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The Global Competition for Talent
Mobility of the Highly Skilled

Chapter 3

Mobility and Its Impact: Data and Evidence

This chapter presents the available data on international mobility as a basis for exploring issues relating to the patterns of mobility and innovation, the importance of mobility of scientific and technological workers in the innovation process, and the impacts of OECD and non-OECD mobility.

Human resources in science and technology (HRST) are a crucial component of modern economies. Over the decade from 1996 to 2006, employment in HRST occupations grew faster than total employment in all OECD countries. As a percentage of total employment in 2006, workers in professional and technical occupations represented more than 30% of total employment in the United States and in the EU25 (OECD 2007a, p. 50). Northern European countries tend to have the largest share of HRST occupations in total employment, although other countries with low initial shares of professionals and technicians, such as Spain, Hungary and Greece, are experiencing strong growth rates and are catching up to other OECD countries.

This chapter explores the available data and evidence on the international mobility of HRST. While the main focus is the mobility of highly skilled professionals, particularly scientists, engineers and researchers, direct data on their movement and flows are limited, so proxy measures are used (Box 3.1). Patterns of mobility are described: the stocks and flows of migrants to and from OECD countries, as well as the perspective of non-OECD economies; international mobility of students; and repatriation of mobile HRST. The chapter then presents some evidence on the impact of mobility and the outlook for the future. Owing to data constraints, patterns of mobility for researchers at the sectoral level or within the private sector are not studied. These areas would benefit from further study.

Box 3.1. **Data availability and limitations**

Recent years have seen major efforts to improve data on international stocks and flows of highly skilled people. This chapter draws on the most recent data. However, statistical data on intersectoral and cross-border flows of the highly skilled, and more generally on HRST and researchers, remain problematic. First, internationally comparable data are difficult to collect because of the heterogeneity of immigration data. Countries have different migration systems, legislation and policies, and definitions of the immigrant population and counting methodologies vary markedly across countries. In some an immigrant is defined according to the place of birth whereas in others citizenship/nationality is used. A complication is the fact that in many countries it is possible to have dual nationality.

Box 3.1. **Data availability and limitations** *(cont.)*

A second problem associated with collecting data on the international mobility of *researchers* stems from the statistical definition of researchers in relation to the standard occupational classifications. It is important to clarify the differences between the highly skilled, HRST, R&D personnel and researchers. Highly skilled refers to persons possessing tertiary-level qualifications (*i.e.* International Standard Classification of Education [ISCED] level 5A, 5B and 6). HRST are defined in the *Canberra Manual* (OECD and Eurostat, 1995) as people who fulfil one of the following conditions: they *i)* have successfully completed *education* at the tertiary level in an S&T field of study (*i.e.* HRSTE); or *ii)* are not formally qualified as above, but are *employed* in an S&T occupation where the above qualifications are normally required (*i.e.* HRSTO).

The HRST definition is broad and covers "people actually or potentially employed in occupations requiring at least a first university degree". Therefore, HRST and highly skilled are similar terms when HRST are defined according to level of education. Doctorate holders are persons who have followed a tertiary programme and have been awarded an advanced research qualification at ISCED level 6. R&D personnel, as defined by the *Frascati Manual* (OECD 2002, pp. 92-93) are "all persons employed directly on R&D", which includes those providing direct services such as R&D managers, technicians and clerical staff. Researchers are defined as "professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and in the management of the projects concerned". However, the International Standard Classification of Occupations does not currently have a code to define "researchers": it only defines research managers. This means that when statistical data sets are merged, such as labour force surveys and census data, R&D personnel and researchers cannot be identified.

It is beyond the scope of this chapter to discuss fully the limitations associated with collecting data on the international mobility of the highly skilled and researchers, but the main issues include inconsistent methodological frameworks, differing occupational and statistical classifications, different sample sizes, and differing survey questions. As a result, regular and comparable data that can be used to map the international mobility of HRST and researchers are lacking. Developing internationally comparable indicators is clearly an area that statisticians and policy makers need to address.

Patterns of mobility

As Chapter 2 shows, mobility patterns are becoming more complex, and the expanding geographical range of possibilities also increasingly blurs distinctions between "sending" and "receiving" countries. The extension of

traditional notions of permanent migration to include temporary or circular mobility increases the difficulty of collecting and analysing relevant data.

The data presented here are taken from various sources, including the OECD Database on Immigrants and Expatriates. This internationally comparable data set, with detailed information on the foreign-born population for almost all OECD member countries, allows for the calculation of emigration rates[1] (by level of qualification) to the OECD area for approximately 100 countries. Although the data are largely based on national censuses conducted in 2000 and 2001, and are thus becoming dated, they provide the best internationally comparable data on foreign-born populations and educational attainment. More up-to-date data will be available when countries undertake their next round of censuses (usually on a ten-year cycle). The database has recently been extended to include information on further demographic and labour market characteristics of immigrants living in OECD countries in 2001 (OECD Database on Immigrants in OECD Countries). In general, the data on international stocks and flows of highly skilled people have improved in recent years, although data on intersectoral and cross-border flows of HRST remain problematic owing to differences in national systems and definitions (see Box 3.1). As a result, there are gaps in the empirical picture.

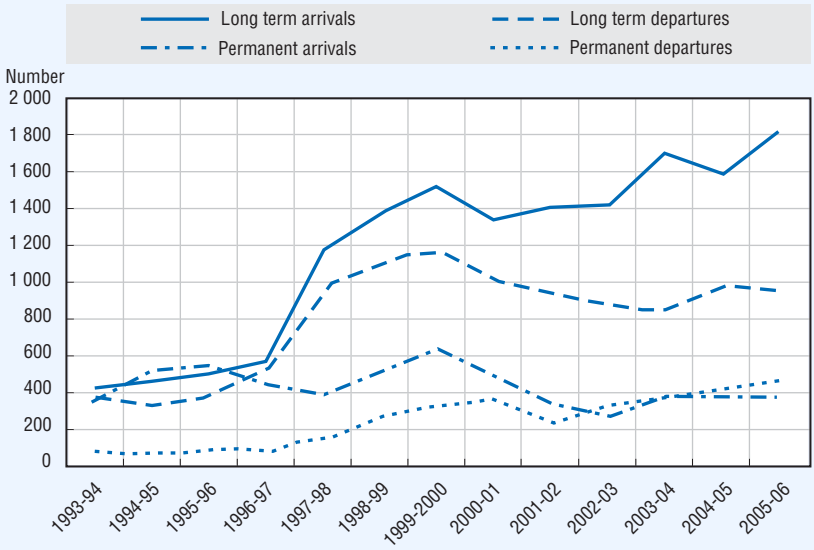
It is important to note that the international mobility of HRST may have increased in recent years because of the globalised market for HRST and changes in science and innovation systems. For example, recent data from Australia show rapid growth in the movement of scientists and academics (Box 3.2). Moreover, intra-EU mobility and migration have changed following the last round of accessions to the EU (OECD, 2007c, p. 43) although the extent of the movement of HRST is not yet known.

Box 3.2. **The migration of academics and scientists: recent evidence from Australia**

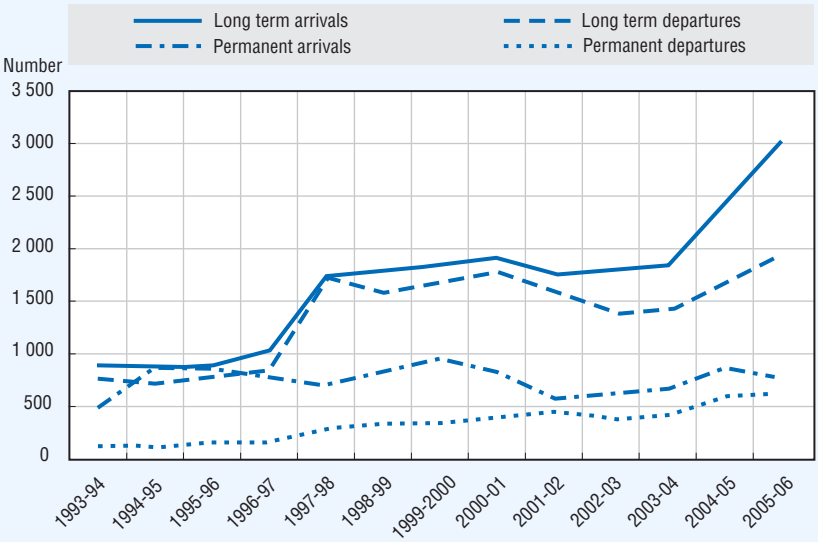
Australia collects detailed data on both stocks and flows of international migration. It is one of the few countries to collect information on persons leaving as well as arriving. Looking at the movement of academics and scientists over the period 1993-94 to 2005-06 shows substantial increases in long-term arrivals and departures. The number of academics and scientists entering Australia on a long-term basis rose from 1 283 in 1995-96 to 4 823 a decade later. The outflow of Australian academics and scientists also increased over the period, although in smaller numbers.

Box 3.2. **The migration of academics and scientists: recent evidence from Australia** *(cont.)*

Academics



Scientists



Source: Hugo (2007), p. 11.

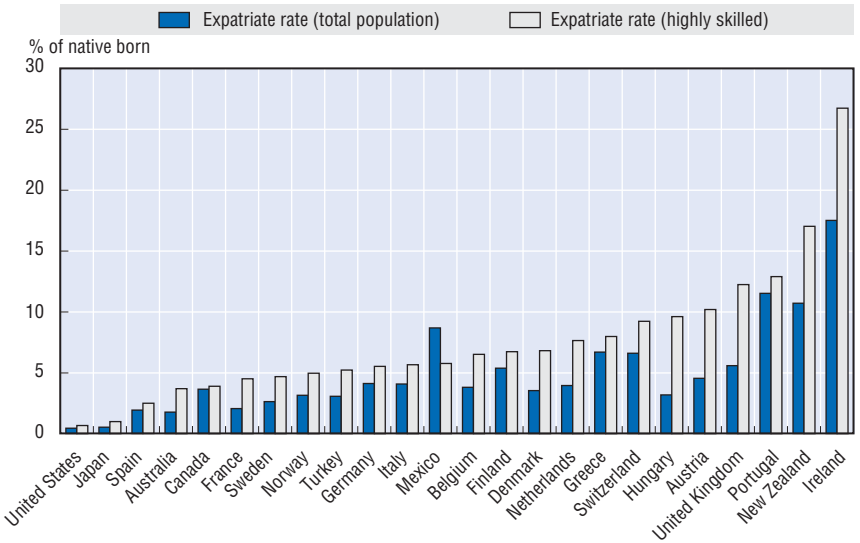
Departures

Figure 3.1 shows that for most OECD countries, the stock of highly skilled (*i.e.* tertiary-educated) expatriates in other OECD countries represents less than 10% of the stock of the highly skilled native-born. For instance, the United States, Japan and Spain all have highly skilled expatriation of well below 5% of stocks, suggesting low mobility rates. However, New Zealand and Ireland have more than 15% of their highly skilled population living in another OECD country. As for Mexico, it is the only OECD country for which general expatriation is greater than highly skilled expatriation as a percentage of the native-born. Table 3.1 gives absolute numbers of highly skilled expatriates from OECD countries living in other OECD countries in 2001. Luxembourg, Norway and the Slovak Republic had the smallest absolute numbers of expatriates, while Germany and the United Kingdom had the largest. In terms of gender, a profile of immigrants in OECD countries showed that, in most, there is little difference in emigration rates for men and women (OECD, 2008a, p. 79).

In terms of educational attainment of expatriates from OECD countries, Figure 3.2 shows that the highly skilled make up more than 25% of migrants for most countries. However, there is again a wide spread, which reflects the

Figure 3.1. **Expatriates in OECD countries, as a percentage of all native-born, by OECD country of birth, 2001**[1]

Total population and highly skilled



1. 2001, or nearest available year, for available countries.

Source: OECD Database on Immigrants and Expatriates.

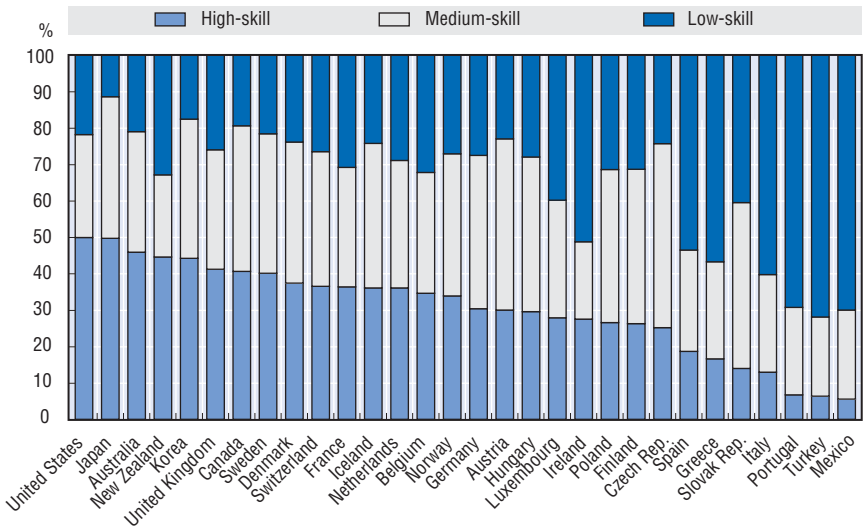
Table 3.1. **Expatriates in OECD countries, highly skilled, by OECD country of birth, 2001**[1]

	Highly skilled expatriates		Highly skilled expatriates
Australia	122 580	Luxembourg	7514
Austria	101 013	Mexico	474 565
Belgium	112 550	Netherlands	209 898
Canada	426 291	New Zealand	168 374
Czech Republic	54 273	Norway	39 433
Denmark	59 874	Poland	327 110
Finland	67 171	Portugal	82 796
France	361 615	Slovak Republic	52 251
Germany	883 624	Spain	59 874
Greece	118 833	Sweden	78 643
Hungary	90 232	Switzerland	107 458
Ireland	186 312	Turkey	130 753
Italy	294 767	United Kingdom	1 276 929
Japan	284 587	United States	412 618
Korea	134 909	Total	6 726 847

1. 2001, or nearest available year.

Source: OECD Database on Immigrants and Expatriates.

Figure 3.2. **Distribution of expatriates by skill level and country of origin, 2001**[1]



1. 2001, or nearest available year

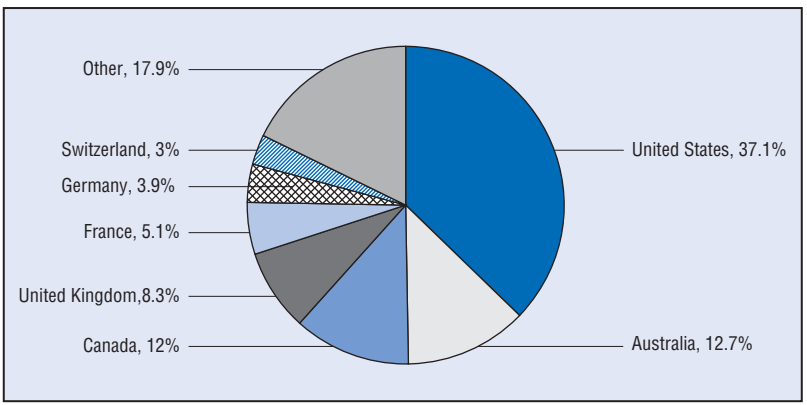
Source: OECD Database on Immigrants and Expatriates; Dumont and Lemaître (2005).

diversity of OECD countries. Almost 50% of expatriates from Japan and the United States are highly skilled, compared with less than 10% in Mexico, Portugal and Turkey.

