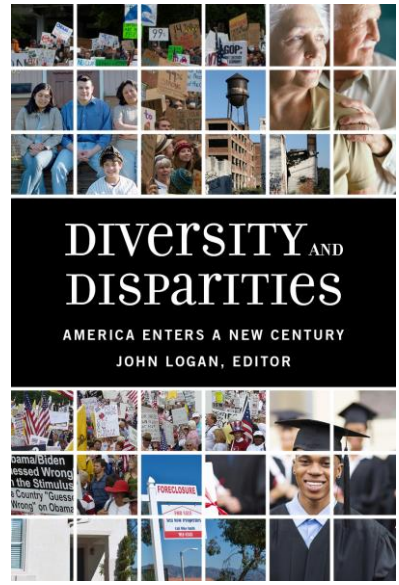

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Chapter 10

U.S. High-Skill Immigration

John Bound and Sarah Turner

Immigration in the United States is characterized by "twin peaks" (Johnson and Slaughter 2001): disproportionately high concentrations of immigrants among very low-skill and very high-skill workers. Researchers and policymakers have focused on the incidence of low-skill immigration, particularly among undocumented workers, and the impact of this immigration on labor force outcomes for workers with minimal levels of education (Borjas 1987, 2003; Card 2005, 2009). However, research on the growth of high-skill immigration and the changing pathways to entry into the U.S. labor market has been more limited.[1]

From a purely theoretical perspective, the underlying economic model of immigration points to some similarities between high-skill and low-skill immigration. The most basic economic arguments suggest that both high-skill and low-skill immigrants (1) impart benefits to employers, to owners of other inputs used in production such as capital, and to consumers; and (2) impose some costs on workers who are close substitutes (Borjas 1999). The groups potentially in competition with high-skill versus low-skill immigrants are quite different—workers trained in science and engineering, on the one hand, and workers with low levels of education, on the other. Their potential employers are quite different as well. These differences contribute to the current lack of consensus on immigration reform.

The welfare effects of high-skill immigration are perceived to be positive in two regards. First, it is likely that high-skill immigrants make substantial tax payments at the local and federal levels, creating a fiscal surplus rather than imposing a burden on public services, which often is associated with low-skill immigration (Camarota 2004). Second, high-skill immigrants contribute to the generation of knowledge and productivity through patents and innovation (Kerr and Lincoln 2010). The costs and benefits associated with training foreign-born students at U.S. universities are difficult to quantify, depending on the extent of public subsidies to universities, the stay-rate of foreign-born degree recipients in the United States, and the extent to which native citizens fail to attain degrees because they have been crowded out of science and engineering fields by foreign-born degree recipients.

This analysis documents changing patterns in the educational and labor force trajectories of college-educated immigrants.[2] A central theme in our analysis is that immigration policy combines with supply and demand to determine the representation of high-skill immigrants in the U.S. population. Changes in both the United States and abroad have affected the impact of immigration on U.S. labor markets. For example, the dramatic expansion of postsecondary attainment abroad has led to changes in the skills that immigrants bring with them to the United States, and many high-skill immigrants enter the U.S. labor market by way of U.S. colleges and universities. Because the vast majority of high-skill immigrants are employed in the formal sec-

tor, the availability of work visas, primarily the H-1B classification, and the opportunities for postsecondary study in the United States through F1 student visas have substantial implications for the entry and continued residence of foreign high-skill workers.

Our analysis begins by presenting basic information on trends in the immigration of high-skill workers derived from census enumerations and the American Community Survey (ACS). We examine educational attainment, occupation, industry, earnings, citizenship, country of birth, and year of immigration. Although we make some use of the census enumerations before 1990, we focus on more recent patterns. Even with the large sample sizes of the census and ACS, we face limitations in the possible level of disaggregation. For example, outcomes for small countries of origin, very specialized subfields, and narrow geographic areas are subject to substantial sampling variation. We complement these data with the 1993 and 2003 cohorts of the National Survey of College Graduates (NSCG), which provides additional information on educational and labor market experiences for college graduates.[3]

In the next section, we present broad trends in immigration by skill level (using education as the indicator of skill), highlighting the very different origins of high-skill versus low-skill immigrants. We then place high-skill immigration in the context of changes in the U.S. labor market, emphasizing the role of immigration in accommodating "demand shocks" in the science and engineering fields. We examine the pathways to the U.S. labor market, identifying country-specific trends and the role of visa policy. Finally, we address the demographic characteristics and family circumstances of high-skill immigrants and their modes of entry into the United States.

THE VOLUME OF IMMIGRATION

Overall Trends in Immigration by Skill Level

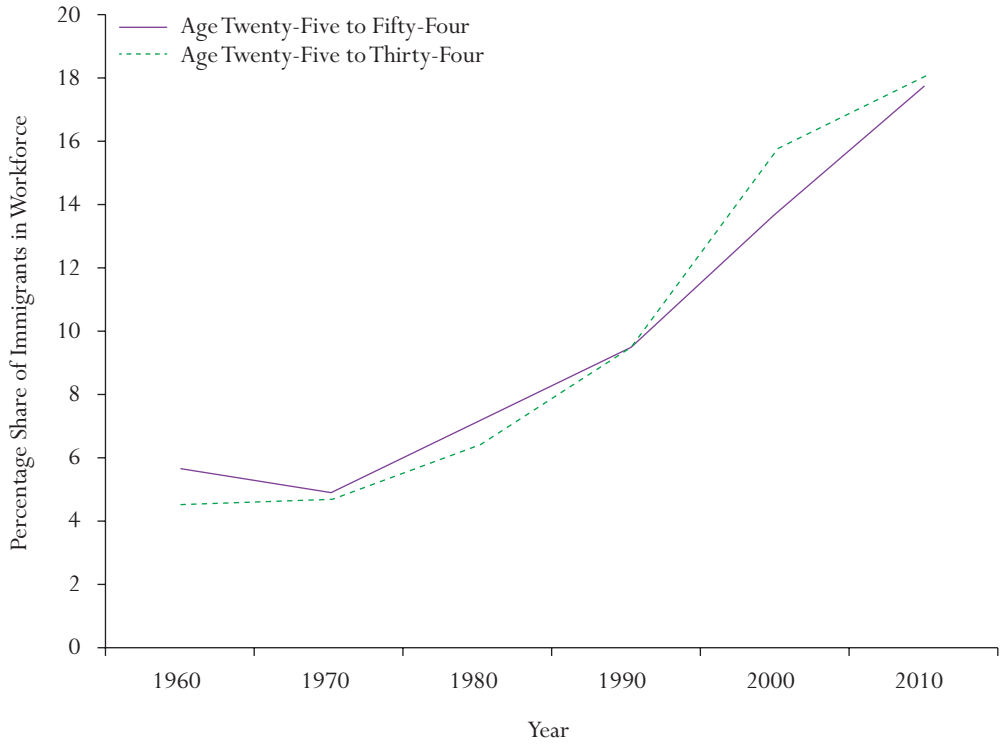
From 1960 to 2010, the overall share of foreign-born among the working-age U.S. population increased from 7 percent to 17.3 percent (figure 10.1), with 75 percent of this growth occurring in the last two decades. Growth among younger age groups (ages twenty-five to thirty-four) was somewhat more pronounced in recent years.

From 1990 to 2011, increases in immigration have occurred at every level of education, and these increases have been even more marked among the employed (see table 10.1). This distribution is a recent change. In 1990 immigrants accounted for only 22 percent of workers with less than a high school degree and 20 percent of doctorate-holding workers.

For workers with less than a high school degree, the immigrant share more than doubled, from 25 to 56 percent, in this period. In the middle education groups, the immigrant share increased from 7 to 13 percent for high school graduates and those with some college. Among the college-educated, immigrant share increased from 8 to 14 percent for college graduates, from 10 to 18 percent for master's degree holders, from 11 to 18 percent for professional degree holders, and from 19 to 33 percent for PhDs. Table 10.2 presents these data from a different angle, showing a much higher fraction of workers with less than a high school education among foreign-born (23.9 percent) than native-born workers (4.0 percent). On the other end of the education spectrum, foreign-born workers are also more concentrated at the master's level and above, making up more than twice the share of workers with a PhD.

These data indicate that immigrants are disproportionately found at the very low-skill and very high-skill levels. As shown in figure 10.2, the geographic origins of these two types of immigrant workers are quite different. In 2010 about 78 percent of low-skill immigrants (high school or less) arrived in the United States from Latin American countries, while about half of

FIGURE 10.1 *Share of Immigrants Ages Twenty-Five to Fifty-Four in the U.S. Workforce in the Previous Year, by Age, 1960–2010*



Source: U.S. Census data, 1960–2000, and ACS, 2010 data.

high-skill immigrants (BA or higher) came from Asian countries. Although the distribution of countries of origin is more dispersed among high-skill than low-skill immigrants, representation shifted toward China and other Asian countries between 1990 and 2010. In 2010 about 15 percent of high-skill immigrants were from India, 10 percent were from China, and about 25 percent were from other Asian countries. These differences by country of origin are affected by the supply of potential immigrants at each education level and also by the cost of immigration. Latin America has a large supply of workers with low education who can travel to the United States relatively inexpensively; however, it is more difficult and costly for low-skill workers in Asia to manage the passage.

Fields of Concentration

High-skill immigrants to the United States tend to work in science and engineering fields. Panel A of figure 10.3 shows the share of immigrants among all college-graduate workers compared to those in science and engineering fields.[4] The immigrant share in science and engineering fields has increased markedly over the last two decades, from about 14 percent of working adults in 1990 to nearly 24 percent in 2010. Among younger U.S. workers (panel B), the immigrant share

TABLE 10.1 *The Foreign-Born, Ages Twenty-Five to Fifty-Four, by Education Level, 1900, 2000, and 2009–2011*

Year	Less Than High School	High School and Some College	BA Degree	MA Degree	Professional Degree	PhD Degree
All foreign-born						
1990	22.24%	7.00%	8.55%	10.68%	12.28%	20.13%
2000	37.59	9.99	11.74	14.75	17.93	28.82
2009–2011	45.20	13.36	15.27	19.32	19.67	33.71
Foreign-born workers						
1990	24.60	6.62	7.87	9.75	11.32	19.47
2000	39.25	8.82	10.42	13.42	15.48	27.93
2009–2011	55.68	13.38	14.01	17.99	18.38	33.23
All workers						
1990	58.72	79.23	87.47	91.18	92.84	94.75
2000	53.91	77.00	85.49	88.96	89.30	91.93
2009–2011	54.30	73.33	83.93	87.94	89.83	92.49

Source: U.S. census 1990, 2000, and ACS, 2009–2011 (combined).
Note: "Foreign-born" is defined as a naturalized citizen or a noncitizen.

in science and engineering fields increased slightly from 1990 to 2010, rising from 15 percent to over 26 percent.

