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FINISHING DEGREES AND FINDING JOBS: U.S. HIGHER EDUCATION AND THE FLOW OF FOREIGN IT WORKERS

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ABSTRACT

The rising importance of Information Technology (IT) occupations in the U.S. economy has been accompanied by an expansion in the representation of high-skill foreign-born IT workers. To illustrate, the share of foreign born in IT occupations increased from about 15.5% to about 31.5% between 1993 and 2010, with this increased representation particularly marked among those younger than 45. This analysis focuses on understanding the role that U.S. higher education and immigration policy play in this transformation. A degree from a U.S. college/university is an important pathway to participation in the U.S. IT labor market, and the foreign-born who obtain U.S. degree credentials are particularly likely to remain in the U.S. Many workers from abroad, including countries like India and China where wages in IT fields lag those in the U.S., receive a substantial return to finding employment in the U.S., even as temporary work visa policies may limit their entry. Limits on temporary work visas, which are particularly binding for those educated abroad, likely increase the attractiveness of degree attainment from U.S. colleges and universities as a pathway to explore opportunities in the U.S labor market in IT.

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1. Introduction

The growth in occupations for high-skill workers in information technology (IT) has been dramatic over the past two decades – beginning in the mid-1990s with the start of the internet boom and continuing with rapid expansions in information technology (IT) innovation. Broadly encompassing programmers, computer scientists, and electrical engineers, the IT workforce increased by more than 1.2 million workers, or by 112%, between 1993 and 2010 (Table 1).[1] Sectors served by these workers have responded to dramatic increases in internet commerce, giving rise to technology firms like Google, Yahoo, and Amazon, as well as maintaining the prosperity of firms like Microsoft and IBM.

One of the distinguishing features of the internet boom in the U.S. has been the extent to which foreign-born workers have been part of the supply response. Among IT workers with at least a bachelor's degree, foreign-born workers have grown from about 16% of the IT workforce in 1993 to nearly 32% in 2010 (Table 1). This kind of labor market response to demand shocks would not have occurred in the 1970s or in an environment with more restrictive immigration policies (Bound, Braga, Golden, Turner 2013; Bound, Braga, Golden, Khanna, 2014).[2] This analysis focuses on understanding the role that U.S. higher education and immigration policy play in the flow of foreign-born IT workers.

To the extent that the U.S. labor market provides a substantial wage premium relative to countries like China and India (Clemens, Montenegro and Pritchett 2008; Clemens, 2013), high-

[1] More concretely, we restrict our analysis to the workers with at least bachelor's degree credentials, and include the following occupations in IT field: computer and information scientists, computer network architects, computer support specialists, computer system analysts, database administrators, information security analysts, network and computer system administrators, software developers, web developers, other computer information science, computer engineers, electrical and electronic engineers, computer and information system managers, and computer programmers from the occupation list of the National Survey of College Graduates.

[2] Bound et al (2013) argue that the increased availability of foreign high skilled labor increased the labor supply elasticity to the sector, leading to both a larger growth in sectoral output and a dampened increase in wages.

skill workers have a strong incentive to immigrate. Yet, limits in the availability of temporary (H-1B) visas, which require employer sponsorship, may limit direct flows from foreign countries to the U.S. labor market. Since the number of foreign students who can enroll in U.S. higher education is not limited by visa policy (but rather by conditions in the higher education market) foreign students have incentives to pursue degrees in the U.S., both to acquire skills and to improve the potential likelihood of finding a job in the U.S. labor market (Rosenzweig 2006). Degree attainment in the U.S. advantages foreign students searching for jobs over those educated abroad, to the extent that U.S. employers have more confidence in worker skills acquired at familiar educational institutions and find it more straightforward to interview candidates on site.

Our analysis provides supporting evidence of this employment and migration behavior. We demonstrate that U.S. degree receipt has been an important pathway for the foreign born to participate in the IT workforce over the past two decades. Those entering the U.S. on student visas and then transitioning to temporary or permanent work visas comprise a significant share of the IT workforce, and the degree receipt of foreign students in IT fields is highly sensitive to the labor market conditions. Despite a substantial literature on high-skill immigration in the workforce, few studies have focused on how a U.S. college education, and its interaction with U.S. visa policies, impact foreign-born flows into high-skill occupations.