Where do highly skilled expatriates go? Figure 3.3 shows that as at 2001 the United States, Canada, Australia and the United Kingdom had attracted the largest absolute numbers of OECD-born highly skilled expatriates, followed by France and Germany. Expatriate numbers are not necessarily related to a country's economic size. Japan, for example, had over 12% of the OECD's GDP in 2000 (at current market prices using current PPPs), but attracted only 0.7% of the OECD's highly skilled expatriates in 2001. In contrast, Australia's share of the OECD's GDP in 2000 was around 2%, yet it attracted 12.7% of OECD-born highly skilled expatriates. This reflects the complex range of factors that influence mobility choices, discussed in Chapter 2.

Figure 3.3. **Main OECD destinations of OECD-born highly skilled expatriates, 2001**[1]

Percentage shares



1. 2001, or nearest available year

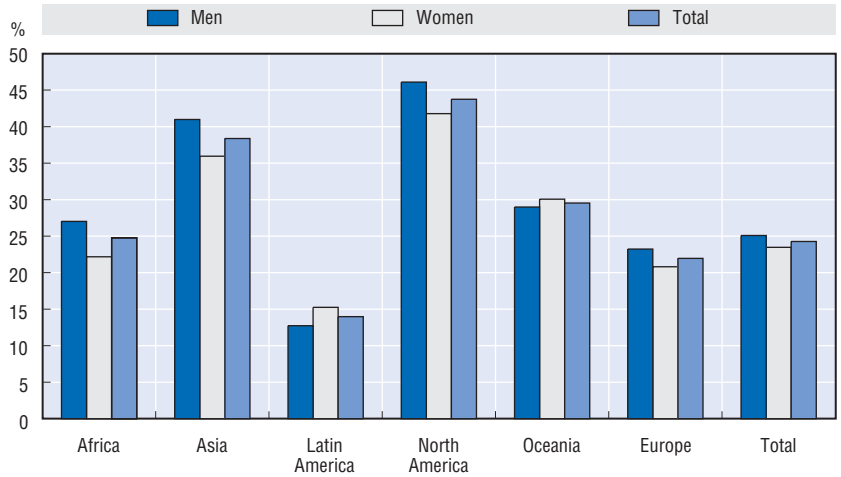
Source: OECD Database on Immigrants and Expatriates.

Arrivals

A snapshot of the characteristics of all immigrants living in OECD countries in 2001 shows that 24.3% of the foreign-born were tertiary-educated. This can be broken down by region of origin and by gender (Figure 3.4). For instance, 38.4% of immigrants born in Asia were tertiary-qualified, compared to 22% of European-born migrants. This differential may be due to several factors, including the tendency for Asian migrants to move to countries with selective immigration policies (*i.e.* the highly skilled tend to move), and the

Figure 3.4. **Percentage of immigrants in OECD countries with tertiary education**

By region of origin and gender



Source: Database on Immigrants in OECD Countries; OECD (2008a), p. 17.

large number of Asian students studying abroad. More broadly, recent migration waves tend to be better educated than earlier ones. Therefore, if immigrants from a certain region are predominantly recent migrants, the average educational level is likely to be higher. For example, 90% of Italian, Greek and Portuguese immigrants in the OECD area migrated before 1990 and were less likely to be tertiary-educated (OECD, 2008a, p. 79). Figure 3.4 also shows that, on average, slightly fewer female migrants are tertiary-educated, compared to male migrants, but this also differs by region of origin. For instance, 15.2% of female migrants born in Latin America were tertiary-qualified, compared to 12.7% of male migrants.

For a number of OECD countries, intra-OECD flows of highly skilled (tertiary-educated) migrants add substantially to the stock of the highly skilled. In Luxembourg, Switzerland, Australia, New Zealand and Ireland, highly skilled migrants from other OECD countries were equivalent to more than 15% of the native-born highly skilled in the country in 2001. In Switzerland, for example, there is a long tradition of employing highly qualified staff from the European countries in which the Swiss national languages (German, French and Italian) are spoken, and inward mobility of human capital has been a major source of personnel in science and technology since the Second World War (Arvanitis and Wörter, 2005, p. 59). For 16 of the OECD countries covered by the data, highly skilled migrants from

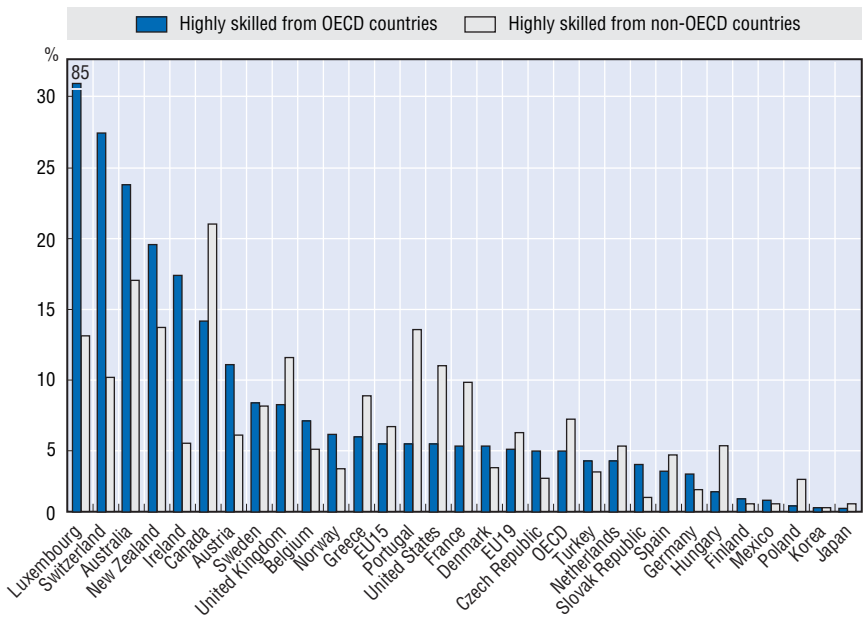
OECD countries were more numerous than those from non-OECD countries (Figure 3.5).

Nevertheless, while intra-OECD migration flows are significant, a number of OECD countries attract a larger number of highly skilled migrants from non-OECD economies. For example, Figure 3.5 shows that in Canada in 2001 these highly skilled migrants were equal to more than 20% of the highly skilled native population. This compares to less than 15% for OECD-sourced skilled migrants. Other countries with significantly higher non-OECD skilled migration relative to intra-OECD migration include Portugal, the United States and France.

Recent figures from the European Union also highlight differences in the significance of foreign skills across countries. Using a set of new indicators on HRST populations by nationality and country of birth, Eurostat found that in 2006, only 6% of HRST aged 25-64 in the European Union were non-nationals (*i.e.* citizens of a country other than their country of residence) (Eurostat, 2007). These non-national HRST were equally divided between

Figure 3.5. **Highly skilled migrants from OECD and non-OECD countries, by OECD country of residence, 2001**[1]

As a percentage of highly skilled natives in the country of residence

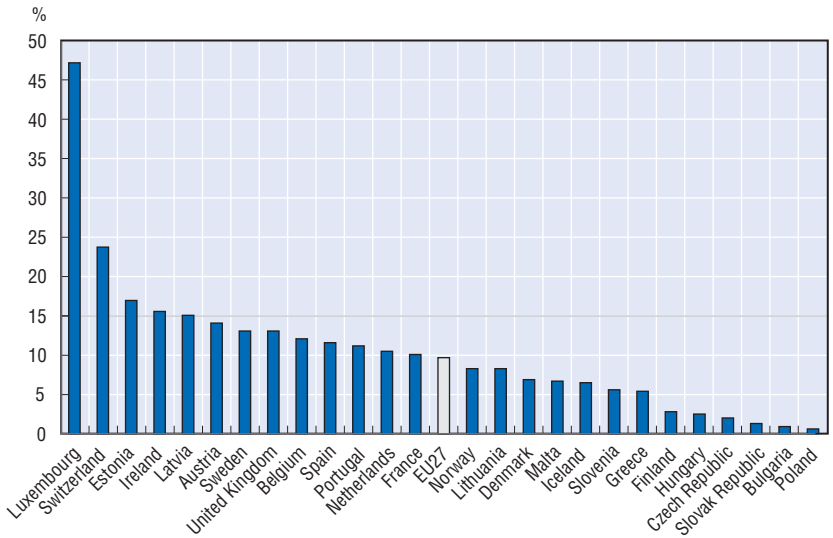


1. 2001, or nearest available year.

Source: OECD Database on Immigrants and Expatriates.

citizens of other EU countries and citizens of countries outside the European Union. At the country level, non-nationals ranged from 46% in Luxembourg, to 0.3% in Slovenia. The shares of foreign-born were a little higher, as some foreign-born immigrants obtain citizenship in their country of residence (Figure 3.6).

Figure 3.6. **Share of foreign-born in HRST aged 25-64, in EU27 and selected countries, 2006**[1]



1. Iceland, Ireland, Luxembourg, Switzerland and Latvia, data from 2005; Lithuania, data from 2003. EU aggregate does not include Bulgaria, Estonia, Germany, Italy, Malta, Romania and the Slovak Republic.

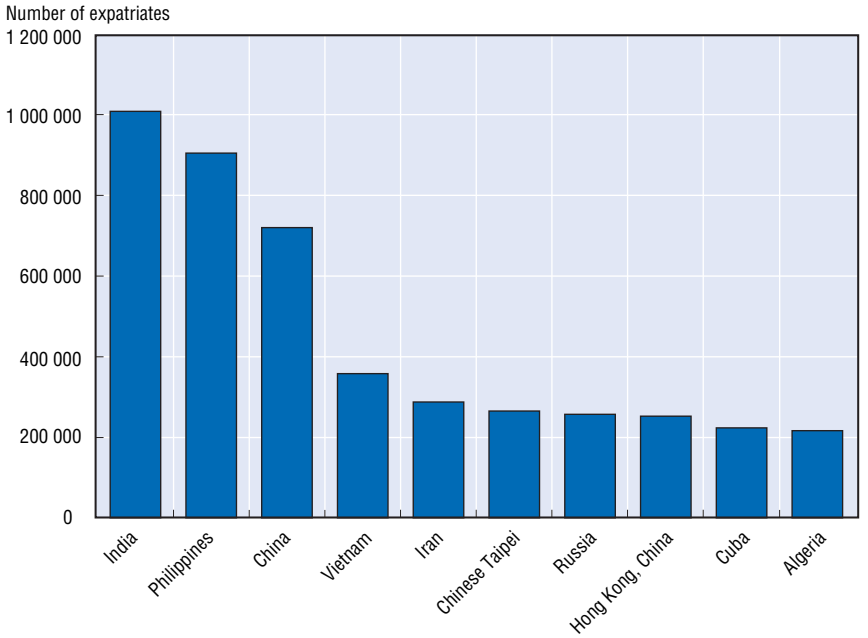
Source: Eurostat (2007).

Foreign-born residents in OECD countries come from many countries. In 2001, the top ten source economies for highly skilled non-OECD expatriates were predominantly Asian, led by India, the Philippines and China (Figure 3.7).

Overall, most OECD countries are net beneficiaries of highly skilled migration, with highly skilled immigration towards OECD countries from other OECD countries and the rest of the world systematically exceeding highly skilled emigration from OECD countries to other OECD countries. Figure 3.8 shows that Mexico, Korea, Ireland, Italy, Finland and some central and eastern European countries experienced a net loss of individuals with a tertiary education, while the other OECD countries experienced a net inflow. These figures do not include expatriation of the highly skilled to non-OECD

Figure 3.7. **Foreign born highly skilled expatriates in OECD countries, by country of origin, 2001**[1]

Top ten non-OECD economies



1. 2001, or nearest available year.

Source: OECD Database on Immigrants and Expatriates.

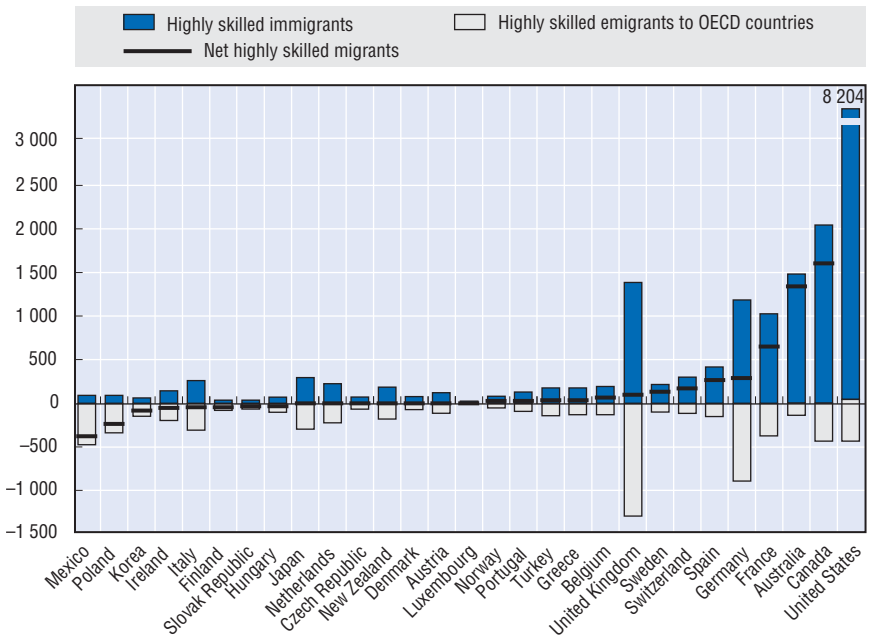
countries which is assumed to be relatively uncommon (see Dumont and Lemaître, 2005); however, as these countries develop, they will likely exert a greater "pull", perhaps especially for descendants of earlier migrants from these countries.

While these data show the net balance of the highly skilled, they do not reveal whether the skill levels and technical specialisations of immigrants and expatriates are similar. It is therefore not possible to analyse skill mismatches and know whether movements are concentrated in particular occupational fields. The difference between incoming and outgoing flows in terms of the level of expertise may also be significant. For example, a country may lose a Nobel prize-winning researcher and gain a person who has recently completed a tertiary-level qualification.

The significance of these highly skilled flows into OECD countries becomes even more apparent when considering researchers and doctorate

Figure 3.8. **Immigrant and emigrant population 15 years and over with a tertiary education in OECD countries, 2001**[1]

Thousands



1. 2001, or nearest available year.

Source: OECD Database on Immigrants and Expatriates.

holders. Figure 3.9 shows that the stocks of doctorate holders are affected by mobility in a number of countries, although countries differ considerably in this respect. For example, in New Zealand, more than 40% of doctorate holders were foreign-born and in Ireland they were over 35%.