Examination of the immigrant share by degree and occupational classification shown in figure 10.4 illustrates the significant and growing concentration of high-skill immigrants in all post-BA occupations, including BA-, MA-, and PhD-level engineering jobs, other PhD-level science jobs, and health professions. At the extreme, immigrants accounted for 64 percent of PhD-level engineers in 2010, up from 42 percent in 1990. Immigrants are also overrepresented in health fields, accounting for about 29 percent of physicians and 19 percent of nurses.[5]

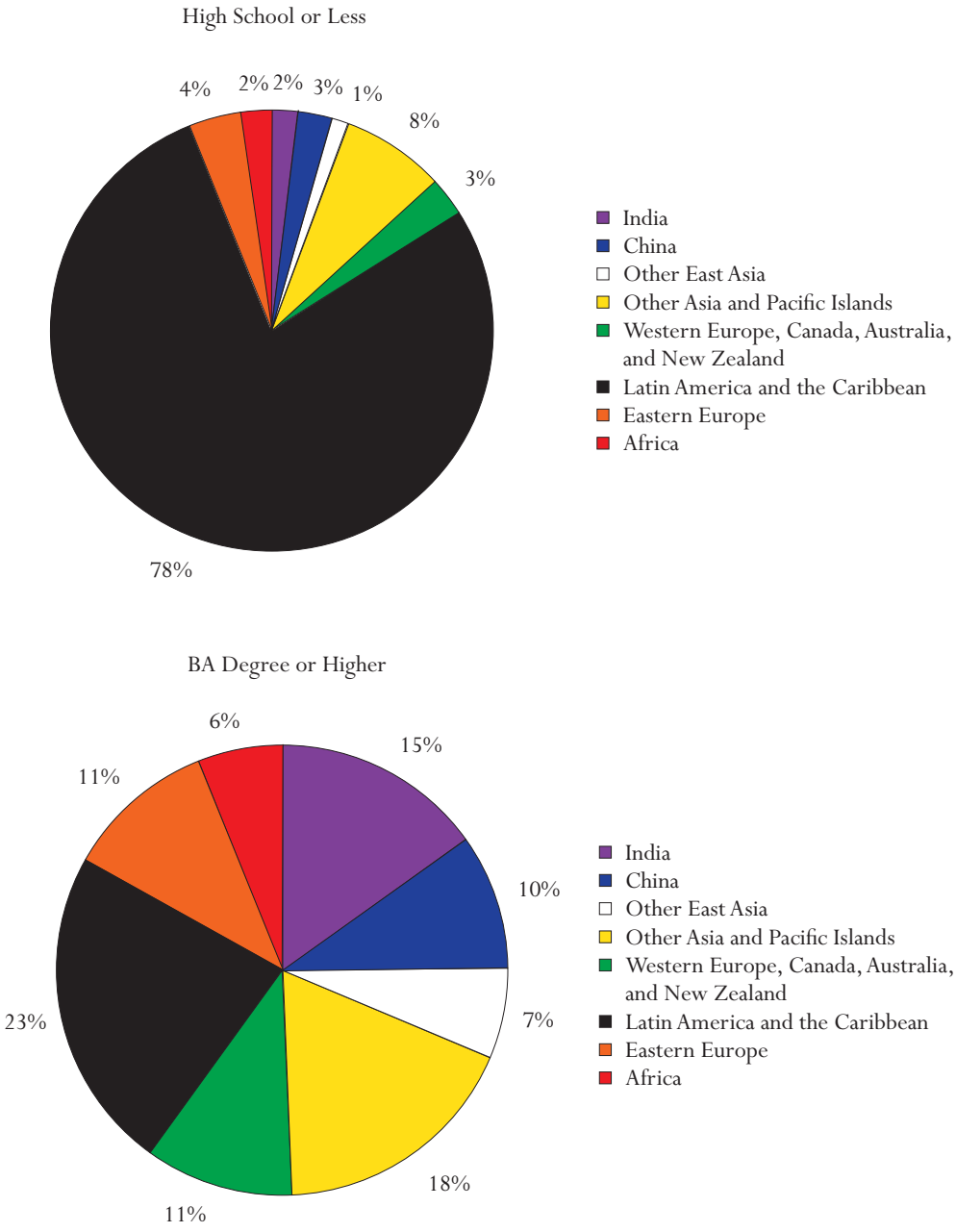
IMMIGRATION AND VISA POLICIES FOR HIGH-SKILL WORKERS

The dynamics of high-skill immigrant flows to the United States follow from U.S. immigration policy. Visa policies determine when potential immigrants can enter the U.S. labor market and also influence whether they obtain their education at home or abroad, how long they are likely to stay in the United States, and whether they are able to attain permanent residency.

Most employers in the "formal" sector require citizenship, permanent residence, or an appropriate visa permitting work, and this requirement is most likely to be enforced for high-skill immigrants. While nearly 75 percent of unauthorized immigrants are estimated to hold a high school degree or less (compared to about 26 percent of all immigrants, as shown in table 10.2), only about 15 percent are estimated to hold a BA degree or higher (Passel and Cohn 2009).[6]

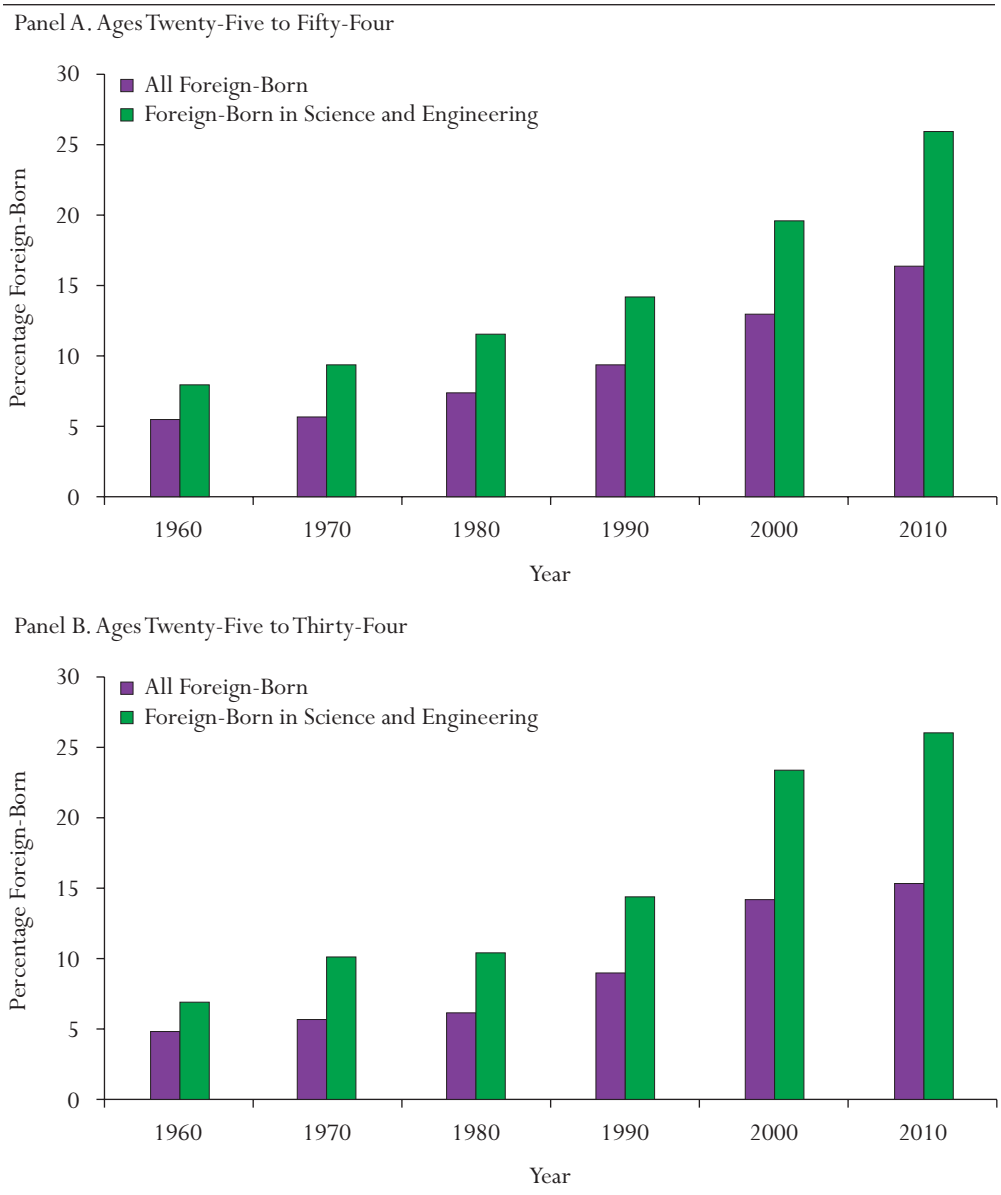
The costs to a firm of hiring a foreign-born worker and the administrative restrictions and financial costs to a high-skill foreign-born worker of coming to the United States have varied markedly over time. They also differ by skill set and country of origin. The immigrant's access to the labor market may be permanent or temporary, depending on the time of entry, the country of origin, and his or her expertise. Because these factors have such important impacts, we review them here in some detail.

FIGURE 10.2 *Geographic Origins of Immigrants, by Continent and Education Level, 2010*



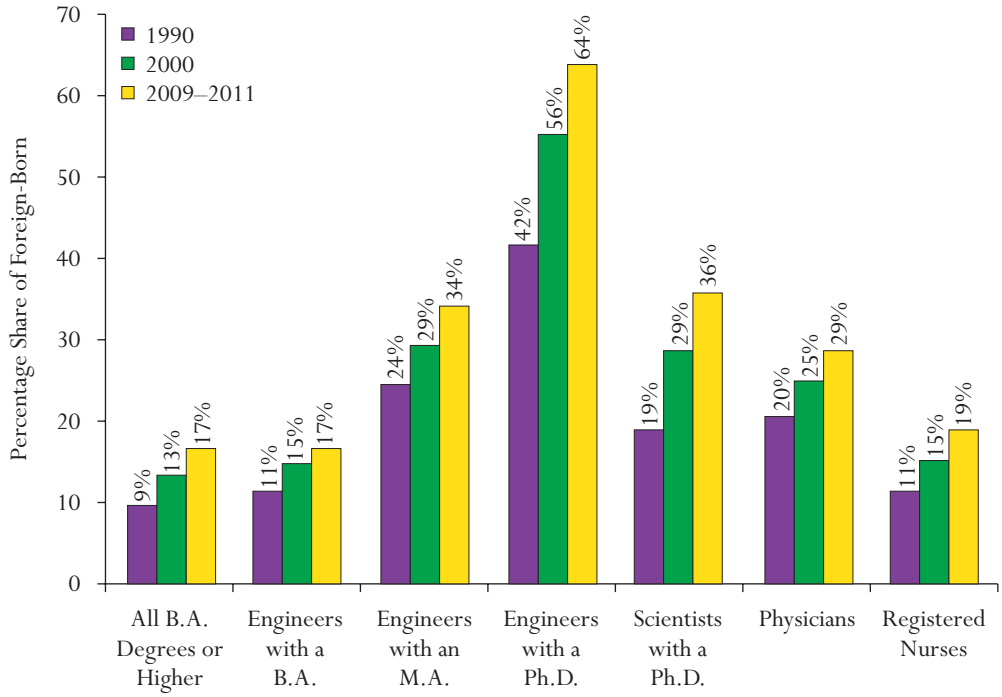
Source: ACS, 2009–2011 (combined samples).

FIGURE 10.3 *The Foreign-Born Among Employed Twenty-Five- to Fifty-Four-Year-Olds with a BA Degree or Higher, by Year and Employment in Science and Engineering, 1960–2010*



Source: U.S. census, 1960–2000, and ACS, 2001–2010.
Note: "Foreign-born" is defined as a naturalized citizen or a noncitizen.

FIGURE 10.4 *The Foreign-Born Among Employed Twenty-Five- to Fifty-Four-Year-Olds with a BA Degree or Higher, by Age Group and Skill Group, 1990, 2000, and 2009–2011*



Source: Authors' tabulations from IPUMS, U.S. census 1990 and 2000, and ACS, 2009–2011 (average values).
Note: "Foreign-born" is defined as a naturalized citizen or a noncitizen.

Permanent Residents

The Displaced Persons Act of 1948 established a pathway to permanent residency for high-skill immigrants. This act gave priority to displaced persons "possessing special educational, scientific and technological or professional qualifications" (Tichenor 2012). The Immigration and Nationality Act of 1952 set national quotas, but reserved 50 percent of each nation's quota for high-skill immigrants.[7]

The Immigration and Nationality Act of 1965 (Hart-Celler Act) replaced the quotas with a preference system tied to four main avenues for permanent residency: family reunification, employment, humanitarian/refugee interests, and diversity (Martin 2012). Family-based immigration is the largest channel for immigration (see table 10.3). Immediate relatives (parents, spouses, minor children) are admitted without limit, while there is a cap of 480,000 for other family-based immigration. We expect that some high-skill immigrants were admitted as children via this channel, then completed their precollegiate and postsecondary training in the United States.[8]

While family-based immigration of children and high-skill relatives often occurs directly from the country of origin, employment-based immigration generally follows a transition from another visa type. The capacity to enter the United States as a permanent resident through an

TABLE 10.2 *Distribution of Education, by Immigration Status, Among Employed Twenty-Five- to Fifty-Four-Year-Olds, 1990, 2000, and 2009–2011*

	1990		2000		2009–2011	
Education	U.S.-Born	Foreign-Born	U.S.-Born	Foreign-Born	U.S.-Born	Foreign-Born
Less than high school	0.081	0.265	0.051	0.239	0.040	0.239
High school and some college	0.645	0.461	0.633	0.444	0.605	0.441
BA degree	0.180	0.155	0.210	0.177	0.235	0.181
MA degree	0.064	0.070	0.074	0.083	0.087	0.090
Professional degree	0.022	0.028	0.024	0.032	0.023	0.024
PhD degree	0.009	0.021	0.009	0.025	0.011	0.025

Source: U.S. census, 1990, 2000, and ACS, 2009–2011.
Note: "Foreign-born" is defined as a naturalized citizen or a noncitizen.

employment-based green card is quite limited: only 140,000 such visas are offered each year.[9] For an employment-based green card, an employer must certify that it has not been able to hire a qualified citizen or permanent resident for the position and must file an immigration petition (form I-140) on the employee's behalf.

