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High-Skilled Immigration and the Rise of STEM Occupations in US Employment

Gordon H. Hanson and Matthew J. Slaughter

12.1 Introduction

US business has long dominated the global technology sector. Among the top ten technology companies in terms of revenues worldwide, six are headquartered in the United States and employ most of their workers in US facilities.[1] The US preeminence in advanced industries is perhaps surprising in light of the perceived weakness of US students in science, technology, engineering, and mathematics (STEM). When it comes to STEM disciplines, US secondary school students tend to underperform their peers in other high-income nations. In the 2012 Program for International Student Assessment (PISA) exam, for instance, US fifteen-year-olds ranked 36th in math and 28th in science out of sixty-five participating countries.[2]

Middling test scores notwithstanding, the US economy has found ways to cope with the labor market demands of the digital age. The country makes up for any shortcomings in "growing its own" STEM talent by importing

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1. These companies (from communications equipment, computers, electronics, internet services, semiconductors, and software and programming) are Apple (US), Samsung (Korea), Hon Hai Precision (Taiwan), Hewlett-Packard (US), IBM (US), Microsoft (US), Hitachi (Japan), Amazon (US), Sony (Japan), and Google (US). See Griffith (2015).

2. See http://www.oecd.org/pisa/.

talent from abroad. Foreign-born workers account for a large fraction of hires in STEM occupations, especially among those with advanced training. Not surprisingly, the tech sector is unified in its support for expanding the number of US visas made available to high-skilled foreign job seekers.[3] Helping maintain US leadership in technology is the country's strength in tertiary education in STEM disciplines, which attracts ambitious foreign students and faculty to US universities. In global rankings of scholarship, US institutions of higher education account for nine of the top ten programs in engineering, for eight of the top ten programs in life and medical sciences, and for seven of the top ten programs in physical sciences.[4]

The United States succeeds in attracting highly trained workers from around the world even though the country's immigration system provides only modest ostensible reward for skill. Family-based immigration absorbs the lion's share of US permanent residence visas. Immediate family members of US citizens, who are eligible for green cards without restriction, accounted for 44.4 percent of admissions of legal permanent residents in 2013 (Office of Immigration Statistics 2014). Additional family members of US citizens and legal residents accounted for another 21.2 percent. Employer-sponsored visas made up only 16.3 percent of the total. These outcomes are consistent with long-standing priorities of US immigration policy. The Immigration Act of 1990, which moderately reformed the landmark Immigration and Nationality Act of 1965, allocated 480,000 visas to family-sponsored categories but just 140,000 visas to employer-sponsored ones.

Despite the pro-family-reunification orientation of US immigration legislation, high-skilled workers find their way into the country and into STEM jobs. The US immigration standards turn out to be more flexible in practice than they appear on paper. A foreign student who succeeds in gaining admission to a US university is likely to garner a student visa. Studying in the United States creates opportunities to make contacts with US employers (Bound, Demirci, et al. 2015) and to meet and to marry a US resident (Jasso et al. 2000), either of which outcome opens a path to obtaining a green card. Although the hurdles involved in securing legal permanent residence can take many years to clear, a foreign citizen with sufficient training and a US job offer is eligible for an H-1B visa, which has come to function as a de facto queue for a green card, at least among those with sought-after skills. These visas, which go primarily to highly educated workers in the tech sector, last for three years and are renewable once. The United States awards 65,000 H-1B visas annually on a first-come, first-served basis, and another 20,000 visas to individuals with a master's or higher degree from a US institution.[5] Other temporary work visas are available to employees of foreign subsid-

3. Jordan (2015).
4. See world university rankings by field at http://cwur.org/.
5. Employees of US universities and nonprofit or public research entities are excluded from the H-1B visa cap.

iaries of US multinational companies and to companies headquartered in countries with which the United States has a free trade agreement.

In this chapter, we document the importance of high-skilled immigration for US employment in STEM fields. To begin, we review patterns of US employment in STEM occupations among workers with at least a college degree. These patterns mirror the cycle of boom and bust in the US technology industry (Bound, Braga, et al. 2015). Among young workers with a college education, the share of hours worked in STEM jobs peaked around the year 2000, at the height of the dot-com bubble. The STEM employment shares are just now approaching these previous highs. Next, we consider the importance of immigrant labor to STEM employment. Immigrants account for a disproportionate share of jobs in STEM occupations, in particular among younger workers and among workers with a master's degree or PhD. Foreign-born presence is most pronounced in computer-related occupations, such as software programming. The majority of foreign-born workers in STEM jobs arrived in the United States at age twenty-one or older. Although we do not know the visa history of these individuals, their age at arrival is consistent with the H-1B visa being an important mode of entry for highly trained STEM workers into the US labor market. Finally, we examine wage differences between native- and foreign-born workers. Opposition to high-skilled immigration, and to H-1B visas in particular, is based in part on the notion that foreign-born workers accept lower wages than the native born, thereby depressing earnings in STEM occupations.[6] Whereas foreign-born workers earn substantially less than native-born workers in non-STEM jobs, the native-to-foreign-born earnings difference in STEM is much smaller. Foreign-born workers in STEM fields reach earnings parity with native workers much more quickly than they do in non-STEM fields. In non-STEM jobs, foreign-born workers require twenty years or more in the United States to reach earnings parity with natives; in STEM fields, they achieve parity in less than a decade.

High-skilled immigration has important consequences for US economic development. In modern growth theory, the share of workers specialized in research and development (R&D) plays a role in setting the pace of long-run growth (Jones 2002). Because high-skilled immigrants are drawn to STEM fields, they are likely to be inputs into US innovation. Recent work finds evidence consistent with high-skilled immigration having contributed to advances in US innovation. The US states and localities that attract more high-skilled foreign labor see faster rates of growth in labor productivity (Hunt and Gauthier-Loiselle 2010; Peri 2012). Kerr and Lincoln (2010) find that individuals with ethnic Chinese and Indian names, a large fraction of

6. See, for example, the justification provided by Senator Chuck Grassley (R-Iowa) for reforming the H-1B visa program (http://www.grassley.senate.gov/issues-legislation/issues/immigration).

which appear to be foreign born, account for rising shares of US patents in computers, electronics, medical devices, and pharmaceuticals. The US metropolitan areas that historically employed more H-1B workers enjoyed larger bumps in patenting when Congress temporarily expanded the program between 1999 and 2003. Further, the patent bump was concentrated among Chinese and Indian inventors, consistent with the added H-1B visas having expanded the US innovation frontier. Yet, the precise magnitude of the foreign-born contribution to US innovation and productivity growth is hard to pin down. Because the allocation of labor across regional markets responds to myriad economic shocks, establishing a causal relationship between inflows of foreign workers and the local pace of innovation is a challenge. High-skilled immigration may displace some US workers in STEM jobs (Borjas and Doran 2012), possibly attenuating the net impact on US innovation capabilities. How much of aggregate US productivity growth can be attributed to high-skilled labor inflows remains unknown.

When it comes to innovation, there appears to be nothing "special" about foreign-born workers, other than their proclivity for studying STEM disciplines in university. The National Survey of College Graduates shows that foreign-born individuals are far more likely than the native born to obtain a patent, and more likely still to obtain a patent that is commercialized (Hunt 2011). It is also the case that foreign-born students are substantially more likely to major in engineering, math, and the physical sciences, all fields strongly associated with later patenting. Once one controls for the major field of study, the foreign-to-native-born differential in patenting disappears. Consistent with Hunt's (2011) findings, the descriptive results we present suggest that highly educated immigrant workers in the United States have a strong revealed comparative advantage in STEM. The literature has yet to explain the origin of these specialization patterns. It could be that the immigrants the United States attracts are better suited for careers in innovation—due to the relative quality of foreign secondary education in STEM, selection mechanisms implicit in US immigration policy, or the relative magnitude of the US earnings premium for successful inventors—and therefore choose to study the subjects that prepare them for later innovative activity. Alternatively, cultural or language barriers may complicate the path of the foreign born to obtaining good US jobs in non-STEM fields, such as advertising, insurance, or law, pushing them into STEM careers.

In the political debate surrounding H-1B visas, the foreign born are criticized for putting US workers out of jobs due to their willingness to work for low wages (Hira 2010). Critics of the H-1B program portray it as allowing Indian firms in business services, such as Wipro and Infosys, to set up low-wage programming shops in the United States (Matloff 2013). Our results do not support such characterizations. After controlling for observable characteristics, there is little discernible difference in the average earnings of native- and foreign-born workers in STEM occupations. Moreover, the pattern of assimilation among foreign-born STEM workers suggests that immigrants end up in higher-wage and not lower-wage positions. Unknown is how the selection of workers into occupations—or the selective return migration of the foreign born—affect these observed native-immigrant wage differences. If native-born workers with high earnings potential move out of STEM jobs more rapidly over time (into, say, management positions) or if, within STEM occupations, lower-wage immigrants are more likely to return to their home countries, our results may overstate the relative wage trajectory of immigrant workers in STEM jobs.

Section 12.2 presents data used in the analysis, section 12.3 documents the role of STEM in overall US employment, section 12.4 describes the presence of foreign-born workers in STEM occupations, section 12.5 examines earnings differences between native- and foreign-born workers, and section 12.6 concludes.