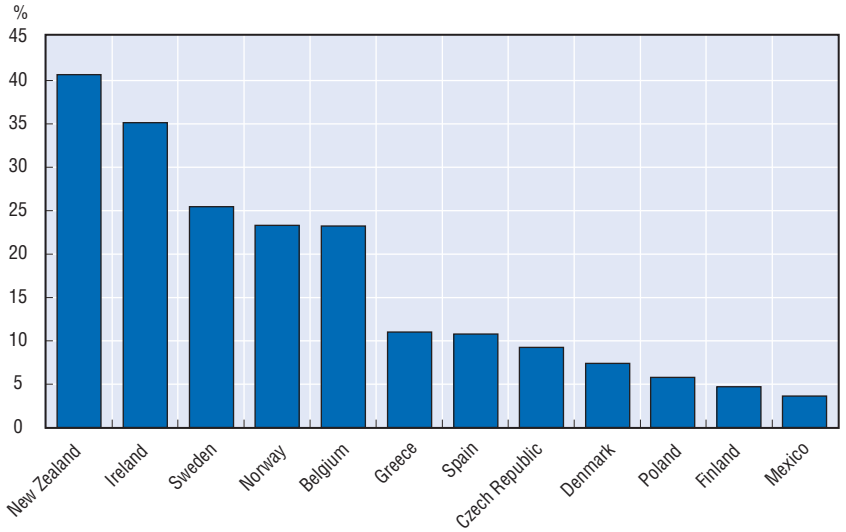
It is also clear that migrants make a significant contribution to the science workforce in many countries. Table 3.2 shows that the share of science professionals in the tertiary-educated workforce is frequently higher for migrants, especially those of Asian origin, than for the native population. For instance, in the United States, over 20% of tertiary-educated migrants from Asia are science professionals, compared with 10.3% of other migrant groups, and 7.7% of tertiary-educated natives.

The perspective of non-OECD economies

The OECD Database on Immigrants and Expatriates allows for the calculation of emigration or expatriation rates to the OECD area for highly skilled people from all OECD countries as well as many non-OECD economies. The emigration rate is calculated by dividing the highly skilled (those with

Figure 3.9. **Foreign-born doctorate holders as a percentage of total doctorate holders, 2001**[1]

By OECD country of residence



1. 2001, or nearest available year.

Source: OECD Database on Immigrants and Expatriates (excluding countries that have provided data for the Careers of Doctorate Holders project).

Table 3.2. **Share of science professionals in tertiary-educated workers, circa 2000**

Percentages

	Canada	United States	United Kingdom	Australia	France	Sweden
Among Asian migrants	12.8	20.1	10.9	12.4	14.5	8.2
Among other migrants	9.5	10.3	8.6	8.7	10.6	7.1
Among natives	5.8	7.7	9.6	6.7	8.9	8.5

Note: Science professionals defined as ISCO Group 21 (Physical, mathematical and engineering science professionals).

Source: Database on Immigrants in OECD Countries; OECD (2008a), p. 23.

tertiary education) expatriate population from the country of origin by the total native-born population of the same country and level of education. Figure 3.10 presents three groups of countries: those with expatriation rates of the highly skilled of less than 10%; those with expatriation rates of 10 to 20%; and those with expatriation rates of 20% or more. Most OECD countries' expatriation rates of the highly skilled are below 10%, although some have higher rates, especially New Zealand (17%) and Ireland (27%).

Among the non-OECD economies with low expatriation rates to OECD countries are most of the large ones, such as Indonesia, Bangladesh, Brazil, India and China. Smaller countries, particularly islands, such as Jamaica, Haiti, Trinidad and Tobago, and Fiji, tend to have much higher expatriation rates, of more than 60% and in some cases more than 80%. African countries also have particularly high expatriation rates of the highly skilled to OECD countries.

Figure 3.10. **Expatriation rates of the highly skilled to the OECD, 2001**[1]

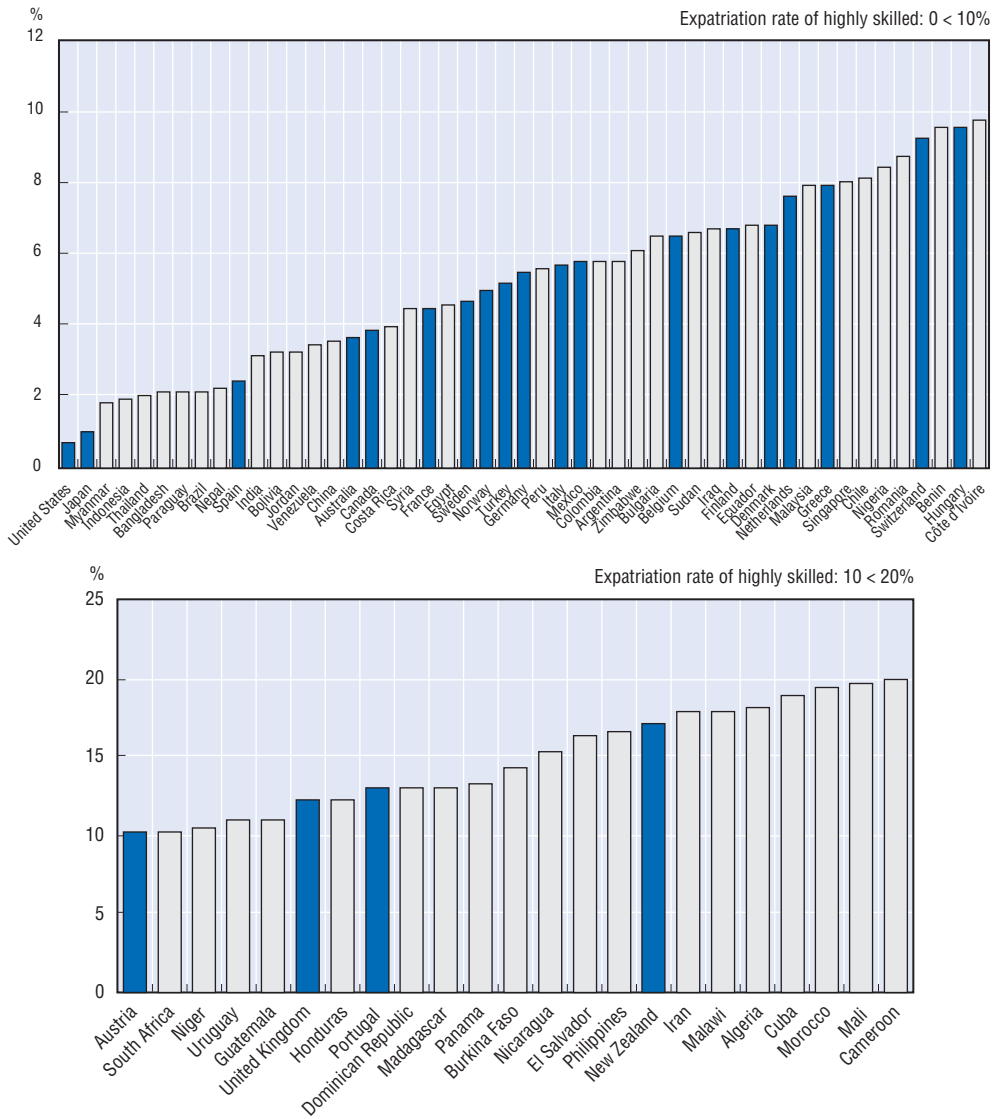
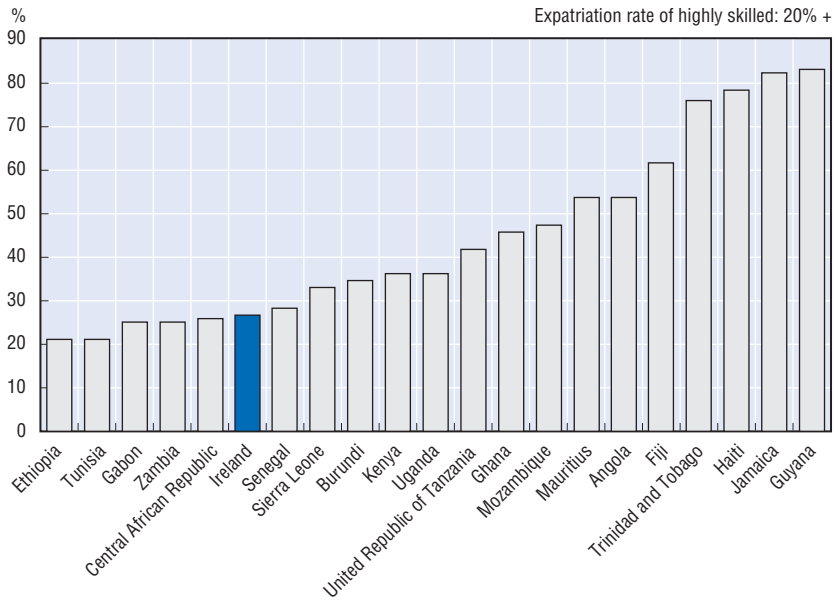


Figure 3.10. **Expatriation rates of the highly skilled to the OECD, 2001**[1] *(cont.)*



1. 2001, or nearest available year

Source: OECD Database on Immigrants and Expatriates (series ERCSHS15).

Nevertheless, as noted above, flows of migrants now seldom go in only one direction. Data from the International Organization for Migration show that, of the top ten migrant-hosting countries in 2000, five were non-OECD economies: the Russian Federation, Ukraine, India, Saudi Arabia and Pakistan, which together hosted more than 20% of the world's international migrants (IOM, 2005, p. 397). However, when the former Soviet Union was broken up into independent states, the number of international migrants increased as people previously classified as internal migrants were reclassified as international migrants. A database constructed by the World Bank, which excludes the Russian Federation, Ukraine and Kazakhstan on the basis that they are not representative of "normal" migration patterns, shows four non-OECD members in the top ten for receiving migrants: India, Saudi Arabia, Pakistan and Hong Kong, China (Parsons *et al.*, 2007).[2] Together, these economies accounted for 10.5% of international migrants. Four of the following five next biggest migrant recipients were also non-OECD members: Côte d'Ivoire, Iran, Israel and Jordan. Overall, the World Bank database showed that South-South migration accounted for 24% of total emigration (South-North was 37% and North-North 16%).

Skilled workers form part of this circulation between non-OECD members. For example, Adepoju (2004) noted that skilled Africans, pressured by uncertain economic conditions at home, had found the economies of Gabon, Botswana, Namibia and South Africa to be convenient alternatives to Europe, the United States and the Gulf States. Unfortunately, there are few data available to quantify the "South-South" flows of skilled migrants. Some data from South Africa suggest that between 1994 and 2001, South Africa gained around 500 researchers a year, a significant number of whom were mid- to late-career professionals from African countries. At the same time, South Africa was losing an estimated 2 500 researchers a year, thus contributing to the low number of researchers in total employment (National Advisory Council on Innovation, 2006, p. 58).

Interestingly, among non-OECD countries, tertiary-educated emigration rates are higher for women than for men, at 13.9 and 9.7%, respectively (OECD, 2008a, p. 79). At the continental level, the average emigration rate of the tertiary educated is higher for women than for men in Africa (27.7% for women, 17.1% for men), and in Latin America (21.1% for women, 17.9% for men). A smaller difference is found in Asia and Oceania, and there is no gap in Europe and North America.

Gender differences in emigration were also found in research by Docquier *et al*. (2007). The study, based on data for 170 countries, found that the emigration rate of skilled females (defined as those having at least one year of post-secondary education) in low-income countries was 10.2% in 2000, compared to 6.3% for skilled males. For high-income countries, the figures were more balanced, with an emigration rate for women of 4% and for men of 3.7%. Large gender differences in emigration rates were also found between regions in Africa (northern and southern Africa had similar rates across genders while middle and western Africa had much higher female rates) and between regions in Asia. The authors found a strong correlation between the gender gap in emigration rates and the gender gap in educational attainment in source countries. It may be that gender gaps in education reflect broader societal gender differences that encourage skilled women to seek opportunities abroad, thus leading to higher female emigration rates. Overall, the study found that the share of females in skilled emigration increased from 46.7 to 49.3% over the period 1990-2000. This result was mainly due to an increase in the supply of skilled women as they gained increased access to schooling in less developed countries.

Student mobility

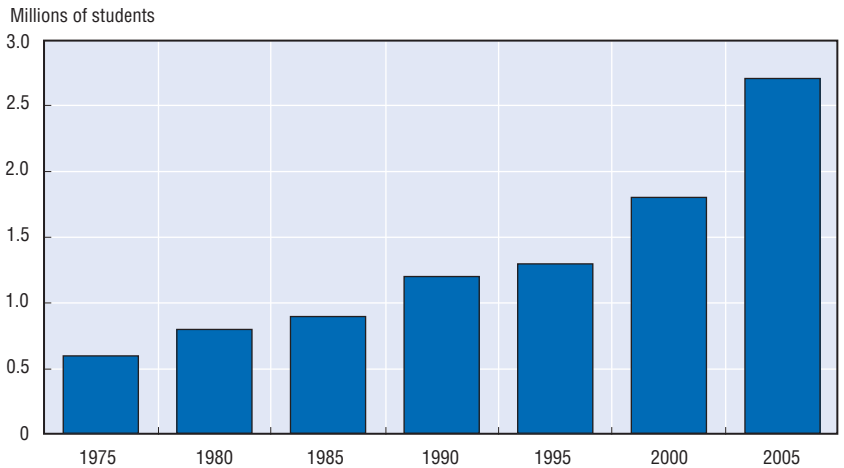
The internationalisation of HRST is also observed in the international mobility of students. OECD countries benefit from the inflow of talented students and scholars. Students, especially from developing countries, often

stay on in OECD countries for further research or employment and contribute to innovation in these countries. Students may also return later for employment. A study of German university graduates, for example, found that studying abroad increases a person's probability of working abroad by 15-20 percentage points (Parey and Waldinger, 2007). Attracting foreign students can provide a highly qualified reserve of labour that is familiar with the prevailing rules and conditions in the host country and is able to foster international networks and co-operation. Foreign students may also contribute to the viability of some programmes that would otherwise not attract a sufficient number of enrolments. Many countries now work actively to attract foreign students, with courses taught in widely spoken foreign languages (*e.g.* English, French, German), attractive fee structures, joint degree programmes with foreign universities, and favourable visa processes, for example.

Countries also benefit from their students studying abroad. Luxembourg, for example, relies on international co-operation and mobility of students and researchers for its research system, as its small size means it can only cover a few fields in higher education and research (Ohler, 2005, p. 42). Indeed, until the establishment in 2003 of the University of Luxembourg, students in all fields had to seek their university education abroad.

Data from the OECD and the UNESCO Institute for Statistics show that the number of students enrolled outside their country of citizenship has risen steadily since 1975, with a particularly sharp increase from 1995 to 2005 (Figure 3.11). Most were enrolled in the OECD area (84%), with the United

Figure 3.11. **Number of students enrolled outside their country of citizenship, 1975-2005**



Source: OECD (2007b), p. 303.

States, the United Kingdom, Germany, France and Australia the top five destinations for foreign tertiary students (OECD, 2007b, pp. 303-304).

