

## Foreign-born scientists: mobility patterns for 16 countries

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**A cross-country survey of research scientists in 16 countries finds considerable variation in immigration and emigration patterns.**

Scientists are a highly mobile group<sup>1–5</sup>. Yet, because of problems that arise in collecting consistent data across countries, it is difficult to make cross-country comparisons regarding the origins and roles of foreign-born scientists in a given country<sup>1,6</sup>. Moreover, most countries have an incomplete picture of the migration patterns of scientists born in their countries because it is difficult to track these individuals once they have emigrated. For example, until only quite recently, the US National Science Foundation's Survey of Doctorate Recipients did not track individuals who train in the United States and then go to another country.

We devised the GlobSci survey to provide consistent cross-country data on active researchers. During February–June 2011, we surveyed corresponding authors of articles published in 2009 in four fields of science who were studying or working in one of 16 'core' countries: Australia, Belgium, Brazil, Canada, Denmark, France, Germany, India, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland,

the United Kingdom and the United States. The four fields are biology, chemistry, materials and Earth and environmental sciences. Collectively, these 16 core countries produce about 70% of all articles published in these fields<sup>7</sup>. The only high-producing country not represented in the GlobSci survey is China, where efforts to field the web-based questionnaire proved unsuccessful. For each discipline, we chose articles from a selection of journals chosen at random from each quartile of the impact factor distribution (see **Supplementary Methods** for a description of the sampling methodology and questionnaire).

### Results

The overall response rate of 35.6% (unadjusted for non-deliverables) was 10–25 points higher than that of most web-based surveys<sup>8</sup>. The median response rate by country was approximately the same. This resulted in 16,504 completed responses; an additional 2,356 respondents answered some but not all of the questions. Response rates varied somewhat by country, being highest for Italy (63.3%) and lowest for Germany (26.2%). Ten countries had overall response rates between 32% and 36.5% (**Supplementary Methods**).

We determined country of origin by asking corresponding authors to report their country of residence at age 18. Data for the 17,182 scientists whose country of origin and country of residence in 2011 could be determined show considerable variation in the percentages of foreign-born workers and students in country (**Table 1**, column 2). Switzerland heads the list, with more than one out of two scientists studying or working in Switzerland in 2011 reporting a different country of origin. Canada is a distant second with 46.9% of its scientists reporting a different country of origin, followed by Australia (44.5%), the

United States (38.4%) and Sweden (37.6%). A number of countries have an extremely low percentage of foreign scientists studying or working in the country. Particularly notable is the virtual absence of foreign scientists studying or working in India, Italy (3.0%), Japan (5.0%), Brazil (7.1%) and Spain (7.3%).

For many countries, 'neighbors' are the most likely source of immigrants (**Table 1**, column 3). For example, Germany is the most likely country of origin of immigrant scientists in the Netherlands, Belgium, Denmark, Sweden and Switzerland. Argentina, Colombia and Peru are important source countries for Brazil. The United States is a major source country of scientists working or studying in Canada. For foreign scientists working or studying in Japan, the most likely countries of origin are China and South Korea. Cultural and language ties also matter: the United Kingdom is the top source country for Australia and is tied for top place as the source country for foreigners in Canada, and Argentina is the major source country for Spain. But geography and language do not always dominate. The top source country for the United States is China. The top source country for the United Kingdom is Germany, followed by Italy.