Our analysis begins by presenting a picture of the current level and recent changes in educational attainment of foreign-born and natives working in IT occupations. Notably, foreign-born IT workers are more likely than their U.S.-born peers to hold advanced degrees and a significant portion of them have received their highest degrees from U.S. institutions. Furthermore, foreign-born IT workers are more likely than their US counterparts to hold degrees in Science and Engineering (S&E) fields, the credentials of which are easier to evaluate by US

employers. The next section reviews the institutional parameters that determine entry to the U.S. for high-skill workers, where we emphasize that unlike student visas, work-visas are subject to caps and costly employer petitions student.

We then examine the growth in enrollment and degrees awarded to the foreign born by U.S. universities. An important finding is that, in the past two decades, degrees received by foreign students at U.S. institutions, particularly at the master's level, have been very responsive to labor market conditions, more so than the responsiveness of their US-born counterparts. In the final section we provide an examination of how the degree receipt location (U.S. or abroad) affects persistence and earnings in the U.S. labor market for foreign-born workers. Notable findings include that foreign-born workers with U.S. degrees are more likely than their counterparts to remain in the U.S., and that labor market premiums/penalties for a U.S. degree vary considerably by country of origin, with workers from China paying a penalty and those from Europe receiving a premium for being educated abroad. For IT workers, the impact on wages for receiving US-degree is almost non-existent, suggesting that a large component of this influx of foreign-students can be attributed to the fact that rather than better wages, a US education provides improved access to the US labor market.

An important conclusion of this analysis is that U.S. higher education institutions and immigration policies both play critical roles in determining the flow of high-skill immigrants to the U.S. labor market. Notably, the expansion in capacity of U.S. graduate programs – particularly in science and engineering – and restrictions in work-visa policies has influenced foreign student entry to the U.S., which in turn has affected the level and composition of high-skill worker immigration. Similarly, wage differentials across countries have influenced the inflow of foreign students, and in turn facilitated the expansion of master's programs. Looking

ahead, changes that affect access to U.S. post-secondary education for the foreign born, including the cost of U.S. higher education and student visa options, will likely affect the flow of high-skill workers to the U.S. labor market. In turn, changes in the attractiveness of the U.S. labor market – particularly in IT occupations – or changes in the availability of work visas are expected to affect the demand from foreigners for degrees from U.S. universities.

2. Descriptive Backdrop: The Changing Composition of IT Workers

Using any national survey data from the past two decades, we find unambiguous increases in the total of number of IT workers and in the representation of foreign-born workers in IT.[3] These foreign-born IT workers are more likely to hold advanced degrees, most of which are from US institutions, and are also more likely to graduate with degrees in computer science or engineering fields than their US counterparts.

Broad Trends

We focus here on the sharp increase in college-educated workers employed in the U.S. IT sector, a number that rose from 1.1 million in 1993 to nearly 2 million in 2003, with a more incremental rise to 2.4 million in 2010. This first interval is often referred to as the "internet boom" era. To put it in perspective, these increases account for 0.4% of the total U.S. population in 1993, 0.7% in 2003, and 0.8% in 2010 (Table 1). While slightly more than half (54%) of this total increase is accounted for by the growth in U.S.-born IT workers, about 575,000 of the IT

[3] This finding is clear in the Current Population Survey (CPS), the American Community Survey (ACS), the Decennial Census enumerations, and the periodic National Survey of College Graduates (NSCG: 1993, 2003, 2010), which includes detailed information on the location, year, and field of post-secondary attainment. The National Survey of College Graduates (NSCG) draws on the Census and ACS for the sampling frame. While the advantage of this survey for the analytics that follow is that we are able to identify whether an individual's post-secondary degrees were obtained in the U.S. or abroad, a disadvantage is that the NSCG will underrepresent college-educated workers residing in the U.S. for short periods of time and those leaving the country owing to the expiration of work visas.

workers added between 1993 and 2010 were born abroad, representing an increase from 15.5% to 31.5% of all IT workers during the period, with the increase concentrated among workers younger than 45.