Within the set of visas allocated for employment, preference groupings determine visa priority. The highest priority is reserved for those with extraordinary capabilities, including researchers, professors, and multinational executives. Next in line are aliens who have advanced degrees or whose abilities benefit U.S. interests (for example, physicians practicing in designated underserved areas). Third in priority are the foreign-born in three categories: skilled workers, college-educated professionals, and unskilled workers.[10] Fourth priority is given to individuals

TABLE 10.3 *Transitions to Legal Permanent Resident Status, 2002 and 2011*

	2002		2011	
	Total	Adjustment of Status	Total	Adjustment of Status
Total	1,059,356	675,067	1,062,040	580,092
Family-sponsored preferences	186,880	63,363	234,931	28,346
Immediate relatives of U.S. citizens	483,676	305,304	453,158	243,174
Employment-based preferences	173,777	133,755	139,339	124,384
First: Priority workers	34,168	24,587	25,251	23,605
Second: Professionals with advanced degrees or aliens of exceptional ability	44,316	38,993	66,831	65,140
Third: Skilled workers, professionals, and unskilled workers	88,002	64,554	37,216	29,757
Fourth: Certain special immigrants	7,149	5,530	6,701	5,306
Fifth: Employment creation (investors)	142	91	3,340	576
Diversity	42,820	1,986	50,103	1,617
Refugees	115,601	115,601	113,045	113,045
Other	56,602	55,058	71,464	69,526

Source: U.S. Department of State, *Yearbook of Immigration Statistics,* 2011.

who have specialized jobs, such as physicians, religious workers, and international organization employees. (This residual category includes many subgroups, such as fifty visas for former interpreters from Afghanistan or Iraq.) Last priority goes to entrepreneurs who invest at least $500,000 to create and sustain at least ten permanent jobs. (Transitions to legal permanent residency by immigration channel and preference category are summarized in appendix tables 10A.3 and 10A.4.)

Adding to the complexity of this system, visas for any given country are capped at 7 percent of the annual U.S. limit for family- and employment-based immigration. This rule, intended to allow immigration from a variety of places, causes considerable lags for those coming from China, India, Mexico, and the Philippines who are not in the highest-priority category.[11] For example, in June 2013, Indian professionals falling into the second- or third-priority categories were granted visas after a wait of nine to ten years.[12]

In addition to these long-standing pathways to permanent residency for high-skill immigrants, Congress has on two occasions given special treatment to foreign groups that probably included a disproportionate share of high-skill immigrants. The Chinese Student Protection Act (CSPA) of 1992 allowed Chinese nationals (including students) who were present in the United States at the time of the Tiananmen Square violence in 1989 to apply for legal permanent resident status.[13] Of the nearly 50,000 individuals making the transition to legal permanent resident status under CSPA, at least 30,000 had initial visa classifications indicating high-skill characteristics (Orrenius, Zavodny, and Kerr 2012). Similarly (though more modestly), the Soviet Scientists Immigration Act (1992) allowed permanent visa status to 750 scientists from the former Soviet Union and former Baltic states.

Although it is possible to enter the United States directly with permanent residency status, Lindsay Lowell (2010) estimates that 90 percent of employment-based and 55 percent of family-based visa holders move up from temporary visa status or from family-sponsored preferences.[14]

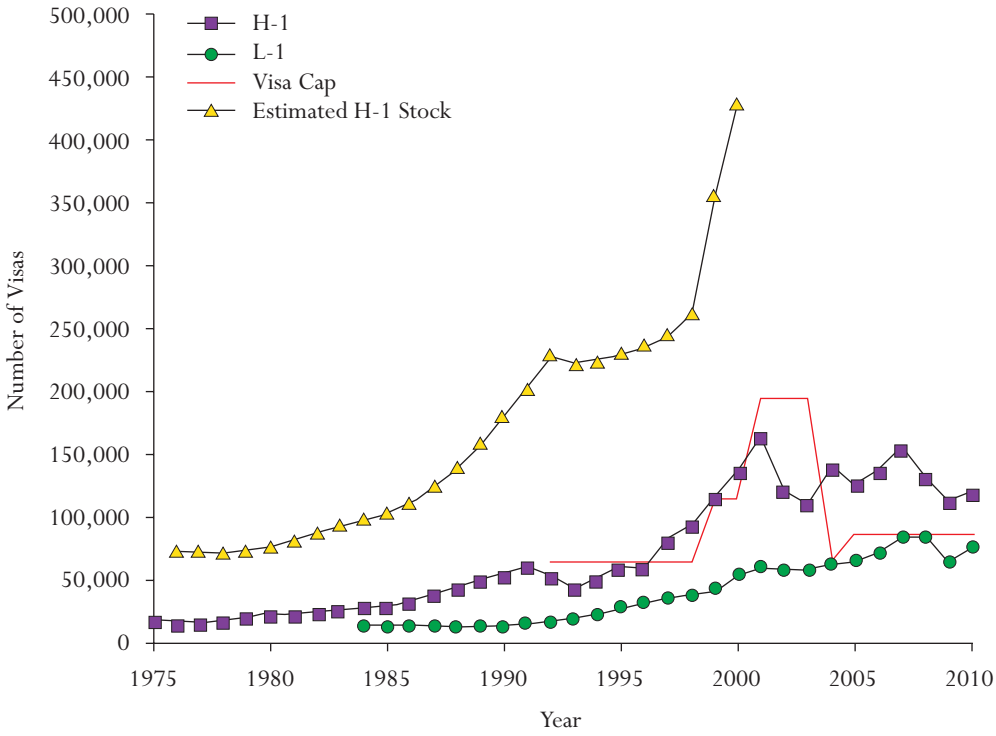
Temporary Work Visas

Since the passage of the 1952 Immigration and Nationality Act, the H-1 designation has provided an employment window for aliens of "distinguished merit and ability." The original expectation of this designation was that U.S. residency would be temporary. This provision was altered as part of the policy reform in 1990.

The Immigration and Naturalization Act of 1990 transformed the H-1 visa program into what is now known as the H-1B visa program, along with the companion H-1A program for nurses.[15] H-1B visas are by definition reserved for high-skill workers. They require that the employee be in a specialty occupation, defined as one that requires "theoretical and practical application of a body of highly specialized knowledge and attainment of a bachelor's [degree] or higher, or its equivalent." H-1B visas are employer-specific and require the employer to post a substantial application fee and certify that the foreign employee will be paid the prevailing wage.[16] H-1B visas are valid for three years, with the potential for a three-year extension.[17] Workers may enter the United States directly on an H-1B visa or may transfer to an H-1B from another visa classification, such as an F student visa. H-1B visa holders may pursue permanent residency while working in temporary jobs in the United States.

Additionally, unlike the original H-1 visa, which did not have a cap, the Immigration Act of 1990 caps H-1B visas annually at 65,000, though visas issued to individuals at nonprofit organizations such as colleges and universities (researchers and faculty, for example) are exempt from the cap. During the early 1990s, the cap was not reached, but the cap became binding in the mid-1990s and was subsequently raised to 115,000 in 1999 and then to 195,000 in 2001. This limit was maintained until 2004, when the H-1B cap reverted to 65,000 once again, although in

FIGURE 10.5 *Trends in the Flow and Stock of Skill-Based Visas, 1975–2010*



Source: Data from 1972–1980 are from Lowell (2000); for 1987 and later are from the U.S. Department of State, Bureau of Consular Affairs, "Nonimmigrant Visa Statistics," available at: http://travel.state.gov/visa/statistics/nivstats/nivstats_4582.html (accessed September 19, 2014). Estimates of the H-1 visa stock are from Lowell (2000).
Note: H-1 visas include H-1A (nursing) and H-1B visas after 1990; in addition to the stated visa cap, H visas assigned to those employed by academic institutions are exempt from the cap and, beginning in 2004, an additional 20,000 H-1B visas were offered to foreign graduates of U.S. universities.

the same year Congress authorized an extra 20,000 H-1B visas for foreign workers holding advanced degrees from U.S. universities through the Visa Reform Act. This cap has been binding every year since 2004 (U.S. Government Accountability Office 2011). In addition, country-specific free trade agreements designate 1,400 H-1B1 visas for Chilean nationals and 5,400 H-1B1 visas for Singapore nationals. In 2000 the sociologist Lindsay Lowell estimated the total number of individuals working on all H-1 visas in the United States to be close to half a million. Figure 10.5 shows trends regarding H-1 visas since 1975.

While the H-1B is the most widely recognized temporary visa, there is a substantial portfolio—a veritable alphabet soup—of other temporary work visa options that can connect foreign-born high-skill workers to the U.S. labor market. Appendix table 10A.1 provides a summary of these alternative types, which include country-specific opportunities for temporary employment along with field-specific options.

Other temporary visa categories include the L-1 visa for intracompany transferees, the O-1 visa for "workers with extraordinary ability or achievement," the TN visa for NAFTA-related professional workers, and the E-1 visa for treaty traders and treaty investors. After H-1B issuances, L-1 intracompany transferee visas are the most frequently issued temporary worker visa

categories. As shown in figure 10.5, the number of L-1s issued climbed from 14,342 in 1990 to 84,532 in 2007, then decreased to 70,728 in 2011. Upon the introduction of the O-1 visa in 1992, 462 were issued, a number that rose to 9,368 in 2009 and declined to 8,828 in 2011. The number of E-1 treaty trader visas issued fell from 20,100 in 1989 to 6,807 in 2011.

Other visa categories, although not officially categorized as "temporary worker" visas, allow non-immigrants to enter the workforce. For example, the J-1 exchange visitor visa, issued to non-immigrant individuals participating in Department of State–approved cultural exchange programs, allows some visa holders to work during their time in this country.[18] The number of exchange visitor visas issued is typically more than double that of H-1B workers, but since not all J-1 visa holders are authorized to work, it is difficult to compare the two types. Over the past two decades, the number of J-1 visas issued has risen fairly steadily, from 146,549 in 1990 to 324,294 in 2011.

The limits on and costs of the H-1B work visas provide incentives for firms and employers to use other visa options to employ high-skill workers. There is some evidence that research universities increasingly use the J-1 category for foreign postdocs and visiting research scientists rather than the more costly H-1B visa. Although the occupations that typically use J-1 visas are physicians (including medical residents), teachers, and visiting scholars, the largest single group of J-1 visa recipients (31 percent of the 2012 total) is foreign nationals traveling to the United States for summer work or travel.[19] Historically, Europe has been the largest source country for J-1 visas (representing 52 percent of visas issued in 2012), although the number of J-1 visitors from Asian countries has increased in the past decade.

