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## **Research and Policy Issues in High-Skilled International Migration: A Perspective with Data from the United States**

Migration across national borders provokes many spirited political and policy debates. Although these debates are often most contentious when they deal with lower skill migrants, high skill migration still produces strong emotion. If it nothing else, immigration of any sort changes the status quo. If lower skilled migrants are sometimes said to take jobs that natives do not want, high-skill migrants are usually employed in the type of jobs that many would prefer go to natives. At the same time, government in both less developed and many developed countries worry about losing their more highly educated workers. As high skill migration appears to become more important to the world economy, it becomes all the more important to understand its likely effects. Unfortunately, these effects have not been well studied or measured and are likely to be more complex than acknowledged in most policy discussion.

As the world largest economy, as the largest educator of foreign students, and as a traditional nation of immigration, the United States is an important nexus for the international movement of high skilled workers. As such, U.S. data on high skill migration to and from the United States can provide some insights into the magnitude and direction of some of the effects of high skilled migration discussed in this paper.

Table 1 outlines one attempt to lay out likely or possible effects of high skill international migration. This needs to include possible positive and negative economic effects for both receiving and sending countries<sup>1</sup>. In addition to country level effects, there are also global effects on the growth of technology and knowledge that can not be easily assigned to individual polities.

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<sup>1</sup> Although policy discussions usually focus on the effects on national or global economies, it seems likely that the migrants themselves incur the greater benefits and costs of high skill migration. Theory would suggest that at least the expected value of individual net benefits is positive for those who choose to migrate, although these benefits and costs may include substantial non-economic factors.

**Table 1: Possible Effects of High Skill International Migration**

<p align="center"><b>Sending Countries: Possible Negatives</b></p> <ul style="list-style-type: none"> <li>• “Brain Drain” Lost productive capacity due to at least temporary absence of higher skilled workers and students</li> <li>• Less support for public funds for higher education</li> </ul>	<p align="center"><b>Receiving Countries: Possible Negatives</b></p> <ul style="list-style-type: none"> <li>• Decreased incentive of natives to seek higher skills</li> <li>• May crowd out native students from best schools</li> <li>• Language and cultural barriers between native and immigrant high skill workers</li> <li>• Technology transfers to possibly hostile countries</li> </ul>
<p align="center"><b>Sending Countries: Possible Positives</b></p> <ul style="list-style-type: none"> <li>• Increased incentive for natives to seek higher skills             <ul style="list-style-type: none"> <li>• Possibility of exporting skills reduces risk/raises expected return of personal education investments</li> <li>• May increase domestic economic return to skills</li> </ul> </li> <li>• Knowledge flows and collaboration             <ul style="list-style-type: none"> <li>• Increased ties to foreign research institutions</li> <li>• Export opportunities for technology</li> </ul> </li> <li>• Return of natives with foreign education and human capital</li> <li>• Remittances and other support from diaspora networks</li> </ul>	<p align="center"><b>Receiving Countries: Possible Positives</b></p> <ul style="list-style-type: none"> <li>• Increased R&amp;D and economic activity due to availability of additional high skill workers</li> <li>• Knowledge flows and collaboration             <ul style="list-style-type: none"> <li>• Increased ties to foreign research institutions</li> <li>• Export opportunities for technology</li> </ul> </li> <li>• Increased enrollment in graduate programs/keeping smaller programs alive</li> </ul>
<p align="center"><b>Possible Global Effects</b></p> <ul style="list-style-type: none"> <li>• Better international flow of knowledge</li> <li>• Better job matches             <ul style="list-style-type: none"> <li>• Greater employment options for workers/researcher’s ability to seek the work most interesting to them.</li> <li>• Greater ability of employers to find rare/unique skill sets</li> </ul> </li> <li>• Formation of international research/technology clusters (Silicon Valley, CERN)</li> <li>• International competition for scarce human capital may have net positive effect on incentives for individual human capital investments</li> </ul>	

The categories, “receiving” and “sending” are not meant to be synonymous with “developed” and “less developed”. Many developed countries, such as Britain, have expressed concerns about retaining its researchers, and many less developed countries do attract foreign talent in areas where they do offer opportunities. Indeed many countries may be both net receivers and senders in different skill areas.

Few of possible effects discussed in this paper are well established empirically, although some “indicator” data does exist. Thus this paper represents an agenda for research.

## **NEGATIVE EFFECTS FOR SENDING COUNTRIES**

A loss of productive capacity due to the at least temporary loss of highly skilled workers and students is the most discussed negative effect of high skill migration for sending countries. This “brain drain” has been an issue not just for countries, but any area whose educated natives migrate—in the United States more rural states often worry about the products of their state universities moving to other parts of the United States where their skills are in greater demand. In addition to the direct effect on the availability of high skill labor, another consequence of highly educated workers leaving a country may be a reduction in political support for funding for higher education.