Other, non-traditional OECD destination countries are also seeking to increase foreign student numbers. For example, the total number of foreign students in Korea reached over 30 000 in 2006 (Table 3.3). International students in science and technology fields are mainly from Southeast Asia. The evidence suggests that most return to their home countries or a third country after graduation, rather than stay in Korea as researchers. Japan has also increased foreign student numbers, with approximately 100 000 foreign undergraduate and graduate students in 2006 (Table 3.4). Here, too, most science and engineering students are from Asian countries. D'Costa (2007) notes that, based on data on visa conversions from student status to worker status, few students remain to work in Japan after completing their studies.

Table 3.3. **International students in Korea, 2006**

Origin	Total	*Of which:* Degree courses		Language courses
		Science and engineering	Human and social sciences	
Asia	29 227	6 158	13 509	6 945
Africa	211	45	137	28
Oceania	125	15	61	23
North America	1 717	114	763	548
South America	200	29	117	36
Europe	1 077	105	342	358
Total	32 557	6 466	14 929	7 938

Source: Korean Ministry of Science and Technology (2007), p. 159.

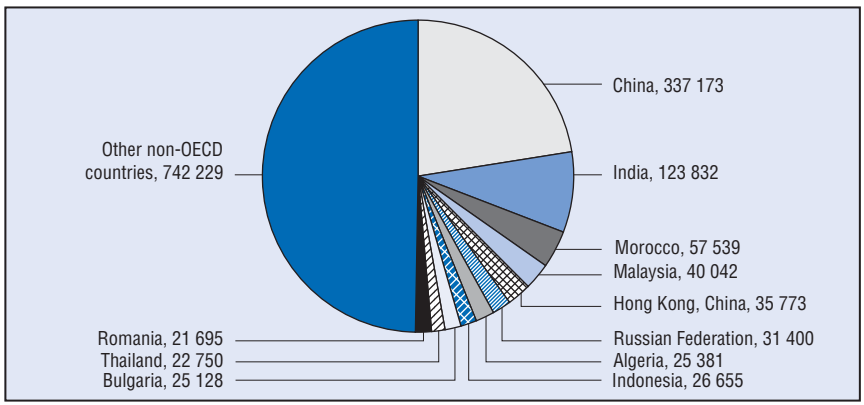
In total, two-thirds of foreign/international students in OECD countries in 2005 were from non-OECD economies (OECD, 2007b, p. 310). Asian students formed the largest group, accounting for nearly half of the overall total and making up more than three-quarters of foreign students in Australia, Greece, Japan, Korea and New Zealand. Figure 3.12 shows the main countries of origin of international students from non-OECD countries, with China and India followed by Morocco and Malaysia. The large number of Chinese students studying overseas is due in part to measures taken by the Chinese government in the wake of system reforms to encourage Chinese students to study abroad. The number of Chinese students studying overseas at their own expense is also increasing rapidly as a result of higher standards of living in China.

Table 3.4. **Foreign students in Japan, 1985-2006**

	1985			2006		
	Total	% of total foreign students	% in social sciences, science and engineering	Total	% of total foreign students	% in social sciences, science and engineering
Foreign undergraduate students						
Total	**14 264**			**68 889**		
China	4 275	30	46.1	46 196	67.1	64.2
N-S Korea	7 351	51.5	51.6	13 081	20.3	51.8
Malaysia	446	3.1	82.5	1 335	1.9	87.8
Thailand	233	1.6	50.2	639	0.1	55.1
Indonesia	94	0.7	46.8	462	0.7	53.2
Vietnam	20	0.1	0.5	777	1.2	68.2
India	41	0.3	9.8	109	0.2	52.3
United Kingdom	83	0.6	43.4	291	0.5	20.3
United States	733	5.1	8.9	1 555	2.2	8.6
Foreign graduate students						
Total	**5 477**			**31 915**		
China	2 087	38.1	49.9	17 566	55	52.1
N-S Korea	1 644	30	39.6	4 322	13.5	44.6
Malaysia	55	1	47.3	433	1.4	70.7
Thailand	260	4.7	52.3	866	2.7	46
Indonesia	128	2.3	42.2	908	2.8	58.4
Vietnam	11	0.2	45.5	778	2.4	63.4
India	58	1.1	46.6	268	0.8	52.2
United Kingdom	30	0.5	26.7	0	0	0
United States	171	3.1	22.8	286	0.9	44.1

Source: D'Costa (2007).

Figure 3.12. **Students from non-OECD economies enrolled in tertiary education in OECD countries, 2004**

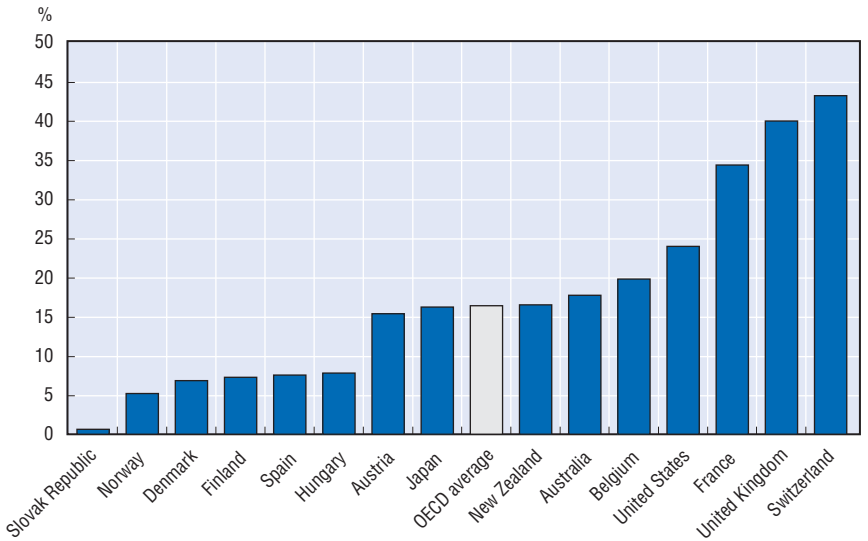


Source: OECD (2007a), p. 61.

International students are a large proportion of total enrolments in advanced research programmes in some OECD countries. Switzerland, the United Kingdom, France and the United States, in particular, have a large number of international students in their advanced programmes – over 40% in Switzerland (Figure 3.13).

Figure 3.13. **International students in advanced research programmes, 2005**[1]

% of total enrolments in advanced research programmes



Note: Advanced research programmes are second-stage tertiary studies that lead to the award of an advanced research qualification. The programmes are devoted to advanced study and original research and are not based on course work alone. The programmes equate to Level 6 of the International Standard Classification of Education (ISCED).

1. For all countries except Finland and Switzerland, international students are defined on the basis of their country of residence. For Finland and Switzerland, international students are defined on the basis of their country of prior education.

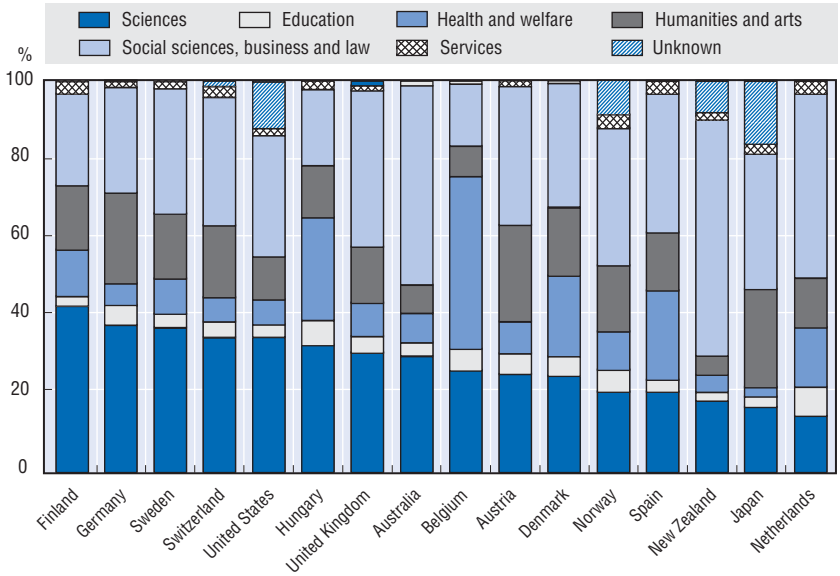
Source: OECD (2007b), p. 317.

Scientific disciplines in a broad sense (that is, including agriculture, engineering, manufacturing and construction programmes) attract large numbers of international students in some OECD countries. Finland receives the largest proportion of its international students in these fields (42%), and the share is also high in Germany, Sweden and Switzerland (Figure 3.14).

The number of students studying abroad in non-OECD economies is also increasing. For instance, Chinese higher education institutions have begun to attract foreign students in recent years. In mainland China in 2005, 44 337 foreign students graduated, 60 904 foreign students entered and 78 323 foreign students enrolled (Table 3.5). While most students were

Figure 3.14. **International students by field of education, 2005**

Percentage of all international tertiary students enrolled in different fields of education



Note: Sciences includes science, agriculture, engineering, manufacturing and construction. Figures for Finland, Germany, Switzerland, Austria and Spain exclude tertiary-type B programmes (ISCED Level 5B – a more practically oriented and occupationally specific programme, which does not give direct access to advanced research programmes). Figures for Germany, Spain, New Zealand and the Netherlands exclude advanced research programmes (ISCED Level 6).

Source: OECD (2007b), p. 311.

Table 3.5. **Foreign students in China, 2005**

By level of training

	Graduates		Degree awarded		Entrants		Enrolments	
	Number	%	Number	%	Number	%	Number	%
Doctoral degree	355	0.8	323	8.5	655	1.1	1 977	2.5
Master's degree	943	2.1	887	23.4	1 596	2.6	3 938	5.0
Normal courses	3 327	7.5	2 581	68.1	12 001	19.7	29 584	37.8
Short-cycle courses	319	0.7	-	-	640	1.1	867	1.1
In-service training	39 393	88.8	-	-	46 012	75.5	41937	53.5
Total	**44 337**	**100**	**3 791**	**100**	**60 904**	**100**	**78 323**	**100**

Source: Ministry of Education, *Educational Statistics Yearbook of China 2005*.

engaged in "in-service training" (which includes on-the-job training programmes for personnel and orientation programmes) rather than degree courses, the Chinese government has introduced various programmes to encourage and attract foreign students to China for higher-level study and research, such as the Great Wall Scholarship, the Scholarship for Chinese Cultural Studies and the Outstanding Student Scholarship. Furthermore, restrictions limiting foreign students from working part-time have been removed in some areas. For example, the Beijing Municipal Commission of Education does not restrict international students to teaching in the tertiary education institution in which they study (OECD, 2006).

In South Africa, higher education institutions play an important role in training international students from the rest of Africa. Most foreign students studying in South Africa (66%) are from countries of the Southern African Development Community (SADC) – Angola, Botswana, the Democratic Republic of Congo, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, Swaziland, Tanzania, Zambia and Zimbabwe. Almost 22% of foreign enrolments in 2001 were at the postgraduate level and 3% were at the doctoral level (National Advisory Council on Innovation, 2006, p. 66). Foreign students accounted for around 9% of total enrolments at South African universities in 2001; it is considered that these numbers could be increased and that South Africa could play a much more significant role in building the human resource base of other sub-Saharan African countries.

Geographic context

While mobility is often measured and discussed at the national level, it is at the regional and local levels that its effects may be felt most strongly. Through their choice of locations, highly skilled migrants can help create, strengthen or weaken existing "centres" and "peripheries" of economic activity. Mahroum (2000) comments that the inflow of scientists to a certain scientific site increases the site's credibility among its peers, and the greater this credibility becomes, the more scientists it attracts.

There is some evidence that the mobility of highly skilled individuals can strengthen existing clusters of scientific activity. Guellec and Cervantes (2002) found that much international migration of scientists and engineers was concentrated around knowledge-intensive clusters and specific research areas (for example, biosciences). The universities of Cambridge and Oxford, in the United Kingdom, received some 15% of all foreign academics employed in the country between 1994 and 1997, for example. A study of German scholars in the United States found that one-third were employed on the west coast, in the academic centres of California, while another third were concentrated in Boston, New York and Washington, DC, on the east coast.

Further confirmation comes from recent research by Wadhwa *et al.* (2007b) on the role of regional technology centres in the United States. In an analysis of immigrant-founded companies in Silicon Valley in California and the Research Triangle Park in North Carolina, the authors found that over half of Silicon Valley start-ups had one or more immigrants as a key founder, compared with the California average of just under 40%. The Research Triangle Park also had a higher percentage of immigrant-founded firms than the state average (18.7 and 13.9%, respectively).

The same study also found a high level of geographical ethnic clustering in immigrant-founded engineering and technology companies, with 40% of Indian founders preferring California and New Jersey, while Chinese founders were heavily concentrated in California, with 49% of those from mainland China and 81% from Chinese Taipei. The authors suggested that the clustering reflected the self-reinforcing nature of social and technical networks.

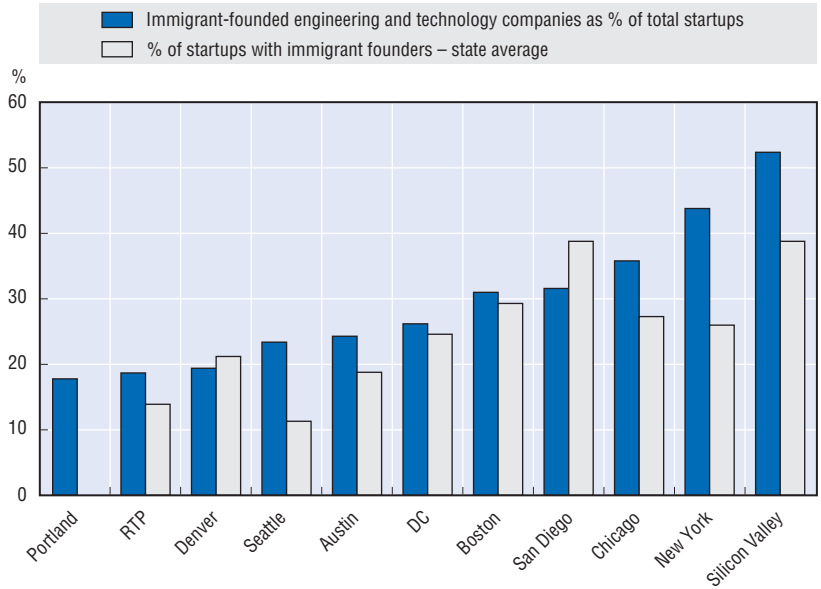
Extending the analysis of the geographical concentration of immigrant-founded companies, Wadhwa *et al.* (2007c) surveyed more than 1 500 start-ups in 11 of the leading centres of technology in the United States for the 1995-2005 period. The study supported earlier findings that immigrant-founded companies cluster in technology centres and thus reinforce centres of scientific and engineering activity. Start-ups in and around major technology centres usually had a higher concentration of immigrant founders than the state average (Figure 3.15). The exceptions were Denver and San Diego, both of which have a significant proportion of military technology and engineering activity, from which immigrants are often excluded.

Return and circular migration

Many migrants choose at some stage to return to their country of origin or to move from their first country of residence to another. The literature reviewed in Chapter 2 also suggested that temporary and circular migration is beginning to play a greater role in mobility, particularly in Europe. As argued by Aydemir and Robinson (2006), information about return or onward migration is essential for understanding the impact of migration on host countries, as "who stays" and "for how long" influences the contribution immigrants make to a host country's human capital stock and population profile, as well as the payoff to settlement and assimilation policies. It is also important for understanding the potential impact on source countries. The evidence suggests that return and onward migration form an important part of mobility and are thus an important consideration for mobility policies.