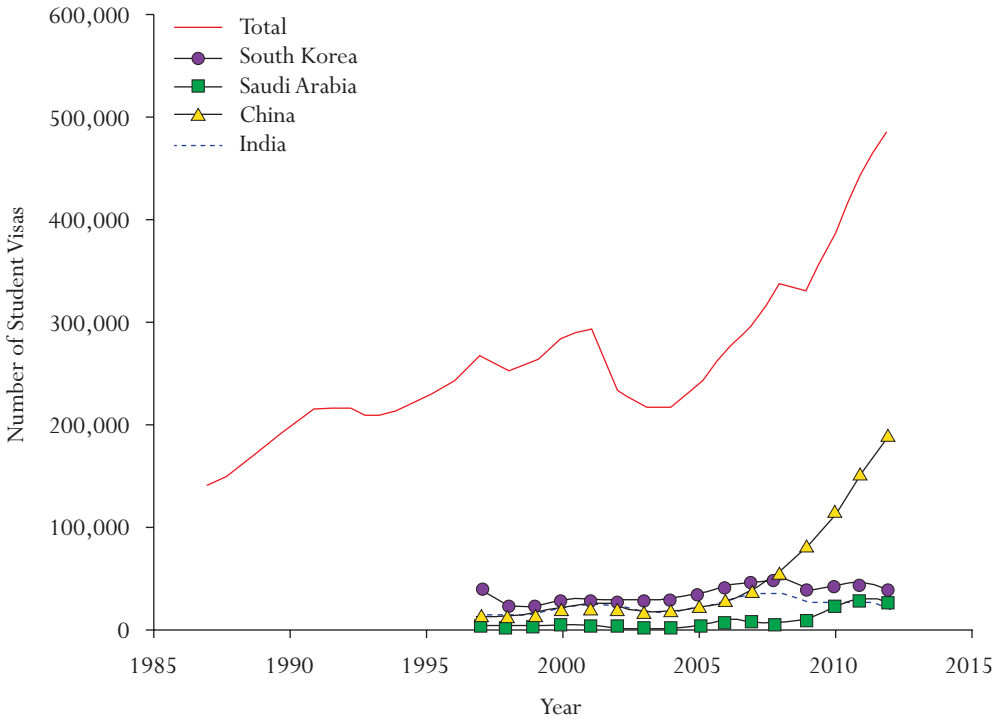
Student Visas

Unlike H-1B employment visas, which are subject to a numerical cap and require a costly petition from an employer, there is effectively no limit on visas for postsecondary study in the United States. Demand for U.S. higher education among foreign students is driven by two main aims: to acquire skills and training that may be in short supply in their home countries or to obtain work in the United States. Employment prospects for foreign-born individuals with a degree from a U.S. institution may be considerably better than for foreign degree–holding individuals; as such, the former face relatively modest barriers to connecting with U.S. firms. Compared to foreign degree–holding students, U.S. degree recipients may be favored by employers because employers are better able to assess the quality of their degree.

To enroll in a U.S. degree program, a student needs a visa, the prerequisite skills, and the capacity to finance the course of study. For most degree programs, the F-1 visa, or full-time student visa, is the primary vehicle for entry.[20] There is no cap on the number of F-1 visas issued; these are issued automatically with the certification of U.S. higher education institutions. As shown in figure 10.6, the number of annual F-1 visas rose by nearly 60 percent, from 241,003 in 1996 to 385,210 in 2010, with a nontrivial decline following both the contraction in the information technology (IT) sector and the events of September 11, 2001, which generated greater administrative hurdles. Students from Asia contribute the majority of students on F-1 visas, with the number from China increasing very dramatically over the last decade.

Foreign students studying at U.S. institutions on an F-type visa may also seek another type of visa, such as an H-1B. Additionally, a student can extend the F visa for one year through participation in optional practical training (OPT) related to his or her major area of study. In 2008 Congress extended the duration of OPT from twelve to twenty-nine months for those in science, technology, engineering, and mathematics (STEM) fields.[21]

FIGURE 10.6 *Trends in Student Visas, 1985–2012*



Source: U.S. Department of State, "Nonimmigrant Visa Issuances by Visa Class and by Nationality," and "Nonimmigrant Visas by Individual Class of Admission," available at: http://travel.state.gov/visa/statistics/nivstats/nivstats_4582.html (accessed September 19, 2014).

LABOR MARKET DETERMINANTS OF HIGH-SKILL IMMIGRATION

Besides these institutional policies, the flow of foreign-born professionals is determined by economic conditions. Changes in the supply of high-skilled workers from abroad, changes in demand for skilled labor in the United States, and the availability of temporary and permanent visas all have an impact on the level of immigration, as well as on the earnings of immigrants and non-immigrants alike.

Demand-Side Determinants of High-Skill Immigration

One of the most notable features of the U.S. economy over the last three decades is the increase in the earnings premium to college graduates (Goldin and Katz 2008). Demand for college-educated workers has grown at a far greater pace than changes in supply. Specifically, the expansion of computer use in the workplace and of skill-intensive jobs in manufacturing and other industries has increased demand for workers in computer science and engineering occupations (Acemoglu and Autor 2011; Autor, Katz, and Krueger 1998; Katz and Murphy 1992).

The economy has also seen unambiguous and differentiated demand shocks in specific science disciplines that have affected both labor and college enrollment. Defense investments and

federal funding for the physical sciences spiked in the 1980s, reversed in the 1990s, and then rebounded in recent years. In the life sciences, the National Institutes of Health (NIH) budget doubled between the late 1990s and 2000. For computer sciences, the high-tech market has expanded and contracted over the past two decades—including a precipitous decline following the dot-com bubble of the late 1990s.

Yet college-educated professionals in the science and engineering fields have not received disproportionate wage gains over this period (Katz and Autor 1999; Card and DiNardo 2002). Figure 10.7, which illustrates trends since 1970 in earnings for holders of BA degrees in some science and engineering occupations, shows that real wages, though they have fluctuated over the period, were at about the same level in 2010 as in 1973. Not surprisingly, PhDs in these fields earned more than BA degree recipients, as shown in figure 10.8. In 1974 median earnings for PhDs in math and computer science and in the physical sciences who were in the first ten years of their careers matched the eighty-fifth percentile of all BAs in the first ten years of their careers. PhDs in the biological sciences matched at the eighty-first percentile. In the top panel of figure 10.8, we compare the evolution of the median earnings of PhD scientists and engineers to the earnings of BAs at the eighty-fifth percentile (which represents the baseline point of comparison at the start of the period), as well as at the eighty-first and ninety-second percentiles of the BA earnings distributions. As the figure shows, in all four cases relative earnings fell. The relative fall was the least for those with math and computer science PhDs (roughly 10 percent) and the most for those in the biological sciences (roughly 33 percent).

Taking a close look at the IT sector, John Bound, Breno Braga, Joseph Golden, and Sarah Turner (2013) compare labor market adjustments to demand shocks generated by technological changes, first during the adoption of microprocessor technology in the late 1970s and then during the Internet boom in the late 1990s. Entry-level wages of those with a BA in computer science or electrical engineering relative to all BAs were greater in the 1970s and 1980s than in the 1990s and beyond.[22] It is plausible that this relative decline in wages is linked to increases in high-skill immigration during this period. Notably, the share of H-1B visa holders employed in IT fields rose from 11 percent in 1989 to more than 60 percent in 1999.[23]

In short, while science and engineering wage trends show short-term response to specific changes in demand, the growing demand for high-skill workers in these fields has been accommodated. We believe high-skill immigration is one factor contributing to the economy's adjustment to labor demand shocks in science and engineering fields.

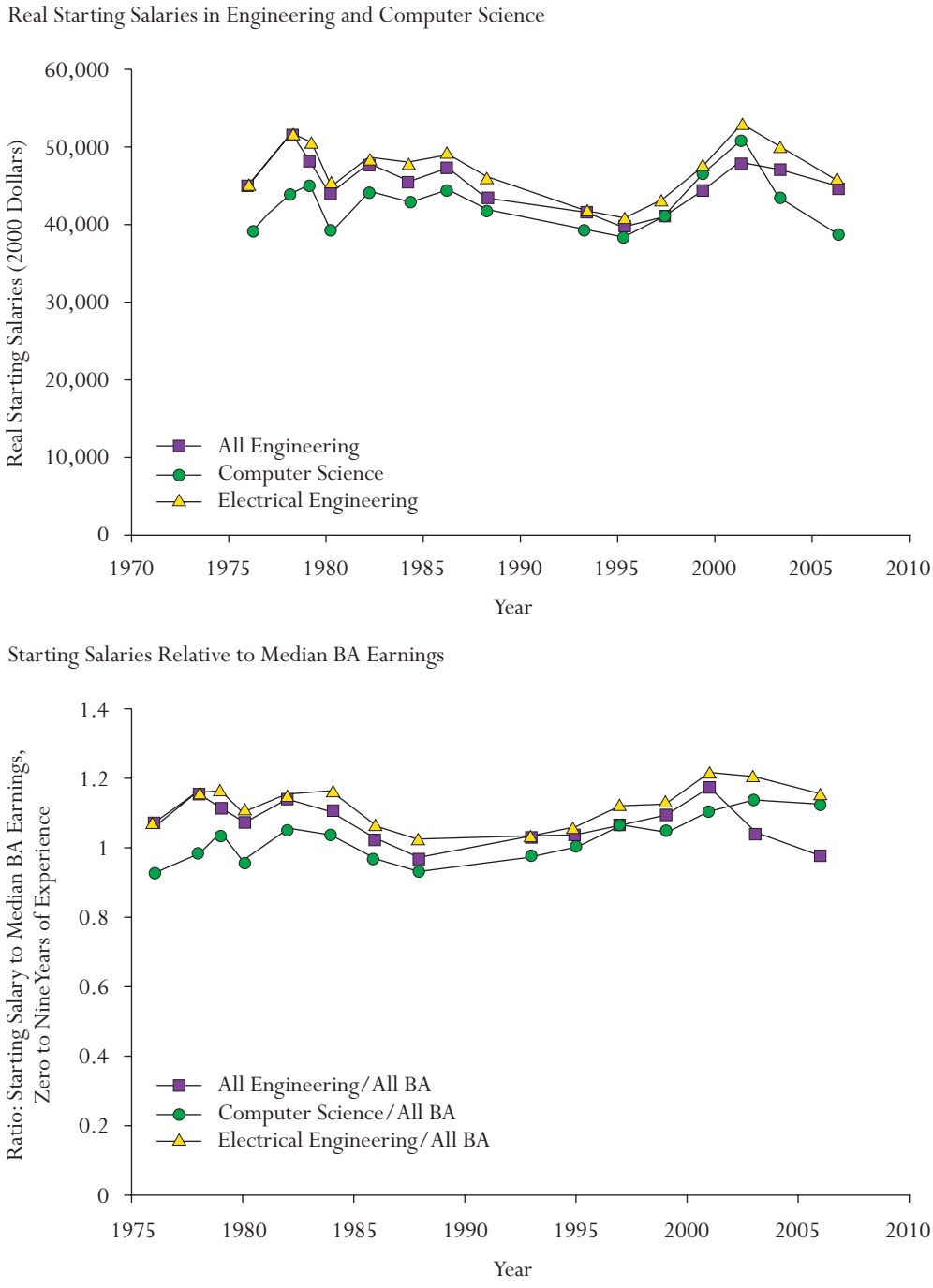
The Supply of High-Skill Potential Immigrants

Growth in postsecondary enrollment in countries outside the United States has been extraordinary in the last three decades, increasing from 55.3 million to 141.5 million, with enrollment growth concentrated in developing countries and especially in Asia (Freeman 2010, table 1).

These marked increases in secondary and postsecondary educational attainment abroad increase the pool of potential high-skill immigrants to the United States. In China, growth in postsecondary enrollment has been astounding, increasing from barely 1 million students in 1980 to nearly 29 million students in 2009. In India, postsecondary enrollment increased from 3.2 million in 1980 to 18.6 million students in 2009. Together, the combination of extraordinary rates of growth and large population bases has dramatically expanded the global supply of college-educated workers. (Some illustrative country-specific trends across Asia, North America, and Europe are reported in table 10.4.)