While a college-degree is widely regarded as a prerequisite to employment in high-skill IT fields, native-born and foreign-born workers differ somewhat in the extent to which they hold post-baccalaureate credentials. In terms of highest degree attained, about 75% of U.S.-born and 50% of foreign-born IT workers held a bachelor's degree, while about half as many U.S.-born as foreign-born (23% vs. 44%) held a master's degree, and only a third as many U.S.-born as foreign-born IT workers (2% vs. 6%) held PhDs (Table 2, Panel B). Notably, foreign-born IT workers were more likely and U.S.-born IT workers were less likely than all college-educated workers in the U.S. economy to hold advanced degrees (Table 2, compare Panels A and B). This "educational differential" is particularly noteworthy among younger cohorts in recent years (Figure 1).

Location of Degrees among Foreign Born

Not only are foreign-born college-educated workers more likely than their native counterparts to hold advanced degrees, but large proportions of them are likely to have attained their highest degree from a U.S. university. Table 3 presents the distribution of college-educated immigrant workers who received their highest degree from a U.S. institution both overall and for those employed in IT fields, by year and degree.

Among foreign-born IT workers, those with advanced degrees are appreciably more likely to have received their degrees from U.S. institutions than those with only a bachelor's degree. For example, for IT workers 25-34 years old in 2010, 73% of those with a master's

degree and 95% of PhD recipients received their highest degree from a U.S. institution, versus 52% of those with a bachelor's degree (Table 3). In fact, the proportion of foreign-born bachelor's degree-only IT workers who attained their degree in the U.S. has declined over the period, from 86% to 52%. This change in the composition of degree location is concurrent with a marked change in the pathway of entry by foreign-born IT workers, shifting from an early-age of arrival in the U.S. – often with parents – to arrival as graduate students or young workers.

Several explanations account for the attractiveness of U.S. degree programs to high-skill workers from abroad. First, with more than 3,000 institutions of higher education and many large research universities, the U.S. market may present a supply of educational opportunities unavailable in many home countries. In addition, U.S. institutions may be perceived as providing higher quality educational experiences than are available in many home countries. While higher education quality varies widely in the U.S., U.S. universities often dominate global rankings, and hold a particular global advantage in research education in the sciences (Bound, Turner and Walsh, 2009; Bird and Turner, 2013).[4] To this end, the earnings of foreign-born IT workers may be treated differently in the labor market based on whether they were educated entirely abroad, or came to the U.S. for their entire post-secondary experience or just for graduate school. Finally, as previously mentioned, holding a U.S. degree may improve immigrants' access to the U.S. labor market because U.S. employers have more information about U.S. degree programs than foreign programs and a greater opportunity to observe candidate qualifications.

[4] Based on rankings of research universities, 6 of the top 10 universities and 15 of the top 30 universities are located in the U.S.

Formal Post-Secondary Training of IT Workers

While it is natural to associate degrees in fields like computer science and electrical engineering with employment in IT occupations, the educational credentials of workers in these occupations are more diverse, particularly for natives. Indeed, among native-born IT workers between the ages of 25 and 34 in 2010, only 37% and 43%held a bachelor's or a master's degree, respectively, in computer science and 18% and 22% held a bachelor's or a master's degree, respectively, in engineering, leaving more than 45% with bachelor's degrees in other fields and 35% with master's degrees in other fields (Table 4, Panel B). A clear implication of this finding is that inflows from other fields, in addition to net new degrees in computer science and engineering, is an important source of supply for the domestic market for IT professionals.

For foreign-born IT workers, the concentration of formal training in computer science and engineering is much more marked. In 2010, 82% of foreign-born IT workers held a bachelor's degree in either computer science or engineering, while 81% held a master's degree in one of these two areas (Table 4 Panel B). This finding suggests that U.S. IT employers select highly skilled immigrants, as computer science and engineering skills are among the most "portable" skills, and perhaps that they find it easier to evaluate nontraditional degree credentials among natives than among foreign-born. The finding may also reflect the greater proportion of Science and Engineering (S&E) degree programs abroad than in the U.S. For example, the rate of S&E degree awards among all first university degrees is about 50% in China, 35% in India, and 31% in the U.S. (*Science and Engineering Indicators*, 2014; Appendix Table 2-37).[5]

[5] S&E fields include physical and biological sciences, mathematics and computer sciences, agricultural sciences, social and behavioral sciences, and engineering in Science and Engineering Indicators, 2014. The figure for India is based on enrollment numbers in 2010 and does not cover social sciences (Government of India, Education Statistics at a Glance 2010–11, Table 12).