12.2 Data

The data for the analysis come from the Integrated Public Use Microdata Series (IPUMS) 5 percent samples of the 1980, 1990, and 2000 US population censuses and 1 percent combined samples of the 2010–2012 American Community Surveys (ACS). We also use data from the IPUMS sample of the March Current Population Survey. We define total employment to be total hours worked for individuals in the civilian population not living in group quarters. Because we focus on individuals with a college or advanced degree and who are oriented toward STEM occupations, in much of the analysis we limit the sample to those twenty-five to fifty-four years of age. Excluding those younger than twenty-five drops individuals still in school or still making their schooling decisions. In early sample years, dropping those older than fifty-four excludes the generation of workers who would have made schooling decisions well before the computer revolution. In the census and ACS, hours worked is calculated as weeks worked last year times usual hours worked per week, weighted by sampling weights. Earnings are calculated, alternatively, as average annual earnings, average weekly earnings, or average earnings per usual hours worked.

Our definition of STEM occupations follows that of the Department of Commerce (Langdon et al. 2011), except that we drop the relatively low-skill categories of technicians, computer support staff, and drafters. These excluded categories have a relatively high fraction of workers who have completed no more than a high school degree. The resulting occupations classified as STEM are

- computer-related fields (computer scientists, computer software developers, computer systems analysts, programmers of numerically controlled machine tools);
- engineers (aerospace, chemical, civil, electrical, geological and petroleum, industrial, materials and metallurgical, mechanical);

- life and medical scientists (agricultural and food scientists, biological scientists, conservation and forestry scientists, medical scientists);
- physical scientists (astronomers and physicists, atmospheric and space scientists, chemists, geologists, mathematicians, statisticians); and
- other STEM occupations (surveyors, cartographers, and mapping scientists).

Occupational definitions used by the US Bureau of the Census have expanded over time as a consequence of technological progress (Lin 2011). In order to compare employment patterns from the 1980s to the present, we are obligated to use the 1990 IPUMS occupation categories. This categorization does not include fields that became common only in the later phases of the digital revolution (e.g., information security analysts, web developers, computer network architects). However, these new categories fall almost entirely within the old categories of software developers, computer scientists, and computer systems analysts. Because we work with STEM occupations either as an aggregate or for the broad category of computer-related fields, the proliferation of occupations within information technology does not pose a problem.

12.3 Employment in STEM Occupations

12.3.1 Rising Employment in STEM Fields

To set the stage for discussing the role of foreign-born workers in US employment in science and technology, it is helpful to consider first how national employment in these lines of work has evolved over time. Figure 12.1 uses the March CPS to show the fraction of total work hours in STEM occupations for twenty-five to fifty-four-year-olds across all education categories. This share rises steadily during the 1990s, plateaus after the 2001 dot-com bust, and then rises again in the middle and late first decade of the twenty-first century. When looking at workers in all education categories, STEM jobs still account for a small fraction of total employment, breaking 6 percent only briefly during the sample period.

To put the employment shares in figure 12.1 in context, in table 12.1 we show the total number of full-time equivalent workers in STEM occupations over 2000–2012 and the fractions of these workers with a BA degree and with a BA degree in a STEM discipline. Full-time equivalent workers are calculated as the sum (weighted by survey weights) of usual hours worked per week times weeks worked last year divided by 2000. The STEM workers are, not surprisingly, a relatively highly educated group. Whereas only 34.5 percent of twenty-five- to fifty-four-year-old full-time workers in non-STEM occupations have a BA degree, college education predominates in STEM jobs, ranging from 58.9 percent among network administrators to

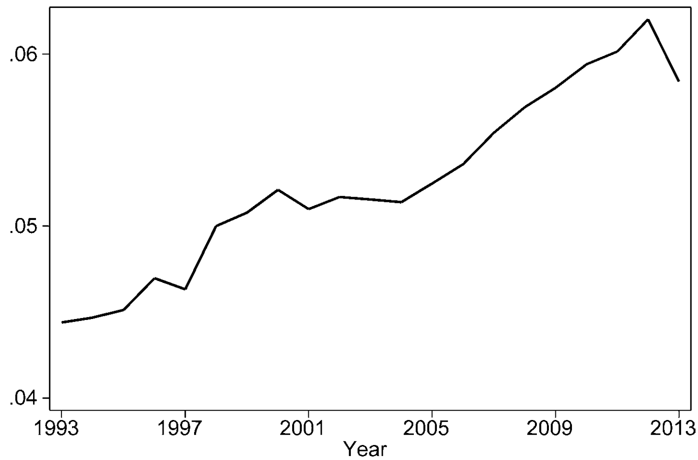

Fig. 12.1 Share of total hours worked in STEM occupations
Source: CPS, 1994–2014.

81.6 percent among engineers and to 91.9 percent among life and physical scientists. In STEM occupations, the majority of those with a BA degree have earned that degree in a STEM field (as seen by taking the ratio of column [3] to column [2] in table 12.1). Consistent with much previous evidence, STEM jobs tend to pay substantially more than non-STEM jobs. Considering just those workers with at least a bachelor's degree, average annual earnings in 2010–2012 for full-time college-educated workers in non-STEM occupations was $78,635, compared with $92,095 for software programmers and $94,297 for engineers. Only earnings for life and physical scientists lag those in non-STEM positions.

Given that STEM jobs tend to require a college education, the upward trend in STEM employment in figure 12.1 may be in part a byproduct of the rising educational attainment of the US labor force. We next examine how employment patterns have changed among workers with at least a BA degree. Figure 12.2 uses the March CPS to show the fraction of total work hours by twenty-five- to fifty-four-year-olds accounted for by STEM occupations in each of three education categories: workers whose highest attainment is a bachelor's degree, workers whose highest attainment is a master's or professional degree, and workers with a PhD. Once we condition on having a college education, employment in the broad science and technology sector has been relatively flat since the late 1990s, ranging from 10–12 percent for college graduates, 9–12 percent for master's and professional degrees, and 14–22 percent for PhDs. (Employment shares among PhDs appear more variable in figure 12.2 due in part to relatively small sample sizes for this subcategory.)

In select lines of work, STEM employment has exploded. Creating soft-

Table 12.1 **Characteristics of STEM workers, 2010–2012**

				Average income (2012 USD)			
		Share of workers with		All workers		Workers with BA	
	No. of workers (millions of FTEs)	BA degree	BA degree in STEM	Annual	Hourly	Annual	Hourly
Non-STEM occupations	88.251	0.345	0.064	53,073	23.9	78,635	34.1
Engineers	1.400	0.816	0.728	89,823	39.7	94,297	41.7
Software programmers	1.325	0.805	0.593	88,300	40.3	92,095	42.1
Network administrators	0.458	0.589	0.333	77,722	35.0	83,966	37.8
Computer scientists	0.392	0.742	0.355	83,378	37.7	88,325	39.9
Physical, life scientists	0.660	0.919	0.649	76,325	34.6	77,528	35.1

Source: Data from ACS 2010–2012.

Notes: Data include all workers twenty-five to fifty-four years old. Values are weighted by annual hours worked/2000 (full-time equivalent units).

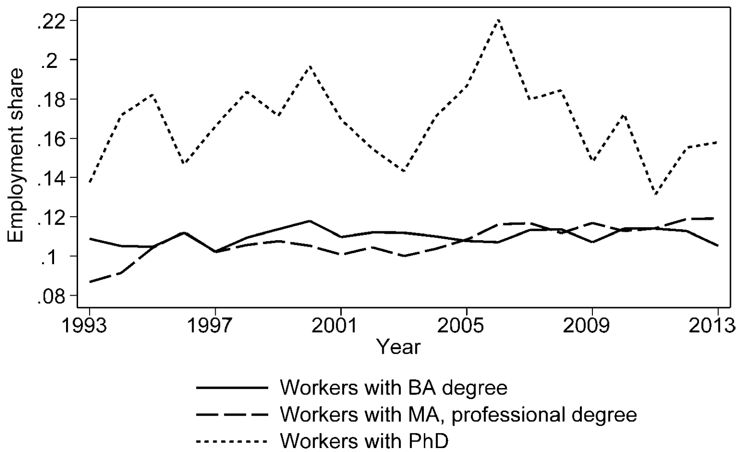

Fig. 12.2 Employment of college-educated males in STEM occupations, share of employment in STEM jobs
Source: CPS, 1994–2014.

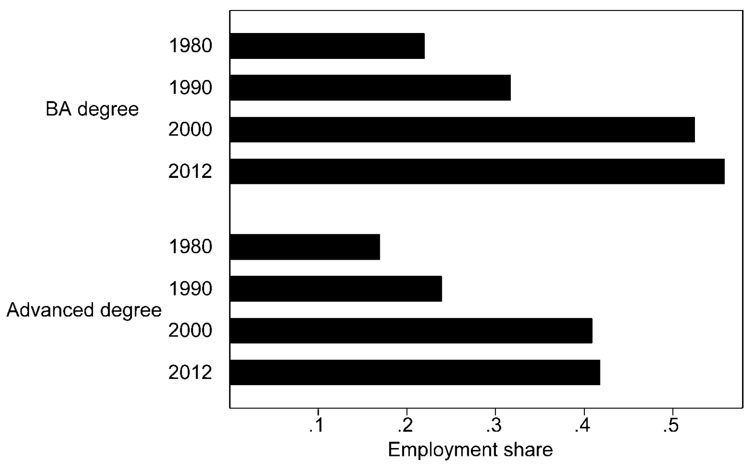

Fig. 12.3 Employment of college-educated males in STEM occupations, share of STEM workers in software, programming
Source: IPUMS census, ACS.

ware, programming computer systems, and managing computer networks were minor occupations in 1980. Today, they are ubiquitous. Computer science is among the most popular majors on many college campuses. The lives of programmers appear in popular culture, inspiring major motion pictures (*The Social Network*, *Steve Jobs: The Man in the Machine*), TV series (*Silicon Valley*), and even contemporary music ("Big Data"). Figure 12.3 shows the share of hours worked in STEM occupations by computer systems analysts and computer scientists, developers of computer software, and programmers of numerically controlled machine tools, where the first two subgroups account for the vast majority of employment in this category. Among bachelor's degree holders, the share of employment in computer-related jobs rises sharply from 22.0 percent in 1980 to 31.7 percent in 1990 before jumping steeply again to 52.5 percent in 2000 and then stabilizing at 55.8 percent for 2010–2012. The STEM employment shares in computer occupations among advanced degree holders (master's degree, professional degree, PhD) show a similar temporal pattern of evolution but are about 10 percentage points lower.