The OECD Database on Immigrants in OECD countries shows that, of the stock of tertiary-educated immigrants in OECD countries in 2001, almost 65% had been in their country of residence for ten or more years, 15% had been resident

Figure 3.15. **Immigrant-founded start-ups in US technology centres, 1995-2005**



Note: Figures for the percentage of start-ups with immigrant founders at the state level not available for Portland. RTP is the Research Triangle Park in North Carolina. DC is Washington, DC.
Source: Wadhwa *et al.* (2007c).

for five to ten years, and 20% for less than five years. However, the percentage of the tertiary educated who stay for ten or more years is less than that for primary- and secondary-educated migrants (67% and 70%, respectively). This may reflect the fact that more recent cohorts of immigrants are more educated, but may also suggest that tertiary-educated migrants tend to stay for shorter periods. Indeed, among countries that operate a selective system of migration that favours the highly skilled, such as Australia, Canada and New Zealand, the percentage of tertiary-educated migrants who stay ten or more years is significantly lower than that of primary- and secondary-educated migrants (Table 3.6).

Table 3.6. **Percentage of the foreign-born population with a duration of stay of ten or more years**
By country of residence and level of education

	Primary-educated	Secondary-educated	Tertiary-educated
Australia	84.1	76.6	67.8
Canada	74.7	71.3	65.1
New Zealand	79	61.2	57.4
OECD (weighted)	67.4	69.4	64.7

Source: OECD (2008a), p. 99.

Recent data from Australia show that, among the permanent departures of overseas-born residents in 2005-06, more than 60% indicated that they were returning to their country of birth (DIAC, 2007). Many had resided in Australia for some time, almost 70% for five years or more and only 14% for less than two years. A very large proportion of overseas-born residents from Hong Kong, China (85%) and Vietnam (80%) who were permanently leaving had resided in Australia for more than five years. In aggregate, 48% of the total permanent departures were in skilled occupations and 45% of these were born abroad.

The data also show that most skilled Australian emigrants return to Australia. The overall rate of return of skilled Australian residents who indicated that they were leaving permanently or on a long-term basis was around 75% (when returns two years after departure were compared[3]). For those moving to the United Kingdom, the return rate was around 85% (Birrell *et al.*, 2004, pp. 22-23).

Register data from the Nordic countries also reveal a tendency to return to one's home country. Among Danish and Finnish citizens who emigrated to other Nordic countries from 1988 to 1996, 50% had returned home after four to five years, and 60% had returned after nine to ten years (Graversen *et al.*, 2001). The return rate was stable over time, with each cohort displaying similar behaviour. The return rate of non-Danish and Finnish citizens to Denmark and Finland after emigrating to another Nordic country was much lower: after nine to ten years, only 10 to 20% had returned.

Analysis of individual longitudinal migration records of foreign-born persons migrating to and from Norway over the period 1967-2003 also found substantial return migration, although patterns varied significantly by country of origin (Bratsberg *et al.*, 2007). During the period, more than 500 000 migrants arrived in Norway, and around half were still there at the beginning of 2004. Immigrants from the OECD area tended to stay for short periods (only 20% remained in Norway after ten years); out-migration was much lower for immigrants from eastern Europe (around 50%) and lower again for immigrants from non-western source countries (around 30%). After 10 years only 15% of immigrants admitted on the grounds of family reunification had left. Primary refugees are slightly more inclined to leave – after ten years, more than 30% had moved on. Immigrants with work visas are the most likely to out-migrate; about 50% had left within ten years of arrival. Around 14% of out-migrants chose to move to a third country, rather than their home country; this was especially true for immigrants from less developed countries. Sweden, the United Kingdom and the United States were the most popular destinations for these out-migrants.

However, the Norwegian picture on out-migration changes slightly when the focus is on scientific researchers. A study by Nerdrum and

Sarpebakken (2006) found that the greater the cultural, economic and geographic distance separating researchers' home countries from Norway, the higher the likelihood that they will leave the Norwegian public research system more quickly than foreigners from more similar and closer countries. The average yearly outgoing mobility rate for OECD-origin academic research staff over the period 1991-2001 was 4.6%, compared to 12.8% for "rest of the world", 4% for other Nordic researchers, and 3.3% for Norwegian researchers.

A study of return and onward migration among working-age men in Canada found that a substantial part of "permanent" migration is in fact temporary, especially for skilled workers (Aydemir and Robinson, 2006). Using a combination of landings records, census data and longitudinal tax filing information, the study found that out-migration 20 years after arrival was around 35% among young working-age male immigrants. About six out of ten of those who leave do so within the first year of arrival, suggesting that many immigrants make a decision relatively quickly. Migrants' characteristics strongly affect the tendency to leave; out-migration rates were higher among immigrants admitted under the skilled worker or business class visa, with around four in ten leaving within ten years of arrival, compared to two or three in ten for those arriving under assisted relative or refugee visa classes. The authors suggested this finding was consistent with the notion of a global labour market, since skilled worker and business groups are more likely to move on the basis of changing relative labour market conditions in various countries. There was also strong evidence of business cycle effects, with cohorts arriving in recessionary periods around 50% more likely to leave than those arriving at other times.

Information on migrant intentions to stay can also reveal something about the likelihood of return and circular migration. Data from the United Kingdom, covering the period 1996 to 2005, show that the intended length of stay for immigrants is falling (Office for National Statistics, 2007). Approximately 45% of migrants who specified the duration at their time of entry in 2005 stated their intention to stay in the United Kingdom for one to two years, while 30% intended to stay more than four years. In 1996, only 35% of migrants intended to stay one to two years and 40% intended to stay more than four years.

Reasons for return

Anecdotal evidence on reasons for return migration is provided by Khadria (2004), drawing on a small survey of returned IT workers in India. The three primary motivating factors behind the return to India of the sampled IT workers were family/personal reasons, recognition of India as a major

emerging IT power, and increasing employment opportunities in India. Higher real earnings in India were also a motivating factor for many workers. Although nominal wages were higher abroad, the cost of living was also much higher. Important motivating factors for settling in Bangalore in particular were abundant employment opportunities, better infrastructure than in other Indian cities, better remuneration packages and availability of experts in the IT sector.

Khadria found that the returning workers had generally moved overseas for less than six years and had mainly gone to work on project assignments for their employers or to gain professional experience. None had gone with the intention of settling permanently abroad, and the majority felt that the knowledge and skills they had gained overseas were very useful for their current jobs in India. Many said their experience helped in interacting with clients (many of whom were from the United States or European countries), acquiring technological innovations and coping with technical change, improving management practices, and confidence building.

A study of Australia's diaspora found similar motivating factors behind the return of migrants (Hugo *et al.*, 2003). Lifestyle and family were the overwhelming reasons for returning to Australia for many migrants, while those not intending to return indicated that a better job or higher salary than the one they currently had would attract them back. Nearly 80% of the expatriates surveyed believed that their overseas residency had benefits for Australia in terms of "creating goodwill towards Australia" and "skills transferable back to Australia".

Research on Portuguese scientists' views on return migration highlights the importance of adequate employment opportunities at home. Fontes (2007) built a sample of 55 Portuguese expatriate scientists who were inventors of biotechnology patents and collected information on their careers and their perspectives on return. Most were still abroad and intended to stay there; however, for most of them, "this decision is based less on the unwillingness to return, than on the awareness of the difficulties to be expected at home" (2007, p. 295). Around 38% of the scientists strongly wished to return and regretted the absence of employment compatible with their qualifications, while 34.5% would only be willing to return if a particularly good opportunity arose. Fontes pointed to the importance of a coherent and sustained strategy that combines incentives to return with the creation of attractive conditions and the strengthening of scientific diaspora networks.

Expectations regarding labour market/employment conditions also play a role in the decision to return. Data on French PhDs, for example, showed that only a small percentage lived outside of France after three years of work

(Martinelli, 2001). In 1999, only 7% of the 1996 PhD cohort was abroad and nearly 60% wanted to return as soon as possible or in a year's time, with only 21% wishing to stay abroad. Martinelli stated that the circumstances of PhDs living abroad explained their desire to return home; in particular, while most young PhDs in France held indefinite-term jobs in 1999, 79% of those abroad were employed on a fixed-term basis.

Returning students

Various factors affect students' decisions to return to their home country after studying abroad. From a survey of nearly 1 000 international students studying business management in five universities in the United Kingdom and the United States, Baruch *et al.* (2007) found the most influential factors in a student's decision to remain or return were: *i)* perception of the labour market in the host country; *ii)* the student's perception of his/her adjustment to the host country; and *iii)* the strength of family ties. Overall, 30% of students indicated their intention to return home after their studies, while another 27% intended to return after a year of practical training. Only 2% indicated an intention to reside in the host country. Indian students were the least inclined to return home; students from China, Chinese Taipei and Thailand, and from countries in Africa, the Arabian peninsula and Latin America, were more inclined to do so.

Preliminary data from Canada, Portugal and the United States on doctorate holders' intentions to move show that among recent foreign doctorate holders, 25% intended to leave Portugal within the next year (compared with approximately 15% of Portuguese citizens) (Table 3.7). In the United States, 40% of foreign citizens who recently received a doctorate intended to move in the next year, compared with only 5% of citizens.

Table 3.7. **Percentage of recent doctorate holders having declared their intention to move out of the country in the next year**

	Canada (2003-04)	Portugal (2000-04)	United States (2003)
Citizens	16.6	14.6	5.0
Foreign citizens	39.2	25.0	40.1

Source: Auriol (2007).

More disaggregated data on the number of temporary visa holders who received an American doctorate and who still work in the United States reveals wide diversity across subject fields. Table 3.8 shows that among

Table 3.8. **Percentage of temporary residents who received US S&E doctorates in 1998 and were in the United States, 1999-2003**

Degree field	Number of foreign doctorate recipients	Percentage in the United States				
		1999	2000	2001	2002	2003
Physical science	1 419	75	74	72	71	69
Mathematics	447	67	63	62	60	59
Computer science	328	71	71	72	72	70
Agricultural science	463	48	47	47	47	46
Life science	1 620	72	68	67	68	67
Computer/electrical engineering	688	78	76	75	74	70
Other engineering	1 894	69	67	67	65	64
Economics	516	40	39	37	37	36
Other social science	583	39	38	37	37	37
Total, all fields	7 958	66	64	63	62	61

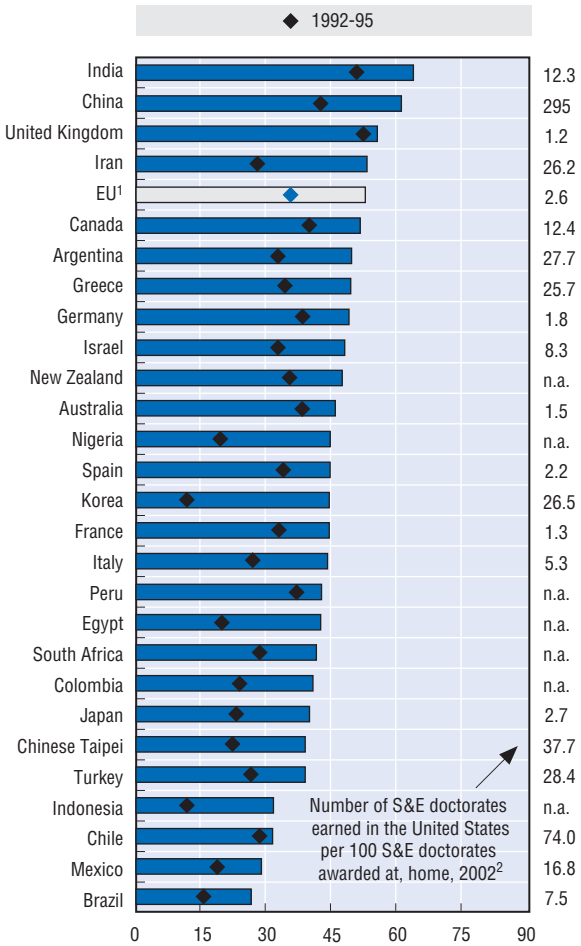
Source: Finn (2005), p. 6.

foreign students with temporary visas who received American doctorates in science and engineering (S&E) in 1998, an average of 61% were still in the United States in 2003. Across fields, the stay rate ranged from 36% in economics to 70% in computer science and computer/electrical engineering.

Stay rates also vary according to students' country of origin. Data from the United States suggest that the propensity of new doctorate holders to remain has increased for all citizenships since the beginning of the 1990s, with the intensity varying according to country of origin (Figure 3.16). The data also show that two-thirds of Indian and Chinese recipients of science and engineering doctorates, and over half of European recipients, receive a postdoctoral appointment or job in the United States after graduation (OECD, 2007a, p. 46).

Korean data from 1995 to 2004 show that the stay rate for Korean recipients of science and engineering doctorates in the United States increased substantially from the mid-1990s, peaked in 2002, and has since declined slightly (Figure 3.17). Korea has the largest international student group in the United States, overtaking the former leader, India, with over 87 000 students in March 2006. The Korean Ministry of Science and Technology hopes to involve these expatriate researchers in its Korean Scientist and Engineers Network (KOSEN), which now exists in 11 countries and receives funding for its activities.

Figure 3.16. **Foreign science and engineering doctorates who intend to stay in the United States, 2000-03**



1. Includes all European countries.
2. OECD estimates based on NSF data. The ratio compares the number of new foreign citizens graduating at doctoral level in S&E fields in the United States to the number of earned S&E doctoral degrees in the country of origin. New S&E doctorates refer to 1996 for Chile, 1999 for Brazil, 2001 for Canada, China, Greece, Italy and Spain, 2003 for Germany, Japan and the United Kingdom.

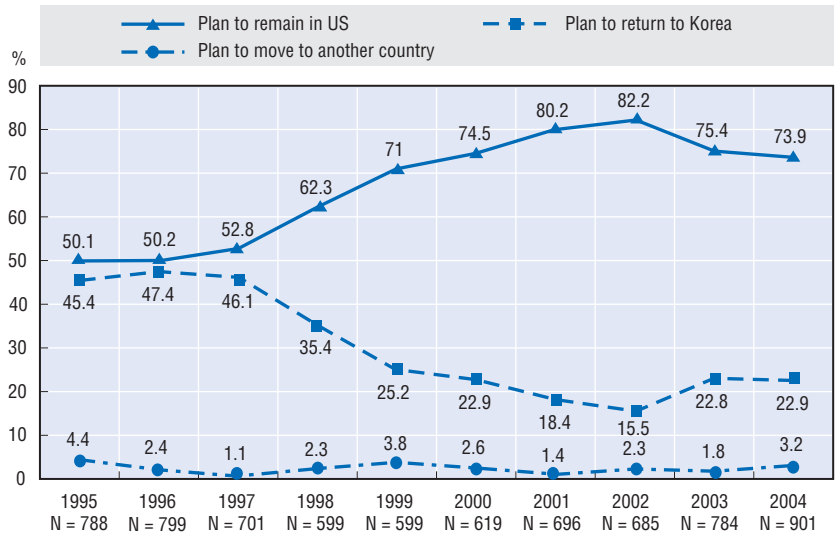
Source: OECD (2007a), p. 47.

