The Human Factor in Innovation

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This chapter will analyse and discuss major global trends related to the presence of skilled labour in countries, drawing on aggregated data collected by UNESCO through its Institute for Statistics (UIS) and other international organizations. Although there is a rich literature on the relation between skills and innovation, it is not possible in this chapter to delve deeply into that literature and explore the data accordingly. Such an analysis would require both more space than is available here and a micro-econometric data analysis. The data presented here are nationally aggregated data that do not allow for such detailed consideration.

The role of innovation

Innovation is instrumental to the increase of human well-being. It can make a difference in addressing urgent developmental challenges such as providing access to drinking water, eradicating neglected diseases, and reducing hunger. Technology and technological advances are a key component of innovation—they raise productivity and, by extension, contribute to economic growth.[1] Particularly in high- and middle-income economies, the evidence of innovation's vital importance is overwhelming, but it is important for economies at all stages of development, although different types and degrees of innovation play different roles at various stages. In order for low- and middle-income countries to reach per capita income levels similar to those of the richest economies, they need to expand both their access to technology and their capacity to use it.[2] This process of 'catching up' generally occurs through imitation and technology acquisition rather than independent research and experimental development (R&D) and innovation.[3] However, technology transfer itself poses substantial problems of adaptation and absorption that are related to investments in technological capability. A successful transfer requires a complex array of skills, knowledge, and organizational structures in order to operate a technology efficiently and accomplish any process of technological change.[4]

Skills for innovation

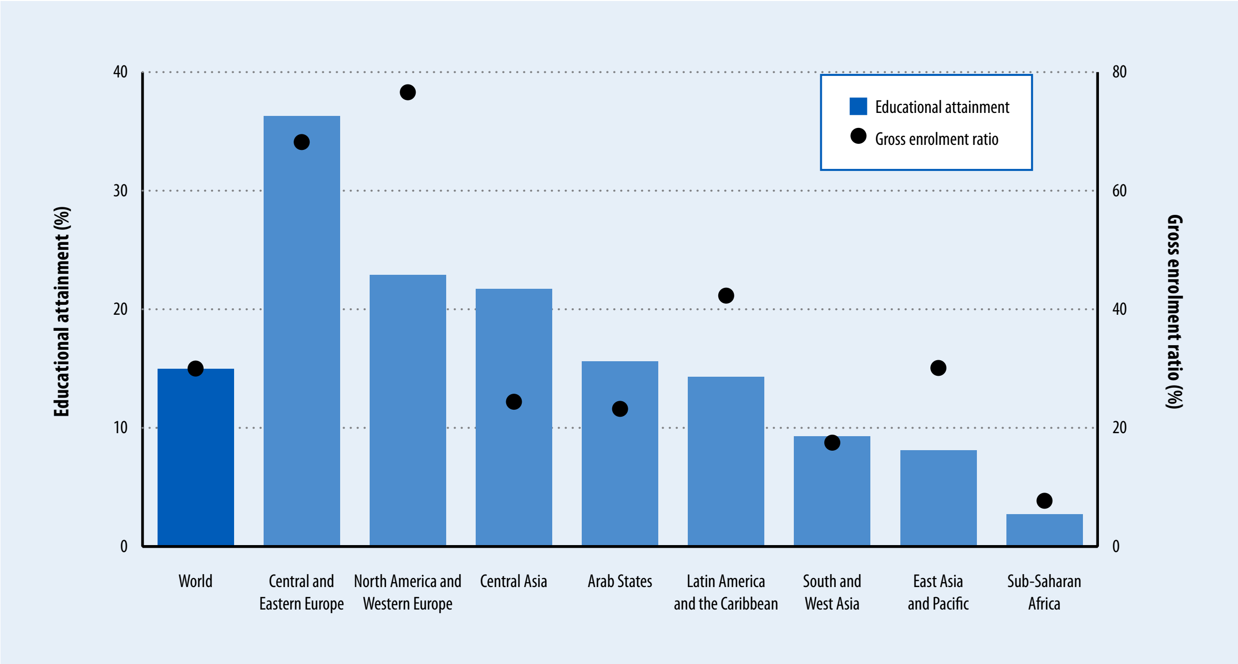
Innovation depends on people who are able to generate and apply knowledge and ideas in the workplace and in society at large, but explicit links between specific skills and innovation are difficult to establish.[5] And although a 'strong connection between education and economic development has often been proposed, the content, mechanisms, and outcomes of this link remain a matter of debate'.[6] The broad definitions of skills and innovation, the difficulty of measuring human capital and innovation outputs and outcomes, and the relative scarcity of innovation-specific empirical studies all serve to limit the clear identification of such relationships. Furthermore, no simple or unambiguous connection exists between a given innovation or technology and the demand it makes for skilled workers.