12.3.2 Revealed Comparative Advantage in STEM Occupations

Who gets STEM jobs? Because the rise of information technology is a recent phenomenon, younger workers are those most likely to have chosen a path of study that gives them entry into the STEM labor force. In part because men are more likely to study STEM disciplines in university—especially in computer science and engineering—they are in turn more likely to be employed in STEM occupations once they enter the labor force. To examine occupational sorting by age and gender, we calculate employment shares for five-year age cohorts, separately for men and women. For college graduates, we consider twenty-five- to twenty-nine-year-olds to be the "entry" cohort—that is, the age at which individuals first have stable, full-time work—which allows for the possibility that it may take individuals several years after obtaining their BA to find their professional bearings. Similarly, for those with an advanced degree we discuss results nominally treating thirty- to thirty-four-year-olds as the "entry" cohort.

Figure 12.4 shows the share of hours worked in STEM occupations for males—both native and foreign born—with at least a college education. Consider first panel A, which shows males with a bachelor's degree. Between 1980 and 1990, the share of twenty-five- to twenty-nine-year-olds in STEM jobs climbs from 11.1 percent to 17.5 percent. During the 1980s, which saw the introduction of the Apple Macintosh personal computer, the Microsoft MS-DOS operating system, and the Intel 80386 microprocessor, STEM jobs drew in relatively large numbers of young workers. The STEM employment share for twenty-five- to twenty-nine-year-olds rises again to 19.0 percent in 2000 as the dot-com wave crests, and then declines somewhat to 17.1 percent for the 2010–2012 period, following the Great Recession and the ensuing slow recovery. The shift toward employment in STEM is much lower among individuals who were in their thirties in the 1980s and nonexistent among those forty years old and older in the 1980s.

Turning to hours worked for those with an advanced degree, shown in panel B of figure 12.4, the lure of STEM employment in the 1980s and 1990s is even more pronounced. Among thirty- to thirty-four-year-olds, the share working in STEM rises from 11.6 percent in 1980 to 15.1 percent in 1990

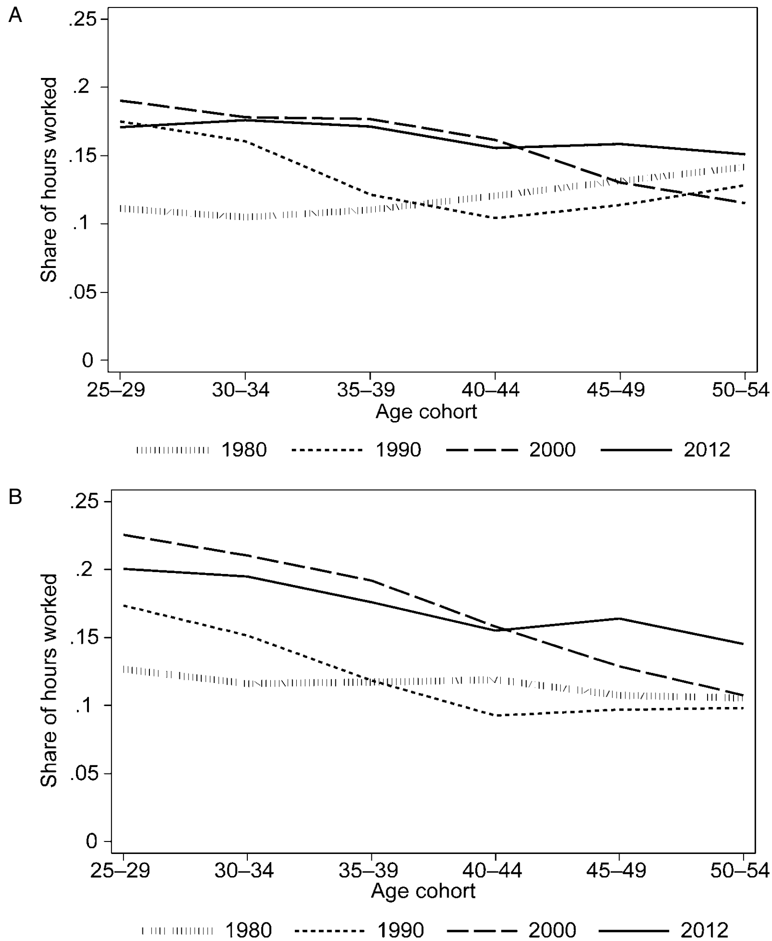

Fig. 12.4 Employment of college-educated males in STEM occupations. *A*, males with BA degree; *B*, males with advanced degree.
Source: IPUMS census, ACS.

and to 21.0 percent in 2000 before falling to 19.5 percent in 2010–2012. The higher incidence of STEM employment among the most educated workers may reflect the need for advanced training in order to perform the job tasks demanded in science and technology. Alternatively, the disproportionate share of STEM workers with graduate degrees may reflect an arms race, in which workers compete via education to improve their chances of obtaining the high-paying jobs available in information technology industries. Anticipating the patterns that we shall see in section 12.4, the arms-race motivation may be particularly strong among immigrant workers. Those born abroad may lack access to informal networks through which native-born workers

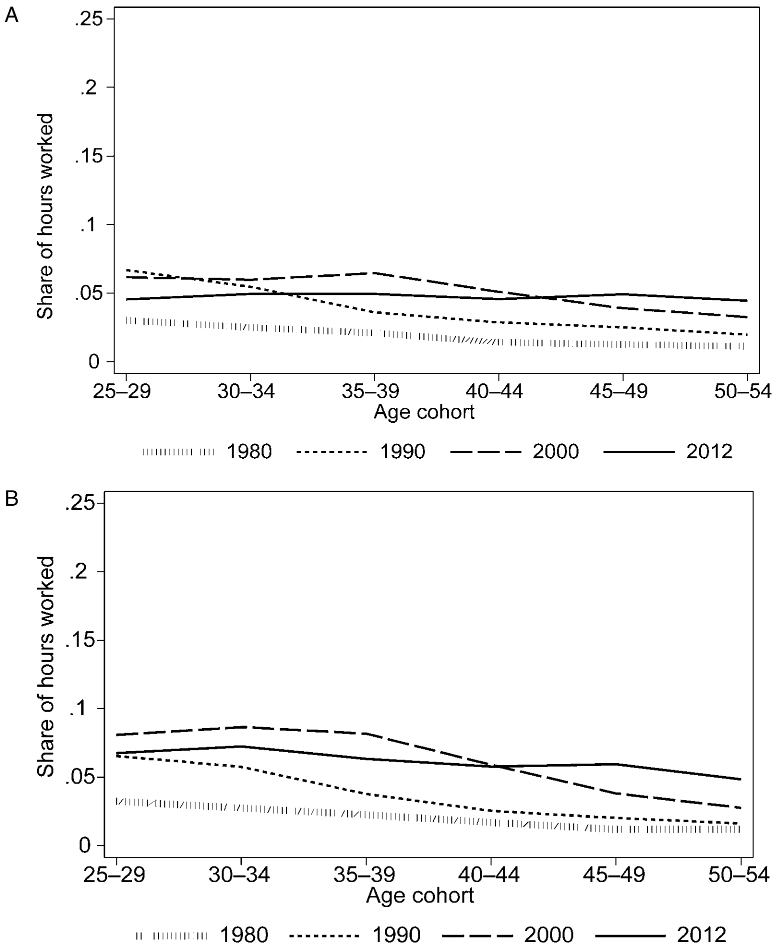

Fig. 12.5 Employment of college-educated females in STEM occupations. *A*, females with BA degree; *B*, females with advanced degree.

Source: IPUMS census, ACS.

obtain information about employment opportunities. Earning an advanced degree provides foreign-born workers with a mechanism for signaling their capabilities, perhaps helping compensate for any lack of informal signaling options.

Silicon Valley is frequently cited in the business press for the lack of professional opportunities that it offers women. The reputation of the tech sector as being male dominated appears to be well founded. Figure 12.5 shows STEM employment shares for females with a bachelor's degree (panel A) and an advanced degree (panel B). Among workers with no more than a bachelor's degree, the share of female employment in STEM occupations is markedly lower than that for males. Among twenty-five- to twenty-nine-year-old women, STEM occupations accounted for only 4.6 percent of employment in 2010–2012 (compared to 17.1 percent for men), a figure that was lower than both 2000 at 6.2 percent (19.0 percent in that year for men) and 1990 at 6.7 percent (17.5 percent in that year for men). For women with an advanced degree (panel B of figure 12.5), specialization in STEM is modestly higher. Among thirty- to thirty-four-year-olds, the share of females in STEM jobs is 7.2 percent in 2010–2012 (19.5 percent in that year for men), down from 8.7 percent in 2000 (21.0 percent in that year for men) and up from 5.8 percent in 1990 (15.1 percent in that year for men). As with men, STEM employment shares are higher among all age cohorts for women with an advanced degree compared to women with no more than a bachelor's degree.

