrastructure to facilitate the effective communication, dissemination, and processing of information.

- An efficient innovation system of firms, research centers, universities, consultants, and other organizations to tap into the growing stock of global knowledge, assimilate and adapt it to local needs, and create new technology.
This chapter focuses on the role of education and training in helping build the second and fourth pillars of a knowledge economy.

Implications of the Knowledge Economy for Education and Training

Preparing workers to compete in the knowledge economy requires a new model of education and training, a model of lifelong learning. A lifelong learning framework encompasses learning throughout the life cycle, from early childhood to retirement. It includes formal, nonformal, and informal education and training.

- Formal education and training includes structured programs that are recognized by the formal education system and lead to approved certificates.
- Nonformal education and training includes structured programs that are not formally recognized by the national system. Examples include apprenticeship training programs and structured on-the-job training.
- Informal education and training includes unstructured learning, which can take place almost anywhere, including the home, community, or workplace. It includes unstructured on-the-job training, the most common form of workplace learning.

Recent knowledge and the accumulated stock of human capital are inputs in the production of new knowledge and wealth. The speed of change in the knowledge economy means that skills depreciate much more rapidly than they once did. To compete effectively in this constantly changing environment, workers need to be able to upgrade their skills on a continuing basis.

Change in the knowledge economy is so rapid that firms can no longer rely solely on new graduates or new labor market entrants as the primary source of new skills and knowledge. Schools and other training institutions thus need to prepare workers for lifelong learning. Educational systems can no longer emphasize task-specific skills but must focus instead on developing learners’ decisionmaking and problem-solving skills and teaching them how to learn on their own and with others.

Lifelong learning is crucial in enabling workers to compete in the global economy. Education helps reduce poverty; if developing countries do not promote lifelong learning opportunities, the skills and technology gap between them and industrial countries will continue to grow. By improving people’s ability to function as members of their communities, education and training also increase social capital (broadly defined as
social cohesion or social ties), thereby helping to build human capital, increase economic growth, and stimulate development. Social capital also improves education and health outcomes and child welfare, increases tolerance for gender and racial equity, enhances civil liberty and economic and civic equity, and decreases crime and tax evasion (Putnam 2001). Education must thus be viewed as fundamental to development, not just because it enhances human capital but because it increases social capital as well.

**Human Capital and Knowledge as Sources of Economic Growth**

Investment in human capital is critical for economic growth. Particularly important are new technology, its dissemination through education, and related externalities (Romer 1989; Lucas 1988; Barro 1991; Mankiw, Romer, and Weil 1992). Researchers have documented the external effects of human capital in Austria, China, and Guatemala (Winter-Ebmer 1994; Wang and Mody 1997; Sakellariou 2001). They have tied growth to knowledge in Israel and found significant spillover effects of human capital in the Republic of Korea (Bregman and Marom 1993; Feenstra and others 1999).

Technology and economic growth are strongly correlated in industrial countries. Computer hardware was linked strongly to output growth in the late 1990s, when it is estimated to have contributed as much as 2.5 percent to increases in output (table 1.1).

**Table 1.1. Contribution of Computer Hardware to Output Growth, 1990–99 (percent)**

<table>
<thead>
<tr>
<th>Country</th>
<th>Period</th>
<th>Contribution to output growth</th>
<th>Period</th>
<th>Contribution to output growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1990–95</td>
<td>0.31</td>
<td>1995–99</td>
<td>0.57</td>
</tr>
<tr>
<td>Canada</td>
<td>1990–96</td>
<td>0.28</td>
<td>1995–99</td>
<td>0.36</td>
</tr>
<tr>
<td>Germany</td>
<td>1990–96</td>
<td>0.19</td>
<td>1995–99</td>
<td>0.14</td>
</tr>
<tr>
<td>Finland</td>
<td>1990–95</td>
<td>0.00</td>
<td>1995–99</td>
<td>0.11</td>
</tr>
<tr>
<td>France</td>
<td>1990–95</td>
<td>0.00</td>
<td>1996–99</td>
<td>0.10</td>
</tr>
<tr>
<td>Italy</td>
<td>1990–96</td>
<td>0.21</td>
<td>1995–99</td>
<td>0.12</td>
</tr>
<tr>
<td>Japan</td>
<td>1990–96</td>
<td>0.19</td>
<td>1995–99</td>
<td>0.29</td>
</tr>
<tr>
<td>Singapore</td>
<td>–</td>
<td>–</td>
<td>1977–97</td>
<td>1.50</td>
</tr>
<tr>
<td>Korea, Rep. of</td>
<td>–</td>
<td>–</td>
<td>1980–95</td>
<td>2.50</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1990–95</td>
<td>0.10</td>
<td>1996–99</td>
<td>0.30</td>
</tr>
<tr>
<td>United States</td>
<td>1990–95</td>
<td>0.33</td>
<td>1996–98</td>
<td>0.82</td>
</tr>
</tbody>
</table>

– Not available.