> How a technology is deployed is mediated by many factors, most notably [...] by firm strategies and work organisation methods. Moreover, the direction of causation is ambiguous: skills and knowledge are both an input and output of innovation. Implementing a particular innovation often requires training a workforce and use of a given innovation by the workforce in the production process and consumption gives rise to incremental improvements to the original innovation'.[7]

To take maximum advantage of R&D and other innovative activities being carried out in a country, framework conditions conducive to innovation are vital. The most important condition is the presence of a large, well-educated stock of human capital, which helps countries accelerate technological catch-up.[8] The connection between human capital and innovation in low- and middle-income countries, and its corresponding impact on productivity, stems mainly from the

Terminology on states and territories used throughout this chapter is that of UNESCO and differs from UN common practice.

Figure 1: Proportion of population aged 25 years and older with tertiary education and gross enrolment ratio in tertiary education, by region (2011, %)



Source: UIS Data Centre, accessed January 2014.

Notes: Based on data for the latest year available for 114 economies; no estimations were made. The 'gross enrolment ratio' (GER) for tertiary education is defined as the number of students enrolled in tertiary education, regardless of age, expressed as a percentage of the five-year age group starting from the official secondary school graduation age. The composition of the regions can be found in the annex at the end of this chapter.

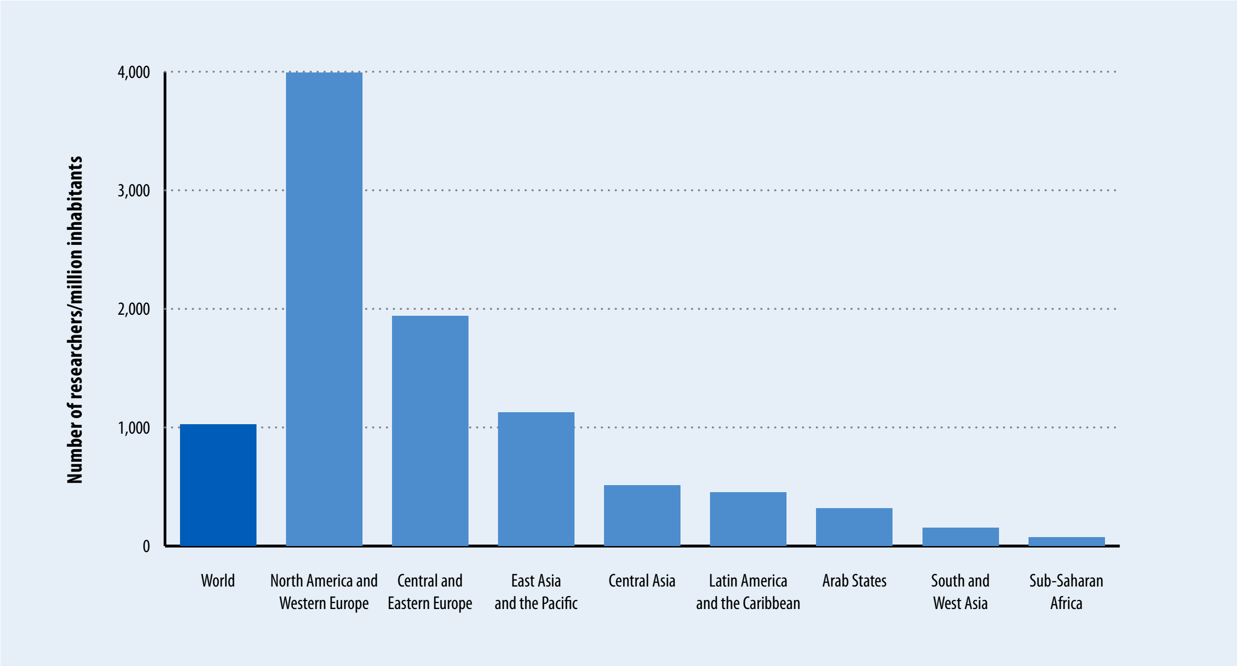
contribution of skilled workers dedicated to adapting existing technologies.[9] The negative effect of a large, poorly educated population is the primary reason for poor innovative performance. Positive externalities from higher educational attainment are found in the form of both a higher rate of innovation and more rapid technology transfer.[10] The existence of skilled labour is a more decisive element in the transmission of tacit knowledge than university or industry research.[11] Improving human capital through formal education and continuous R&D activities increases firms' absorptive capacity, thereby facilitating technology adoption and mastery. The chain reaction that results from a more highly skilled labour force offers possibilities for generating improvements and follow-up innovations.[12]

Higher education and educational attainment

Although the link between a country's stock of highly educated people and its wealth is not clear-cut or direct, correlations can be observed. Analysing enrolment rates in tertiary education provides an indication of whether and how this situation may change in the years to come. Figure 1 shows the proportion of the population over 25 years old that has completed tertiary education, broken down by region on the primary axis. The figure also shows regional averages for the gross enrolment ratio (GER) in tertiary education for the year 2011 on the secondary axis.