College educated migrants to the United States do have a significant proportion of their formal education from outside of the United States. As shown in Table 2, about 55 percent of the college educated foreign born in 1993<sup>2</sup> had at least one post-secondary degree from an institution outside of the United States, and 40 percent had their highest degree (or most recent if at the same degree level) from a foreign institution. Even at the highest education level, nearly one-third the foreign-born with doctorates who were resident in the United States

**Table 2: Percent of U.S. Foreign Born with Foreign Degrees**

	<b>Percent With Highest Degree From Foreign School</b>	<b>Percent With Any Foreign Degree</b>	<b>Percent With Foreign Secondary School</b>
<b>Bachelor’s Degree</b>	<b>49.1</b>	<b>51.1</b>	<b>67.4</b>
<b>Master’s Degree</b>	<b>24.1</b>	<b>57.2</b>	<b>76.4</b>
<b>Professional Degree</b>	<b>60.0</b>	<b>69.3</b>	<b>74.3</b>
<b>Ph.D.</b>	<b>31.2</b>	<b>73.3</b>	<b>86.7</b>
<b>All Degree Levels</b>	<b>40.2</b>	<b>54.7</b>	<b>71.0</b>

**Source: NSF/SRS 1993 National Survey of College Graduates**

received their doctorates from foreign institutions. Although many immigrants to the U.S. do arrive as children, 71 percent of the college educated foreign born graduated from a foreign secondary school, with their pre-university education funded outside the United States.

Many countries also are concerned with the return rates of their nationals who go to other countries for graduate training. Finn (1999) shows that slightly around half (53 cent) of 1992-1993 recipients of science and engineering doctorates from U.S. schools were working in the United States in 1997

## **POSITIVE EFFECTS FOR SENDING COUNTRIES**

Less often discussed are positive effects that may exist for countries whose highly skilled natives and citizens move across borders. In part, this is because of the difficulty of measurement. Although data on international migration is often poor,<sup>3</sup> counts of initial migrations of people are easier to obtain than return migration or knowledge flows. Nevertheless, there are several indicators that such benefits might exist. While there is talk of “brain drain”, other have talked of “brain gain” or “brain circulation” to describe some of the complex effects.

### **Incentives for human capital investment**

The most difficult to measure, but theoretically likely, benefit may be an increase in the incentive of natives to invest in their own human capital. This can occur in theory through three mechanisms:<sup>4</sup> 1) through an increase in the domestic return to skills due to the relative scarcity created by the “brain drain”, 2) through an increase in the expected value of an individual’s human capital investment if they have migration as an option, and 3) a reduction in the risk associated with the return on individual human capital investment if migration serves as a labor market stabilizer.

The first effect is the improvement of labor market conditions for highly skilled workers when their domestic supply is reduced by emigration to other national labor markets. Other channels, through which migration leads to increased supply, of course may offset this.

The second effect results from any uncertainties that individuals might have about their likely migration behavior. To show this in a simple algebraic form, the expected value of individual’s human capital can be expressed as:

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<sup>2</sup> The 1993 National Survey of College Graduates, with over 150,000 observations, is a National Science Foundation survey which provides a valid national sample of college graduates up to age 75 who were in the U.S. at the time of the 1990 Census and in April 1993.

<sup>3</sup> The data limitations in the United States are possibly most succinctly illustrated through the title of a National Academy of Sciences study: *Immigration Statistics: A Story of Neglect*. Aspects of the immigrant labor force are picked in different data systems, but many data gaps remain.

<sup>4</sup> The domestic demand for skilled labor, and hence the return on human capital, may also increase due to other effects discussed later in this paper which might lead to increased R&D in sending countries. Although many of these hypothesized effects clearly are interrelated, this paper does not attempt to theorize beyond partial equilibrium effects.

$$E(H) = P_m E_f(H) + (1 - P_m) E_d(H)$$

where  $P_m$  is the subjective individual probability of migration,  $E_f$  is the expected value of human capital  $H$  in the best foreign labor market, and  $E_d$  is the expected value of the same human capital in the domestic labor market. Where the expected foreign value of human capital is much greater than the domestic value, the even a small nonzero expectation of migration may have an important effect on the expected value of a human capital investment decision.<sup>5</sup>

The third effect depends upon whether the amount of emigration of high skill labor from a country is related to current labor market conditions. If a downturn in demand for high-skilled labor in a country results in more high skilled workers leaving, that might tend to reduce the fluctuations in employment and salaries, reducing the “risk” associated with the human capital investment. To some extent this role of a labor market stabilizer may be offset by any instability caused by return migration driven by changes in conditions in receiving countries.<sup>6</sup>