Attitudes to mobility in Europe

Evidence on return and circular migration in Europe can be found in the analysis of the 2005 Eurobarometer survey results on attitudes to mobility (see Box 3.3). A comparison of the intentions to move in the next five years of

Figure 3.17. **Post-graduation plans of Korean doctorate recipients from US universities in science and engineering fields**

Percentages



Source: Korean Ministry of Science and Technology (2007), p. 138.

Box 3.3. **Attitudes to mobility in Europe: the 2005 Eurobarometer survey**

As part of preparations for the European Year of Workers' Mobility in 2006, a Eurobarometer survey on geographic and labour market mobility was undertaken in September 2005. More than 24 000 EU citizens were surveyed, with face-to-face interviews in people's homes and in the appropriate national language.

Past moves

The survey found that one-third of Europeans had moved out of their region of origin at least once in the past, with 24% of respondents having settled in another region, 4% in another member state and 3% in a country outside the EU, and 12% said they had participated in a training or education programme in another EU member state. In general, Nordic countries had the highest overall levels of mobility (around 40% of the working-age population had lived in a different region or country), followed by Ireland and the United Kingdom. Southern Europe and the eastern European member states had the lowest levels of mobility. The data are likely to under-represent the true level of mobility, because respondents who did move are underrepresented in host country samples and are not included in samples of the country of origin.

Box 3.3. **Attitudes to mobility in Europe: the 2005 Eurobarometer survey** *(cont.)*

In all cases, the higher the level of education, the greater the willingness to migrate. The survey showed that around 7% of the highly educated (that is, people who left full-time education after the age of 20) had moved within the EU since leaving the parental home, compared to 4% among the less educated.

Long-distance moves (*i.e.* outside the region, within the EU) were often related to the labour market; 34% of respondents cited a new job or a job transfer as the key reason for the move. However, gender differences were apparent for long distance moves, with 27% of women and 44% of men citing a new job or job transfer as the motivation. Women more often made long distance moves in order to follow their partner (EFILWC, 2006, p. 19). Of those who had moved in the past, more than 45% declared that no aspect of their life deteriorated after the move, and many saw their job, money and housing conditions improve (25%, 22% and 36%, respectively).

Future moves

Only 3% of respondents expected to move within the EU in the next five years. The intention to migrate was greater among men, people under 35 years of age, singles, the better educated and students, and the unemployed (EFILWC, 2006, p. 22). The four countries in which respondents most expected to move were Latvia, Poland, Lithuania and Estonia. In this group, 75% of people with mobility intentions were under 35 years of age, 32% had high levels of education and 34% were still studying.

Benefits of mobility

Europeans overall view long-distance mobility positively; 49% say it is good for individuals (12% against), 50% say it is good for the labour market (21% against), and 62% say it is good for European integration (11% against) (EFILWC, 2006, p. 21). When asked about what the EU represents for them, 53% said "freedom to travel and work in the EU". This answer came first, and well ahead of the euro (44%) or safeguarding peace (36%). Views are split across member states, however, with more than 60% of respondents in Denmark, Ireland, the Slovak Republic and Sweden saying mobility is good for individuals against less than 30% in Greece.

Source: EC (2006); EFILWC (2006).

respondents who had and had not moved in the past showed that those who had moved in the past had a higher propensity to move in the near future, especially if they had moved over a long distance. The European Foundation for the Improvement of Living and Working Conditions (EFILWC) suggested that this could imply that they are ready to move to another new location, but

that it could also reveal a wish to move back to their original region or country (EFILWC, 2006, p. 24).

The survey also shed light on factors that may bolster any trend towards increasing circular migration. In particular, respondents were asked what they thought would be the greatest difficulties they would have to face if they wished to move to another EU country. Concerns included culture and language (67% of respondents), employment (43%), transferability of pension rights (13%), housing (15%), and access to public facilities such as healthcare and social benefits (14%) (EFILWC, 2006, p. 26). As long as such concerns exist, potential migrants will be tempted to take advantage of more temporary forms of migration, so that ties with the home country remain close and the challenge of living permanently in a different culture can be avoided.

Impact

It is not easy to find clear quantitative evidence on the impact of mobility. In many cases, causality cannot be proven, and it is challenging to construct a counterfactual case. Many variables and factors influence science and technology outcomes and they are hard to untangle. This section presents data and evidence on internationalisation of the labour market, innovation and research collaboration. In some cases the link to mobility is clear, while in others, it seems logical but has not been proven.

Labour market internationalisation

A direct impact of mobility of highly skilled workers is increasing internationalisation of the labour market for the highly skilled. This is occurring both in private industry and in academia. For example, results from the Australian innovation survey found that 7.1% of innovating businesses employed new skilled staff from overseas as a way to acquire knowledge or abilities, while 2% used overseas consultants or advisors and 1.2% exchanged staff with other businesses overseas (ABS, 2005, p. 29). The use of overseas talent to acquire knowledge was greatest in the communication services industry. To acquire knowledge or abilities from overseas higher education or research institutions, 0.6% of innovating businesses employed new graduates, 0.7% employed academic or research staff and 0.7% used consultants.

A firm-level survey of 850 enterprises with highly qualified staff in France, Germany, the Netherlands and the United Kingdom also found international employees playing an important role in industry (Winkelmann, 2002). Overall, nearly 40% of firms hired highly qualified foreign employees for an average of 11% of the total highly qualified staff. Among the main reasons for hiring foreign staff – derived from the data on German firms – were knowledge of foreign languages, including English, and knowledge of foreign

markets. Data from the United States also reveal the importance of flows of foreign skilled workers, and Table 3.9 shows the increasing number of visas issued to workers with specialty occupations, as well as visas issued under NAFTA provisions and for intra-company transfers.

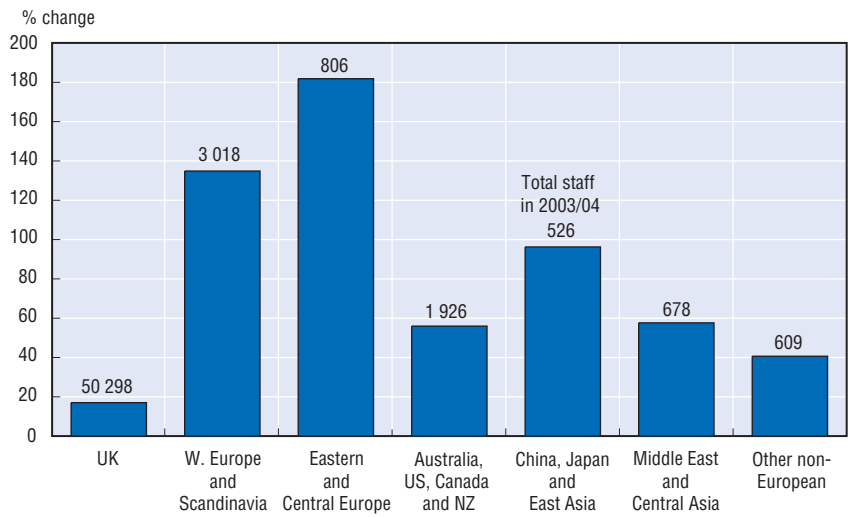
A report by Universities UK (2007) found that academic staff recruited from overseas are now a significant element of the UK university workforce. Figure 3.18 shows the growth in permanent academic staff by nationality from 1995/96 to 2003/04 and the strong increase in international staff, albeit

Table 3.9. **US inflows of highly skilled workers**

	1985	1990	1995	2000	2001	2002	2003
Specialty occupations (H-1B visa)	47 322	100 446	117 574	355 605	384 191	370 490	360 498
Professional workers (NAFTA TN visa)			23 904	91 279	95 486	73 699	59 446
Intra-company transferees (L1 visa)	65 349	63 180	112 124	294 658	328 480	313 699	298 054

Source: D'Costa (2008), p. 61.

Figure 3.18. **Percentage change in permanent academic staff in UK universities, by nationality, 1995/96 to 2003/04**



Source: Universities UK (2007), calculated from Table 8, p. 11.

sometimes from a small base. Universities UK highlighted the positive aspects of this staffing profile, noting that international staff provide the British system with highly qualified and talented people, who are likely to develop research collaborations with academics that will continue for the rest of their careers. They also noted the importance of international staff in ensuring the continued provision of teaching and research at appropriate levels in key subjects in which there are declining numbers of British nationals (2007, p. 20).

In Norway 16% of scientific academic staff held foreign citizenship in 2001 (Nerdrum and Sarpebakken, 2006). Foreign researchers were distributed unevenly across scientific fields, but their share rose in all fields from 1991 to 2001. The highest share of foreigners in 1991 was in humanities (14% of staff), but in 2001, the highest share was in engineering and technology (22%).

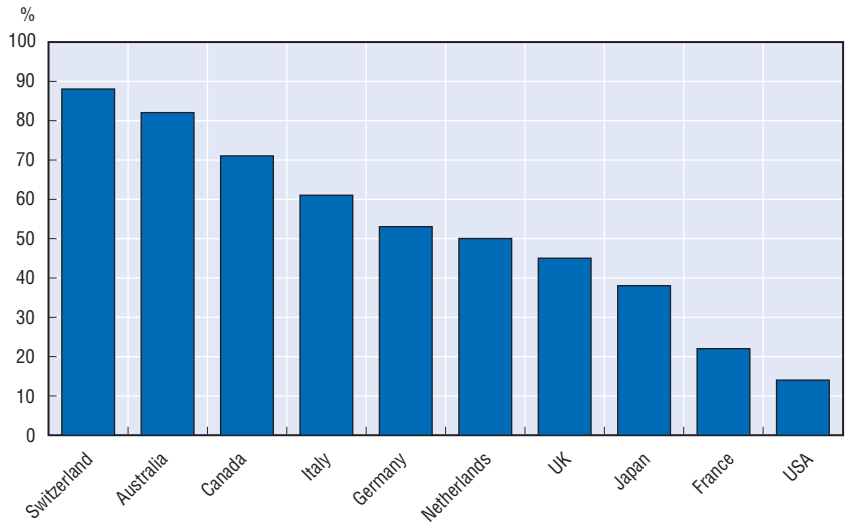
The international mobility of academic staff may help countries meet the challenge of ageing academic workforces. The OECD's recent review of tertiary education showed that in many OECD countries the average age of academics is high. In the Netherlands, 47% of teaching staff in universities of applied science were aged 50 or more in 2005, while data from 2003 for Austria, Belgium (Flemish Community), France and Sweden showed that over 50% of professors were over 55 (OECD, 2008b, pp. 191-192). Recruiting staff from abroad, or developing joint international exchanges in teaching and research, might help academic institutions adjust as older cohorts of workers begin to retire.

There is some evidence that mobility of academics is associated with higher quality output. A study of highly cited researchers (Evidence, 2005) found that a very large share had research experience out of their home country. For example, 45% of highly cited researchers based in the United Kingdom had spent some time in another country during their research careers (Figure 3.19). The study suggested that relative national mobility and international research performance may be related: "The mobile populations of Switzerland and the Netherlands produce high relative research performance for a small research economy. Mobility may lead to better international connections and hence to better collaborative research, which may overcome the constraints of smaller research economies." (Evidence, 2005, p. 10)

The most common reason given by the highly cited for moving was related to career development, followed by intellectual opportunities, with 80% of those moving judging that their career had strongly improved (Bekhradnia and Sastry, 2005). Many British researchers subsequently maintained the overseas research links that they had established.

Figure 3.19. **Share of highly cited researchers with research experience outside of their home country**

By country of current institution



Note: Based on a sample of 494 researchers from the ISI Highly Cited database (1985-2004).
Source: Evidence (2005), p. 25.

Innovation

It is difficult to find empirical evidence that directly links mobility with innovation outcomes. Two studies described below attempt to assess immigrant contributions to innovation-related activities, in particular patent applications and creation of engineering/technology firms. However, it is not straightforward to prove causality or to say that this has strengthened innovation more than would have otherwise occurred.

The first study, analysing patent applications filed with the World Intellectual Property Organization (WIPO) at its United States office, found that the proportion of applications naming foreign nationals residing in the United States as inventors or co-inventors had increased from 7.6% in 1998 to 25.6% in 2006 (Wadhwa *et al.*, 2007a). Applications filed by foreigners were greatest in technology hubs such as California, Massachusetts, New Jersey and New York. Chinese (mainland and Chinese Taipei) and Indian immigrants were the largest contributors in 2006: an estimated 30.5% of inventors named on patent applications were either Chinese or Indian nationals residing in the United States or Chinese or Indian-born US citizens. The top patent areas for

these inventors were sanitation/medical preparations, medicine, pharmaceuticals, semiconductors and electronics. Foreign nationals residing in the United States, plus foreign nationals based outside the United States, also made a substantial contribution to the patent filings of a number of large multinational companies, including Qualcomm (72%), Merck and Co (65%), General Electric (64%), Siemens (63%) and Cisco (60%).

The second study looked at the involvement of skilled immigrants in firm creation. When observing the engineering and technology companies started in the United States from 1995 to 2005, Wadhwa *et al*. (2007b) found that more than 25% had at least one key founder who was foreign-born, with California, New Jersey, Georgia and Massachusetts displaying an above-average rate of immigrant-founded companies. Nationwide, these companies produced an estimated USD 52 billion in sales and employed 450 000 in 2005. Almost 80% of immigrant-founded companies were in software and innovation or manufacturing-related services.

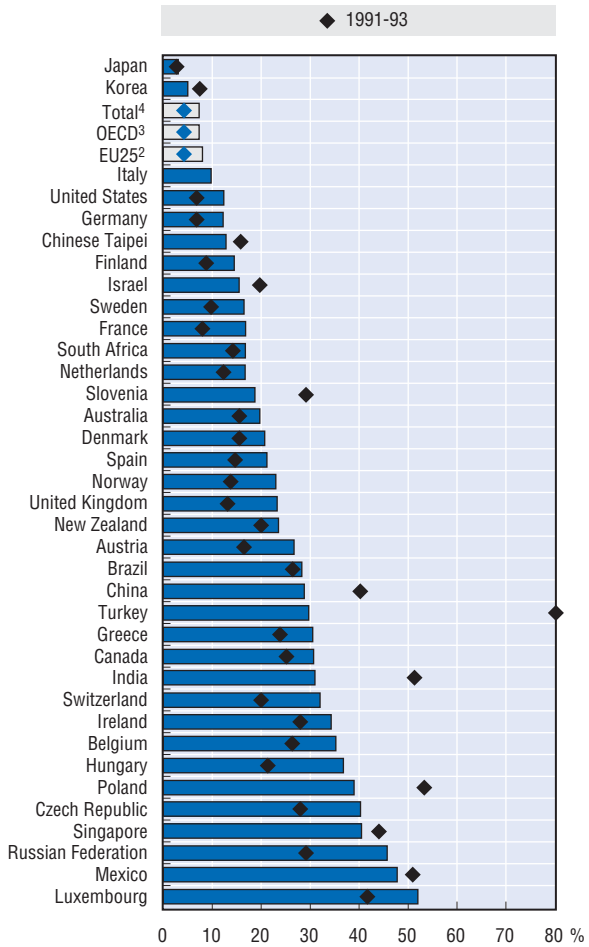
More broadly, there is certainly evidence of increasing international co-operation in invention, as measured by patents. The world share of patents involving international co-invention increased from 4% in 1991-93 to 7% in 2001-03, with small and less developed economies particularly actively engaged in international collaboration. Figure 3.20 presents data on the number of patents with foreign co-inventors for a number of countries. While the share with foreign co-inventors declined in some countries from 1991-93 levels, it rose in most countries. Again, it is difficult to link this directly to the mobility of HRST.