*Source: Original sources cited in Patrinos 2001a.*
The link between education and economic growth strengthens as the rate of technology transfer increases (Sab and Smith 2001). The fact that an impact on growth is observed only in more affluent countries, where the overall level of education is higher, suggests that technology adoption is strongly linked to the education of the labor force (Pohjola 2000).

The threshold level of human capital accumulation beyond which a country may experience accelerating growth is estimated at a literacy rate of 40 percent (Azariadis and Drazen 1990). Once countries reach this threshold, they can increase growth by opening their economies to technology transfer, as Costa Rica has done (box 1.1).

The impact of education on economic growth may be as high as the private returns to education estimated in microeconomic studies (see Krueger and Lindahl 1999; Topel 1999). Estimates suggest that changes in educational attainment—as opposed to the initial level of education used in most of the macroeconomic growth literature—affect cross-country income growth at least as much as they affect microeconomic estimates of the private rate of return to years of schooling. Typically, an additional year of schooling raises incomes 10 percent; in very poor countries it can increase incomes 20 percent or more (Psacharopoulos and Patrinos 2002). Data on within-country changes in education and productivity suggest that a one-year increase in average years of schooling for a country’s labor force raises output per worker 5–15 percent (Topel 1999).

The quality of education, and therefore of labor, also affects economic growth (Barro 2001; Hanushek and Kimko 2000). Science achievement, for example, has a positive effect on growth.

**Box 1.1. Why Did Intel Choose Costa Rica as the Site of a Multimillion Dollar Plant?**

In 1996 Costa Rica beat out Brazil, Chile, Indonesia, Mexico, the Philippines, and Thailand to become the site of Intel’s $300 million semiconductor assembly and test plant. Many factors made Costa Rica attractive to Intel—its stable economic and political system, its liberalized economy, a growing electronics sector, and incentives and tax breaks—but the crucial factor in securing its selection was its educated labor force.

Since 1948, when democracy was restored, Costa Rica has placed strong emphasis on education, adopting a demand-driven approach. The government invested heavily in education and technology training, and it adopted a bilingual ESL (English as Second Language) curriculum. Computers were introduced into elementary schools as early as 1988; by 1996 many schools were equipped with them.

Technological progress is likely to raise the value of education in producing human capital (Schultz 1975). As developing countries liberalize their trade regimes and open themselves to technology transfer from industrial countries, the value of education rises. Education thus becomes more important.

Of course, the impact of education varies by country; without appropriate incentives high returns will not materialize (Pritchett 2001; Wolff 2000). As discussed in chapter 2, the quality of education is important. The productivity of schooling may be much lower in countries where the government does not promote an environment favorable to the creation of higher-paying jobs and a significant number of educated workers work in the public sector (Pissarides 2000; see also Gundlach 2001). Policies that artificially compress wage differentials also reduce the returns to post-schooling investment. This is particularly true in Sub-Saharan Africa and the Middle East and North Africa, less so in Latin America and Asia.

The literature establishes that education matters, but it does not describe the channels through which it affects growth. Large indirect effects of education, operating through intervening variables, raise the social rates of return significantly, sometimes with long delays. The size of these effects is not clear, however, with some estimates yielding negative and others yielding very high positive values (table 1.2). A study of Uganda found that a one-year increase in the average number of years of primary schooling of neighboring farmers was associated with a

<table>
<thead>
<tr>
<th>Source</th>
<th>Social return</th>
<th>Private return</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-country Mincer regressions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benhabib and Spiegel 1994</td>
<td>3.9</td>
<td>–</td>
</tr>
<tr>
<td>Benhabib and Spiegel 1994</td>
<td>Negative</td>
<td>–</td>
</tr>
<tr>
<td>Heckman and Klenow 1997</td>
<td>23.0</td>
<td>6–10</td>
</tr>
<tr>
<td>Heckman and Klenow 1997</td>
<td>10.6</td>
<td>–</td>
</tr>
<tr>
<td>Topel 1999</td>
<td>22.6</td>
<td>–</td>
</tr>
<tr>
<td>Topel 1999</td>
<td>6.2</td>
<td>–</td>
</tr>
<tr>
<td>Micro studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rauch 1993 (United States)</td>
<td>8.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Acemoglu and Angrist 1999 (United States)</td>
<td>14.6</td>
<td>7.3</td>
</tr>
<tr>
<td>Acemoglu and Angrist 1999 (United States)</td>
<td>9.1</td>
<td>7.4</td>
</tr>
<tr>
<td>Rural farmer studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appleton and Bahlhuta 1996 (Uganda)</td>
<td>4.3</td>
<td>2.8</td>
</tr>
<tr>
<td>Weir 1999 (Ethiopia)</td>
<td>56.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