Putting figure 12.5 together with figure 12.4 reveals that the underrepresentation of women in STEM has not improved over time. To see this, we measure occupational specialization using the revealed comparative advantage of males in STEM, given by

[share of male employment in STEM jobs/share of male employment in non-STEM jobs]/[share of female employment in STEM jobs/share of female employment in non-STEM jobs].

Among twenty-five- to twenty-nine-year-olds with a bachelor's degree, revealed comparative advantage for men in STEM rises from 3.0 $(.175/(1-.175))/(.067/(1-.067))$ in 1990 to 4.4 $(.171/(1-.171))/(.045/(1-.045))$ in 2010–2012. Stated differently, the log odds of a college-educated male being employed in STEM relative to a college-educated female being employed in STEM rises from 1.10 in 1990 to 1.48 in 2010–2012. Among thirty- to thirty-four-year-olds with an advanced degree, revealed comparative advantage for men in STEM rises less sharply from 2.9 $(.152/(1-.152))/(.058/(1-.058))$ to 3.1 $(.195/(1-.195))/(.072/(1-.072))$, for an increase in the log odds of 1.07 to 1.13. Among the foreign born, more educated women are also underrepresented in STEM jobs when compared to immigrant men. When we turn next to comparing employment patterns for native- and foreign-born workers, will we examine employment for men and women summed together.

12.4 Foreign-Born Workers in STEM Occupations

12.4.1 Immigrant Workers in the US Economy

To provide context for the analysis of specialization patterns by native- and foreign-born workers in STEM occupations, we first examine the share of the foreign born across all occupations. Panel A of figure 12.6 shows the fraction of hours worked accounted for by the foreign born among twenty-five- to fifty-four-year-old workers (males and females combined) with a

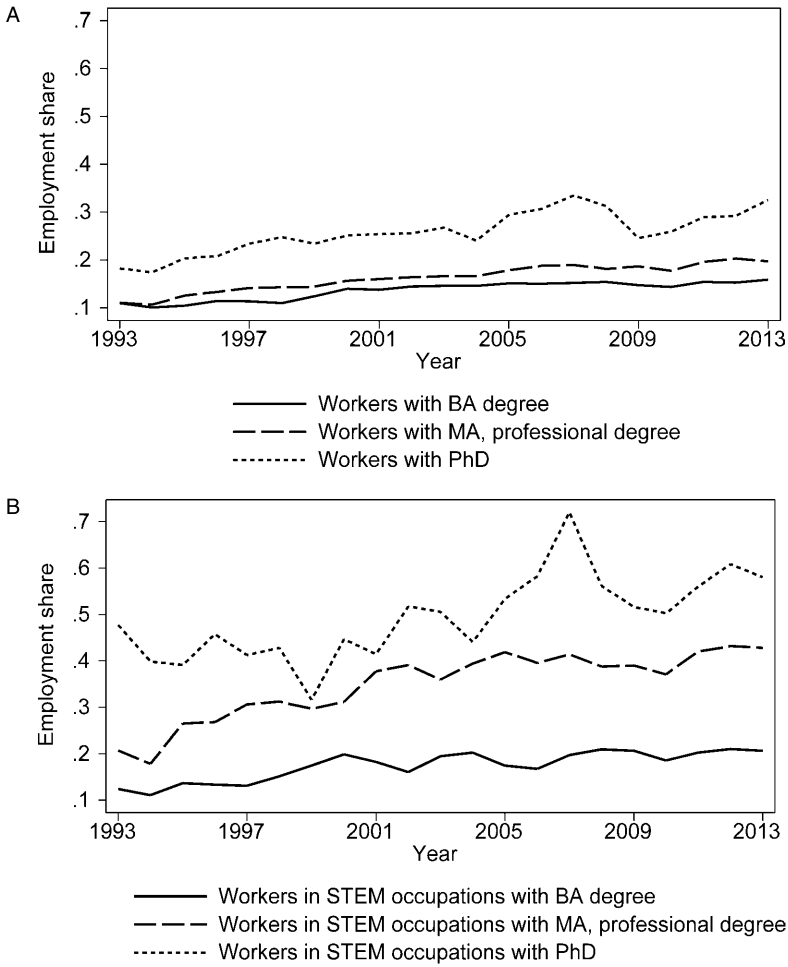

Fig. 12.6 Share of foreign-born workers in employment. *A*, foreign-born share of US employment; *B*, foreign-born share of employment, STEM jobs.
Source: IPUMS census, ACS; CPS, 1994–2014.

bachelor's degree, master's or professional degree, and a PhD. As the literature has documented, the immigrant share of US employment for the more educated is rising steadily over time. Among workers whose highest attainment is a bachelor's degree, the foreign-born employment share reaches 15.2 percent in 2013, up from 10.1 percent in 1993. As is also well known, for workers with at least a college degree immigrant employment shares rise monotonically by education level. In 2013, the foreign born account for 18.1 percent of hours worked among master's and professional degrees and 28.9 percent among PhDs. For comparison, in 2013 the share of the foreign born in the total US civilian labor force was 16.5 percent, up from 9.2 percent in 1990. Immigrants are, then, mildly underrepresented among college graduates, slightly overrepresented among those with master's degrees, and strongly overrepresented among PhDs.

Relative to employment across all occupations, the presence of the foreign born in STEM employment is higher for all education groups, as seen in panel B of figure 12.6, which shows foreign-born employment shares for the same categories as panel A, but now for jobs in STEM. In 2013, the foreign-born share of STEM employment is 19.2 percent among bachelor degrees, higher at 40.7 percent among master's degrees, and higher still at 54.5 percent among PhDs. Since the middle of the first decade of the twenty-first century, immigrants have accounted for the majority of US workers in STEM with doctoral degrees. The majority of advanced degree holders who are foreign born obtained their degrees in the United States (Bound, Turner, and Walsh 2009). Thus, there is a sense in which the United States *is* growing its own STEM talent. Universities in the United States have become a pipeline for advanced degree recipients born abroad to enter the US labor force. These institutions attract foreign students and train them in STEM disciplines before sending them to work for US employers. The large majority of those completing their PhDs in the United States, in particular those from lower- and middle-income countries, intend to stay in the United States after graduation (Grogger and Hanson 2015).

Also apparent in figure 12.6 are differences in the cyclicality of foreign-born employment in STEM by education level. Whereas among college graduates the foreign-born share peaks in 2000 and has been stable since, among master's degree holders the foreign-born share rises by over 10 percentage points in the first decade of the twenty-first century, and among PhDs the foreign-born share rises by a full 25 percentage points between 2001 and 2007, before dipping during the Great Recession.

12.4.2 Revealed Comparative Advantage of Foreign-Born Workers

We have already seen that among the college educated, young workers are relatively likely to select into STEM employment. Since a disproportionate share of the foreign born are workers in their twenties and thirties, it is conceivable that the rising presence of immigrants in US STEM careers is simply a byproduct of differing demographic patterns among natives and immigrants. Evidence on this possibility is seen in panel A of figure 12.7, which shows the share of workers in STEM occupations that are foreign born by five-year age cohorts for those with bachelor's degrees. The foreign-born share among twenty-five- to twenty-nine-year-olds in STEM jobs rises from 5.8 percent in 1980 to 9.1 percent in 1990 and then peaks at 21.1 percent in 2000 before declining to 17.0 percent in 2010–2012. The corresponding shares of non-STEM jobs going to immigrants (for twenty-five- to twenty-nine-year-olds with a bachelor's degree), as shown in panel B of figure 12.7,

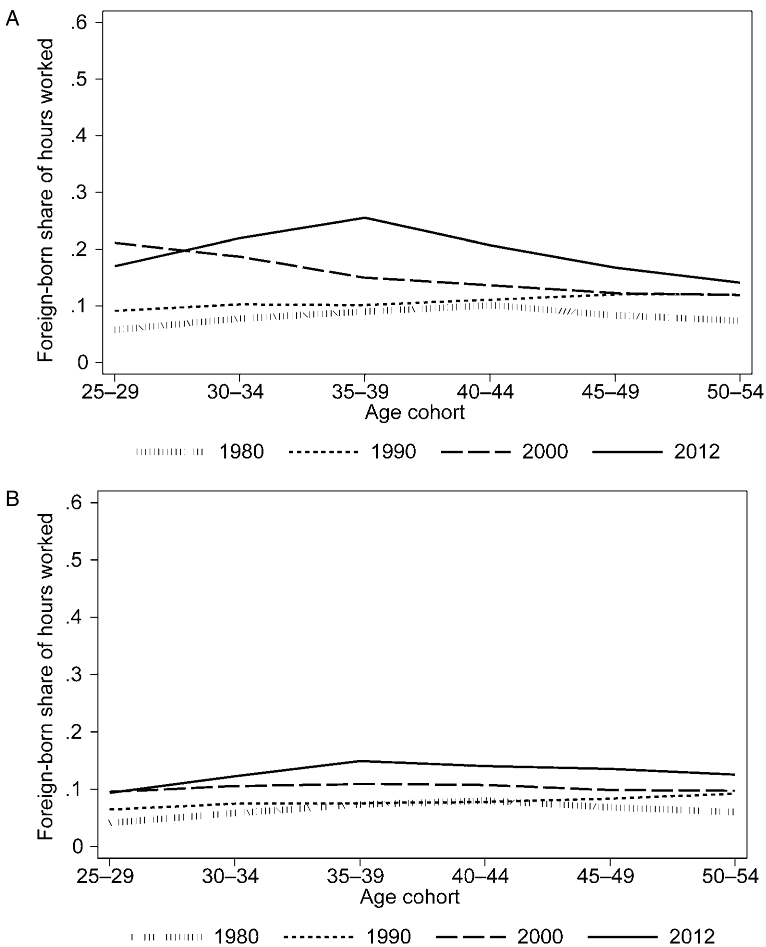

Fig. 12.7 Share of workers who are foreign born bachelor's degree holders. *A*, STEM occupations; *B*, non-STEM occupations.
Source: IPUMS census, ACS.

are 4.2 percent in 1980, 6.5 percent in 1990, 9.5 percent in 2000, and 9.2 percent in 2010–2012. Even controlling for age, the foreign born are strongly overrepresented in STEM employment.