### **Knowledge flows and collaborations**

International migrants (other than refugee) seldom break of all ties with their country of origins. There is reason to believe that high-skill migrants, who have extensive education and often work experience in their country of origin, may maintain contacts with former colleague and education institutions. This may provide a benefit for sending nations through facilitating the formation of international networks of contact and knowledge exchange—both with expatriate natives and with contacts that returning expatriates made while abroad. Some evidence for this is seen in figure 1, which show a +.61 correlation between the log of the number of U.S. doctorates received by natives of a country and percentage of that country’s internationally co-authored articles that are with the United States.<sup>7</sup>

This is not an unexpected effect—that contact in graduate school may lead to research collaboration across borders. The same effect is likely to be created by the movement of people employed by industries who may cross and re-cross borders. Movement of workers between firms has long been recognized as a power source of knowledge transfer—both of technology and of more subtle things such as business practices and networks of contacts—and this is likely to occur even when the firms are across national borders.

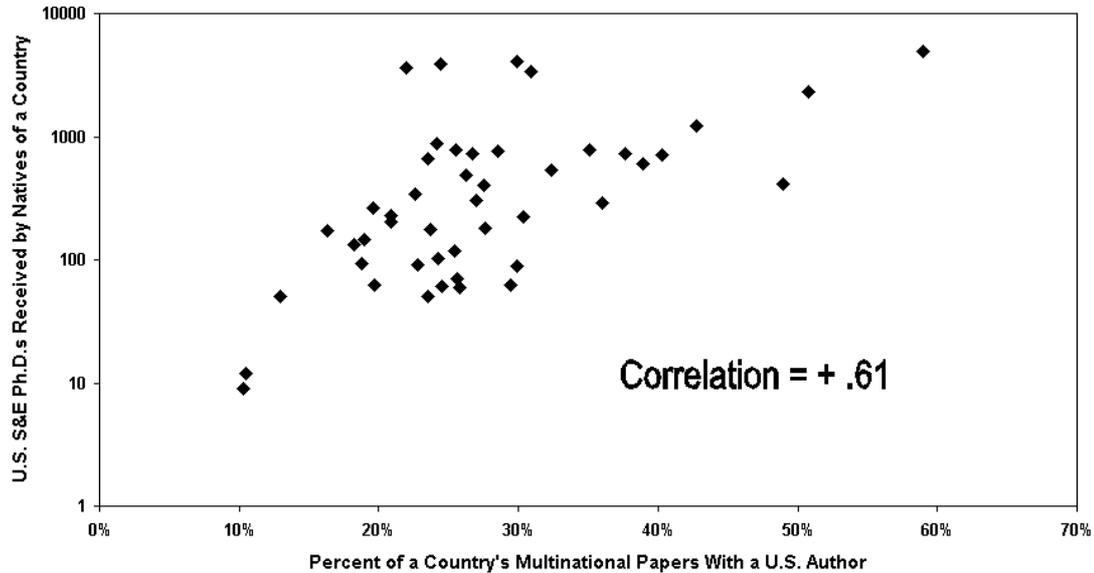
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<sup>5</sup> In a further straining of the “brain drain” metaphor, an Indian, commenting on the Cable News Network about the disparity between degree production and opportunities in India, said, “Better a brain drain than brains down the drain.”

<sup>6</sup> A prominent example of labor market instability being caused by return migration involved not high-skill, but low skill labor—the return migration of workers from southeast Asia from the Arabian peninsula at the time of the Gulf war.

<sup>7</sup> This is determined by the location of the institution that each co-author is affiliated with. Thus it could be between natives of the same country, one of whom works in the United States, or any other combinations of nativities.

**Figure 1: Scatter Plot of Percent of 1991-1995 Multinational Papers With a U.S. Author to the Number of 1986-1990 U.S. S&E Ph.D.s Received by Natives of a Country**



other post graduate work experience. As shown in table 3, Finn found stay rates that varied by field of degree, ranging from 32 percent in the social sciences to 61 percent in the physical sciences and mathematics

	1994	1995	1996	1997
<b>All S&amp;E Ph.D. recipients</b>	48	51	52	53
Physical sciences & mathematics	55	59	60	61
Life sciences	48	51	53	54
Social sciences	29	31	32	32
Engineering	49	53	53	54

SOURCE: Michael G. Finn, "Stay Rates of Foreign Doctorate Recipients From U.S. Universities" (Oak Ridge, TN: Oak Ridge Institute for Science and Education), 1999.