Countries also vary in the degree of diversity of the foreign born who work or study in country, as measured by the percentage of immigrant researchers from the top four source countries (concentration rate; **Table 1**, column 4). High concentration rates indicate less diversity (see **Supplementary Methods** for an alternative measure of concentration). The countries with the highest concentration rates are Japan and Switzerland (six out of ten immigrant scientists working or studying there hail from one of four countries). Brazil and Belgium are not far behind, with concentration rates around 50. Countries with lower concentration

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**Table 1** Mobility patterns for 16 countries

Country of work or study in 2011 (out of 17,182 respondents)	Proportion in foreign country at 18 (%)	Countries supplying ≥10% foreign workforce (%)	Four country concentration rate (%)	Country of origin at age 18 (out of 15,115 respondents)	Proportion of natives outside the country in 2011 (%)	Destination countries hosting >10% of natives outside country in 2011 (%)	Proportion with international experience (%)	Rate of return of those with international experience (%)
Australia (629)	44.5	UK (21.1) China (12.5)	43.6	Australia (418)	18.3	US (45.8) UK (24.7)	62.9	70.8
Belgium (253)	18.2	Germany (15.2) France (15.2) Italy (13.0)	52.2	Belgium (261)	21.7	France (30.0) US (20.0) UK (10.2)	52.8	58.9
Brazil (702)	7.1	Argentina (16.0) France (14.0) Colombia (12.0) Peru (12.0)	54.0	Brazil (700)	8.3	US (34.0) Canada (15.7) Germany (15.5)	51.1	83.7
Canada (902)	46.9	UK (13.5) US (13.5) China (10.9)	43.5	Canada (613)	23.7	US (70.1)	66.8	64.4
Denmark (206)	21.8	Germany (24.4)	44.5	Denmark (183)	13.3	UK (37.5) US (36.4)	54.3	75.4
France (1,380)	17.3	Italy (13.8)	37.2	France (1,303)	13.2	US (22.8) UK (14.5) Canada (14.0)	59.2	77.7
Germany (1,187)	23.2	None	30.2	Germany (1,254)	23.3	US (29.5) Switzerland (19.1) UK (18.0)	58.0	59.9
India (525)	0.8	Not computable	100	India (806)	39.8	US (75.1)	75.1	47.1
Italy (1,792)	3.0	France (13.0) Germany (11.1) Spain (11.1)	42.6	Italy (1,938)	16.2	US (25.0) UK (19.7) France (15.5) Germany (10.7)	40.0	59.5
Japan (1,707)	5.0	China (33.7) South Korea (11.6)	60.5	Japan (1,676)	3.1	US (51.4)	39.5	92.0
Netherlands (347)	27.7	Germany (14.6) Italy (12.5)	40.6	Netherlands (339)	26.4	US (22.9) UK (19.5) Germany (18.8)	53.1	50.3
Spain (1,185)	7.3	Argentina (12.6) France (10.3) Italy (10.3)	40.2	Spain (1,175)	8.4	US (31.0) Germany (16.2) UK (15.5) France (14.1)	63.1	86.7
Sweden (314)	37.6	Germany (11.9) Russian Fed. (10.2)	34.7	Sweden (226)	13.9	US (23.8) UK (13.8) Germany (11.5)	53.9	74.2
Switzerland (330)	56.7	Germany (36.9)	59.4	Switzerland (209)	33.1	US (34.2) Germany (29.5)	78.4	57.8
UK (1,205)	32.9	Germany (15.2) Italy (10.4)	37.6	UK (1,090)	25.1	US (46.9) Canada (16.6) Australia (16.6)	56.4	55.4
US (4,518)	38.4	China (16.9) India (12.3)	42.9	US (2,924)	5.0	Canada (32.2) UK (16.3) Australia (10.1) Germany (10.0)	19.2	74.2