The already substantial presence of immigrants in STEM jobs for a birth cohort at "labor market entry" becomes even larger as the cohort ages. Consider the cohort born between 1971 and 1975, which is the heart of Generation X. Panel A of figure 12.7 shows that by 2010–2012, the share of immigrants among Gen X thirty-five- to thirty-nine-year olds with BA degrees employed in STEM reaches 25.6 percent, up 4.5 percentage points over the level for twenty-five- to twenty-nine-year olds in 2000. This increase

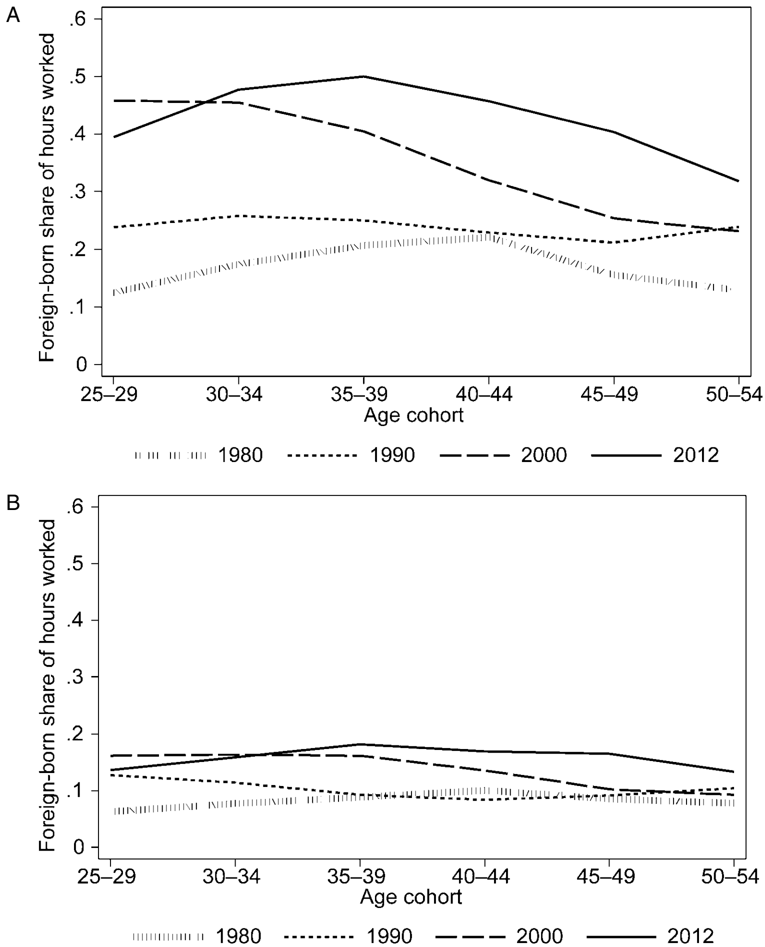

Fig. 12.8 Share of workers who are foreign-born advanced degree holders. ***A*, STEM occupations; *B*, non-STEM occupations.**
Source: IPUMS census, ACS.

is accounted for by a combination of immigrants in this birth cohort who arrived during the first decade of the twenty-first century being disproportionately selected into STEM jobs and immigrants in this birth cohort already in the country as of 2000 being relatively unlikely to exit STEM employment. Similar patterns of rising shares of STEM employment going to immigrant workers exist for other birth cohorts, as well.

The relatively strong specialization of immigrant workers in STEM occupations is even more pronounced among for those with advanced degrees, as seen in figure 12.8. For the period 2010–2012, the share of STEM jobs going to the foreign born relative to the share of non-STEM jobs going to the foreign born is 39.4 percent versus 13.6 percent among twenty-five- to twenty-nine-year olds, 47.7 percent versus 15.9 percent among thirty- to thirty-four-year-olds, and 50.0 percent versus 18.2 percent among thirty-five- to thirty-nine-year-olds. Thus, among prime-age workers with an advanced degree, the foreign born now account for one-half of total hours worked in STEM occupations. This fraction is up from one-quarter in the 1990s and from one-fifth in the 1980s. Many of the highly educated workers employed in engineering, science, and technology are at the forefront of US innovation. Foreign-born professionals would seem to have become a vital part of the US R&D labor force. These workers enter STEM employment in their youth and remain in technical occupations after decades of potential labor market experience.

Putting together panels A and B of figure 12.7, and similarly for figure 12.8, the employment of foreign-born workers is consistent with their having a strong revealed comparative advantage in STEM occupations. Among twenty-five- to twenty-nine-year-olds with a bachelor's degree, revealed comparative advantage of foreign-born workers in STEM, which is defined as

[share of foreign-born employment in STEM / share of foreign-born employment in non-STEM] / [share of native-born employment in STEM / share of native-born employment in non-STEM]

rises from 1.4 $(.058/(1-.058))/(.042/(1-.042))$ in 1980 to 2.0 $(.17/(1-.17))/(.094/(1-.094))$ in 2010–2012. The log odds of a young foreign-born college graduate being employed in STEM relative to a young native-born college graduate being employed in STEM increases from 0.34 to 0.69 over this period. Similar increases are evident among older college-educated workers. The revealed comparative advantage of the foreign born in STEM appears to be even stronger among individuals with advanced degrees. Among thirty- to thirty-four-year-olds with a master's degree, professional degree or PhD, the revealed comparative advantage of the foreign born rises from 2.5 $(.174/(1-.174))/(.077/(1-.077))$ in 1980 to 4.8 $(.477/(1-.477))/(.159/(1-.159))$ in 2010–2012, for a substantial increase in the log odds of STEM employment for the foreign born relative to the native born of 0.9 to 1.6. Among holders of an advanced degree, the revealed comparative advantage of foreign- over native-born workers in STEM is much larger than that even of male over females workers.

Software development is among the most rapidly growing areas for STEM jobs and among the most hotly contested occupations regarding the allocation of H-1B visas. The revealed comparative advantage of the foreign born in computer-related occupations is manifestly stronger than their comparative advantage in STEM positions overall, as seen in figure 12.9. In this subcategory, 23.0 percent of hours worked among twenty-five- to twenty-nine-year-olds with bachelor's degrees were foreign born in 2010–2012, up from 10.5 percent in 1990 and 60.0 percent of hours worked among thirty- to thirty-four-year-olds with advanced degrees were by the foreign born in

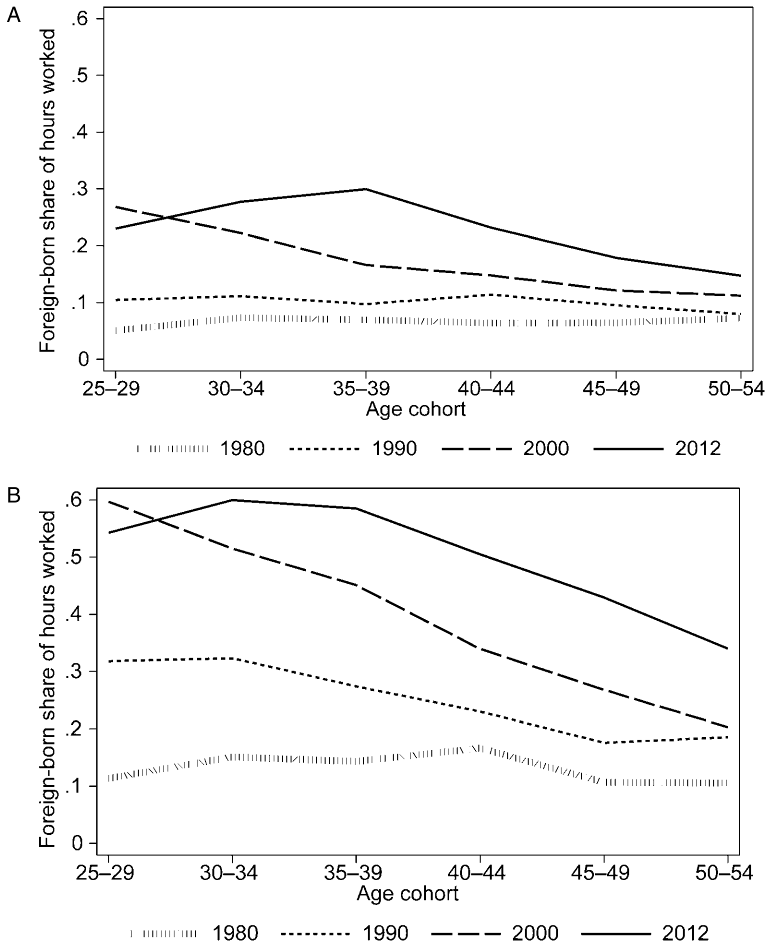

Fig. 12.9 Share of foreign born in computer occupations. *A*, workers with BA degree; *B*, workers with advanced degree.
Source: IPUMS census, ACS.