Research collaboration: international co-authorship

Another trend that has emerged in parallel with the greater mobility of HRST is increased research collaboration. International co-authorship, *i.e.* articles written by two or more authors of different countries, has grown in the last decade. This may indicate the crucial role of interaction among researchers with different knowledge backgrounds in order to diversify their sources of knowledge.

Studies undertaken by OECD member countries point to this trend. For example, motivated by an unexpected plateau in the absolute number of science and engineering articles published by United States-based authors in major peer-reviewed journals, the National Science Foundation (NSF) examined patterns and trends in articles produced between 1988 and 2003. A striking change over the period was the increase in various types of international collaborative articles, while single-author and single-institution output declined. This trend was apparent in all major S&E publishing centres (Table 3.10).

Figure 3.20. **Patents with foreign co-inventors**[1]
2001-03



Note: Patent counts are based on the priority date, the inventor's country of residence, using simple counts.

1. Share of patent applications to the European Patent Office (EPO) with at least one foreign co-inventor in total patents invented domestically. This graph only covers countries/economies with more than 200 EPO applications over 2001-03.
2. The EU is treated as one country; intra-EU co-operation is excluded.
3. Patents of OECD residents that involve international co-operation.
4. All EPO patents that involve international co-operation.

Source: OECD (2007a), p. 167.

The number of single institution-authored S&E articles from the United States fell over the period 1988-2001, from 60% to around 45% (NSF, 2007, p. 31). According to field-specific data, in the biological sciences, geosciences and

Table 3.10. **Indicators of international collaboration for major S&E publishing centres**

Selected years, 1992-2003

Indicator and publishing centre	1992	1997	2003
Ratio of fractional to whole S&E article counts			
United States	0.931	0.905	0.871
EU15	0.913	0.890	0.862
Japan	0.938	0.913	0.887
East Asia-4	0.865	0.874	0.873
Proportion of international to domestic addresses			
United States	0.135	0.193	0.261
EU15	0.170	0.217	0.271
Japan	0.143	0.211	0.255
East Asia-4	0.359	0.354	0.316
Per cent of S&E articles with an international address			
United States	13.9	18.8	24.8
EU15	17.3	21.8	27.2
Japan	11.8	16.5	21.5
East Asia-4	25.3	25.5	25.4

Notes: For articles with collaborating institutions from multiple publishing centres, fractional counts assign each publishing centre fractional credit on the basis of the proportion of its participating institutions, and whole counts assign each publishing centre one credit for its participation regardless of the number of participating institutions. Proportion of foreign to domestic addresses measured across total articles of each publishing centre. An international address is an institutional address outside the indicated publishing centre. East Asia-4 includes China, Korea, Singapore and Chinese Taipei. China includes Hong Kong.

Source: NSF (2007), p. 11.

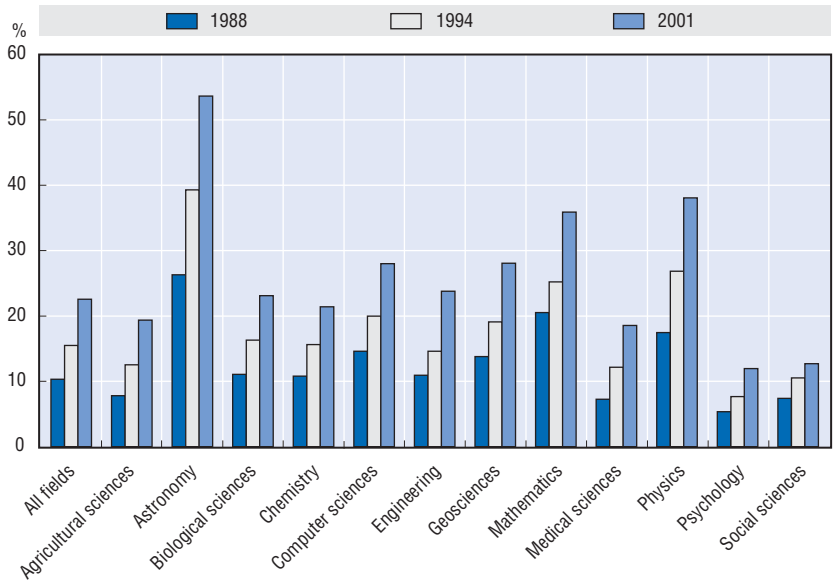
medical sciences more than 90% of the top 200 research universities had more collaboration in 1995-2001 than in 1988-94 (NSF, 2007, p. 29). Over all fields, the number of S&E articles with authors from multiple countries increased from 1988 to 2001; over 50% of astronomy articles, for instance, are now internationally co-authored (Figure 3.21).

There is evidence that some of this collaboration is associated with linkages between highly skilled migrants and their country of origin. Regets (2007) presents data showing a positive correlation (0.66) between the number of US doctorates received by foreign-born students and the percentage of that country's internationally co-authored articles with the United States (Figure 3.22). Regets suggests that contacts with former colleagues and educational institutions may facilitate the formation of international networks and knowledge exchanges, thus bringing benefits to sending countries.

Greater international collaboration in terms of co-authorship was also found in a study for the United Kingdom's Office of Science and Innovation (Evidence, 2007). Focusing on seven research fields, and analysing the data for eight partner countries, the study found that the volume of international

Figure 3.21. **US S&E articles (whole counts) with at least one author at a top 200 research university and one author at a foreign institution**

By field, selected years 1988-2001

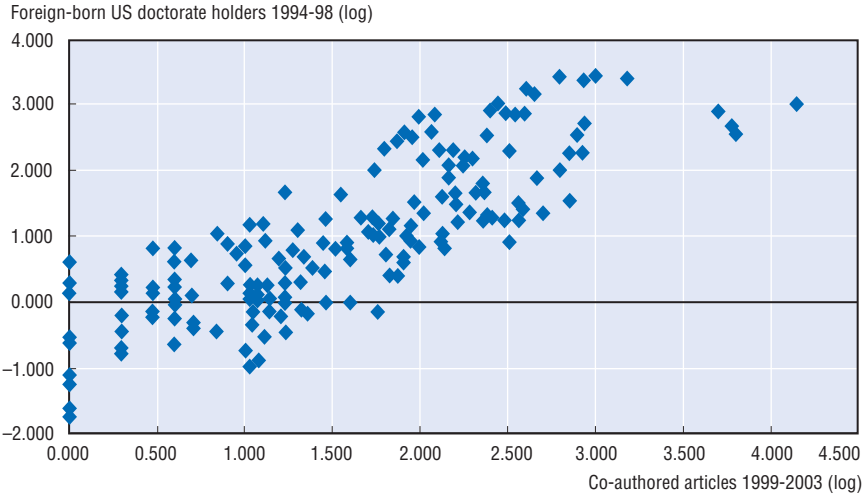


Note: Articles on a whole count basis (*i.e.* for articles with collaborating institutions, each group of institutions receives one credit for its participation, regardless of the number of participating institutions within that group). "All fields" includes health sciences and professional fields. Top 200 research universities based on total R&D expenditures during the 1988-2001 period.

Source: NSF (2007).

Figure 3.22. **Relationship of foreign-born US S&E doctorate recipients to their country's scientific collaboration with the United States**

1994-98 graduates and 1999-2003 articles



Source: Regets (2007), p. 6.

collaboration increased significantly between 1996-2000 and 2001-05. The increase in the absolute volume of collaborative papers varied across countries; for France, collaborative output increased by 30%, while for China it increased by more than 100% (p. 3). Of the focus countries, the United Kingdom displayed the most rapid increase in the share of international collaboration relative to domestic output, with 40% of output in 2001-05 being collaborative, compared to 29% in 1996-2000. Table 3.11 presents the United Kingdom's collaborative output by field and by partner country; it shows that the change in collaborative output has been strongly positive across the board.

In Finland too collaboration has increased, especially since the mid-1990s. Lehvo and Nuutinen (2006) report that joint publications with researchers from other EU countries rose by 85% from 1995 to 2004, while joint publications with other Nordic countries increased by 78%. The most important partner countries for Finnish researchers were the United States, Sweden, the United Kingdom, Germany, France, the Netherlands and Russia.

Particular patterns of co-authorship are likely to be affected by the relative capacity (in both quantity and quality) of countries in each research field, as well as by geographical proximity and language. Evidence (2007) noted that the United Kingdom has expanded collaboration with Germany which has complementary research strengths. In Finland, Lehvo and Nuutinen (2006) found that the intensity of publishing co-operation with each partner country depended on whether or not the work was on the natural sciences or medical sciences, the two fields that accounted for over 80% of all Finnish publications. Work by Igami and Saka (2007) for the OECD also shows that the amount of collaboration depends on the research area.

Table 3.11. **Change in international collaboration in the United Kingdom, 1996-2000 to 2001-05**

Research field	% change in total output	% change in collaborative output				
		United States	France	Germany	China	India
Clinical	41	45	36	56	77	70
Health	29	39	23	43	43	23
Biological sciences	35	36	34	39	109	36
Environment	57	65	53	88	115	89
Mathematics	43	16	78	44	70	55
Physical sciences	28	32	38	36	98	75
Engineering	28	31	29	29	87	34
Average	*37*	*38*	*42*	*48*	*86*	*55*

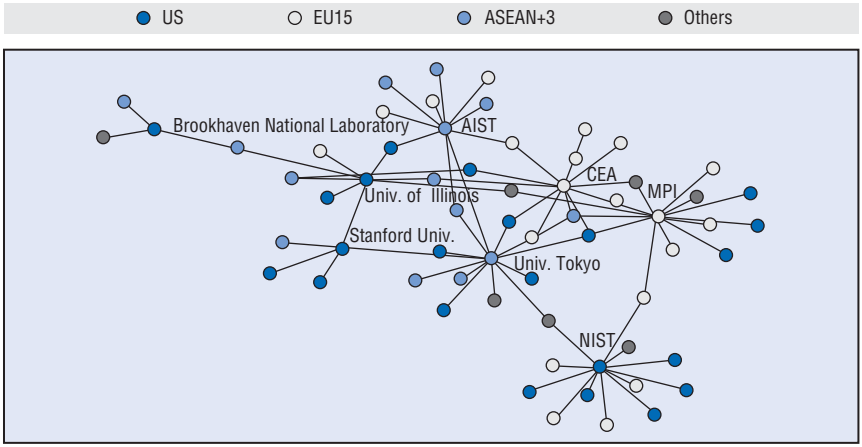
Source: Evidence (2007), p. 17.

The research categories of "Superconductivity and quantum computing", "Particle physics and cosmology" and "Environment" showed higher rates of international co-authorship from 1999 to 2004 than categories such as "Chemical synthesis" or "Health care". The authors noted a higher rate of international co-authorship in the EU countries than in the Asian countries studied, especially in countries producing small numbers of papers, while the rate of co-authorship between the EU15 (as a group) and other countries was similar to Asian co-authorship rates. The authors suggest that individual EU countries access a wide variety of researchers via international co-operation within the EU.

Institutional linkages are also important determinants of collaboration patterns. The work of Igami and Saka (2007) revealed striking patterns of co-operation and collaboration at the institutional level. For the top 81 institutions (based on highly cited papers) in the area of "Superconductivity and quantum computing", for example, the authors produced a map of co-authorship networks, which clearly shows the complex international interaction between centres of excellence in this area of research (Figure 3.23).

Evidence (2007) found that the average impact of collaborative work, as measured by citations, was significantly higher than the average impact of national work. Table 3.12 presents data on biological sciences papers that highlight the superior citation performance of collaborative work. The report

Figure 3.23. **Co-authorship network in "Superconductivity and quantum computing"**



Note: Each circle represents an institution. AIST: National Institute of Advanced Industrial Science and Technology (Japan); CEA: French Atomic Energy Commission (France); MPI: Max Planck Institute (Germany); NIST: National Institute of Standards and Technology (United States).

Source: Igami and Saka (2007).

Table 3.12. **Average impact of national papers and co-authored papers, 2001-05**

Biological sciences

Author	Impact[1]
United Kingdom only	*1.42*
United Kingdom + United States	2.40
United Kingdom + France	2.20
United Kingdom + Germany	2.24
United Kingdom + China	1.67
United States only	*1.43*
United States + United Kingdom	2.40
United States + France	2.31
United States + Germany	2.24
United States + China	1.22
France only	*1.17*
France + United Kingdom	2.20
France + United States	2.31
France + Germany	2.38
France + China	2.86

1. Citation counts are normalised to take account of year of publication and field.

Source: Evidence (2007), p. 25.

notes that work with China often records a lower impact than that of co-authored work with other countries. Nevertheless, the value of research collaboration cannot be interpreted solely in bibliometric terms, with access to knowledge and facilities and the establishment of longer-term relationships also valuable outcomes of collaboration.

The link between increased mobility and increased international joint publishing again seems logical but is not empirically proven. However, there is some support for the link. For example, Bell *et al.* (2007) suggested that the increased collaboration in American academic research was driven by advances in electronic communication and improvements in travel that allowed more conference attendance (thus enabling academics to meet potential collaborators and initiate working relationships), although encouragement from funding agencies and university faculties also played an important role. Bell's work also suggested that the increased presence of foreign institutions and academics, both through collaborative and sole-authored work, may be linked to student mobility. Interviews conducted with academics suggested that other nations have benefited from training their citizens at international centres of research excellence, often in the United States: "Many of these researchers either return to their native countries or maintain strong professional ties to institutions in those countries, thus

improving the research infrastructure." (p. 22) This was posited to have contributed to the substantial improvement of research capacity in major European countries, Japan and emerging Asian economies.

Outlook – the internationalisation of R&D

When looking towards future patterns of HRST mobility, it is useful to look at the broader context of R&D activity. Over the past decade, many countries, including newly emerging economies, have greatly improved their ability to exploit and perform research. This is resulting in a changing geography of research and scientific activity, with more countries participating more intensively.

Figure 3.24a shows that the percentage of GDP spent on R&D varies across the OECD, with Sweden, Finland and Japan in the lead. However, in some countries with lower R&D intensity, such as Turkey and Mexico, R&D expenditure is growing faster and should help narrow the spread.

Some non-OECD countries are also becoming important R&D spenders (Figure 3.24b). For example, with gross domestic expenditure on R&D (GERD) at USD 87 billion, China's spending is around one-third that of the European Union and has been growing at around 18% annually (in real terms) since 2000. GERD has also grown strongly in South Africa (11.3% a year between 1997 and 2005) and it reached USD 20.2 billion in Russia in 2006. Figure 3.25 shows GERD as a percentage of GDP in selected non-OECD economies.