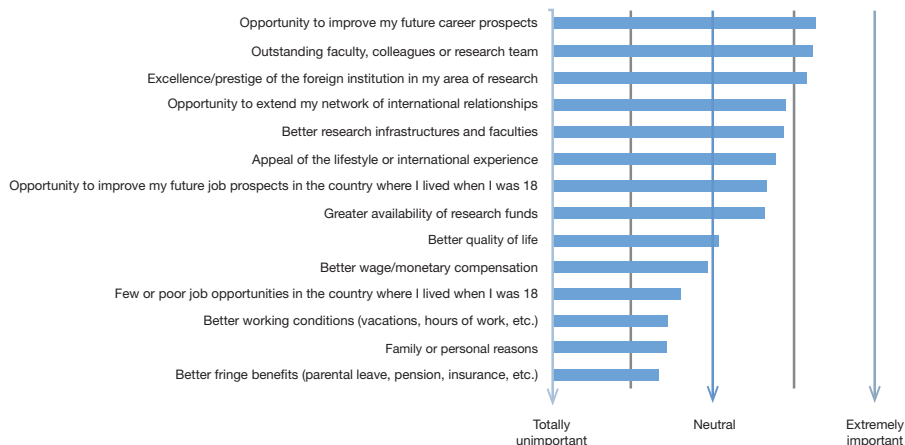
Columns 5–9, answers weighted by the inverse of current country response rate.

rates—reflecting more diversity—include Denmark, Australia, Canada, the United States, Italy, the Netherlands and Spain. The countries with the greatest diversity are Germany and Sweden, where only about one in three immigrants come from one of the top four source countries.

Immigrant scientists were asked to evaluate the importance of 14 possible reasons for coming to work in their current country of residence. We found virtually no variation

in the responses: scientists in every country chose the “opportunity to improve my future career prospects” and the presence of “outstanding faculty, colleagues or research team” above all other reasons (Fig. 1). “Excellence/prestige of the foreign institution in my area of research” and the “opportunity to extend my network of international relationships” tie for third place. Regardless of the country, respondents list family reasons or fringe benefits last.

One strength of the survey is that it not only provides information on immigrants working or studying in one of 16 core countries but also provides information on scientists who lived in a core country at age 18 and were working or studying in one of the other 15 core countries in 2011. Moreover, the survey also captures past international experience of those who have returned to a core country. This information is summarized in columns 5–9 of Table 1 for the 15,115 respondents



**Figure 1** Factors influencing emigration for postdoc, employment or academic job. Answers to the question, “How important was each of the following factors behind your choice to take a postdoc, employment or academic job in a country different from the one where you lived when you were 18?” ranked by order of importance.

who lived in a core country at age 18. Because response rates varied by country, probability weights have been used to compute the reported rates.

We again found considerable variation among countries in the percentage of emigrating scientists. Perhaps not surprisingly, India heads the list, with 39.8% of the scientists who lived there at age 18 working or studying outside the country in 2011. But Switzerland has the second highest rate among the 16, with approximately one-third of its native scientists studying or working abroad in 2011. The Netherlands and the United Kingdom are next, with approximately one-fourth of their scientists studying or working outside the country. The country with the lowest percentage of emigrants is Japan (3.1%), but the United States is close behind at 5.0%, followed by Brazil and Spain.

There is considerably less variation in the country of destination (Table 1, column 7). Indeed, the United States is the top destination country for emigrants from 13 of the other 15 core countries; for the remaining two it is the second most likely destination country. The most likely destination country for individuals living in the United States at age 18 is Canada.

Migrants from Sweden and Canada are the most likely to report that they will return home at some time in the future, with more than one in three saying that they will (Fig. 2), whereas fewer than one in five of those from the United Kingdom, Italy, Denmark

and Belgium say that they plan to return at some time in the future. Indians working outside the country are less likely than the average emigrant in this study to report that they plan to return. Nearly one out of two emigrant scientists from the Netherlands and Japan see their return as conditional on job opportunities. Four out of ten scientists from five other countries (Italy, Spain, France, Germany and Switzerland) indicate that their return is conditional on job opportunities. Job prospects figure less importantly in the possible return for emigrants from other countries, with those from Sweden, Brazil and India placing the least emphasis on job prospects.