3. Policy and Institutional Context

The factors that determine the flow of high-skill workers to the U.S. labor market include the quality and quantity of educational institutions in the home country, opportunities for post-secondary study in the U.S., relative labor market opportunities, and U.S. visa policies. In this section we focus on the role of U.S. visa policies and its potential behavioral implications. In particular, we note that U.S. visa policies may affect not just decisions to participate in the U.S. labor market and the type and duration of employment, but also educational investments of high-skill foreign-born workers.[6] Work-visa caps may encourage foreign-born job-seekers to access the US labor market by entering as students instead.

Until about 1990, the primary source of high-skill immigrants to the U.S. labor market was via permanent residency or "green card" provisions. But in recent decades, avenues to temporary residency of high-skill individuals from abroad – via both temporary work status (primarily H-1B) and student status (primarily F visas) – has become a significant step on the pathway to permanent residency.[7]

Permanent Residents

Some degree of preference for high-skill immigrants has long been a part of U.S. immigration policy. The Displaced Persons Act of 1948 established a pathway to permanent residency for high-skill immigrants and gave priority to displaced persons "possessing special

[6] For jobs most likely to engage foreign-born workers, permanent residence status or appropriate visa permitting work are most likely required given the difficulty of formal sector transactions with undocumented workers. While nearly 75% of unauthorized immigrants (compared to about 26% of all immigrants) are estimated to hold a high school degree or less, only about 15% are estimated to hold a BA degree or higher (Passell and Cohn, 2010).

[7] Permanent residents may also become naturalized citizens; typically, permanent residents may apply for citizenship five years after attaining permanent residency. While it is possible to enter the U.S. directly with permanent residency status, Lowell (2010) estimates that 90% of employment-based and 55% of family-based visa holders move up from temporary visa status.

educational, scientific and technological or professional qualifications" (Tichenor, 2012). The Immigration and Nationality Act of 1952 set national quotas**,** but reserved 50% of each nation's quota for high-skill immigrants.

Employment endorsement is one of the four avenues for permanent immigration identified by the Immigration and Nationality Act of 1965 (Hart-Celler Act), which replaced the country-wise quotas with a preference system focusing on skills and family ties.[8] Employment-based immigration generally follows a transition from another visa type. Indeed, in 2011, 90% of all employment-based green cards were designated an "adjustment of status" rather than new entry (*Handbook of Immigration Statistics*, 2011). However, the capacity to enter the U.S. as a permanent resident through an employment-based green card is quite limited: only 140,000 such visas are offered each year.[9] An employment-based green card also has significant requirements for employers, who must certify their firm's inability to hire a qualified citizen or permanent resident for the employee's position and file an immigration petition (form I-140) on the employee's behalf.

Beyond employer certification, education and skills play a key role in determining preference groupings for permanent visa priority. The highest priority is reserved for those with extraordinary capabilities, including researchers, professors, and multinational executives. Next in line are those who have advanced degrees or whose abilities benefit U.S. interests (e.g., physicians practicing in designated underserved areas). Third in priority are skilled workers, college-educated professionals, and unskilled workers. Two lower levels of priority are also

[8] The four main avenues for permanent residency are: family reunification, employment, humanitarian/refugee interests, and diversity (Martin, 2012). Family-based immigration is the largest channel for immigration. Immediate relatives (parents, spouses, minor children) are admitted without limit, while there is a cap of 480,000 for other family-based immigration. Some high-skill immigrants are admitted as children via this channel, completing their pre-collegiate and post-secondary training in the U.S.

[9] Less than one-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).

designated.[10] Of all the employment-based green cards awarded in 2011, 66% were issued to foreign-born workers who met one of the first two priorities, and 92% went to those who met one of the first three.