2010–2012, up from 32.3 percent in 1990. Given that occupational sorting tends to be stable over time for individual birth cohorts, the foreign born would appear to be set to account for a high fraction of US workers who are employed in computer-related jobs for many years to come (unless, for some reason, foreign-born workers currently on H-1B visas fail to gain legal permanent residence at the rates they have in the past).

12.4.3 Age of US Entry by Foreign-Born Workers in STEM Jobs

How do foreign-born STEM workers enter the United States? Although the ACS does not report the types of visas through which an individual first gained entry to the United States or first secured a US job, it does report

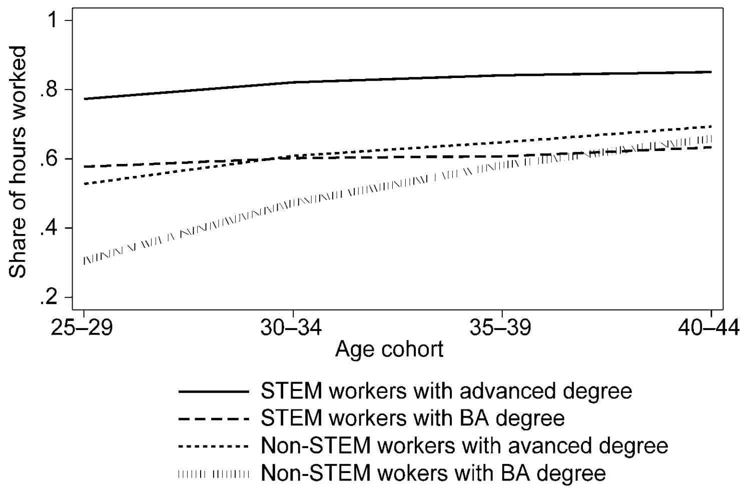

Fig. 12.10 Share of foreign-born workers arriving in the United States at age twenty-one or older, 2012
Source: IPUMS census, ACS.

the age at which an individual first arrived in the United States. The STEM occupations that employ foreign-born workers primarily hire those who arrived in the United States at age twenty-one or older. In figure 12.10, we see that among bachelor's degree holders, those arriving in the United States at age twenty-one or older account for 60.5 percent of immigrant workers with STEM jobs (across all age cohorts in that year), compared to 51.9 percent of immigrant workers in non-STEM jobs. This pattern is even stronger among advanced degree holders. Those arriving in the United States at age twenty-one or older are 82.7 percent of foreign-born workers in STEM with a master's degree, professional degree, or PhD compared to 63.6 percent of similarly educated immigrants in non-STEM jobs. Although we cannot determine the type of visa through which these individuals entered the United States, the pattern of post-age twenty-one entry is consistent with work visas, including the H-1B, being an important admissions channel for STEM-oriented immigrants.

12.4.4 Explanations for Foreign-Born Comparative Advantage in STEM

The preceding results, while consistent with immigrant workers having a comparative advantage in STEM, are silent on the factors behind this outcome. One explanation is that K–12 education in other countries offers stronger training in math and science than is available in the United States. The inferior performance of US fifteen-year-olds in PISA exams is consistent with this possibility. Yet, US students also perform relatively poorly in reading, ranking 24th in this dimension in the 2012 test. Although the ranking for reading is superior to US scores in science (28th) and math (36th), it would not seem to indicate an overriding comparative disadvantage among US high school students in technical fields. Relative to most other high-income countries, US fifteen-year-olds may have an absolute disadvantage in all disciplines and a mild comparative disadvantage in math and science. However, it could be unwise to read too much into the consequences of relatively poor US exam scores, as little is known about the cross-country variation in how individual performance on standardized tests translates into professional success.

A second explanation for immigrant success in STEM is that these jobs are the only positions available to more educated immigrants and that advanced degrees are how one demonstrates competence in technical disciplines. Non-STEM professions in which more educated workers predominate include arts, the media, finance, management, insurance, marketing, medicine, law, and other business services (architecture, consulting, real estate). Some of these fields, such as insurance and marketing, are ones in which the foreign born or nonnative English speakers may have an absolute disadvantage because they lack a nuanced understanding of American culture or because subtleties in face-to-face communication are an important feature of interactions in the marketplace. Others of these fields, such as the law or real estate, may involve an occupational accreditation process that imposes relatively high entry costs on those born abroad.

A third explanation is that US immigration policy has implicit screens that favor more educated immigrants in STEM fields over those in non-STEM fields. The H-1B visas do go in disproportionate numbers to workers in STEM occupations (Kerr and Lincoln 2010). However, there is nothing preordained about this outcome in terms of US immigration policy. The H-1B visas are designated for "specialty occupations," which are defined as those in which (a) a bachelor's or higher degree or its equivalent is normally the minimum entry requirement for the position, (b) the degree requirement is common to the industry in parallel positions among similar organizations, (c) the employer normally requires a degree or its equivalent for the position, or (d) the nature of the specific duties is so specialized and complex that the knowledge required to perform the duties is usually associated with attainment of a bachelor's or higher degree.[7] The H-1B visas are thus available to the more educated in non-STEM lines of work, too. That most H-1B visas are captured by STEM workers may simply be the consequences of strong relative labor demand for STEM labor by US companies.

Are immigrant workers displacing native-born workers in STEM jobs? Rising immigration of more educated workers has not led to an overall

7. See http://www.uscis.gov/eir/visa-guide/h-1b-specialty-occupation/understanding-h-1b-requirements.

expansion in the share of total US employment in STEM occupations. The expansion of labor supply for workers with expertise in technical fields may shift the mix of output toward industries intensive in the use of these skills. Under directed technical change, expanded incentives for innovation emanating from the labor supply shock could provide a further boost to US output in high-tech sectors (Acemoglu 2002). Yet, expanded immigration of highly educated individuals has occurred along with an unchanged share of aggregate employment in STEM occupations, consistent with foreign-born workers having displaced native-born ones in the competition for positions in STEM fields. Of course, many other events occurred in the US labor market in the first decade of the twenty-first century, most notably the bursting of the dot-com bubble and the Great Recession. The magnitude of these shocks makes it difficult to know how employment of US native-born workers in STEM occupations would have fared absent high-skilled immigration.

Evidence on native displacement effects from immigration is mixed. Lewis (2011) and Gandal, Hanson, and Slaughter (2004) find no evidence that immigration inflows shifts the output mix in regional or national economies toward industries intensive in the use of immigrant labor. Borjas and Doran (2012) find that the arrival of Russian mathematicians in the United States induced the exit of incumbent scholars in the subfields of the discipline in which Russia had historically been dominant. Kerr, Kerr, and Lincoln (2015) do not detect evidence of displacement effects of skilled immigrants on native workers, at least inside firms. Within US manufacturing establishments, the arrival of young, high-skilled foreign-born workers is associated with increases and not decreases in the employment of young, high-skilled native-born workers.

12.5 Wage Differences between Native- and Foreign-Born Workers

It is well known that across all occupations, immigrants earn less than natives, even once one controls for age, education, gender, and race. Do similar earnings differences between the native and foreign born materialize when we examine more educated workers and, in particular, those employed in STEM occupations? This issue is of central concern in the public debate about US immigration policy. Concerns have been expressed about foreign-born STEM workers being willing to accept lower earnings than US native-born workers.[8] We aim to provide fresh evidence on the subject.

To begin we compare earnings for native-born and foreign-born workers in STEM occupations. Figure 12.11 shows annual earnings for full-time, full-year male workers twenty-five to forty-four years old who have at least a bachelor's degree. We show earnings by foreign-born status, whether workers have just a bachelor's or an advanced degree, and by year. In 1990, average

8. See, for example, Porter (2013).

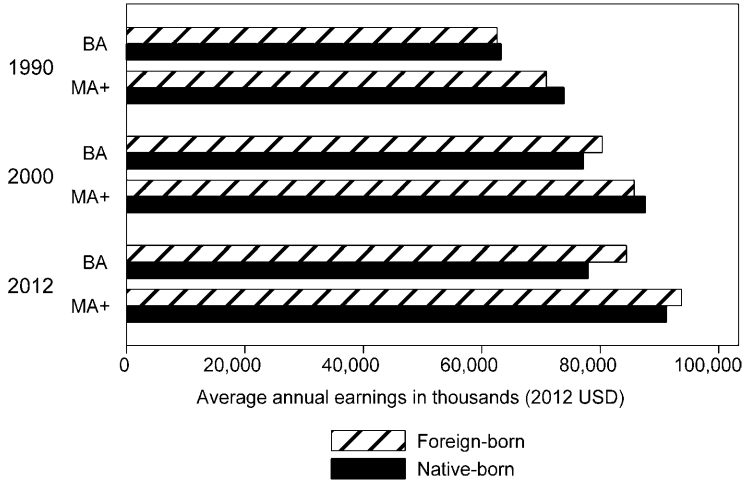

Fig. 12.11 Earnings comparisons, males age twenty-five to forty-four, annual earnings, male full-time STEM workers
Source: Census 1990, 2000; ACS 2010–2012.

annual earnings for natives exceed those for immigrants; in 2000 the picture is mixed, with native-born earnings exceeding those for immigrants among those with an advanced degree but not among those with just a bachelor's degree; and by 2012, the earnings of the foreign born exceed those of the native born in both degree categories. Similar patterns obtain when we examine average weekly wages or average hourly wages. Although the comparison in figure 12.11 is for workers who have selected into STEM jobs, there may be important sources of unobserved heterogeneity between workers. In particular, the foreign born may be relatively likely to work in high-paying occupations. We next perform wage comparisons, while flexibly controlling for individual characteristics.