– Not available.

Sources: Venniker 2000; Appleton 2000.
4.3 percent rise in output—a larger increase than the 2.8 percent effect of an increase in the farmer’s own education (Appleton and Balihuta 1996). The indirect feedback effects on per capita economic growth are estimated at about 93 percent of the total effects (direct and indirect) for the composite Sub-Saharan Africa average (Appiah and McMahon 2002). In the more advanced African countries, indirect feedback effects account for about 48 percent of the total.

Education also has an important effect on several nonmarket outcomes, including crime reduction, social cohesion, income distribution, charitable giving, and more efficient labor market search. The annual value of one year of schooling on these outcomes is about the same as the annual earnings-based effects. That is, the value of incremental schooling reported in standard human capital estimates may capture only about half of the total value of an additional year of schooling (Wolfe and Have- man 2001).

Education has an important effect on female productivity in the labor market. Even more important are the positive effects on female labor supply; the associated declines in fertility; and the improvements in the health, education, and life chances of the children of educated women. There is a strong linkage between mothers’ education and children’s development. In India, for example, children raised by literate mothers are more likely to study two additional hours a day than children of illiterate mothers (World Bank 2001f). These findings have important implications for economic growth and lifelong learning from an inter-generational perspective.

The State of Education in Developing Countries and Transition Economies

Education is inadequate in most developing countries. Coverage is insufficient, access is inequitable (especially in tertiary [higher] education and in employee and adult training), and the quality of education is poor. Adult literacy rates are low, and too few children complete basic education. The goal of education for all remains elusive in many low-income countries.

In the transition economies of Europe and Central Asia, the quality of education is inadequate and the education system is too rigid. Rote learning, exam-driven schooling, and the soaring cost of private education have long been policy concerns in some Asian countries.

Evidence from international assessments of students suggests that some developing countries and transition economies lag significantly behind industrial countries in providing their people with the skills needed in the knowledge economy (see chapter 2). Policy actions are
needed to reduce inequities in the distribution of learning opportunities and discrepancies in the incidence of the costs and benefits of education.

Developing countries and transition economies face the dual challenge of addressing the longstanding issues of access, quality, and equity while moving toward a lifelong learning system. Basic education and skills remain the foundation of lifelong learning, and countries with low or declining basic education coverage must set increasing coverage as their top priority. The quality and nature of the learning process must change, however, and outcomes must improve.

**Increased Demand for Skills**

Increasing returns to schooling and rising wage inequality are well documented for some industrial countries and a few developing countries in the 1980s and 1990s. These changes partly reflect the important technological developments that took place during this time.

**Rising Returns to Schooling**

A reversal of the 1970s trend of declining rewards to higher education and falling rates of return to schooling occurred in the United States and other industrial market economies in the 1980s and 1990s. The gap in wages between educated and less educated workers widened significantly during the 1980s (table 1.3). Between 1978 and 1987 the rate of return to edu-