What stands out is that the highest proportion of population with a university degree is found in Central and Eastern Europe, at 36%—far ahead of richer North America and Western Europe (23%) and also ahead of Central Asia (22%). At the other end of the scale, and more according to expectations, we find Sub-Saharan Africa at only 3%. The data further show that the highest enrolment ratio is found in North America and Western Europe, indicating that this region is catching up in educational attainment—but only slowly, because the countries in Central and Eastern Europe follow closely. The two regions that follow—Latin America and the Caribbean and East Asia and the Pacific—are adding more people with a tertiary education to their populations than the other regions, and will therefore over time move up in the rankings. It is noteworthy that the global enrolment ratio, at 30%, is double the global stock of people with a tertiary education, meaning that more people are pursuing tertiary education than in the

Figure 2: Researchers per million inhabitants (2009)



Source: UIS Data Centre, accessed January 2014; data calculated December 2011.
Note: The composition of the regions can be found in the annex at the end of this chapter.

past. Looking at the evolution of the global GER over the last decade, the premium placed on a higher education degree becomes clear. There has been an explosion in enrolment in tertiary education, with the global GER almost doubling between 1998 and 2011. This growth has been uneven across regions, however. The highest growth rates are in Asia, with the exception of Central Asia, where the GER even decreased after 2007.

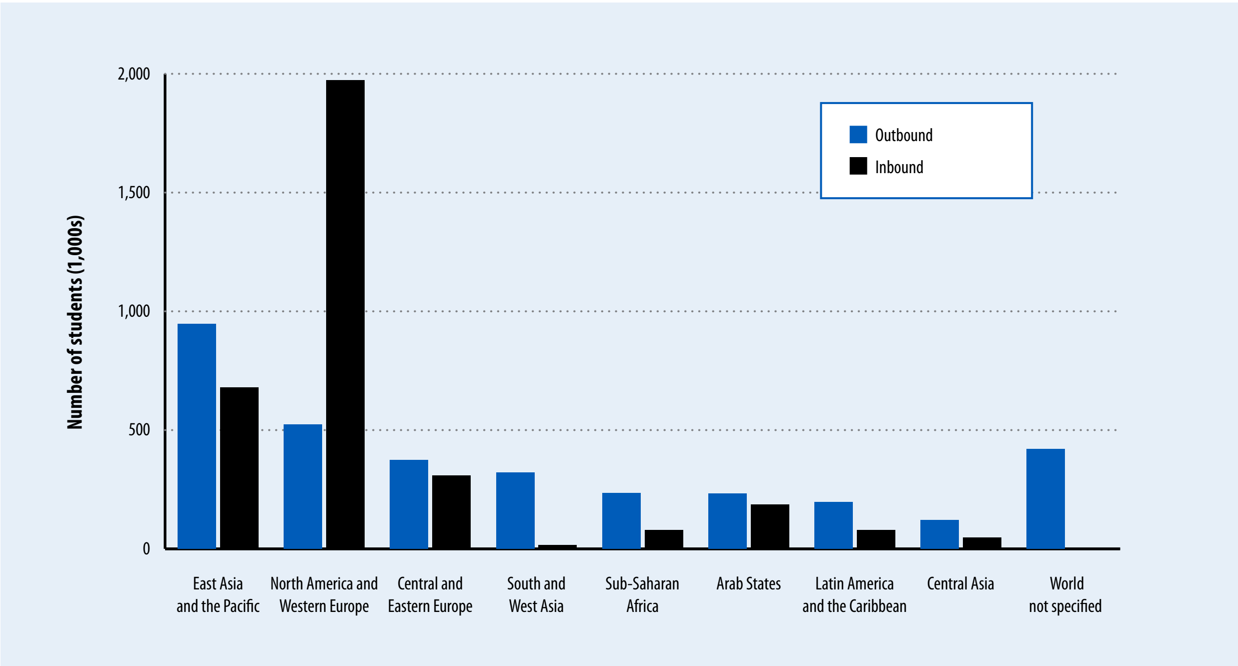
Research and experimental development

Since World War II, investment in R&D has been regarded as one of the key strategies needed to secure technological potential and, therefore, innovation and economic growth. However, R&D is unprofitable for low levels of human capital; it becomes profitable only when human capital reaches a certain threshold.[13] This implies a correlation between the data shown in the previous section and the volume of R&D carried out in economies. Figure 2 sheds light on this.