Also noteworthy is that the stay rates shown in table 3 hold steady or increase somewhat with time since degree. However, another data source, the NSF's Survey of Doctorate Recipients, suggests that who do stay in the U.S. leave after a period of time. This seeming contradiction may be reconciled through a complex pattern of migration—while some individuals who earned a U.S. doctorate leave each year, some others return.<sup>11</sup>

In 1995, a special effort was made in collecting the Survey of Doctorate Recipients (SDR) to discover if a survey non-respondent was resident outside of the United States. Since it is quite possible that some of other non-respondents, whose location was never discovered, also resided outside of the United States, this should be considered a lower-bound estimate. Table 4 presents these estimates for foreign born individuals in the SDR (which included in its sample only those who earned doctorates from U.S. schools who were a U.S. citizen, U.S. permanent resident, or whom had plans to stay in the U.S. at the time of their degree). Thus the SDR included only those foreign-born Ph.D. recipients who had particularly strong ties to the United States. Among this group, about one-fifth of those who graduated in the last three decades were identified as residing abroad, and for graduates from the last ten years, over 4 percent had moved from the United States in the previous two years.

In addition to knowledge transfers, the return of natives to a sending country also brings a gain of human capital that may not have been developed

<sup>11</sup> Finn matches Social Security numbers from the Survey of Earned Doctorates to individual earnings records. In order to protect confidentiality, the Social Security Administration reports back to Finn the percentage of a Ph.D. cohort that was found in their records, and not information on any individual. Thus we do not know directly if the same individuals are present each year.

had the migrants stayed in their home countries, often financed to a considerable extent by foreign employers and educational institutions.

**Table 4: Lower Bound Estimates of Foreign Born With U.S. S&E Ph.D.s Working Outside of the U.S. In 1995 (Only Those Who Were U.S. Citizens, Permanent Residents, or Definite Plans to Stay At Time of Degree)**

Decade of Ph.D.	Percent in 1995	
	Percent Out of U.S. In 1995	Who Left U.S. Since 1993
1945-54	6.1	0.6
1955-64	13.7	0.8
1965-74	22.7	1.3
1975-84	22.2	2.3
1985-94	19.4	4.1

Source: NSF/SRS 1993, 1995 Survey of Doctorate Recipients

### **Support from diaspora networks**

There are in the general immigration literature many studies of the effects of having large populations of natives outside of a country's border. These include both the creation of new export opportunities for their home countries and the value of remittances to relatives and institutions in their home countries. It seems plausible that high skill migrants create the same type of opportunities, albeit perhaps in different ways.

Less skilled migrants often form part of the retail and wholesale infrastructure in their new countries. High skilled migrants may be less likely to become retail or wholesale managers, but more likely to be involved in the purchase or selection of technology products and services. For example, there is significant anecdotal evidence that Indian migrants have played a key role in the business partnerships and relationships between U.S. and Indian technology firms.

Remittances from high skill migrants may also be only a variation of the phenomenon discussed in the general immigration literature. High skilled migrants are smaller in number, but often higher in income. In addition to gifts to

relatives, high skill migrants may also serve a significant financial and other role as alumni of education institutions in their home countries.

## **NEGATIVE EFFECTS FOR RECEIVING COUNTRIES**

Many participants in discussions of immigration policy have been surprised in recent years to find that high-skill international migration is no less politically controversial within receiving countries than is immigration in general. There is a very large literature in economics seeking to find the effect of lower-skilled immigrants on the opportunities of lower-skilled natives<sup>12</sup>. But little has been done to look at the effects of higher skilled migration. Nevertheless, several hypothesized effects have come

### **Decreased incentive for natives to seek higher skills**

If high-skill migrants are substitutes for natives in the domestic labor market, then a normal type of static supply and demand analysis would suggest a reduction in the wages associated with higher skilled occupations.<sup>13</sup> This in turn would lead to a decreased incentive by natives to make human capital investments.

There are a number of theoretical factors that may moderate any such effect on native human-capital investment patterns. First, the same analyses that assume lower skilled migrants to be substitutes for both lower skilled natives and for capital also assume the high-skilled migrants are complements to both lower skilled workers and to capital. Thus high-skill migrants might do more to create new capital investment and utilization of a perhaps underused segment of the labor force. This is to say that to some extent higher skilled workers may produce economic changes that increases the demand for their services, and thus mitigate the effect of increased supply upon compensation.