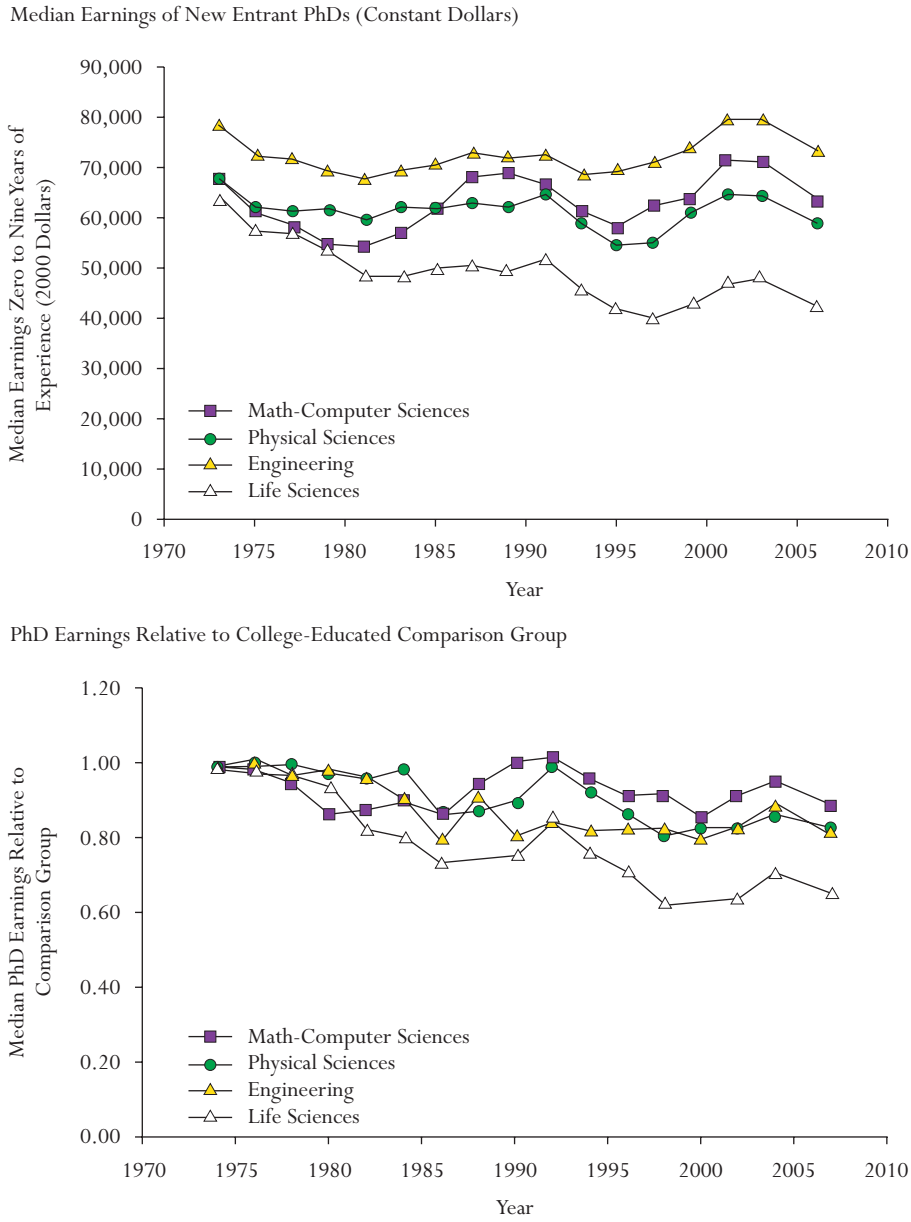
Changes in postsecondary enrollment have translated to changes in degree receipt at the BA, MA, and PhD levels. A significant distinction between the United States and many Asian

FIGURE 10.7 *Trends in Wages for BA-Level Scientists and Engineers Working Full-Time, Relative to All BA Recipients, 1970–2006*



Source: New Entrants Surveys (NES), 1976–1988, and Survey of Recent College Graduates (SRCG), 1992–2006.

FIGURE 10.8 *Trends in Wages for PhD-Level, Male Scientists and Engineers with Zero to Nine Years of Experience, Relative to BA Recipients, 1970–2006*



Source: Data on the median earnings of doctorate recipients by field are for "new entrants" (zero to nine years of experience) from the Survey of Doctorate Recipients and include only men. The bottom panel presents PhD earnings relative to a comparison group defined as the matching percentile from the Current Population Survey of the overall BA wage distribution observed in the baseline year (1974) for men with zero to nine years of experience; these matched percentiles are the eighty-fifth for math–computer science, the eighty-fifth for physical sciences, the ninety-second for engineers, and the eighty-first for the life sciences.

TABLE 10.4 *Tertiary Enrollment in Selected Countries, 1980–2009*

								Percentage Change	
	1980	1985	1990	1995	2000	2005	2009	1985–2009	1995–2009
Australia	323,716	370,048	485,075	964,998	845,132	1,024,589	1,199,845	224.2%	24.3%
Brazil	1,409,243	—	1,540,080	—	2,781,328	4,572,297	6,115,138	—	—
China	1,019,950	2,746,124	3,924,546	5,278,935	7,364,111	20,601,219	29,295,841	966.8	455.0
France	1,060,412	1,255,538	1,587,202	2,072,552	2,015,344	2,187,383	2,172,855	73.1	4.8
India	3,278,793	4,271,618	4,780,181	4,932,669	9,404,460	11,777,296	18,648,923	336.6	278.1
Indonesia	—	980,162	1,515,689	2,229,796	—	3,660,270	4,859,409	395.8	117.9
Israel	97,624	—	122,568	182,836	255,891	310,937	342,707	—	87.4
Republic of Korea	538,726	1,345,114	1,630,374	2,065,579	3,003,498	3,210,184	3,219,216	139.3	55.9
United Kingdom	795,985	1,006,969	1,177,792	1,813,280	2,024,138	2,287,541	2,415,222	139.9	33.2
United States	11,569,899	12,241,940	13,538,000	14,278,799	13,202,880	17,272,044	19,102,814	56.0	33.8
Vietnam	133,558	—	185,788	203,300	732,187	1,354,543	1,774,321	—	772.8

Source: UNESCO, "Enrollment in Tertiary Education," available at http://data.uis.unesco.org/.

countries is in the proportion of college degrees awarded in science and engineering fields. Of the BA degrees awarded in 2006, nearly 53 percent of those in China and more than 40 percent of those in South Korea and Taiwan were in science and engineering fields, compared to only about 32 percent in the United States. China, India, South Korea, and some other Asian countries have also invested in the production of advanced degrees, breaking the near-monopoly previously held by the United States, the United Kingdom, Germany, and Japan.

The rapid expansion in the number of college-educated workers abroad not only dramatically increases the potential pool of high-skill workers who may seek to join the U.S. labor force but may also increase demand for advanced degree programs offered in the United States. These trends reinforce our view that immigration is the likely explanation for much of the labor market adjustment to demand shocks.

The basic supply-demand model suggests that while immigration brings gains in output, the availability of foreign high-skill workers lowers wages and crowds out U.S.-born workers as long as the demand for labor slopes down (Borjas 2003). However, direct evidence on the magnitude of such crowding out is difficult to obtain, and research on this question has often found no effects. For example, Kerr and Lincoln (2010) find that variation in immigrant flows at the local level related to national changes in H-1B flows does not appear to depress native wages or employment, which would imply a very large elasticity of demand. A central challenge to interpretation of the evidence is that changes in supply and demand for workers may occur concurrently, complicating the capacity to infer the net effect of immigration on wages.

PATHWAYS TO ENTRY

We now trace the pathways to immigrant entry into the U.S. labor market and the persistence of high-skill foreign-born workers in this market. Of particular interest is the timing of immigrant entry in relation to educational attainment and the role of colleges and universities in giving immigrants access to the U.S. labor market. There is potentially a large intergenerational component to immigration if today's high-skill immigrants arrived as young children. Further, immigration may interact with educational attainment because many immigrants enter the United States as students and then enter the labor force.

Our analysis covers immigrants currently in the country. It would be preferable to provide more detail about retention rates or the likelihood of becoming permanent residents or naturalized citizens among all foreign-born students entering the United States on either work or student visas, but such information is not available.

Age and Education Level at Immigration

The age distribution of older working-age immigrants (thirty-five to fifty-four) at entry to the United States provides an indicator of their pathway to entry. Among these immigrants at every educational level, more than half did not arrive in the United States until they were at least twenty-five years old (table 10.5).[24] This share is highest (rising to about two-thirds) among professional degree and PhD recipients, suggesting that many of the latter entered the United States via graduate training or a high-skill job. Few of these older working-age immigrants arrived in the United States between the ages of eighteen and twenty-one, the typical age of undergraduate enrollment.[25] Low-skill immigrants are the group most likely to enter the United States between the ages of eighteen and twenty-one (about 18.1 percent). (We suspect that 18 percent is an underestimate because this group is likely to enter and then return to their home countries.)

TABLE 10.5 *Distribution of the Age of Entry of Immigrants Ages Thirty-Five to Fifty-Four, 2000*

Age of Entry	Less Than High School	High School and Some College	BA Degree	MA Degree	Professional Degree	PhD Degree
Zero to Seventeen	0.18	0.26	0.21	0.18	0.19	0.10
Eighteen to twenty-one	0.18	0.14	0.10	0.10	0.06	0.08
Twenty-two to twenty-four	0.13	0.12	0.12	0.14	0.09	0.14
Twenty-five to thirty-four	0.32	0.31	0.36	0.38	0.43	0.45
Thirty-five and older	0.20	0.17	0.21	0.20	0.24	0.23

Source: U.S. census, 2000.

For high-skill immigrants, we can examine the interplay between the timing of educational attainment and arrival in the United States by using the 1993 and 2003 cohorts of the National Survey of College Graduates. The NSCG provides detailed information for high-skill immigrants who were in the United States for both the decennial census years (1990 and 2000) and the point of observation three years later. (A disadvantage is that it is a follow-up survey three years after the initial survey; hence, it omits the non-immigrant foreign-born who stay in the United States only a short time.)

A very high proportion of immigrants, particularly those with advanced degrees, received their highest credential in the United States, not in their home country. Table 10.6 presents data on the location of the highest degree among immigrants with BAs, MAs, and PhDs working in science and engineering occupations in 2003. For those with graduate degrees, a strikingly high proportion received this degree in the United States, with these shares somewhat higher among those employed in engineering and computer science fields. At the master's degree level, nearly 45 percent of engineers and 50 percent of those in computer science received their MA in the

TABLE 10.6 *Location of Degrees Attained by Foreign-Born Workers, by Occupation, 2003*

	American High School	High School Abroad and American BA	High School and BA Abroad	High School and BA Abroad and American Highest Degree	High School, BA, and Highest Degree Abroad
All BA degrees	0.30	0.15	0.55		
Engineers, BA	0.30	0.22	0.48		
Computer science and math, BA	0.31	0.16	0.53		
RN, pharmacists, dietitians	0.29	0.17	0.55		
Diagnosing and treating health	0.44	0.12	0.44		
All MA degrees	0.24	0.18		0.35	0.23
Engineers, MA	0.19	0.19		0.45	0.17
Computer science and math, MA	0.13	0.12		0.51	0.24
All PhD degrees	0.12	0.13		0.47	0.28
Engineers and scientists, PhD	0.11	0.10		0.51	0.29
Engineers, PhD	0.09	0.08		0.63	0.20.00
Computer science and math, PhD	0.06	0.07		0.62	0.24.73

Source: NSCG, 2003.

United States after completing prior studies abroad. At the PhD level, more than 60 percent of engineers and computer scientists studied abroad and then received a U.S. PhD.

Although U.S. higher education remains an important gateway to immigrant labor market participation in engineering and computer science fields, there has been a modest increase in the share of high-skill immigrants who received all of their education abroad. In particular, between 1993 and 2003 (not shown here), the share of computer science immigrants educated entirely abroad increased from 36 to 52 percent at the BA level, from 11 to 24 percent at the MA level, and from 17.6 to 24.7 percent at the PhD level. We hypothesize that this shift reflects the increased demand for computer science expertise over this period, the growth of international networks linking U.S. employers and potential immigrants, and the expanded capacity of foreign tertiary education to award degrees in high-demand areas.

U.S. Higher Education and Foreign Degree Attainment

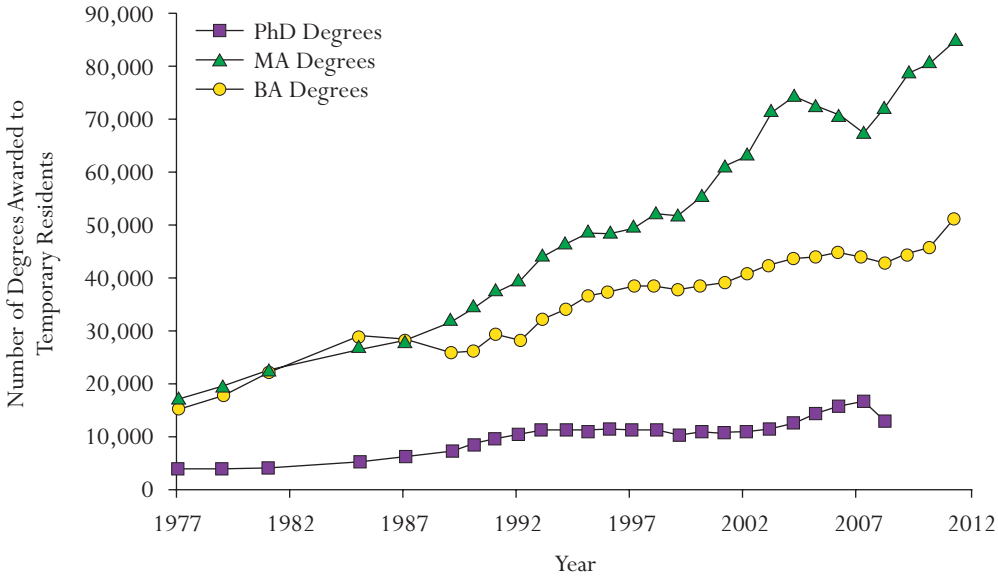
Demand for U.S. higher education among foreign students reflects both their desire to acquire skills and training that may be in short supply in their home countries and an option on employment in the U.S. labor market. As noted earlier, foreign-born recipients of U.S. degrees hold an advantage over those holding only foreign degrees. The impact on demand for higher education at both the undergraduate and graduate levels in the United States is substantial. At least in recent history, U.S. institutions have held a strong advantage in degree production at the highest levels. Thus, even as countries expand the capacity of their postsecondary institutions, it is unlikely that this growth will be reflected in degree programs that can compete with the most highly ranked programs in the United States. Mark Rosenzweig, Douglas Irwin, and Jaffrey Williamson (2006) examine the extent to which home-country degree production is a substitute or a complement for foreign degree production. They find that in emerging economies, an increase in a country's postsecondary enrollment will increase the pool of students seeking to study abroad.