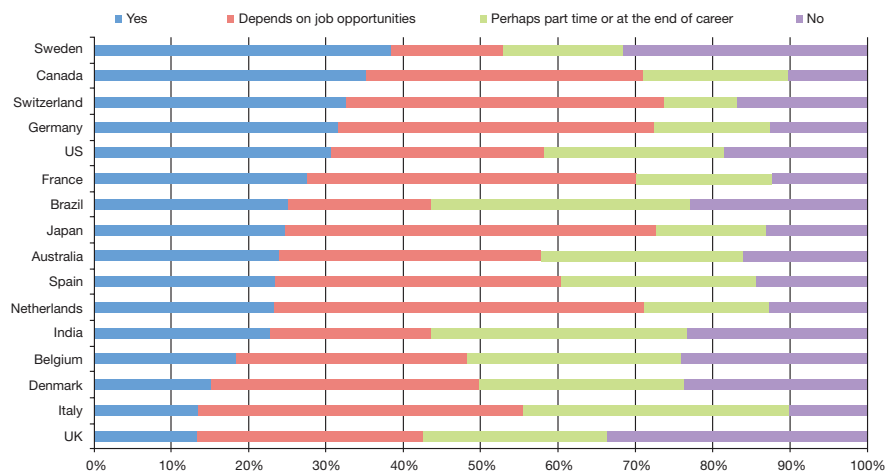
Information regarding the international experience of natives of one of the core countries at age 18, regardless of where they worked in 2011, is provided in Table 1, column 8. Particularly notable is that half or more of the scientists from 13 of the 16 countries have international experience. The rate is highest for Switzerland (78.4%), followed closely

by India, where approximately three out of four scientists have international experience. Scientists from the United States have by far the lowest rate of international experience. Table 1 also provides information on the percentage of scientists with international experience who had returned to their country of origin when the survey was administered (Table 1, column 9). Considerable variation exists, ranging from a high of 92.0%, for emigrants from Japan, to a low of 47.1%, for those from India. Regardless of country of origin, respondents reported “personal or family reasons” as the most important factor in their return, among a list that included career as well as lifestyle reasons (see Supplementary Methods).

**Conclusions**

The GlobSci survey is, to our knowledge, the most comprehensive study of mobility patterns of scientists actively engaged in research in 16 core countries. The survey finds a high rate of foreign-raised talent studying and working in a number of countries. Contrary to what is commonly thought, the United States is not atypical in its strong reliance on foreign talent. But there are a number of countries—including India, Italy, Japan, Brazil and Spain—in which foreign scientists and engineers are extremely rare. The survey also finds considerable variation in emigration patterns. Swiss and Indian scientists are the most mobile, and those from the United States are the least. The survey also documents that, for almost every core country studied, the United States is the dominant destination country.

Policy levers are extremely important in attracting scientists to work or study abroad: for every country studied, opportunities to improve one’s future or the availability of outstanding faculty, colleagues or research teams prove the most important reasons for



**Figure 2** Likelihood of return to home country. Answers to the question, “Is it possible that you will return in the future?” Listed by respondent country of residency at age 18, in descending order of percentage affirmative answers.

emigration. But policy levers seem to have a minimal role in bringing migrants back to their home countries. For these returnees, regardless of country, “personal or family reasons” are the most important factors influencing the decision to return. It does not follow, however, that countries cannot influence the return decisions of emigrants living abroad. As noted above, emigrant scientists from a handful of countries report that their decision to return in the future will depend in part on the job market.

The GlobSci survey is not without limitations. First, it is restricted to researchers who have published in one of 16 countries. Second, it is limited to four fields of science. Third, owing to problems encountered in administering the survey, China was excluded from

the core countries studied. Fourth, GlobSci provides only a snapshot of scientists active in 2009, so it cannot be used to compare cohorts of scientists over time. Despite these limitations, GlobSci is, to the best of our knowledge, the largest survey of scientists working in these four fields<sup>8</sup>.

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#### AUTHOR CONTRIBUTIONS

All authors contributed equally to this research.

#### COMPETING FINANCIAL INTERESTS

The authors declare no competing financial interests.

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