Although there have been no detailed econometric studies, the most basic statistics suggest that high-skill migration is most prevalent in field where there are relatively good employment opportunities. This may be for many different reasons. Workers may be less willing to undertake the costs of migration unless the opportunities are great. Employers may not want to pay the often-

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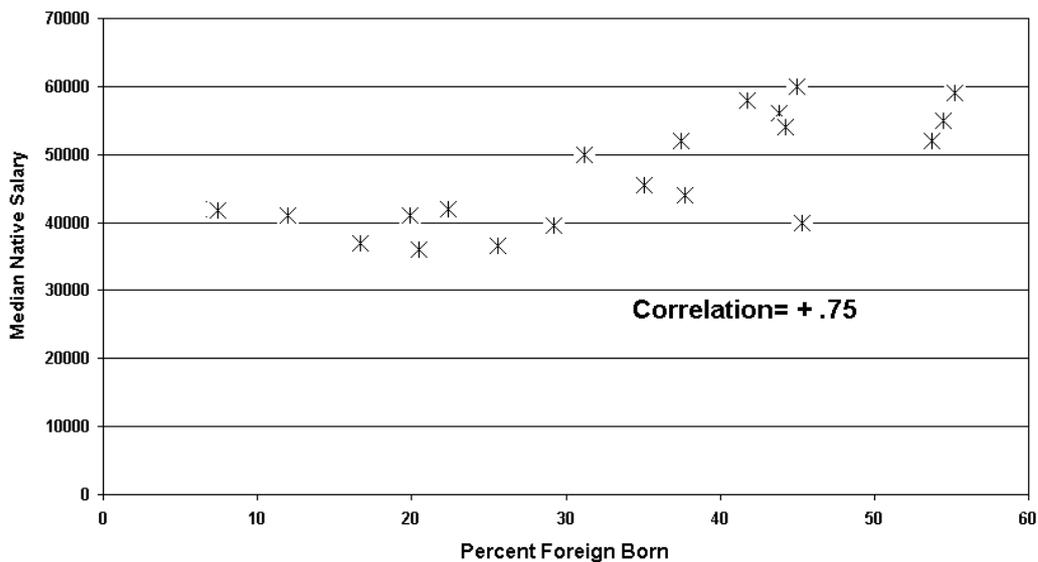
<sup>12</sup> For a good summary of this literature, see Friedberg and Hunt (1999).

<sup>13</sup> As in many policy debates, there is often a lack of symmetry in the arguments made. For example, economic critics of lower-skilled immigration often worry that lower-skilled immigrants act as substitutes in the labor market for lower skilled natives, while complementing the labor of higher-skilled natives—thus making the rich richer, and the poor poorer. At the same time there is concern that if high skilled immigrants are substitutes for high skilled natives it would reduce the incentive for natives to invest in human capital. If you accepted each proposition, it would then be possible to make the dual argument—that lower skilled migrants would increase the incentive for natives to invest in human capital and that high skill migrants reduce income inequality.

considerable legal costs associated with obtaining work visas unless they face a tight domestic labor market. Or, it has been suggested that the influx of diverse human capital brought by migrants may contribute to creating opportunities in a field.

Figures 2 and 3 compare the proportion of U.S. science and engineering Ph.D. holders who are foreign born in a list of major S&E fields of degree to measures of labor market conditions for recent Ph.D. recipients in those fields.<sup>14</sup> In general, the higher the proportion foreign born, the higher the salary. This is not driven just by the high proportion of foreign born among U.S. Ph.D.s in engineering, since even in many broad fields higher foreign-born representation is associated with higher salaries: In the social sciences, economists are paid

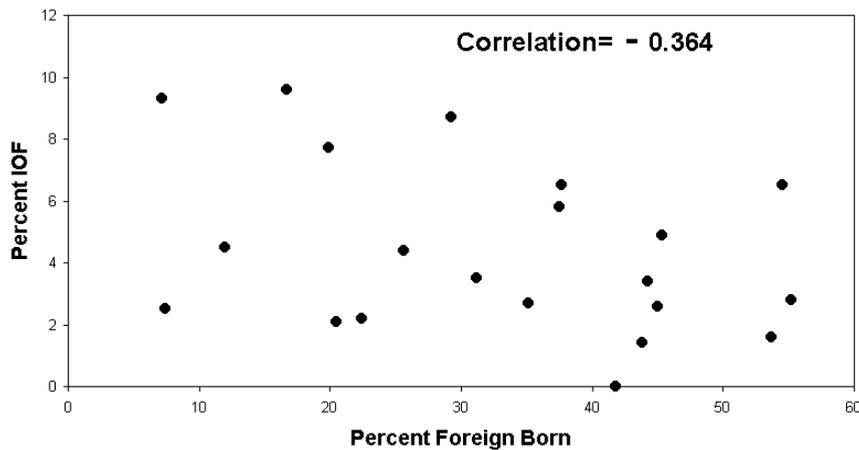
**Figure 2: 1988-1992 Science and Engineering Ph.D.s:  
Comparison of Percent Foreign Born to Median Native  
Salary for Selected Fields**



more than sociologists. In the life sciences, biological scientists are paid more than agricultural scientists. In the physical sciences, physicists are paid more than geologists. In each case the lower paid field had fewer foreign-born Ph.D. holders. In figure 2, the correlation between median salary and percentage foreign born is a strong positive .75.