### Table 1.3. Value of Higher Education in Industrial Countries, 1970s–1990s

<table>
<thead>
<tr>
<th>Decade</th>
<th>Country</th>
<th>Year</th>
<th>Wage ratio (higher/secondary)</th>
<th>Year</th>
<th>Wage ratio (higher/secondary)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970s</td>
<td>Canada</td>
<td>1970</td>
<td>1.65</td>
<td>1980</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>Sweden</td>
<td>1968</td>
<td>1.40</td>
<td>1981</td>
<td>1.16</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>1974</td>
<td>1.64</td>
<td>1980</td>
<td>1.53</td>
</tr>
<tr>
<td></td>
<td>United States</td>
<td>1969</td>
<td>1.49</td>
<td>1978</td>
<td>1.35</td>
</tr>
<tr>
<td>1980s</td>
<td>Canada</td>
<td>1980</td>
<td>1.29</td>
<td>1989</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>Sweden</td>
<td>1981</td>
<td>1.16</td>
<td>1986</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>1980</td>
<td>1.33</td>
<td>1989</td>
<td>1.46</td>
</tr>
<tr>
<td></td>
<td>United States</td>
<td>1979</td>
<td>1.47</td>
<td>1987</td>
<td>1.52</td>
</tr>
<tr>
<td>1990s</td>
<td>Canada</td>
<td>1992</td>
<td>1.62</td>
<td>1997</td>
<td>1.48</td>
</tr>
<tr>
<td></td>
<td>Sweden</td>
<td>1992</td>
<td>1.60</td>
<td>1998</td>
<td>1.36</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>1992</td>
<td>1.71</td>
<td>1999</td>
<td>1.59</td>
</tr>
<tr>
<td></td>
<td>United States</td>
<td>1992</td>
<td>1.64</td>
<td>1999</td>
<td>1.83</td>
</tr>
</tbody>
</table>

*Sources: Patrinos 2001a; OECD 1992, 2001b.*
cation for male workers in the United States rose from 7.9 percent to 9.2 percent, and the average number of years of schooling increased from 12.6 to 13.3 years (Ryscavage and Henle 1990).

Increasing wage disparity was particularly severe in the rapidly expanding service sector, where the decline in the variance in schooling was most dramatic. Ryscavage and Henle (1990) found that among white-collar workers classified as administrators, officials, and sales workers, more educated workers increased their earnings advantage over less educated workers. The wages of educated workers in traded services increased the most, while goods industries that were declining, such as manufacturing, experienced decreases in output, employment, and wages (Murphy and Welch 1991).

The decline in earnings differentials in the mid- to late 1990s suggests that the supply of education caught up with demand. It is noteworthy, however, that in the industrial country with the highest growth during this period, the United States, the demand for educated labor resulted in an increase in earnings differentials between those with higher education and those with only secondary education.

In most lower-income countries for which comparable data are available, the returns to primary schooling have declined with the expansion of the supply of education. This is not to say that the returns to schooling are low. On the contrary, returns to schooling are highest in lower-income countries (figure 1.1). As universal primary education is achieved, shortages of skills in the labor force occur more at the junior and senior secondary levels, and the relative returns to these levels of education rise.

**Figure 1.1. Private Returns to Investment in Education, by Level of Education and Country Income Group (percent)**

![Private Returns to Investment in Education, by Level of Education and Country Income Group](image)

*Source: Psacharopoulos and Patrinos 2002.*
Later, as universal secondary education is nearly achieved, relative shortages occur for people with still more advanced skills, and the rates of return to two- and four-year college degrees are highest.

In middle-income countries, the earnings ratio appeared to trend downward in the few countries for which 1980s data are available (table 1.4). By the 1990s, however, the trend was clearly upward in the Czech Republic, Greece, and the middle-income Latin American countries.

Between 1980 and 2000 the proportion of the population with higher education rose from 7 to 20 percent in Argentina, from 5 to 8 percent in Brazil, from 7 to 16 percent in Chile, from 9 to 11 percent in the Czech Republic, from 8 to 14 percent in Greece, from 8 to 13 percent in Uruguay, and from 7 to 18 percent in Venezuela (Barro and Lee 2000). Returns to schooling increased in Mexico for higher levels of schooling, particularly university-level education. In Brazil returns to higher education rose from 16 percent in 1982 to 20 percent in 1988 (figure 1.2). This evidence suggests that there is increased demand for highly skilled labor, especially in countries with open markets.

The relative supply of skilled labor increased at the same time that trade liberalization in Chile, Colombia, Costa Rica, Mexico, and Uruguay increased demand for partly skilled labor more than demand for unskilled labor (Robbins 1996; World Bank 2002h). This suggests that labor demand in these countries has shifted toward workers with above-average skill

Table 1.4. Higher/Secondary Education Earnings Ratios in Middle-Income Countries, 1980s–1990s