The capacity to finance study in the United States is likely to be a primary determinant of foreign demand. U.S. institutions rarely provide need-based financial aid to foreign students at the undergraduate level, making four years of either private or out-of-state public tuition out of reach for all but the most affluent foreign students. At the other extreme, PhD programs can often provide financial aid through teaching assistant (TA), resident assistant (RA), and fellowship support. Fewer than 5 percent of foreign students support themselves as self-payers (Blanchard, Bound, and Turner 2009). In the middle ground, master's programs are more likely to be an option than BA programs given their shorter duration, and some foreign students gain admittance to PhD programs with full financial aid, only to depart with a master's degree.

Hence, three factors explain the large number of foreign students enrolled in U.S. graduate programs and the high immigrant representation among postbaccalaureate degree recipients: (1) substitutes for U.S. graduate education and elite undergraduate education are not likely to be available in their home countries; (2) advanced degree attainment increases the likelihood that a firm can satisfy H-1B requirements; and (3) the foreign-born are more likely to be able to finance graduate study than undergraduate study because MA programs are of short duration and PhD programs often provide financial aid.

Figure 10.9 plots the number of degrees awarded to foreign students by education level from 1977 to 2011. The number of BA degrees awarded to temporary residents increased by 328 percent, from 15,744 to 51,703, during this thirty-four-year period. The increases in the number of MA and PhD degrees awarded to temporary residents were even more dramatic, with the number of MAs rising by a factor of 4.8 and PhD degrees by a factor of 4.7. The increase

FIGURE 10.9 *Trends in Degrees Awarded to Temporary Residents by U.S. Colleges and Universities, 1977–2012*



Source: Authors' tabulations from U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System (IPEDS), "Degrees and Certificates Conferred."

in MA degrees includes those earned on the path to a PhD degree as well as terminal MA degrees. We suspect that terminal MA degrees in which students pay full tuition have increased as a share of all master's degrees in recent years.

Country of Origin and Degree Attainment

We now examine the relationship between country of origin, degree level, and occupational specialization. Table 10.7 shows the five largest source countries for immigrants ages twenty-five to fifty-four, by education level and field, in 2009–2011. As shown, nearly 23 percent of science and engineering PhDs were from China, 31 percent of nurses were from the Philippines, and almost 40 percent of MA-degree recipients working in math and computer science were from India. The rise in the representation of immigrants from China is noteworthy. In each field the share of immigrants from China in 2010 was more than twice the level observed in 1990 (not shown).

To examine the link between visa status on entry to the United States and current visa status, we look to the 2003 National Survey of College Graduates, which included foreign-born individuals in the United States as of the 2000 census. In effect, these estimates were conditional on retention in the United States for three years. The proportion of the current immigrant population who had entered on a student visa varied with education and specialization (see appendix table 10A.3). Among foreign-born workers in engineering and computer science, about 30 percent of those with a BA or MA degree had entered the United States on a student visa, while more than 70 percent of those with a PhD degree had entered this way. In contrast, im-

TABLE 10.7 *Country of Origin and Occupational Specialization of Foreign-Born Workers Ages Twenty-Five to Fifty-Four, 2009–2011*

All BA Degrees (no MA or PhD)		BA—Engineers		BA—Computer Science and Math	
Philippines	0.11	Vietnam	0.12	India	0.25
India	0.09	India	0.10	Philippines	0.07
Mexico	0.08	Philippines	0.08	Vietnam	0.06
Korea	0.05	Mexico	0.05	China	0.04
Vietnam	0.04	China	0.05	Korea	0.03
MA—Engineers		MA—Computer Science and Math		PhD—Engineering and Science	
India	0.27	India	0.38	China	0.23
China	0.13	China	0.13	India	0.12
Taiwan	0.05	Taiwan	0.05	Korea	0.05
Vietnam	0.04	Germany	0.03	Canada	0.04
Iran	0.03	Pakistan	0.02	Germany	0.04
Registered Nurses		Physicians			
Philippines	0.31	India	0.20		
India	0.06	China	0.05		
Canada	0.04	Pakistan	0.05		
Jamaica	0.04	Philippines	0.05		
Nigeria	0.04	Canada	0.04		

Source: ACS, 2009–2011.

migrants in nursing were much more likely to enter directly as permanent residents than on student visas. Temporary work visas were the entry pathway for 17 percent of engineers and 26 percent of computer science professionals with BA and MA degrees, respectively, while only 9 percent of doctorate-level scientists and engineers used this path.

For immigrants entering the United States via temporary visas, the likelihood of becoming a naturalized citizen or gaining a green card was high. More than 72 percent of science and engineering PhDs who had entered on a temporary visa transitioned to permanent residency or citizenship. Among engineers and computer scientists at the BA or MA level, those who had entered on a student visa were somewhat more likely to hold permanent residency or citizenship than those entering on a temporary work visa.

Persistence and Stay Rates

Understanding what fraction of those entering the United States under temporary visa arrangements remain in the United States and what fraction eventually return home is of considerable interest from both the social science and policy perspectives. One often hears concern that after training the world's best and brightest, the United States does not let them stay. Indeed, high-skill immigrants usually enter the United States under visas that are explicitly temporary—the F, J, H, and L visas—although individuals holding the F and the H visas are not prohibited from moving directly from their temporary status to the status of a permanent resident. In theory, it should be possible to follow legal immigrants from their initial entry into the United States through the visa system and through possible exit using administrative data to determine what fraction of those who enter the United States on a student visa eventually end up with either a work visa or a green card and what fraction of those who enter on an H-1B eventually end up

with a green card. Such data are not publicly available, however, and as far as we know, the federal government has not integrated administrative information in this way.

The best information we have on persistence comes from tabulations done by the Social Security Administration (SSA) for the economist Michael Finn (2012), who used the National Science Foundation's Survey of Earned Doctorates (SED), a census of those receiving PhDs from U.S. institutions, to identify recent PhDs. He then sent this information to the SSA to identify which of the foreign-born who were on temporary or permanent visas at the time they received their PhD have continued to work in the United States at intervals of one, two, five, and ten years after degree receipt. He estimates that, as of 2009, 64 percent of those who received their PhD five years earlier continued to live in the United States, while 66 percent of those who received their PhD ten years earlier did so.

Stay rates for doctorate recipients tend to be somewhat higher in the STEM fields and have been trending up. Stay rates also vary by country of origin. Focusing on just those with temporary visas who received a PhD in a STEM field, Finn finds that 89 percent of those from China and 79 percent of those from India remain in the United States five years after receiving their PhD. In contrast, he finds that five-year stay rates for those from Japan, South Korea, and Taiwan are all under 50 percent. More generally, those from Latin America, Canada, and western Europe have below-average (62 percent) five-year stay rates. These patterns, while not definitive, suggest that persistence rates reflect not only visa availability but market forces. Doctorate recipients from high-income countries with well-established universities may face better home-country options than those from low-income countries. As a result, those from western Europe and Canada may not choose to stay permanently in the United States unless they obtain employment in top research universities or labs (Bound, Turner, and Walsh 2009).

In closely related work, Jeff Grogger and Gordon Hanson (2013) use the data within the SED on intentions to stay in the United States to study patterns across individual characteristics, countries, and decades. Historically, the SED data on intentions closely tracks the data on actual stay patterns calculated by Finn (2012). Grogger and Hanson find that over the period 1960 to 2008 the likelihood of reporting intentions to stay in the United States was high among science and engineering PhDs: 77 percent of those students with stronger academic ability (measured by parental educational attainment and success in obtaining graduate fellowships) planned to stay. Students were less likely to report an intention to stay if they came from a high-income country or a country that had recently democratized. Grogger and Hanson also find that foreign PhDs were more likely to intend to stay in the United States during periods of strong U.S. GDP growth.

Researchers have used various indirect approaches to estimate persistence rates. One method is to construct synthetic cohorts of foreigners using repeated cross-sectional data. For example, one can use the 1990 and 2000 U.S. census enumerations and the 2010 ACS to identify the foreign-born who immigrated to the United States between 1985 and 1990 and who were twenty-five to twenty-nine years old as of 1990, thirty-five to thirty-nine in 2000, and forty-five to forty-nine in 2010. Comparisons of the size of these three populations give an estimate of net ten- and twenty-year persistence rates. We have done this kind of calculation, restricting ourselves to individuals identified as having at least a BA degree. Of course, someone who had no BA degree in 1990 might have had one by 2000, but restricting our attention to those age twenty-five and older should minimize this issue. Strikingly, this method yields estimates of ten- and twenty-year net persistence rates very close to 100 percent.[26]

The 1993 National Survey of College Graduates allows us to calculate three-year stay rates. The sampling frame for the 1993 NSCG was drawn from the 1990 census. It is possible to link the sampling frame to the 1993 NSCG and then calculate loss to follow-up. Not all of this loss

will have been due to emigration, but a comparison between the foreign- and U.S.-born can give a crude estimate of the fraction who left. Recall that the sampling frame for the 1993 NSCG was those with a bachelor's degree in 1990. We calculated loss to follow-up separately for age groups: those who were minors when they immigrated, those who were age eighteen to twenty-four, and those who were twenty-five or older. The fractions lost to follow-up were 19 percent of those who immigrated as minors, 25 percent of those who immigrated when they were eighteen to twenty-four, and 28 percent of those who immigrated after they were twenty-five. These fractions represent upper bounds on three-year emigration rates. For the same sample period, 16 percent of the U.S.-born were lost to follow-up, suggesting that many of the immigrants lost to follow-up may not have emigrated. Indeed, the difference-in-difference estimate suggests that very few of those who arrived as minors subsequently emigrated, but that roughly 10 percent of those who immigrated as adults did. The implied stay rate is substantially higher than the 49 percent two-year stay rate that Finn (2012) calculated for the 1989 PhD cohort.

In another study, Lowell (2010) used administrative data to calculate emigration among those who initially obtained an H-1B visa between 1992 and 1996. Aggregating across these five years, he estimates that just over 50 percent of these individuals ultimately emigrated.

SOCIODEMOGRAPHIC OUTCOMES

Possibly related to retention is immigrant assimilation: the extent to which these foreign-born individuals make similar location choices and have similar family outcomes as natives.

Geography

In the United States, some states (largely those in the Northeast) have relatively high concentrations of college-educated workers, which can be attributed to the structure of local industry as well as relatively widespread availability of college and university opportunities. Indeed, we expect the location choices of the native-born to adjust relatively rapidly to changes in product demand. To the extent that high-skill immigration responds to demand shocks in the labor market, we would expect the distribution of immigrants to approach the distribution of those born in the United States. Alternatively, if immigrant networks are an important draw, we might expect to see a very different concentration of natives and foreign-born by state for different levels of education.

Table 10.8 shows the concentration ratio (CR5, or percentage who live in the most common five states) and the index of dissimilarity to describe the distribution of natives and immigrants by state for different levels of S&E education and for RNs and MDs. As the table indicates, less well-educated immigrants and immigrant RNs are much more highly concentrated in a small set of states (notably California) than are their native-born counterparts. While better-educated immigrants are also more concentrated than their native-born counterparts, the differences are much less dramatic for these groups, while indices of dissimilarity fall by roughly 50%.