Human capital resources are also increasing rapidly in non-OECD countries. In the four large emerging economies, Brazil, Russia, India and China, for example, 171 million people aged 25-64 had a tertiary degree in 2004, as many as in the entire OECD area. In China alone, 3.9 million students entered university for the first time in 2005, about half of the OECD total. However, the number of tertiary-educated individuals as a proportion of the total population aged 25-64 still remains much higher in the OECD area (25.1% as compared to 7.8% for Brazil, 9.5% for China and 11.4% for India), indicating that these countries' knowledge base still has much room for catching up (OECD, 2007a, p. 60). There are also likely differences in the types of skills of tertiary graduates in different countries, so that these human capital resources may not be fully substitutable for those in OECD countries.

Patent activity and research publications also show a broadening of science and technology activity across countries. OECD figures on triadic patent families (a set of patents taken at the European Patent Office, the Japan Patent Office and the United States Patent & Trademark Office that protect the same invention) show that, against a backdrop of steadily increasing patent filings, the United States and Europe have experienced a decline in their share of the total, while that of Asia has surged. Japan's share in triadic patent

Figure 3.24a. **R&D intensity,[3] 2006 (left) and evolution of GDP expenditure on R&D, 1996-2006 (right)**

Average annual growth rate, constant prices

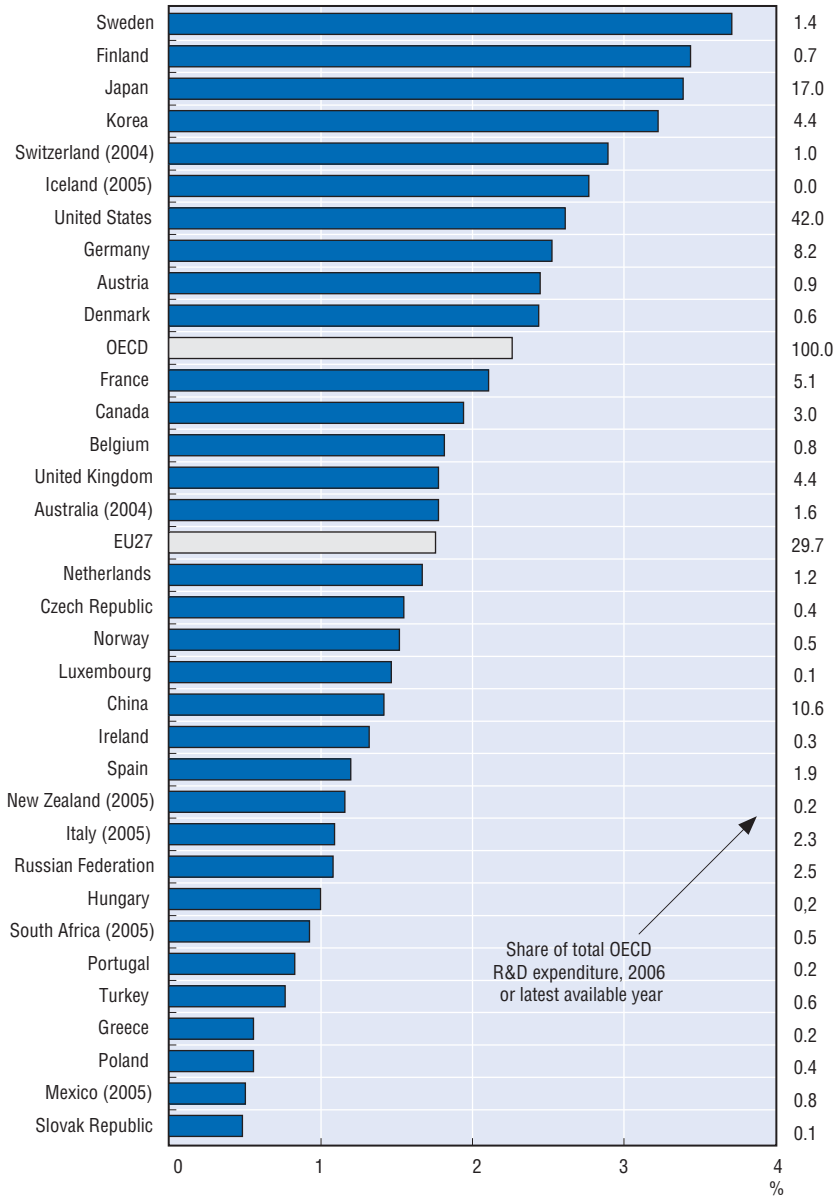
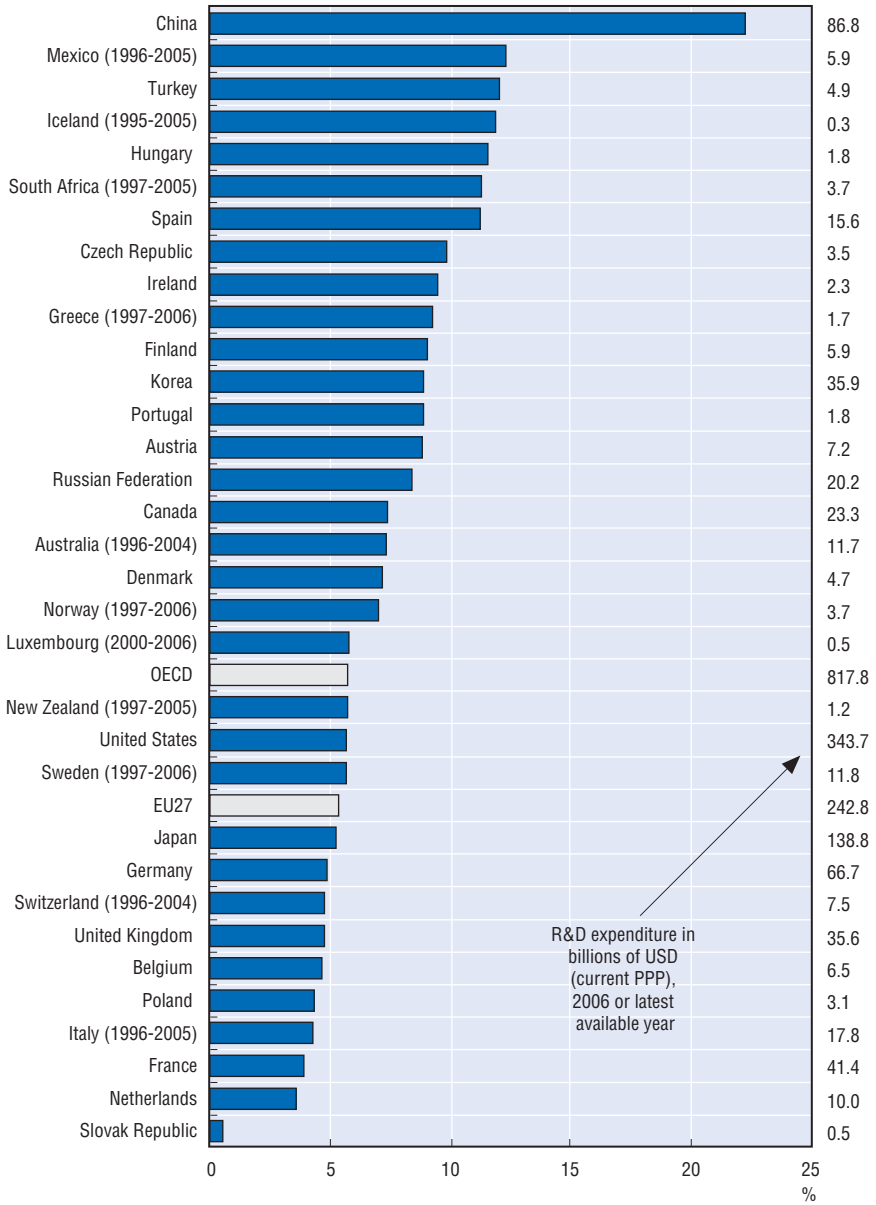


Figure 3.24b. **R&D intensity,[3] 2006 (left) and evolution of GDP expenditure on R&D, 1996-2006 (right)**

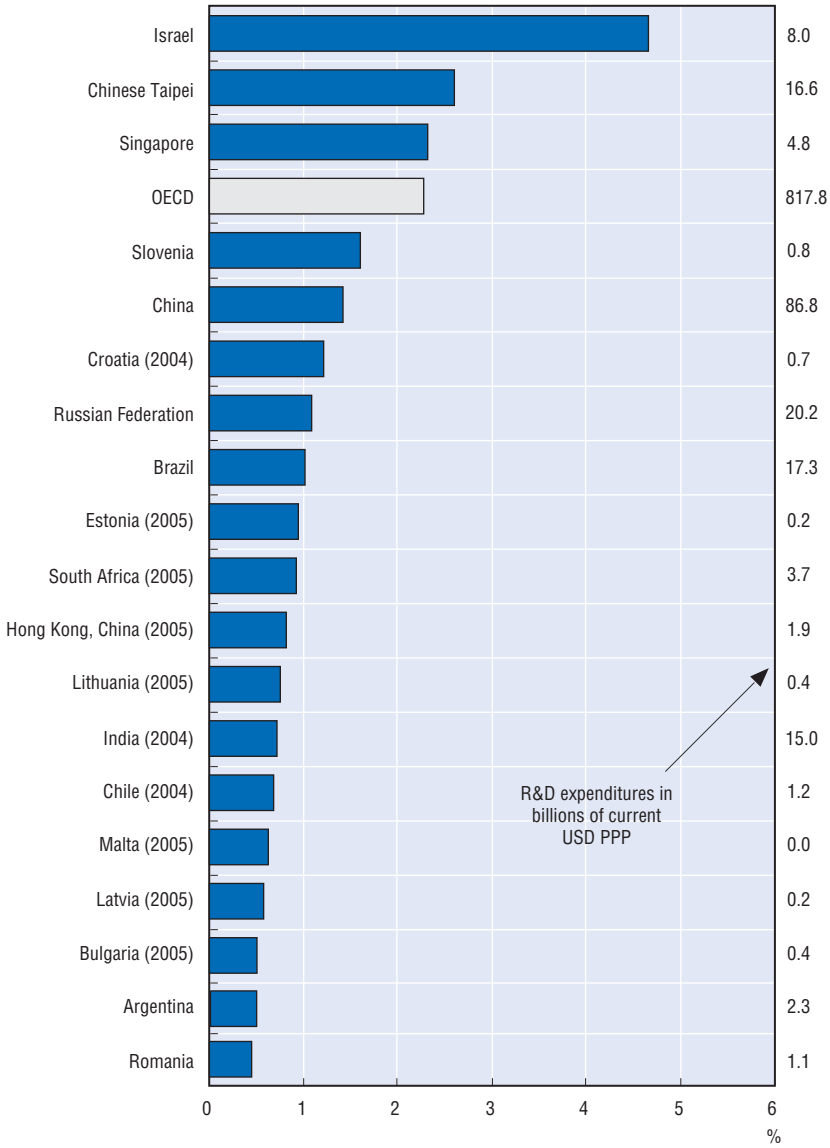
Average annual growth rate, constant prices



3. Gross domestic expenditure on R&D as a percentage of GDP.

Source: OECD MSTI database, April 2008 and OECD (2007a), p. 25.

Figure 3.25. **Gross expenditure on R&D (GERD), 2006**
As a percentage of GDP, in billions of current USD PPP



Source: OECD MSTI database, April 2008; Eurostat, *NewCronos database*, June 2007; and OECD, based on national sources.

families gained almost 2 percentage points, to reach nearly 29% in 2005, and the annual rise in triadic patent filing from China, India, Korea and Chinese Taipei ranged from 20 to 37%. China has entered the top 15 countries, having gained 16 positions since 1995 (OECD, 2007a, p. 84). Over the past ten years, research publication intensity has also increased worldwide and has expanded remarkably in some emerging economies. Scientific articles from Latin America more than tripled, closely followed by Southeast Asia (Indonesia, Malaysia, the Philippines, Thailand and Vietnam) (OECD, 2007a, p. 92).

The technological activities of multinational firms are also increasingly internationalised (OECD, 2008, forthcoming). As firms search for technological competence, better adaptation to markets and lower R&D costs, research activities are being moved overseas ever more intensively. Indicators include the increasing amount of foreign ownership of domestic inventions (in Mexico, over 50% of domestic inventions belong to foreign residents, for example) and an increase in the domestic ownership of inventions made abroad (for example, 21% of France's patents include foreign inventions) (OECD, 2007a, pp. 162-164). The share of foreign affiliates in total R&D is higher than their share in total manufacturing turnover in most OECD countries, a sign that research is now more internationalised than production (OECD, 2007a, p. 172). There is also a global shift of high- and medium-high technology manufacturing towards non-OECD countries (OECD, 2007a, p. 210).

Summary

The data and information presented in this chapter suggest that the international mobility of highly skilled HRST is a significant phenomenon. For most OECD countries, emigration of the highly skilled to other OECD countries represents up to 15% of native stocks of the highly skilled, and for a number of countries, intra-OECD flows add substantially to the stock. Non-OECD flows are also important, with Canada, France and the United States attracting large numbers of skilled non-OECD nationals. The number of students enrolled outside their country of citizenship has risen sharply over the past decade, with China, India and Morocco the three top non-OECD source countries. In addition to these growing flows, there is also evidence that return and circular migration is increasing, an indication that temporary migration is a key consideration for mobility policies.

With the appropriate caveats about causality and counterfactuals, there is also evidence that mobility has been accompanied by increasing collaboration and increasing foreign involvement in innovation and job creation. Co-authored articles, involving academics from several institutions and countries, are becoming more frequent, and there is increasing

international co-invention, as evidenced by patent data. Increased mobility is clearly associated with the increasing internationalisation of labour markets.

At the same time, the data show that R&D activity is continuing to internationalise, with more countries participating in science and technology activity. Some non-OECD countries are becoming important R&D spenders, and Asia has experienced a surge in patent filings.

What does this mean for policy? A key question is whether mobility will continue as R&D activity is increasingly internationalised, or whether the spread of innovative activity will gradually encourage more circular migration, or lower mobility, as highly skilled professionals find increasing opportunities at home. Should OECD governments focus their efforts on enabling greater temporary and circular migration, and are there areas in which government intervention is particularly necessary? Policy making in this area would be assisted by further work to improve the data, so that countries can better understand the patterns and changes in stocks and flows of scientists, engineers and researchers and the broader highly skilled group. While there have been major efforts in recent years to improve the data on international stocks and flows of the highly skilled, difficulties relating to the comparability of international data, differing and/or insufficient disaggregation of classifications and the timeliness of data still remain.

Notes

1. "Emigration rates" are calculated by dividing the number of foreign-born residing in OECD countries and originating in a particular country by the total number of natives of that country, including those no longer living in the country. This does not correspond to the usual definition of an emigration rate, which relates flows of migrants over a certain period of time to the initial stock of persons in the country of origin. See Dumont and Lemaître (2005, p. 7).
2. The database (version 4c) was constructed using data from the 2000 round of censuses (taken between 1995 and 2004) and covered 226 countries and territories.
3. Birrell *et al*. (2004) found most Australian residents who depart "long-term" return to Australia within two years. Thus the overall return rate of skilled Australians was calculated as a ratio of departures at time x to arrivals at time x + 2 years.

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