<table>
<thead>
<tr>
<th>Country</th>
<th>1981 Ratio</th>
<th>Years of schooling</th>
<th>1985 Ratio</th>
<th>Years of schooling</th>
<th>1990 Ratio</th>
<th>Years of schooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>2.44</td>
<td>6.62</td>
<td>1.71</td>
<td>7.77</td>
<td>1.66</td>
<td>8.12</td>
</tr>
<tr>
<td>Brazil</td>
<td>2.30</td>
<td>2.98</td>
<td>2.01</td>
<td>3.76</td>
<td>2.59</td>
<td>4.17</td>
</tr>
<tr>
<td>Chile</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2.96</td>
<td>7.53</td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>–</td>
<td>–</td>
<td>1.29</td>
<td>9.39</td>
<td>1.63</td>
<td>9.38</td>
</tr>
<tr>
<td>Greece</td>
<td>1.62</td>
<td>6.56</td>
<td>1.25</td>
<td>6.95</td>
<td>1.28</td>
<td>8.05</td>
</tr>
<tr>
<td>Uruguay</td>
<td>1.54</td>
<td>5.75</td>
<td>1.54</td>
<td>6.69</td>
<td>1.88</td>
<td>6.88</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1.82</td>
<td>4.93</td>
<td>1.72</td>
<td>4.89</td>
<td>1.82</td>
<td>5.48</td>
</tr>
</tbody>
</table>

Notes:
- Ratio = earnings of learners with higher education over earnings of learners with secondary education.
- Data are for 1980.
- Data are for 1990.
- Data are for 2000.

Sources: Patrinos 2001a; Carlson 2001; Klazar, Sedmihradsky, and Vancurova 2001; World Bank 1998g. Years of schooling are from Barro and Lee 2000.
levels, thereby increasing income inequality (Slaughter and Swagel 1997). In Mexico and Venezuela a higher level of foreign investment in an industry—often one employing better-educated workers—is associated with higher wages in that industry, also contributing to rising inequality (Aitken, Harrison, and Lipsey 1996). In Poland wages and growth rates are higher in industries with greater foreign presence (Bedi and Cieoelik 2002). In transition economies the longer the reform process—and therefore the longer market forces, openness, and foreign investment have been allowed to operate—the higher the premium to education over time (World Bank 2002e).

If the incomes of more educated workers continue to rise despite an increase in their numbers, demand for these workers can be assumed to have risen more than supply. If increases in demand continue to outstrip increases in supply, returns to schooling (and income inequality) will continue to increase (Psacharopoulos 1989; Tinbergen 1975; see also Welch 1970). The relationship can be viewed as a “race between education and technology” (Tinbergen 1975).

Technological Change and the Demand for Skilled Labor

The rise in earnings inequality can be explained by changes in technology, the production process, work organization, and patterns of international trade (Wood 1994). Changes in the production process led to changes in the demand for certain types of labor. Organizational and technological changes may have caused the shift in demand to dominate the shift in supply, leading to a rise in returns to schooling and increased earnings inequality in advanced economies and some middle-income countries.

In Malaysia widespread adoption of ICTs has been associated with wage and productivity gains (Tan 2000). Significant “learning effects” occur with experience using ICTs, and productivity gains increase with training (Berman and Machin 2000). Skill-biased technology transfer is central to the increased demand for skilled workers in middle-income countries (Berman and Machin 2000).

Education supports innovation and helps speed the diffusion of technology. It not only facilitates learning and communication but also increases substantially the ability to deal creatively with change. Educated workers have a comparative advantage with respect to adjustment to, and implementation of, new technologies (Bartel and Lichtenberg 1987, 1988). Because better-educated workers usually have a broader set of basic skills, it is easier for them to assimilate new knowledge, and their earnings rise more quickly than those with lower educational levels (box 1.2). Better-educated people are also better able to deal with economic

Box 1.2. Technological and Organizational Change: A Case Study of a Commercial Bank in the United States

Technological change can have vastly different effects, even on departments within the same institution. The same technological change can result in both computer-labor substitution and computer-skill complementarity (skill-biased technological change), depending on the nature of work and the organization of the workplace. Technological change and organizational change are interdependent. Conceptual and problem-solving skills are one set of skills that are likely to be made more valuable by ICTs. To examine how computer technology complements skilled labor, the study looked at what computers do to model and test how computers alter the demand for skilled labor. It found that computers are associated with declining relative demand in the industry for routine skills and increased demand for nonroutine cognitive skills.

disequilibria (Schultz 1975). Firms undergoing rapid technological change want to employ better-educated and more talented workers, in whom they are also more willing to invest in training and retraining. Thus the more volatile the state of technology, the more productive education is (Nelson and Phelps 1966; Welch 1970).