Pooling data from the 1990 and 2000 population censuses and the 2010–2012 American Communities Surveys, we limit the sample to twenty-five- to fifty-four-year-olds who are full-time (at least thirty-five usual hours worked per week) and full-year (at least forty weeks worked last year) workers with at least a bachelor's degree. We use three measures of earnings: log annual earnings, log weekly earnings (annual earnings divided by weeks worked last year), and log hourly earnings (annual earnings divided by weeks worked last year times usual hours worked per week). All regressions are weighted by annual hours worked (multiplied by the census sampling weight) and include as controls indicators for gender, race, the census geographic region, the year, and a full set of interactions between indicators for education (bachelor's degree, master's degree, professional degree, PhD) and age (five-year age groupings). Later regressions include indicators for the industry of employment.

Table 12.2 **Earnings regressions for native born and foreign born**

	Log hourly earnings		Log weekly earnings		Log annual earnings	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
STEM = 1	0.191	0.112	0.154	0.069	0.164	0.073
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Foreign born = 1	−0.101	−0.124	−0.120	−0.146	−0.119	−0.149
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
STEM × foreign born	0.094	0.095	0.084	0.086	0.079	0.082
	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)
Industry dummies	No	Yes	No	Yes	No	Yes
R^2	0.285	0.327	0.297	0.341	0.296	0.345

Sources: Data from 1990 and 2000 census and 2010–2012 ACS.

Notes: N = 2,550,537. Robust standard errors are in parentheses. Sample is full-time, full-year workers twenty-five to fifty-four years old with at least a BA degree. Additional regressors: dummy variables for gender, race, year, census region, and five-year age category interacted with educational degree (BA, MA or prof. degree, PhD). Regressions are weighted by sampling weights.

The regression shown in column (1) of table 12.2 reveals that STEM workers receive hourly earnings that are on average 19.1 log points higher than those of non-STEM workers who have similar demographic characteristics, education, and region of residence. For weekly and annual earnings, shown in columns (3) and (5), the STEM earnings premium is broadly similar at 15.4 log points and 16.4 log points, respectively. Column (2) adds controls for ten one-digit industries, which compresses the STEM hourly earnings premium to 11.2 log points; declines are similar for weekly and annual earnings, shown in columns (4) and (6). Although these findings may seem to suggest that STEM positions are "good jobs" that pay high wages, we should caution that these results are purely descriptive and say nothing about the origin of the STEM earnings differential. This differential may reflect higher-ability workers being disproportionately selected into STEM occupations, such that the coefficient on the STEM earnings dummy picks up the average difference in unobserved ability between STEM and non-STEM positions. Alternatively, the STEM earnings bump may reflect a compensating differential for the higher cost of obtaining the training needed to work in a STEM field (e.g., the extra hours of study required for a computer science or engineering degree). A yet further alternative is that employers that hire relatively large numbers of STEM workers (e.g., Apple, Google, Microsoft) earn rents and share these rents with their employees.

Across all more educated workers, the foreign born in non-STEM occupations earn less than the native born, as shown by the negative and significant coefficient on the indicator for a worker being an immigrant. For hourly earnings, the immigrant wage discount is −10.1 log points (column [1]); for weekly and annual earnings it is comparable at −12.0 log points (column [3]) and −11.9 log points (column [5]), respectively. Immigrant earnings discounts increase modestly when indicators for one-digit industries are added (columns [2], [4], and [6]). These estimated immigrant earnings differentials are also descriptive. They may represent an unobserved-ability differential between similarly educated native- and foreign-born workers or they may capture the limited portability of human capital between countries, such that a degree from, say, China is worth less in the US labor market than is US degree. Earnings differences from either of these sources would be unlikely to diminish over time. A source of *temporary* earnings differences between immigrants and natives is adjustment costs in settling into a new labor market. It may take foreign-born workers a while after arriving in the United States to find employment that is well matched to their particular skills. Assimilation into the US labor market, which we examine in more detail below, may attenuate or even reverse native-immigrant earnings differences.

The earnings discount for foreign-born workers falls considerably when we compare native- and foreign-born individuals employed in STEM occupations. This result is seen in the positive and statistically significant interaction between the STEM indicator and the foreign-born indicator. For hourly earnings in column (1), the immigrant wage discount falls to −0.7 (−10.1 + 9.4) log points; for weekly and annual earnings the immigrant discount falls to −3.6 (−12.0 + 8.4) log points (column [3]) and −4.0 (−11.9 + 7.9) log points (column [5]), respectively. Although all of these differentials are statistically significant, they are far smaller than the earnings differences observed between native and immigrant workers in non-STEM occupations.

Moreover, once we limit the sample to STEM workers—which implicitly allows the returns to education and labor market experience to vary between STEM and non-STEM categories—the immigrant-native earnings difference becomes of indeterminate sign. Unreported results for regressions similar to table 12.2 in which we restrict the sample to workers employed in STEM occupations show that the immigrant earnings differential is positive and significant for hourly earnings (at 1.7 log points without industry controls and 2.6 log points with industry controls), while negative and weakly significant for weekly earnings (−0.3 log points without industry controls and −1.4 log points with industry controls) and negative and strongly significant for annual earnings (−0.7 log points without industry controls and −1.8 log points with industry controls).

Could the immigrant earnings discount be a consequence of adjustment costs that are erased by labor market assimilation? Borjas (2014) finds suggestive evidence that the process of assimilation in immigrant wages—which was evident in earlier decades—has broken down. That is, across all education groups immigrants' earnings appear to be catching up to natives' earnings more slowly than they did in the past. We examine patterns of assimilation for more educated immigrants to see if his findings are repli-

Table 12.3 Year-by-year earnings regressions, non-STEM

	1990 (1)	2000 (2)	2010–2012 (3)
Foreign born, 0–5 years in the United States	−0.289	−0.244	−0.246
	(0.007)	(0.006)	(0.007)
Foreign born, 6–10 years in the United States	−0.222	−0.222	−0.194
	(0.006)	(0.005)	(0.006)
Foreign born, 11–15 years in the United States	−0.104	−0.172	−0.096
	(0.006)	(0.005)	(0.006)
Foreign born, 16–20 years in the United States	−0.034	−0.086	−0.050
	(0.006)	(0.005)	(0.006)
Foreign born, 20+ years in the United States	0.018	0.012	0.003
	(0.004)	(0.004)	(0.004)
R^2	0.165	0.135	0.181
N	692,417	897,896	654,200

Sources: Data from 1990, 2000 census; 2010–2012 ACS.

Notes: Robust standard errors are in parentheses. Sample is full-time, full-year workers twenty-five to fifty-four years old with at least a BA. Additional regressors: dummy variables for gender, race, census region, and five-year age category interacted with ed. degree (BA, MA or prof. degree, PhD). Regressions use sampling weights.

cated among more skilled workers. Because one cannot separately identify wage effects for the birth cohort, the year of immigration, and years since immigration (Borjas 1987), we are unable to decompose the immigrant-native earnings difference into separate effects for the birth cohort (which may reflect time variation in the quality of education), the immigration entry cohort (which may reflect time-varying conditions that shape the pattern of selection into international migration), and years since immigration (which may pick up assimilation effects). Still, it is instructive to examine how earnings for immigrant entry cohorts evolve over time. Tables 12.3 and 12.4 show earnings regressions run separately by year and that include indicators for gender, race, and education-age interactions. The regressions also include indicators for the immigration entry cohort measured as the years a foreign-born individual has resided in the United States (zero to five years, six to ten years, eleven to fifteen years, sixteen to twenty years, twenty or more years) as of a particular year (1990, 2000, 2010–2012), following the structure in Borjas (2014). Table 12.3 shows results for workers employed in non-STEM occupations; table 12.4 shows results for workers employed in STEM occupations.

Looking down column (1) in table 12.3, we see how the immigrant-native earnings difference for recently arrived immigrants (five or fewer years in the United States) compares with that for immigrants who have longer tenure in the country (six to ten years, eleven to fifteen years, sixteen to twenty years, twenty-one or more years). For non-STEM immigrant workers in 2010–

Table 12.4 **Year-by-year earnings regressions, STEM**

	1990 (1)	2000 (2)	2010–2012 (3)
Foreign born, 0–5 years in the United States	−0.173	0.007	−0.057
	(0.012)	(0.007)	(0.008)
Foreign born, 6–10 years in the United States	−0.071	0.043	0.043
	(0.008)	(0.007)	(0.007)
Foreign born, 11–15 years in the United States	0.000	0.045	0.085
	(0.007)	(0.008)	(0.006)
Foreign born, 16–20 years in the United States	0.035	0.059	0.062
	(0.008)	(0.008)	(0.008)
Foreign born, 20+ years in the United States	0.031	0.060	0.041
	(0.007)	(0.006)	(0.006)
R^2	0.184	0.118	0.181
N	85,078	129,497	91,449

Sources: Data from 1990, 2000 census; 2010–2012 ACS.

Notes: Robust standard errors are in parentheses. Sample is full-time, full-year workers twenty-five to fifty-four years old with at least a BA. Additional regressors: dummy variables for gender, race, census region, and five-year age category interacted with ed. degree (BA, MA or prof. degree, PhD). Regressions use sampling weights.