Marriage and Family Formation

Immigrants are much more likely to be married than non-immigrants at low levels of educational attainment, but not at high levels (see appendix table 10A.2). Most married immigrants select spouses from their country of birth. This pattern is somewhat more dramatic for the least well educated (roughly three-quarters marry someone from their country of birth) but is true across all education groups.

TABLE 10.8 *Measures of Distribution Across States of U.S.-Born and Foreign-Born Twenty-Five- to Fifty-Four-Year-Olds, 2009–2011*

	Concentration Index (CR5)	Index of Dissimilarity
Less than high school		
U.S.-born	0.32	0.39
Foreign-born	0.64	—
High school and some college		0.35
U.S.-born	0.32	0.35
Foreign-born	0.61	—
BA degree		
U.S.-born	0.33	0.29
Foreign-born	0.60	—
MA degree		
U.S.-born	0.34	0.23
Foreign-born	0.53	—
PhD degree		
U.S.-born	0.34	0.17
Foreign-born	0.46	—
BA degree—science and engineering		
U.S.-born	0.30	0.31
Foreign-born	0.57	—
MA degree—science and engineering		
U.S.-born	0.32	0.21
Foreign-born	0.50	—
PhD degree—science and engineering		
U.S.-born	0.33	0.16
Foreign-born	0.45	—
Registered nurses		
U.S.-born	0.29	0.41
Foreign-born	0.63	—
Physicians		
U.S.-born	0.33	0.19
Foreign-born	0.46	—

Source: ACS, 2009–2011 (combined).
Note: "Foreign-born" is defined as a naturalized citizen or a noncitizen. The concentration index (CR5) is the total employment share of the five states with the highest employment. The index of dissimilarity is defined as $1/2\ \Sigma_{i=1}^{50} |f_i - a_i|$ where i is a state index, f_i is the share of foreigners, and a_i is the share of Americans in state i.

Among high-skill workers, foreign-born men are only slightly more likely than native-born men to be married, while foreign-born women are seven to nine percentage points more likely to be married than native-born women. High-skill men are more likely than high-skill women to have the same country of origin as their spouse.

There is a high degree of intergenerational transmission of educational attainment. There is substantial evidence that the children of college-educated parents are much more likely to be college-educated than are children of those without a college education. The same is true of the children of those with advanced degrees. Thus, it seems likely that if we were able to identify not

only first- but second-generation immigrants using census data, we would find an even greater overrepresentation of immigrants among the highly skilled.

CONCLUSION AND THOUGHTS ON THE FUTURE

The evidence presented in this chapter highlights the importance of the growing high-skill immigrant population in the United States. Both visa policies and labor market incentives have shaped the pattern of immigration. Without question, gains in educational attainment abroad at both the secondary and postsecondary levels have dramatically increased the potential supply of high-skill immigrants coming to the United States. Furthermore, the concentration of foreign students in science and engineering alters relative supplies even more. In turn, increased demand for science and engineering skills in the U.S. economy in recent decades appears to have been accommodated in part by expansion in labor supplies through the entry of foreign-born high-skill workers (Bound, Braga, Golden, and Turner 2013).

The substantial representation of foreign-born workers in the U.S. science and engineering workforce and the growth in the global pool of workers with science and engineering training underscores the need to move away from "closed economy" models of high-skill labor markets in the United States. Yet the adjustment to any change in technology or policy affecting the demand and supply for high-skill workers from abroad is likely to be complex, with effects extending far beyond the metrics of U.S. wages and employment. For example:

- Education and career decisions of U.S. natives are likely to be highly intertwined with patterns of high-skill immigration.
- Incentives for the foreign-born to study in the United States are closely coupled with potential labor force participation in the United States. Universities may actively recruit foreign students to fill doctorate programs and to provide additional tuition revenue at the undergraduate level, while preference for H-1B visas and opportunities for optional practical training via the F visa may increase foreign student demand for U.S. programs.
- High-skill workers from abroad may have an impact on innovation and science in the U.S. economy; as such, the full welfare implications of immigration are not captured in analyses of employment and earnings.
- The flow of high-skill foreign-born workers to the United States also has substantial effects on source countries, raising questions about the level of wages and employment abroad in the absence of flows to the United States.[27]

The long wait times for green cards and the quick exhaustion of caps for H-1B and other temporary visa types imply that policy has generated disequilibrium conditions in the flow of high-skill workers to the U.S. labor market. Available evidence suggests that skilled workers from low-income countries gain substantially from migration to the United States (Clemens 2013), resulting in excess demand for employment visas, both permanent and temporary. In addition, the counterfactual to reductions in the flow of high-skill foreign-born workers to the U.S. economy need not be greater employment of natives: firms may respond to limitations in the supply of high-skill workers by "offshoring."[28] Changes in U.S. policy with respect to the availability and cost of visas for education and employment could greatly affect high-skill immigration and retention.

Although employment-based immigration and temporary work opportunities for high-skill workers are widely discussed topics, the limited nature of relevant data remains a huge con-

straint on the research that could inform public policy. Neither survey data nor administrative data currently accessible to researchers provide the information needed to measure employment and earnings by visa status, analyze transitions among different visa classifications, or examine the timing and location of postsecondary investments in U.S. universities among the foreign-born. Available longitudinal surveys with information on immigrants (including the New Immigrant Survey [NIS]) are often limited to immigrants with permanent visas or those who have shown high rates of persistence in the United States. Because of the retrospective frame of these surveys and the selection built into them, researchers are unable to make substantial progress in understanding the determinants of retention in the United States (as well as return migration) or the wage and employment changes that come with the transition to permanent residency.

Measures of persistence in the U.S. labor market, along with educational investments and the associated transitions from temporary visa classifications to permanent residency, are critical indicators of the welfare benefits and costs of high-skill immigration. However, without better indicators of outcomes for temporary visa recipients—including those with short employment spells—and of transition from student visas to work and other visas, it is difficult to measure the overall welfare benefits and costs of high-skill immigration. To a large degree, constraints in access to the administrative data that would inform these questions are organizational and bureaucratic, not technical. In effect, the government collects the relevant data, but has no mechanism that would provide researchers with access to that data.

APPENDIX

TABLE 10A.1 *Descriptions of Temporary Visas*

Visa Type	Description	Countries of Eligibility	Duration of Visa
H-1B: Temporary workers in specialty occupations	Requires the theoretical and practical application of a body of highly specialized knowledge requiring completion of a specific course of higher education. Capped at 65,000. This category also includes fashion models and government-to-government research and development or coproduction projects administered by the Department of Defense.	All countries	Three years, with three-year possible extension
O-1: Workers with extraordinary ability or achievement	To qualify for an O-1 visa, the beneficiary must demonstrate extraordinary ability by sustained national or international acclaim and must be coming temporarily to the United States to continue work in the area of extraordinary ability. Extraordinary ability in the fields of science, education, business, or athletics means a level of expertise indicating that the person is one of the small percentage who have risen to the very top of the field of endeavor. Extraordinary ability in the field of the arts means distinction.	All countries	Up to three years, with one-year incremental extensions approved by U.S. Citizenship and Immigration Services (USCIS)
TN: North American Free Trade Agreement (NAFTA) professional workers	NAFTA created special economic and trade relationships for the United States, Canada, and Mexico. The TN non-immigrant classification Permanentits qualified Canadian and Mexican citizens to seek temporary entry into the United States to engage in business activities at a professional level. Among the types of professionals who are eligible to seek admission as TN non-immigrants are accountants, engineers, lawyers, pharmacists, scientists, and teachers.	Citizens of Canada and Mexico	Up to three years

TABLE 10A.1 *Continued*

Visa Type	Description	Countries of Eligibility	Duration of Visa
L-1: Intracompany transferees	L-1A: Enables a U.S. employer to transfer an executive or manager from one of its affiliated foreign offices to one of its offices in the United States. This classification also enables a foreign company that does not yet have an affiliated U.S. office to send an executive or manager to the United States with the purpose of establishing one. L-1B: Enables a U.S. employer to transfer a professional employee with specialized knowledge relating to the organization's interests from one of its affiliated foreign offices to one of its offices in the United States. This classification also enables a foreign company that does not yet have an affiliated U.S. office to send an employee with specialized knowledge to the United States to help establish one.	All Countries	Those entering the United States to establish a new office are allowed to stay one year. All others are given a maximum stay of three years. Can request two-year increment extensions. Maximum of seven years total.
E-1: Treaty traders and their spouses and children	Allows a national of a treaty country (a country with which the United States maintains a treaty of commerce and navigation) to be admitted to the United States solely to engage in international trade on his or her own behalf. Certain employees of such a person or of a qualifying organization may also be eligible for this classification.	U.S. treaty countries	Two-year maximum initial stay plus two-year approved increments. No limit on total stay.
J-1: Exchange visitors	Authorized for those who intend to participate in an approved program for the purpose of teaching, instructing, or lecturing, studying, observing, conducting research, consulting, demonstrating special skills, receiving training, or to receive graduate medical education or training. J-1 non-immigrants are therefore sponsored by an exchange program that is designated as such by the U.S. Department of State.	All countries	Duration of the exchange program plus thirty-day grace period

Source: Description for H-1B, O-1, TN, L-1, and E-1 are from the visa-specific pages on the USCIS website: http://www.uscis.gov/portal/site/uscis. Description for J-1 is from the U.S. Department of State J-1 Visa Exchange Visitor Program website: http://j1visa.state.gov/. Both sites accessed September 19, 2014.

TABLE 10A.2 *Marital Status of Twenty-Five- to Fifty-Four-Year-Olds, by Citizenship, 2008–2010*

	U.S.-Born Men	Foreign-Born Men	U.S.-Born Women	Foreign-Born Women
Less than high school (percentage)				
Not married	0.65	0.42	0.65	0.39
Married to native	0.31	0.07	0.30	0.07
Married to immigrant, same country	0.00	0.44	0.00	0.47
Married to immigrant, different country	0.04	0.07	0.06	0.07
Total (N)	4,392,020	2,893,602	3,196,957	2,466,476
High school and some college (percentage)				
Not married	0.50	0.41	0.48	0.38
Married to native	0.44	0.13	0.45	0.16
Married to immigrant, same country	0.00	0.38	0.00	0.37
Married to immigrant, different country	0.06	0.08	0.06	0.08
Total (N)	27,451,324	3,315,555	27,045,605	3,423,455
BA degree (percentage)				
Not married	0.40	0.35	0.40	0.32
Married to native	0.52	0.13	0.52	0.19
Married to immigrant, same country	0.00	0.43	0.00	0.40
Married to immigrant, different country	0.08	0.09	0.08	0.09
Total (N)	8,639,378	1,258,949	9,698,148	1,512,199
MA degree (percentage)				
Not married	0.30	0.27	0.38	0.28
Married to native	0.59	0.12	0.54	0.17
Married to immigrant, same country	0.00	0.52	0.00	0.45
Married to immigrant, different country	0.11	0.09	0.09	0.09
Total (N)	2,611,738	676,101	3,682,657	630,194
Professional or PhD degree (percentage)				
Not married	0.28	0.24	0.38	0.31
Married to native	0.61	0.13	0.52	0.18
Married to immigrant, same country	0.00	0.53	0.00	0.40
Married to immigrant, different country	0.12	0.10	0.10	0.10
Total (N)	1,290,322	373,170	1,062,521	278,866

Source: ACS, 2008–2010 (average values).
Note: All imputed values are dropped (own and spouse's).