**Migration**

Another indicator of the premium to human capital is migration of people from their home countries to countries in which their skills, and the benefits of their educational investment, are more highly rewarded. About 120 million people (2 percent of the world’s population) live in countries in which they were not born (most of these immigrants are lower-skilled workers). The main economic rationale for moving is higher wages and greater employment opportunities. Migration, which is costly in terms of time and out-of-pocket expenditures, represents a form of human capital. It is a powerful means of raising incomes and promoting the diffusion of knowledge. From a global perspective, economic welfare is increased if people are more productive abroad than they would have been in their home country (box 1.3). Migrants thus increase world welfare, including in the country they left.

In the short term, migration, especially the migration of highly skilled people, can hurt the source country. The loss of people who provide vital public services—doctors, information technology specialists, teachers—can retard low-income countries’ development, even if the number of such emigrants is small. Migration may prevent the source country from being able to reach the critical mass of human capital that may spark innovations, in entrepreneurship or knowledge creation, adaptation, and

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**Box 1.3. Impact of Migration of Technology Graduates from India**

About 40 percent of India’s technology graduates leave the country and do not return. In 1998 Indian engineers were running more than 775 technology companies in California’s Silicon Valley—companies that together billed $3.6 billion in sales and employed 16,600 people. About 40 percent of Silicon Valley start-ups were established by Indians.

Although many Indians never return to their native country, most eventually invest in India and contribute to the development of the local information technology industry. Many Indian expatriates invest in Bangalore, in southern India, the Silicon Valley of India. Other benefits include remittances and investments in homes.

use. A migrant may increase the supply of goods and services only to already wealthy inhabitants of the recipient country. The higher salary earned by a doctor, for example, may reflect the greater ability of rich people to pay for medical services. Given funding sources, the creativity of highly skilled researchers may be used to conduct research on problems that are of primary concern to the industrial world rather than their home countries.

Migration pressures will continue to mount in developing countries, especially for highly skilled workers, as countries trade more openly. Industrial countries could help ease these pressures by opening their doors to the less skilled as well as to highly skilled migrants (World Bank 2002e).

Source countries could help by adopting economic and other policies that make effective use of human capital in both public and private sectors and motivate migrants to return. These policies, which need to differentiate between the pressures on low- and high-skilled people, include not only economic but political considerations.

In countries that have closed the gaps at the secondary and tertiary levels but lack a large number of high-quality research centers or doctoral and postdoctoral graduate programs, investments in such programs make good sense. Several countries have innovative programs designed to repatriate and retain high-quality researchers, many of whom were trained at top universities abroad. In Mexico, for example, monthly grants are given to top researchers. The program helps repatriate Mexicans who completed their Ph.D.s abroad and who want to engage in scientific research activities in Mexico. By 2000 the program provided grants to about 7,500 registered researchers, 15 percent of whom had become involved through the repatriation program.

Policymakers also need to examine the pricing and financing of higher education, as well as taxation. In many countries, free or low-cost higher education combined with high marginal tax rates encourage high demand for higher education but also emigration.

Women, Technology, and Education

Gender inequality in access to all levels of schooling persists in most regions of the developing world, with the exception of Latin America. Gender differences in tertiary education enrollments are particularly pronounced in the Arab world, in some countries in Sub-Saharan Africa, and in South Asia. Even in countries where gender parity in education has been achieved, girls are often channeled into disciplines that lead to low-paying jobs. In Africa, Asia, and Latin America and the Caribbean, women’s enrollment in engineering is low, ranging from less than 2 percent
in Kenya to 27 percent in Colombia. In medical and health-related courses, female enrollment rates range from 25 percent in Kenya to 68 percent in Nicaragua (World Bank 2002d, 2002h). Throughout the world female participation in on-the-job training is significantly lower than male participation, in part because women often work in the informal sector or have lower educational attainment (OECD and Statistics Canada 2002).

The low level of education attainment by females has negative consequences for society as a whole, especially given the importance of mothers’ education for student achievement. Results of the Programme for International Student Assessment (PISA) show that in reading, math, and science literacy, students whose mothers had received higher education performed considerably better than those whose mothers had received only primary or secondary education (OECD 2001e).

The implications of gender disparity in education are enormous given the importance of education in the knowledge economy. Much more effort needs to go toward achieving gender equity at the basic education level. While primary education is a foundation for further learning, however, it is clearly not enough. Countries must increase female participation at the upper secondary level. Ensuring equal access to higher levels of education and employment training, especially in science and engineering, is essential if a country is to be able to compete in the knowledge economy. Countries will not achieve education for all if gender inequality persists.

To expand the pool of women who pursue careers in science and technology, policymakers need to ensure that careers and role models are not stereotyped as gender specific. They need to develop measures to interest girls in science and math before they reach the tertiary level. Governments could, for example, train more female teachers in science and math, who could serve as role models for girls.