<sup>14</sup> Both measures were derived from the NSF/SRS 1993 Survey of Doctorate Recipients.

**Figure 3: 1988-1992 Science and Engineering Ph.D.s in 1993: Comparison of Percent Foreign Born to Percent Involuntarily Out-of-Field for Selected Fields of Degree**



The same pattern holds when comparing the percentage of a recent Ph.D. cohort that is foreign born with a measure of labor market distress. For high skill workers, the unemployment rate can be a poor measure of labor market conditions in a field, since high skill workers are usually highly employable in some capacity. A statistic generated from the NSF SESTAT data file, the percent involuntarily working outside their field of degree, often provides a more sensitive indicator of labor market conditions. Figure 3 shows the involuntary out of field rate for recent Ph.D.s to be inversely related (-.364) with the percentage foreign born.

### **Crowding out of natives from advanced education**

Another often discussed but little studied possible effect of high skilled migration on receiving countries is a “crowding out” of natives from graduate programs and other sources of advanced training. To some extent this is a simple argument to understand: if a given university has a limited number of openings for graduate students, then a migrant student would prevent a native from taking that slot.

The number of graduate departments for which the assumption of a fixed number of opening may not be valid may offset this argument, at least in terms of aggregate positions in graduate programs. Beyond the top tier of institutions, some graduate programs would prefer to admit more high quality graduate students to help faculty with both teaching and research. This is particularly true

for graduate programs that may have trouble justifying their existence in terms of total graduate enrollment.

**Table 5: Comparison of Change in Foreign Student Enrollment with Other Enrollment Changes at the Departmental Level (NSF Graduate Student Survey, 1982-1995)**

**A increase in enrollment in a department of one foreign student is associated with a change of:**

**0.02 Under-represented minority (U.S. citizen or permanent resident)**

**0.33 U.S. white (U.S. citizen or permanent resident)**

**-0.07 U.S. Asian (U.S. citizen or permanent resident)**

Model: Fixed effects (department-level) regression estimates of changes in the enrollment of under represented minorities controlling for department size in the previous period, dummy variables for year, and the change in the enrollment of U.S. whites and U.S. Asians.

One attempt to look at the issue of displacement can be made using the National Science Foundation's *Survey of Graduate Students and Postdocs* (GSS). This is an annual survey of graduate departments of science and engineering to tabulate their enrollment. Using GSS records from 1982-1995, it is possible to create pooled longitudinal<sup>15</sup> file with academic departments as the unit of observation. From this file, it is possible to make empirical estimates of the observed effect of changes in foreign student enrollment on the enrollment of various ethnic categories of U.S. citizen and permanent resident enrollment. As summarized in table 5, an increase in enrollment of 1.0 foreign student was associated with a increase enrollment of 1/3 (0.33) of a white U.S. student, of an additional 0.02 U.S. under-represented minority students, and a decrease of 0.07 U.S. Asian students. With the exception of the odd, if small, decrease for U.S. Asians, increases in the enrollment of one group was associated with increases in the enrollment of all groups—a result inconsistent with displacement.

<sup>15</sup> Econometricians have done considerable work on methods to analyze pooled cross-sectional data of this nature. In this case a "fixed effects" regression was performed that held constant overtime department-specific effects, but similar results were found using random effects and simple OLS models.

## **Other negative effects**

Two additional possible negative effects of high skill migration for receiving nations are included here for thoroughness, although even less analysis has been done on these topics than in other areas.

Some critics of high skill migration have raised concerns about cultural differences between natives and migrants as a barrier to native participation in technology. This criticism can range from concerns about the ability of native students to understand the accents of foreign-born teachers, to workplace discrimination against natives who are not part of the same ethnic group as their boss. Although this concern is difficult to evaluate, it would be a mistake to assume that this is not an important part of political response in many countries to high skilled migration.

Technology transfer to potentially hostile countries is another issue difficult to analyze. In terms of a general transfer of knowledge that is useful to both civilian and military industries, this almost certainly occurs. In the more specific sense of espionage to obtain classified information on military technologies, it may be a murkier picture. In the context of the United States, major public espionage cases have sometimes involved ethnic affinity,<sup>16</sup> but in other cases have involved natives apparently motivated by money, power, or ideology.