Adding to the complexity of this system, visas for any given country are capped at 7% of the annual U.S. limit for family- and employment-based immigration. This rule, intended to allow immigration from a variety of places,[11] causes considerable lags for those coming from China, India, Mexico, and the Philippines who are not in the highest priority category. Martin (2012) notes that Indian professionals, entering under lower priorities, have had to wait between 5 and 10 years. In March 2014, Indians hoping to acquire visas who fell into the second priority category had waited since November of 2004, while those in the third priority had waited more than 10 years from September 2003.[12]

Constraints on employment-based permanent residency opportunities may have several behavioral implications. First, high-skill foreign-born workers may face constraints in their capacity to stay in the U.S. or to switch jobs. These constraints are most likely to bind for those from countries like India and China and those with lower educational attainment or priority rankings. Lowell and Avato (2013) provide some evidence that those with temporary work visas tend to face substantial earnings penalties in S&E occupations. While Mithas and Lucas (2010) demonstrate a similar result for temporary work visa holders in the IT industry, who earn less than green card holders. Kandilov (2007) and Mukhopadhyay and Oxborrow (2011) estimate

[10] Additional "priorities" include: Fourth priority is given to individuals who have specialized jobs such as physicians, religious workers, and international organization employees. Last priority goes to entrepreneurs who invest at least $500,000 to create and sustain at least 10 permanent jobs. See http://travel.state.gov/visa/immigrants/types/types_1323.html for details.

[11] U.S. State Department. (May 2013) "The Operation of the Immigrant Numerical Control System." Retrieved from http://www.travel.state.gov/pdf/Immigrant%20Visa%20Control%20System_operation%20of.pdf

[12] U.S. State Department. (March 2014) Visa Bulletin for March 2014, Volume IX Number 66. Retrieved from http://travel.state.gov/content/visas/english/law-and-policy/bulletin/2014/visa-bulletin-for-march-2014.html

that the acquisition of a green card increases earnings by up to 18%.[13] Second, those with the highest returns to staying may make investments in advanced degrees in order to increase their priority status for a permanent visa. In addition to the traditional employment-based pathway to permanent residency for high-skill immigrants, Congress has occasionally given special treatment to foreign groups that likely included a disproportionate share of high-skill immigrants.[14]

Temporary Work and Student Visas

For those without permanent U.S. residency, two other possibilities for immigration and entry into IT and high-skill occupations are the H-1B visa for temporary workers and the F visa for students. Clearly, the direct path to employment as a temporary worker is through the H-1B program, while an indirect route to either a temporary or permanent work visa is through a student visa that yields an in-demand degree. It is critical to understand both options, as together they represent the dominant pathway to entrance to the U.S. labor market among foreign born. Indeed, in 2010, temporary work visas (H-1B) accounted for about 39% of the first visa status of IT workers ages 25-34 and student visas (F) accounted for about 35%, with these shares markedly smaller in older cohorts for whom entry via permanent residency was far more common (Table 5 Panel B).

[13] Lan (2012) studies the impact of the Chinese Student Protection Act on the labor market performance of Chinese doctorate students and finds that the provision of green cards increases earnings and the probability to be employed in non-postdoc positions.

[14] The Chinese Student Protection Act (CSPA, 1992) allowed Chinese nationals (including students) who were present in the U.S. at the time of the Tiananmen Square violence in 1989 to apply for legal permanent resident status. Of the nearly 50,000 individuals making the transition to legal permanent resident status under CSPA, at least 60% had initial visa classifications indicating high-skill characteristics and about 40% held student visas (Orrenius, Zavodny, Kerr, 2012). Notably, nearly all of these students would have been graduate students given the trivial number of undergraduate students from China enrolled at U.S. institutions in the 1980s. A similar country specific program is the Soviet Scientists Immigration Act (1992) allowed permanent visa status to 750 scientists from the USSR and former Baltic states. Note that the Soviet Scientists Immigration Act is distinguished from the CSPA in that it applies mostly to those who have completed post-secondary education.

The H-1B: Temporary Work

The H-1 visa designation dates to the passage of the 1952 Immigration and Nationality Act and is intended to provide an employment window for aliens of "distinguished merit and ability." The original expectation of the H-1 designation was that residency in the U.S. would be temporary. The Immigration and Naturalization Act of 1990 transformed the H-1 visa program into what is now known as the H-1B program, which includes a "dual purpose provision" that creates the potential for workers to transition to permanent residency.[15] H-1B visas are valid for three years with the potential for a three-year extension.[16] 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.[17] Workers may enter the U.S. directly on an H-1B visa or may transfer to an H-1B from another visa classification such as an F student visa. In 2012, about 45% of initial H-1B visa beneficiaries had transferred from another visa classification (U.S. Citizenship and Immigration Services, 2013).