But targeting individuals is not enough. New institutional and organizational arrangements that ensure female students’ access to higher levels of education must be created, women must be hired as faculty members, and female researchers must participate in research and development activities. At the same time, governments need to overhaul their own staffing policies and practices to interest more female science and engineering majors in public sector careers. More could be done to increase public awareness on gender equality by, for example, publishing statistics on gender inequality in job opportunities and wages. Increasing female participation in on-the-job training might require reform of labor regulations that allow employers to reduce women’s access to jobs that provide such training (by hiring them only on a temporary basis, for example, or limiting promotion out of fear that women will have children and leave the labor force).
Employer Demands and Private Education
Sector Responses

In the rapidly changing knowledge economy workers must constantly acquire new skills. In this environment, firms can no longer rely solely on new graduates or new labor market entrants as the primary source of new skills and knowledge. Instead, they need workers who are willing and able to update their skills throughout their lifetimes. To support the new demands, the private sector is playing a growing role in education and training throughout the world.

Employer Demands and Employee Training

In traditional industries most jobs require employees to learn how to perform routine functions, which, for the most part, remain constant over time (Nelson and Phelps 1966). Most learning takes place when a worker starts a new job—through formal and informal apprenticeship programs and informal on-the-job training, for example. During this initial training either the worker accepts lower wages while investing time in training (in which case the worker bears the costs) or the employer absorbs the costs in the form of forgone production by the trainee.

Learning also occurs in household production and community activities. This informal investment of time over the life cycle is a large and important part of the total investment in lifelong learning, but it is usually unobserved and undocumented.

The current rate of technological change has raised the skill requirements of most jobs and placed a premium on flexibility. Most workers require supplementary skills to remain competitive in their current jobs. Policies need to reflect this change, by creating incentives to keep people learning throughout their working lives (OECD 2001a).

In Colombia, Indonesia, Malaysia, Mexico, and Taiwan (China) training has a positive and statistically significant impact on firm-level productivity (Tan and Batra 1995). But not all workers have the same access to training. Employers do not train unskilled workers to the same extent as more highly educated workers. Tan and Batra (1995) found that larger firms, especially multiplant firms, are more likely to provide formal training for skilled workers. Enterprise training, especially in-house training, is most common at high-tech firms, firms relying on advanced technologies, firms with semi- or fully automatic production lines, and export-oriented firms. For workers in small or microenterprises, particularly firms that are not exposed to international markets and in which workers have low educational attainment, the gap between those who have access to skill upgrading—and hence higher productivity and
higher wages—and those who do not will grow. With few exceptions govern-
ment policies to encourage training in small and medium-size enter-
prises, through training levies or even grants, have not been very suc-
cessful (Ziderman 2001). Providing such training represents a major chal-
lenge for all countries, especially those in which large proportions of
the labor force work in the informal sector.

The provision of education and training is now a global market. The
global market for education is estimated at more than $2 trillion a year
(Moe, Bailey, and Lau 1999). In the late 1990s more than 1.5 million peo-
ple pursued higher education outside their home countries, in a market
worth almost $30 billion (WTO 1998). While one-third of the global mar-
ket is in the United States, a sizable 15 percent is in developing countries
and transition economies (Vawda and Patrinos forthcoming).

Corporations are spending more and more on training to become com-
petitive in the global knowledge economy (box 1.4). International Data
Corporation (www.idc.com) estimates that worldwide corporate training
expenditures reached $28 billion by the end of 2002, up from $18 billion
in 1997. In 1999 about one-third of the $100 billion for-profit education
industry in the United States came from corporate and government train-
ing (Moe, Bailey, and Lau 1999; www.eduventures.com).

In another sign of the growing global market, the World Trade Organi-
zation (WTO) has begun negotiations over trade in services, including edu-
cation. The General Agreement on Trade in Services (GATS) came into force
in January 1995. It is the first and only set of multilateral rules covering
international trade in services. Negotiated by governments themselves, it
sets the framework within which firms and learners can operate. One of the
most significant achievements of the Uruguay Round, the GATS offers for
trade in services the same stability that arises from mutually agreed on
rules, binding market access, and nondiscriminatory commitments that the
General Agreement on Tariffs and Trade (GATT) has provided for trade in
goods for more than five decades. However, education remains one of the
sectors in which WTO members have been least inclined to make liberal-
ization commitments (Larsen, Morris, and Martin 2001). By 2003, 53 coun-
tries had made commitments for at least one education subsector.