2012 (column [3]), the wage discount relative to natives is −24.6 log points among those with five or fewer years in the United States, −19.4 log points for those with six to ten years in the United States, −9.6 log points for those with eleven to fifteen years in the United States, and −5.0 log points for those with sixteen to twenty years in the United States. Only for the foreign born with twenty-one or more years in the United States does the wage discount relative to the native born disappear. This pattern could be the consequence of assimilation, as immigrants shed their earnings disadvantages relative to the native born over time. It could also be due to selective out-migration of immigrants, if say within any entry cohort those with lower earnings potential in the United States are those most likely to return to their home countries. Or it could be due to decreases over time in the average ability of later immigrant cohorts relative to earlier immigrant cohorts.

Whatever the origin of the entry cohort effect on earnings, it is far different for workers in STEM occupations, as seen in table 12.4. In 2010–2012 (column [3]), recently arrived STEM workers earn 5.7 log points less than their native-born counterparts. This differential becomes positive for those with six or more years in the country, indicating that in less than a decade immigrant STEM workers begin earning more than native-born STEM workers. Again, we cannot say whether or not this pattern reflects assimilation. It could be that lower-wage immigrant workers in STEM are those most likely to be on temporary work visas that either do not get renewed or do not get converted into green cards. Or it could be that native STEM workers are disproportionately likely to get promoted out of STEM jobs into management positions, which may convert them into non-STEM lines of work.

Comparing across columns in tables 12.3 and 12.4, we obtain a sense of how the earnings discount for a particular entry cohort fairs over time. In columns (1) and (2) of table 12.3 for non-STEM workers, we see that the −28.9 log point earnings discount earned by the cohort that entered the United States between 1985 and 1990 (and so had zero to five years in the United States in 1990, column [1]) had fallen to 17.2 log points in 2000 (by which point this entry cohort had eleven to sixteen years in the United States). The corresponding fall in the wage discount for the 1995–2000 entry cohort—from 24.4 log points in 2000 (column [2]) to 9.6 log points in 2010–2012 (column [3])—is even larger. Thus, in contrast to Borjas (2014), we do not see evidence consistent with the assimilation of more educated non-STEM immigrant workers into the US labor market becoming weaker over time. Indeed, if anything, assimilation of more educated non-STEM immigrant workers appears to be accelerating. There is no evidence of a similar acceleration of assimilation for immigrant workers in STEM occupations.

Overall, we observe that the average immigrant earnings discount relative to native-born workers is far smaller in STEM occupations than in non-STEM occupations, that immigrant workers in STEM with six or more years in the United States have earnings parity with natives, and that the process of earnings assimilation for immigration entry cohorts is uneven across time.

12.6 Discussion

The United States has built its strength in high technology in part through its businesses having access to exceptional talent in science and engineering. Although US universities continue to dominate STEM disciplines globally, it is individuals born abroad who increasingly make up the US STEM labor force, particularly among those with advanced degrees. In software development and programming, and other computer-related occupations, the foreign born make up the majority of US workers in STEM jobs with a master's degree or higher. The success of Amazon, Facebook, Google, Microsoft, and other technology standouts thus seems to depend, at least partially, on the ability of the US economy to import talent from abroad. In the press, it is entry-level programmers from abroad admitted under H-1B visas won by foreign outsourcing shops who draw much of the attention. In the data, what catches the eye is the strong and rising presence of foreign-born master's and doctorate degree holders in STEM fields, whose training, occupational status, and earnings put them in the highest rungs of the US skill and wage distributions.

It is little wonder why high-skilled workers from lower-wage countries desire to move to the United States to make their careers. Earnings for technology workers from India rise by a factor of six when individuals succeed in obtaining a US work visa (Clemens 2010). Grogger and Hanson (2011) show that the absolute reward for skill in the US labor market is substantially higher than in other high-income countries (either in pretax or posttax terms). Although foreign-born workers earn less than their native-born counterparts with similar demographic characteristics and educational attainment, the wage discount for immigrants in STEM jobs is substantially smaller than in non-STEM jobs. Immigrants in STEM occupations with ten or more years of experience in the United States earn equal to or more than native-born workers doing similar tasks. The data thus provide little support for the claim made by critics of US immigration policy that foreign-born workers in STEM jobs accept persistently lower wages than their native-born counterparts.

Our understanding of immigration and its impacts on the US economy is limited by the scarcity of data at the individual level regarding how workers gain entry into the US labor market. We are largely unable to distinguish among workers who arrive on family-based visas, employer-sponsored visas, student visas, or H-1B visas or how these individuals may transition from temporary visa status into permanent residence. These shortcomings in the data impede analysis of how shocks to foreign economies or changes in US immigration policy affect the supply of high-skilled foreign labor in the United States. Relaxing these data constraints is essential for the informed study of how high-skilled immigration affects US economic outcomes, including the pace of productivity growth, the earnings premium commanded by highly skilled labor, and differential wage and employment growth across local labor markets in the United States.

References

Acemoglu, Daron. 2002. "Directed Technical Change." *Review of Economic Studies* 69 (4): 781–809.

Borjas, George. 1987. "Self-Selection and the Earnings of Immigrants." *American Economic Review* 77 (4): 531–53.

———. 2014. *Immigration Economics*. Cambridge, MA: Harvard University Press.

Borjas, George, and Kirk Doran. 2012. "The Collapse of the Soviet Union and the Productivity of American Mathematicians." *Quarterly Journal of Economics* 127 (3): 1143–203.

Bound, John, Breno Braga, Joseph Golden, and Gaurav Khanna. 2015. "Recruitment of Foreigners in the Market for Computer Scientists in the United States." *Journal of Labor Economics* 33 (S1): S187–223.

Bound, John, Murat Demirci, Gaurav Khanna, and Sarah Turner. 2015. "Finishing Degrees and Finding Jobs: U.S. Higher Education and the Flow of Foreign IT Workers." In *Innovation Policy and the Economy*, vol. 15, edited by William Kerr, Josh Lerner, and Scott Stern. Chicago: University of Chicago Press.

Bound, John, Sarah Turner, and Patrick Walsh. 2009. "Internationalization of U.S. Doctorate Education." NBER Working Paper no. 14792, Cambridge, MA.

Clemens, Michael. 2010. "The Roots of Global Wage Gaps: Evidence from Randomized Processing of U.S. Visas." Working paper no. 212, Center for Global Development.

Gandal, Neil, Gordon Hanson, and Matthew Slaughter. 2004. "Technology, Trade, and Adjustment to Immigration in Israel." *European Economic Review* 48 (2): 403–28.

Griffith, Erin. 2015. "The World's Largest Tech Companies: Apple Beats Samsung, Microsoft, Google." *Forbes*, May 11.

Grogger, Jeffrey, and Gordon H. Hanson. 2011. "Income Maximization and the Selection and Sorting of International Migrants." *Journal of Development Economics* 95 (1): 42–57.

———. 2015. "Attracting Talent: Location Choices of Foreign-Born PhDs in the US." NBER Working Paper no. 18780, Cambridge, MA.

Hira, Ron. 2010. "The H-1B and L-1 Visa Programs: Out of Control." Briefing Paper no. 280, Economic Policy Institute.

Hunt, Jennifer. 2011. "Which Immigrants Are Most Innovative and Entrepreneurial? Distinctions by Entry Visa." *Journal of Labor Economics* 29 (3): 417–57.

Hunt, Jennifer, and Marjolaine Gauthier-Loiselle. 2010. "How Much Does Immigration Boost Innovation?" *American Economic Journal: Macroeconomics* 2 (2): 31–56.

Jasso, Guillermina, Douglas S. Massey, Mark R. Rosenzweig, and James P. Smith. 2000. "Assortative Mating among Married New Legal Immigrants to the United States: Evidence from the New Immigrant Survey Pilot." *International Migration Review* 34 (2): 443–59.

Jones, Charles I. 2002. "Sources of U.S. Economic Growth in a World of Ideas." *American Economic Review* 92 (1): 220–39.

Jordan, Miriam. 2015. "U.S. Firms, Workers Try to Beat H-1B Visa Lottery System." *Wall Street Journal*, June 2.

Kerr, Sari Pekkala, William R. Kerr, and William F. Lincoln. 2015. "Skilled Immigration and the Employment Structures of U.S. Firms." *Journal of Labor Economics* 33 (S1): 147–86.

Kerr, William R., and William F. Lincoln. 2010. "The Supply Side of Innovation: H-1B Visa Reforms and U.S. Ethnic Invention." *Journal of Labor Economics* 28 (3): 473–508.

Langdon, David, George McKittrick, David Beede, Beethika Kahn, and Mark Doms. 2011. "STEM: Good Jobs for Now and for the Future." Economics and Statistics Administration no. 03-11, US Department of Commerce.

Lewis, Ethan. 2011. "Immigration, Skill Mix, and Capital-Skill Complementarity." *Quarterly Journal of Economics* 126 (2): 1029–69.

Lin, Jeffrey. 2011. "Technological Adaption, Cities, and New Work." *Review of Economics and Statistics* 93 (2): 554–74.

Matloff, Norman. 2013. "Are Foreign Students the 'Best and the Brightest'? Data and Implications for Immigration Policy." Economic Policy Institute Briefing Paper no. 356, Economic Policy Institute.

Office of Immigration Statistics. 2014. *2013 Yearbook of Immigration Statistics*. Washington, DC: US Department of Homeland Security.

Peri, Giovanni. 2012. "The Effect of Immigration on Productivity: Evidence from U.S. States." *Review of Economics and Statistics* 94 (1): 348–58.

Porter, Eduardo. 2013. "Immigration and the Labor Market." *New York Times*, June 25. http://economix.blogs.nytimes.com/2013/06/25/immigration-and-the-labor-market/?_r=0.