Figure 2 shows the strong correlation between the educational attainment and enrolment (GER) shown in Figure 1 and the number of researchers. The two regions with the highest numbers of people with a tertiary education and with the highest enrolment ratios in higher education are also the two regions with the most researchers as a proportion of the total population: North America and Western Europe and Central and Eastern Europe. At the other end, South and West Asia and Sub-Saharan Africa have the fewest highly educated people and the fewest researchers. East Asia and the Pacific deserves a special mention, as it ranks higher on the share of researchers in the population than it does on the attainment scale. This region is dominated by China, which has not only been extensively expanding its higher education system, but has enlarged its research system even more.

Digging a bit deeper into the data contributes a perspective on the role of women in research. Although globally more girls than boys enter university, at the PhD level, even though they are close, the share of girls drops below 50%. However, the proportion of women in research shows a particularly large gap, with women making up only 30% of the global research population. This gap can be observed not only in the poorer parts of the world, but also in the richer parts. Various explanations are offered, including gender stereotyping and working conditions that are unfavourable for women, especially during their childbearing years. The fact remains, however, that a great deal of potential remains unused, and governments should

Figure 3: Internationally mobile students, thousands (2009)



Source: UIS Data Centre, accessed January 2014.
Notes: 'Internationally mobile students' (or 'mobile students') are those who have crossed a national border and moved to another country with the objective of studying. The composition of the regions can be found in the annex at the end of this chapter.

take action to tap into this pool of potential researchers.

Despite the observed correlations among attainment, enrolment, and the number of researchers, more elements are at play than skills alone. For example, in the Community Innovation Survey 2010[14]—when firms in the European Union were asked which factors were the most important obstacles to innovation—the lack of qualified personnel as a highly important factor hampering innovation activities on average ranked only 6th for innovative enterprises and 7th for non-innovative enterprises out of 11 factors proposed.[15] The UIS is currently collecting global innovation statistics. When the results are released in July 2014, the lack of skills will be an indicator that can be studied for many more countries.

International mobility

The last decades have seen an explosion in the cross-border traffic of people of all skill levels. In this migratory trend, the most relevant factor for innovation is the movement of highly skilled people, whether they are students or experienced professionals. Figure 3 shows the number of internationally mobile students in 2009.

In 2009, almost 3.4 million students were studying abroad. By far the most popular destinations were the developed economies of North America and Western Europe—this was the only region with a net inflow. It received close to 2 million students, of which about one-third attended university in the United States of America (USA). Mobility is of course not limited to students. The Careers of Doctorate Holders (CDH) survey—developed by the Organisation for Economic Co-operation and Development (OECD), the UIS, and Eurostat[16]—includes a module on international mobility. According to Auriol et al., '[t]he 2009 CDH figures reveal that, in the countries for which data are available, an average of 14% of national citizens with a doctorate have been internationally mobile in the previous 10 years';[17] furthermore, 'the USA steadily appears among the three first destination countries [...]. Likewise, the three largest EU countries (France, Germany, and the United Kingdom) appear among the favourite destinations, as well as those countries with strong historical, cultural, or linguistic links with the reporting country'.[18]

The CDH indicators provide interesting information on international mobility, but they do not enlighten us about the migration patterns of doctorate holders and the possible resulting brain drain for economies. The data at hand are too sparse and insufficiently robust to allow such analysis. In order to study migration better, the OECD has compiled data on migrant stocks from a wide array of origin countries. This database (called DIOC-E) covers 89 destination countries and includes information on 110 million migrants aged 15 and over.[19] Of all migrants in the database, 68% live in OECD countries; the remaining 32% live in the non-OECD countries currently included in the database. Low-skilled migration to both OECD and non-OECD countries still dominates in absolute terms. However, the emigration rate for highly skilled persons exceeds the total emigration rate in all regions, which reflects the selective nature of migration. The magnitude of the global emigration rate of highly skilled persons from Africa is striking: it is estimated at 10.6% (9.7% for migration to OECD countries), compared with other regions of origin and the world average of 5.4% (4.3% to OECD countries).[20]