TABLE 10A.3 *Entry Visa Status and Current Visa Status of All Foreign-Born Workers in the United States, 2003*

Entry Visa	Percentage Distribution	Current Visa Status: Naturalized	Permanent Resident	Temporary: Work	Temporary: Student	Temporary: Other
BA and MA, no PhD						
Permanent U.S. resident	44.4%	0.789	0.208	0.000	0.000	0.002
Temporary resident: work	13.1	0.262	0.490	0.225	0.002	0.021
Temporary resident: student	20.2	0.514	0.330	0.118	0.013	0.025
Temporary resident: other	22.2	0.605	0.298	0.047	0.002	0.048
BA and MA, no PhD—engineers						
Permanent U.S. resident	39.7	0.880	0.120	0.000	0.000	0.000
Temporary resident: work	17.3	0.151	0.415	0.397	0.000	0.037
Temporary resident: student	30.3	0.548	0.284	0.143	0.013	0.013
Temporary resident: other	12.6	0.690	0.205	0.093	0.000	0.012
BA and MA, no PhD—computer science and math scientists						
Permanent U.S. resident	29.1	0.811	0.185	0.001	0.002	0.000
Temporary resident: work	25.6	0.107	0.539	0.328	0.000	0.025
Temporary resident: student	29.5	0.404	0.370	0.213	0.003	0.009
Temporary resident: other	15.9	0.585	0.342	0.061	0.000	0.011
PhD						
Permanent U.S. resident	12.1	0.758	0.233	0.009	0.000	0.000
Temporary resident: work	9.3	0.245	0.553	0.189	0.000	0.014
Temporary resident: student	67.3	0.423	0.342	0.180	0.035	0.021
Temporary resident: other	11.3	0.585	0.313	0.061	0.013	0.027
PhD—engineers and scientists						
Permanent U.S. resident	10.3	0.787	0.199	0.014	0.000	0.000
Temporary resident: work	8.8	0.225	0.589	0.166	0.000	0.020
Temporary resident: student	71.1	0.377	0.360	0.212	0.035	0.016
Temporary resident: other	9.8	0.588	0.294	0.098	0.011	0.010
RN—pharmacists, dietitians						
Permanent U.S. resident	46.3	0.848	0.152	0.000	0.000	0.000
Temporary resident: work	27.3	0.566	0.324	0.111	0.000	0.000
Temporary resident: student	12.6	0.818	0.167	0.015	0.000	0.000
Temporary resident: other	13.8	0.721	0.279	0.000	0.000	0.000
Diagnosing and treating health						
Permanent U.S. resident	43.5	0.883	0.117	0.000	0.000	0.000
Temporary resident: work	7.4	0.325	0.511	0.156	0.000	0.008
Temporary resident: student	28.6	0.591	0.209	0.169	0.020	0.010
Temporary resident: other	20.5	0.792	0.109	0.064	0.018	0.016

Source: Author's tabulations from NSCG, 2003.

TABLE 10A.4 *Entry Visa Status and Current Visa Status of Foreign-Born Workers, Ages Twenty-Five to Fifty-Four, Who Did Not Attend High School in the United States, 2003*

		Current Visa Status				
Entry Visa	Percentage Distribution	Naturalized	Permanent Resident	Temporary: Work	Temporary: Student	Temporary: Other
BA and MA, no PhD						
Permanent U.S. resident	35.3%	0.679	0.315	0.001	0.000	0.004
Temporary resident: work	17.5	0.235	0.506	0.235	0.002	0.022
Temporary resident: student	25.7	0.493	0.338	0.127	0.015	0.027
Temporary resident: other	21.4	0.485	0.377	0.065	0.004	0.070
BA and MA, no PhD—engineers						
Permanent U.S. resident	28.6	0.809	0.191	0.000	0.000	0.000
Temporary resident: work	22.3	0.103	0.436	0.422	0.000	0.039
Temporary resident: student	37.8	0.532	0.299	0.140	0.014	0.014
Temporary resident: other	11.3	0.587	0.256	0.138	0.000	0.018
BA and MA, no PhD—computer science and math scientists						
Permanent U.S. resident	17.9	0.658	0.335	0.003	0.005	0.000
Temporary resident: work	32.3	0.097	0.546	0.332	0.000	0.026
Temporary resident: student	36.1	0.389	0.377	0.221	0.003	0.009
Temporary resident: other	13.6	0.442	0.457	0.083	0.000	0.017
PhD						
Permanent U.S. resident	8.6	0.651	0.335	0.014	0.000	0.000
Temporary resident: work	10.2	0.232	0.562	0.192	0.000	0.014
Temporary resident: student	72.7	0.418	0.347	0.181	0.035	0.019
Temporary resident: other	8.5	0.420	0.430	0.090	0.019	0.040
PhD—engineers and scientists						
Permanent U.S. resident	6.3	0.647	0.328	0.026	0.000	0.000
Temporary resident: work	9.5	0.211	0.599	0.169	0.000	0.021
Temporary resident: student	76.5	0.374	0.364	0.212	0.035	0.014
Temporary resident: other	7.7	0.461	0.373	0.138	0.015	0.014
RN—pharmacists, dietitians						
Permanent U.S. resident	34.4	0.772	0.228	0.000	0.000	0.000
Temporary resident: work	38.7	0.559	0.328	0.112	0.000	0.000
Temporary resident: student	14.4	0.838	0.143	0.019	0.000	0.000
Temporary resident: other	12.4	0.742	0.258	0.000	0.000	0.000
Diagnosing and treating health						
Permanent U.S. resident	34.5	0.812	0.188	0.000	0.000	0.000
Temporary resident: work	10.7	0.292	0.536	0.163	0.000	0.009
Temporary resident: student	38.7	0.547	0.230	0.189	0.023	0.012
Temporary resident: other	16.1	0.644	0.165	0.124	0.035	0.032

Source: Author's tabulations from NSCG, 2003.
Note: "Foreign-born" is defined as a naturalized citizen or noncitizen.

NOTES

1. That is not to say the topic has been completely unaddressed. Recent work by William Kerr and William Lincoln (2010), Pia Orrenius and Madeline Zavodny (2010), and others has expanded research in this area.
2. In this chapter, we use the terms "immigrant" and "immigration" to refer to anyone designated as foreign-born in counts such as the census. We are unable to distinguish between immigrants who intend to stay in the United States and those in the United States on a temporary basis. In government statistics that distinguish the foreign-born by type of visa, those with temporary visas are described as "nonresidents" rather than as immigrants.
3. Beyond the standard publicly available microdata, we access a range of supplementary sources to complete the portrait of high-skill workers in the science and engineering fields. Data from the Survey of Earned Doctorates (SED), which is essentially a census of recipients of doctorates from U.S. universities maintained by the National Science Foundation (NSF), provide indicators of doctorate production by university, field of study, age, and country of citizenship over the last nearly four decades. The SED provides an explicit picture of the total PhD output of U.S. universities, as well as the transition to initial employment.
4. Science fields include mathematics and computer science, natural and life sciences, social science, and postsecondary teaching.
5. We are reluctant to overinterpret the data for those in the twenty-five- to thirty-four-year-old age range because degree receipt, particularly among the native-born, is likely to persist well into the thirties.
6. Jeffrey Passel and D'Vera Cohn (2011) estimate that there were more than 11 million unauthorized immigrants in the United States in 2010, up from 8.4 million in 2000 and down slightly from the peak of 12 million in 2007.
7. National quotas on immigration were first imposed in 1921. Under the Immigration Restriction Act of 1921, quotas were set proportional to the number of individuals living in the United States as of 1990. The intent of this law was to restrict immigration flows from eastern and southern Europe. Earlier, during the latter part of the nineteenth century, Congress had enacted laws (such as the Page Act of 1875 and the Chinese Exclusion Act of 1882) that put restrictions on the immigration of Asians to the United States.
8. Additional channels of immigration include the humanitarian/refugee provision (about 168,000) and diversity visas (about 50,000). The Diversity Immigrant Visa Program provides up to 55,000 diversity visas annually, drawn from random selection among all entries, to persons who meet eligibility requirements from countries with low rates of immigration to the United States; see U.S. Department of State, Bureau of Consular Affairs, "The Diversity Visa Process," available at: http://travel.state.gov/visa/immigrants/types/types_1322.html (accessed September 19, 2014).
9. Less than half of the employment-based visas have gone to workers themselves, as this total includes dependents of these immigrants in the employment-based visa cap (Orrenius and Zavodny 2010).
10. For details, see U.S. Department of State, Bureau of Consular Affairs, "Employment-Based Immigrant Visa," available at: http://travel.state.gov/visa/immigrants/types/types_1323.html (accessed September 19, 2014).
11. U.S. Department of State, "The Operation of the Immigrant Numerical Control System," available at: http://www.travel.state.gov/pdf/Immigrant%20Visa%20Control%20System_operation%20of.pdf (accessed September 19, 2014).
12. U.S. Department of State, Bureau of Consular Affairs, "Visa Bulletin for June 2013," vol. 9, no. 57, available at: http://travel.state.gov/content/visas/english/law-and-policy/bulletin/2013/visa-bulletin-for-june-2013.html (accessed September 19, 2014).
13. Slightly earlier, in April 1990, an executive order deferred deportations and granted employment authorization to Chinese nationals who were in the United States at the time of the Tiananmen Square events (Orrenius, Zavodny, and Kerr 2012).
14. Permanent residents may also become naturalized citizens; typically, permanent residents may apply for citizenship five years after attaining permanent residency.
15. The H-1A visa category was created exclusively for the temporary employment of foreign-born nurses under the 1989 Immigration Nursing Relief Act, which expired in 1995. In 1995, 7,261 nurses were admitted under this program. A second program, the H-1C visa program, was established through the Nursing Relief for Disadvantaged Areas Act of 1999 and opened visa opportunities for those employed in designated "health professional shortage areas" that served a minimum share of Medicaid and Medicare patients. This program was discontinued in 2009. Nursing professionals continue to receive priority in green card applications as a field of national interest.

16. The minimum application fees totaled $3,575 in the most recent year. These fees are somewhat higher for firms with more than twenty-five employees (an additional $750 per employee) and in cases requesting expedited processing ($1,225 per employee).
17. An H-1B visa holder who has applied for a green card or permanent resident status may receive a three-year H-1B extension, following from the American Competitiveness in the Twenty-First Century Act of 2000, if he/she is awaiting green card consideration based on date of application and preference category.
18. U.S. Citizenship and Immigration Services (USCIS), "Exchange Visitors," available at: http://www.uscis.gov/working-united-states/students-and-exchange-visitors/exchange-visitors (accessed September 19, 2014).
19. U.S. Department of State, J-1 Visa Exchange Visitor Program, "Facts and Figures," available at: http://j1visa.state.gov/basics/facts-and-figures/ (accessed September 19, 2014).
20. Foreign students who wish to study in the United States must first apply to and be accepted by a Student and Exchange Visitors Program (SEVP)–certified school. The school then provides "Form I-20A-B, Certificate of Eligibility for Nonimmigrant (F-1) Student Status—For Academic and Language Students." The student's information given on this form is recorded in the Student and Exchange Visitor Information System (SEVIS) database. After submitting the I-20 form, students are required to submit the SEVIS I-901 fee, which currently, for F-1 visas, is $200; see U.S. Immigration and Customs Enforcement (ICE), "I-901 Student and Exchange Visitor Information System (SEVIS) Fee," available at: http://www.ice.gov/sevis/i901/ (accessed September 19, 2014). After receiving the SEVIS I-901 receipt, the student can apply for a visa at any U.S. embassy. To maintain the F visa, an individual must refrain from unauthorized employment and maintain a full course load.
21. A further administrative change extended the number of designated STEM programs from about 90 to nearly 400 in June 2012.
22. Measured at the peaks in each technology boom, the ratio of median earnings of computer science graduates to all BA recipients was 1.78 in 1979 and 1.54 in 2001.
23. See Bound, Braga, Golden, and Khanna (2013) for data from the U.S. Government Accountability Office (GAO) for 1992 and from the Immigration and Naturalization Service (INS) for 2000. Also note that India is the country that shows the largest growth in H visas issued in the 1990s, rising from 2,250 in 1990 to 16,485 in 1995 to 61,530 in 2000; see U.S. Department of State's *Annual Reports of the Visa Office* and *Yearbook of Immigration Statistics.*
24. We omit younger persons from table 10.5 because a large share of them are still students.
25. Very recent evidence suggests an increase in the number of foreign students pursuing U.S. undergraduate degrees, though it is too early to predict whether these students will stay in the United States (Bird and Turner 2012).
26. Richard Freeman (2010) estimates that among foreign-born recipients of BA degrees from U.S. universities, stay rates are exceedingly high. He estimates that about 550,000 noncitizens and nonpermanent residents obtained science and engineering degrees in the United States between 1960 and 2003, while the stock of U.S.-educated science and engineering BA recipients in 2003 was about 723,000.
27. For example, the evaporation of the demand for nursing in the United States during the Great Recession created a "glut" of trained nurses in the Philippines, with attendant effects on the Filipino economy.
28. For a discussion of offshoring in the presence of a highly elastic demand schedule for native workers, see Feenstra (2009).

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