Growth of the Private Education and Training Sector

The private education and training sector is growing, not only in the
United States and other industrial economies but also in low-income
countries, including many in Africa. In the United States the number of
two-year for-profit degree-granting institutions grew 78 percent and the
number of four-year institutions grew 266 percent between 1990 and 2001
(Newman and Couturier 2002). In Brazil the number of tertiary education
Finland transformed its economy from one based on exports of natural resource–based products to one based on exports of high-tech products. As late as 1990, computer and telecommunications products accounted for less than 7 percent of Finnish exports; by 2000 the share had increased to nearly 30 percent. Finland made this transformation by steadily establishing an environment that enables innovation and the adaptation of technologies.

By the early 1900s Nokia, Ltd., was the largest pulp and paper mill in Finland. Three companies—Nokia, Finnish Rubber Works, and Finnish Cable Works—formed a conglomerate that drew heavily on imported technology. All three companies benefited from access to the large Russian market.

In 1967 the three companies merged, establishing four divisions: paper, cable, rubber, and electronics. For many years the electronics division was not profitable, but Nokia made sure that the division had access to the latest technology. By the early 1970s the electronics division grew with the expansion of the public radiotelephone system, originally developed by Finnish Cable Works.

In 1977 Nokia decided to transform itself from a producer of paper, tires, and cable to a global electronics giant. The company knew it lacked the necessary skills and experience to compete in the international market, however. Raising the level of human resources was essential for Nokia to be able to absorb and diffuse the skills and knowledge it obtained through acquisitions from, and strategic alliances with, technologically advanced foreign firms. It thus engaged in an aggressive human resource development program within the company that encouraged work abroad in foreign affiliates. At the same time Nokia’s Chief Executive Officer, Kari Kairamo, was involved in modernizing the public education system, establishing broad international student-exchange programs, fostering continuous lifelong learning, and promoting close collaboration between industry and academia. By forming strategic alliances with foreign firms and strengthening human capital, Nokia prepared itself to compete in the global telecommunications market by the late 1980s.

Sources: Blomström and Kokko 2001; World Bank 2002d.
institutions grew more than 70 percent between 1995 and 2002, with most of the growth occurring in private colleges and universities, which accounted for 71 percent of higher education enrollment in 2002 (Souza 2002). In the late 1990s, 15–20 percent of all students in Côte d’Ivoire, Gambia, and Senegal attended private institutions. In Côte d’Ivoire, Gambia, Ghana, Senegal, and Zimbabwe, 11–14 percent of all primary education students attended private institutions. In Côte d’Ivoire enrollments in private institutions rose 20 percent at the primary level, 33 percent at the secondary, 140 percent at the technical/professional secondary, and almost 670 percent at the higher education level between 1991 and 1995. In Gambia private school enrollments increased 41 percent at the primary level, 123 percent at the junior secondary level, and 20 percent at the senior secondary level between 1993 and 1996. In Ghana enrollments in private primary schools increased 344 percent between 1986 and 1996 and accounted for 13 percent of all primary enrollments in 1997. In Senegal enrollments in private primary institutions increased 123 percent between 1987 and 1997, when they accounted for more than 12 percent of all primary enrollments (IFC 2001).

The private sector is growing rapidly in transition economies as well. Poland has 195 private higher education institutions, enrolling more than 377,000 students. Since the government gave permission for private universities to exist in the late 1990s, the Czech Republic has 26 private higher education institutions. Private business schools—unheard of in Eastern Europe 10 years ago—are also thriving: in 1998 there were 91 private business schools in Poland, 29 in the Czech Republic, 18 in Romania, and 4 in Bulgaria. Between 1995 and 1999, 500 new higher education institutions were established in China.

The growth of the private education sector signals an important change in the market for education. Clearly the demand for more and better education is increasing. The growth of the education industry in industrial countries has much to do with dissatisfaction with the traditional education and training system. It also reflects the fact that employers are looking for workers able to learn new skills while employed.

The global knowledge economy and the impact of technology on education are driving this change. Technology affects the delivery of education, giving an edge to providers able to offer flexible learning opportunities. In many middle-income countries, the private education sector is growing, a reflection of the need to expand schooling opportunities, relieve the fiscal burden, and promote innovation (Tooley 1999). Even in low-income countries private education is growing, in an attempt to keep up with technological developments and access global knowledge (Vawda and Patrinos forthcoming). Market forces are thus playing an increasing role in education around the world (Patrinos 2000).