Historically, the USA has been the destination of choice of many science and engineering (S&E) students and workers. This continues to be the case. The National Science Foundation's *Science and Engineering Indicators* provides interesting information on foreign-born scientists and engineers in the USA. For example, in 2011, foreign-born individuals accounted for 21% of workers employed in non-academic S&E occupations in the USA, which is higher than their representation in the overall population (13%).[21] Furthermore, in most S&E occupations, the higher the degree level, the greater the proportion of the workforce who are foreign born: workers from overseas range from between 13% and 23% at the bachelor's level to over 40% at the doctoral level. The leading countries of origin among immigrants with a highest degree in S&E are China and India. Most foreign-born noncitizen recipients of US S&E doctorates report that they plan to stay in the USA after graduation (75%); this proportion has risen over time, with the highest proportions reported by S&E doctorate recipients from China and India (86% to 87%, a proportion that has been declining since the early 2000s).[22]

Concluding remarks

The data analysed in this chapter broadly confirm preconceptions about the link between innovation and skills. UIS data show a correlation between educational attainment and level of development. Generally, the more developed the region, the higher the percentage of the population that have completed tertiary education, although the correlation is not perfect. And more and more students are enrolling in tertiary education, clearly showing the importance attached to education before entering the labour market. On tertiary enrolment, again the richer regions are far ahead of the poorer regions, in particular Sub-Saharan Africa. Furthermore, the regions with the highest numbers of people with tertiary education and with the highest enrolment ratios in higher education are also those with the most researchers as a proportion of the total population. This can be explained in part by the fact that economies that are catching up are more dependent on technology transfer than they are on original R&D. Moreover, R&D is generally unprofitable for firms with low levels of human capital.

Economies at the lowest levels of development may be trapped in a vicious circle. Low economic development does not offer a context that provides enough incentives for young people to pursue higher education, and without a skilled population, economies will not grow. Furthermore, people vote with their feet and move to places that offer more opportunities. Internationally mobile students overwhelmingly move to North America and Western Europe, which is the only region with a net inflow of foreign students. The USA remains the most popular destination not just for students but also for highly skilled professionals, and an important part of that country's innovative prowess can be ascribed to these very talented foreigners.

However, correlation is not the same as causation. These data neither provide explanations nor do they indicate the direction of potential causation. Does a lack of skills lead to poor development, or does poor development lead to a less-skilled population? The data presented here are nationally aggregated data, further summed up to regional totals, which does not allow for such a detailed analysis. To properly answer the question of how skills relate to innovation, more information is needed about the demand for skills by employers and the supply of these skills by highly educated people. To that end, firm-level surveys should ask more questions about skills and how those skills relate to firm performance.

But surveys also need to be carried out at the level of the individual. The CDH survey is a prime example of the type of survey and data collection that warrants being taken up more widely. So far, there is also insufficient hard evidence about the extent of brain drain and its impact. More information is needed, but it is extraordinarily difficult to collect. Finally, to fully understand the link between innovation and human resources, all information collected needs to be analysed at the microdata level using econometric methods (see Box 1, Annex 1 in Chapter 1).

Notes

1 See OECD, 2012; UIS, 2014; and many others.

2 Crespi and Zuniga, 2012.

3 Bell and Pavitt, 1993; Katz, 1986.

4 Archibugi and Pietrobelli, 2003.

5 OECD, 2011.

6 Bruland, 2003.

7 Toner, 2011, p.59.

8 Nelson and Phelps, 1966; Griffith et al., 2004.

9 López Boo, 2009; Navarro et al, 2010.

10 Bilbao-Osorio and Rodríguez-Pose, 2004.

11 Audretsch and Feldman, 1996.

12 Goedhuys et al., 2008.

13 Sorensen, 1999.

14 See http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/documents/CIS_Survey_form_2010.pdf.

15 The 11 hampering factors are: Lack of qualified personnel; Lack of information on technology; Lack of information on markets; Difficulty in finding cooperation partners for innovation; Markets dominated by established enterprises; Uncertain demand for innovative goods or services; No need to innovate due to prior innovations; No need to innovate due to no demand for innovations; Lack of funds within the enterprise or group; Lack of finance from sources outside the enterprise; and Innovation costs too high.

16 Auriol et al., 2012.

17 'This is a low estimate since the data are based on the declarations of returnees and do not take into account those who are currently and may remain abroad. [Furthermore, most of the data are for] individuals in countries that host world-leading research organisations [who] may [therefore] perceive a lesser need to move abroad.' Auriol et al., 2013, p. 57. Other factors may play a role too.

18 Auriol et al., 2013, p. 57.

19 For further information about the DIOC-E database, see http://www.oecd.org/migration/databaseonimmigrantsinoecdandnon-oecdcountriesdioc-e.htm. Results are written up in Dumont et al., 2010.

20 Dumont et al., 2010.

21 NSB, 2014.

22 NSB, 2014.

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