## **POSITIVE EFFECTS FOR RECEIVING COUNTRIES**

Many of the positive effects of high skill migration for receiving countries have been discussed in the discussion of positive effects for sending countries—gains related to increases in international collaboration and technology transfers, with all that that implies for increasing domestic productivity and developing global markets.

### **Increased Economic Activity and R&D**

Even in a model of high skill migration where there is no “brain circulation”, receiving nations are the recipients of a brain gain. They experience an exogenous increase in their stock of human capital, often including scarce or unique sets of skills that are needed to overcome bottlenecks in production or research.

In the United States, high skill foreign born workers are a large part of the total science and engineering labor force (table 6): one-quarter of S&E doctorate

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<sup>16</sup> In at least one case, a U.S. native, not a migrant, held the ethnic affinity that may have been a contributory motive for espionage.

holders; one-fifth of those holding any level of degree in engineering, computer science, chemistry, or physics; around half of Ph.D. holders in computer science, electrical engineering, industrial and civil engineering. These estimates, and others like them shown in table 6 from the NSF SESTAT data file, are underestimates of the total proportion of foreign-born scientists in the United

**Table 6: Percentage foreign-born, S&E trained U.S. scientists and engineers, by field of highest degree and degree level: 1997**

Field of highest degree	Labor			
	force, total	Bachelor's	Master's	Doctorate
<b>All S&amp;E</b>	<b>12.7</b>	<b>9.7</b>	<b>19.2</b>	<b>26.1</b>
<b>Engineering</b>	<b>19.8</b>	<b>14.9</b>	<b>30.1</b>	<b>44.0</b>
Aerospace engineering	12.4	10.0	14.3	37.2
Chemical engineering	21.4	15.8	35.6	40.1
Civil engineering	21.2	16.5	33.8	52.0
Electrical engineering	22.7	18.0	32.2	46.8
Industrial engineering	16.9	11.2	32.3	50.9
Mechanical engineering	17.8	13.5	32.7	45.4
Other engineering	17.4	10.8	23.1	40.3
<b>Life sciences</b>	<b>10.7</b>	<b>7.8</b>	<b>12.8</b>	<b>24.7</b>
Agriculture	6.9	4.3	14.4	21.7
Biological sciences	12.3	9.3	13.0	25.5
<b>Computer/math</b>	<b>16.5</b>	<b>12.7</b>	<b>24.6</b>	<b>35.6</b>
Computer sciences	20.4	15.6	30.8	49.5
Mathematical sciences	11.8	9.4	14.8	30.7
<b>Physical sciences</b>	<b>16.0</b>	<b>11.8</b>	<b>17.2</b>	<b>28.5</b>
Chemistry	20.0	15.9	23.9	29.1
Geosciences	8.0	5.4	10.2	19.5
Physics/astronomy	18.8	11.8	18.6	30.8
Other phys sciences	10.2	8.8	12.2	30.0
<b>Social sciences</b>	<b>7.0</b>	<b>6.1</b>	<b>9.4</b>	<b>12.7</b>
Economics	13.7	11.2	26.3	26.4
Political science	7.0	6.2	10.3	15.7
Psychology	5.4	5.1	5.8	7.2
Sociology/Anthropology	4.9	3.9	12.1	13.1
Other social sciences	7.7	6.3	10.7	20.3

SOURCE: National Science Foundation, Division of Science Resources Studies (NSF/SRS), 1997 SESTAT File

States. Because of practical difficulties tracking high skill migrants, SESTAT data on the United States S&E labor force excludes individuals whose science and engineering degrees were from foreign educational institutions unless they were in the United States as of the decennial census in 1990. This would exclude, for example, the majority of individuals entering the U.S. with the high skill H-1b temporary visa. The U.S. Immigration and Naturalization Service reports that 60 percent of H-1b visa recipients are foreign degreed.

### **Knowledge flows and collaboration**

As shown in figure 1 and discussed earlier, there are strong reasons to believe that international migration leads to increased international collaboration and transmission of knowledge. With reference to the United States, the increased connection to the rest of the world has always been a benefit of having large numbers of foreign students and large numbers of high skilled immigrants. But this may become an even more important factor as the rest of the world continues to expand its R&D capacity—as of 1997, the United States R&D spending was down to 43 percent of the OECD total<sup>17</sup>.

### **Increased enrollment in graduate programs**

This is the other side of concerns about displacement of natives in graduate programs. In the context of the United States, the availability of foreign students may allow many graduate departments to expand or maintain graduate programs. In other cases, foreign students may allow more elite programs to maintain very high standards by choosing among the best of both foreign and native applicants. To the extent that the benefits of a graduate program accrue to graduate students, this might not be an important benefit, or might even be viewed as a cost if graduate education is partially subsidized. However, graduate programs are also important sources of new research and knowledge. This may provide a benefit to receiving countries even if foreign student were to immediately leave after graduate and form no part of later knowledge networks.

## **GLOBAL EFFECTS**

In addition to any benefits or costs that might be viewed as accruing to particular countries that are sending or receiving high skill migrants, there are possible global effects not assignable to individual countries. These are essentially all effects that could result in greater efficiency in the production of knowledge, and in the production of goods and services.

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<sup>17</sup> See *Science and Engineering Indicators 2000*.

A better international flow of knowledge increases the efficiency of new knowledge production everywhere. It leads both to better selections of solutions to particular problems, and a reduction of duplication in R&D.

An international job market has important implications for the quality of job matches for both workers and employers. In a world where increased specialization leads to increased employer dependence on scarce or unique skill sets, it becomes clear why employers find it increasingly efficient to search across borders. At the same time, greater employment options resulting from a global labor market may allow workers to find the work most interesting to them.

There may also be a global benefit from the formation of international research and technology centers. Researchers on innovation have long noted the apparent benefits of geographic clustering of particular research activities. To a great extent, this specialized clustering required high skill international migration for staffing.

For all of the reasons above, high skill international migration is like to have, at the global level, a positive effect upon the incentives for human capital investment. It increases the opportunities for high skilled workers both by providing the option of job search across borders, but in addition, by encouraging the growth of new knowledge.

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## Appendix

### Trend Data on High Skilled Immigrants in the United States

#### A1: Foreign Born Managerial and Professional Workers in the U.S. By Occupation: U.S. Census (1990) and Current Population Survey (1995,1999)

	1990	1995	1999
Managerial and Professional	2,364,000	2,953,000	3,724,000
Professional	1,310,000	1,708,000	2,104,000
Science & Engineering	387,000	---	---

Source: 1990 Census, 1995 and 1999 Current Population Survey

**A2: Foreign Born College Graduates in the U.S.: U.S. Census (1990)  
and Current Population Survey (1995,1999)**

	1990	1995	1999
<b>Bachelor's Degree</b>	<b>1,769,000</b>	<b>2,831,000</b>	<b>3,352,000</b>
<b>Advanced Degree</b>	<b>1,350,000</b>	<b>1,581,000</b>	<b>2,042,000</b>
<b>Total</b>	<b>3,119,000</b>	<b>4,412,000</b>	<b>5,394,000</b>

**Source: 1990 Census, 1995 and 1999 Current Population Survey**



### **A3: Foreign-Born Individuals With Science and Engineering High Degrees**

	<b>1993</b>	<b>1995</b>	<b>1997</b>
<b>Total</b>	1,082,000	1,122,000	1,149,000
<b>Bachelor's Degrees</b>	616,000	657,000	680,000
<b>Master's Degrees</b>	295,000	300,000	324,000
<b>Doctorates</b>	164,000	159,000	144,000
<b>Field of High Degree:</b>			
<b>Engineering</b>	408,000	420,000	428,000
<b>Life Sciences</b>	155,000	160,000	162,000
<b>Math/Comp Sci</b>	160,000	170,000	184,000
<b>Physical Sciences</b>	115,000	116,000	113,000
<b>Social Sciences</b>	244,000	256,000	262,000
<b>Occupation:</b>			
<b>Engineering</b>	200,473	199,000	212,000
<b>Life Sciences</b>	43,000	42,000	41,000
<b>Math/Comp Sci</b>	109,000	124,000	157,000
<b>Physical Sciences</b>	45,000	44,000	43,000
<b>Social Sciences</b>	24,000	24,000	26,000
<b>Non-S&amp;E Occupation</b>	480,000	502,000	494,000

**Source: NSF/SRS 1993, 1995, 1997 SESTAT Data Files**

**Note: Includes those with only foreign degrees only if resident in U.S. In April 1990**

**A4: U.S. Immigration Service Permanent visas issued, by S&E occupation**

<b>Year</b>	<b>Total</b>	<b>Engineers</b>	<b>Natural Scientists</b>	<b>Mathematical and Computer Scientists</b>	<b>Social Scientists</b>
1988	11,000	8,100	1,200	1,200	500
1989	11,800	8,700	1,200	1,500	400
1990	12,600	9,300	1,200	1,600	500
1991	14,100	10,500	1,300	1,700	600
1992	22,900	15,600	2,800	3,400	1,100
1993	23,600	14,500	3,900	4,200	1,000
1994	17,200	10,700	3,100	2,800	700
1995	14,100	9,000	2,400	2,100	600
1996	19,400	11,600	3,700	3,300	800
1997	17,100	10,300	3,500	2,600	700
1998	13,500	7,900	2,500	2,500	600