[15] By statute, H-1B visas are "… are reserved for high-skill workers, requiring 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 or higher, or its equivalent …" While the H-1B is the most widely recognized temporary visa, there is a substantial portfolio of other temporary work visa options which can connect foreign-born high skill workers to the U.S. labor market. Appendix Table 1 of Bound and Turner (2013) summarizes these alternative types. Other temporary visa categories include the L-1 visa for Intracompany Transfers, the O-1 visa for "Workers with Extraordinary Ability or Achievement," the TN visa for NAFTA Professional Workers, and the E-1 visa for Treaty Traders and Treaty Investors. Behind H-1B issuances, L-1 Intracompany Transfer visas are the most issued of the other temporary worker visa categories. In addition, there is some evidence that research universities increasingly use the J-1 category for foreign post-docs and visiting research scientists rather than the more costly H-1B visa. While occupational categories typically using J-1 visas include physicians, (including medical residents), teachers, and visiting scholars, the largest single group of J-1 visa recipients is foreign nationals traveling to the U.S. for summer work or travel – comprising 31% of the 2012 total.

[16] In cases where an H-1B holder has applied for a "green card" or permanent residences status but has not achieved current priority date for processing, they may receive a three-year H-1B extension, following from the American Competitiveness in the Twenty-First Century Act of 2000.

[17] The minimum application fees total $3575 in the most recent year and are somewhat larger for firms with more than 25 employees (an additional $750 per employee) and cases requesting expedited processing ($1225 per employee).

The annual number of H-1B visas is currently capped at 65,000, though visas issued to individuals employed at colleges and universities (e.g., researchers and faculty) or non-profit research organizations are exempt from the cap. During the early 1990s the cap was not reached, but after the cap became binding in the mid-1990s it was 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, and has been binding ever since. However, also in 2004 the Visa Reform Act[18] authorized that an extra 20,000 H-1B visas be reserved for foreign workers holding advanced degrees from U.S. universities, which may have encouraged foreign students to pursue advanced degrees from U.S. universities to increase the likelihood of eventually obtaining an H-1B visa.[19]

The F Student Visa

Given the constraints on permanent and temporary work visas, the U.S. higher education system may function as an important pathway for the foreign-born to gain access to the U.S. labor market. Unlike H-1B employment visas, which are subject to a numerical cap and require a costly petition from an employer, visas for postsecondary study in the U.S. are effectively unlimited in number and do not require expensive institutional intervention.

The full-time student visa (F-1), which is the vehicle of entry for most degree programs, is issued to foreign-born students accepted by any certified U.S. higher education institution.[20] As

[18] U.S. Government Accountability Office, "H-1B Visa Program: Reforms are Needed to Minimize the Risks and Costs of the Current Program," January, 2011: http://www.gao.gov/assets/320/314501.pdf

[19] 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. It is notable that neither country-specific visa quota has been filled since inception: the total number of H-1B1 visas for both Chile and Singapore is less than 1,000.

[20] The mechanics of receiving an F visa are as follows. 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 them provides the form 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 SEVIS database. After submitting the I-20 form, students are required to submit the SEVIS I-901 fee. For F-1 visas, this amount is currently $200 (U.S. Immigration and Customs Enforcement (ICE) Website, "Fact Sheet: I-901 SEVIS

depicted in Figure 2, the number of annually issued F-1 visas has risen sharply and steadily since the late 1980s, with the notable exception of a non-trivial decline following both the contraction in the U.S. IT sector and the events of 9/11, which generated greater administrative hurdles to obtaining student visas. Students from Asia contribute the majority of students on F-1 visas, with the number from China increasing very dramatically over the last decade (Figure 2).

Entry through the F visa program has the potential to improve access to the U.S. labor market by allowing for a limited-period work permission through the Optional Practical Training (OPT) program, which is not subject to a quota. The OPT program, available to international students who have attended a certified U.S. university on a full-time basis for at least one academic year, extends the F visa status for one year for work in jobs related to the eligible student's major area of study.[21] In 2008, Congress revised the OPT program by limiting the possible unemployed period to a maximum of 90 days, and by extending the duration of the visa from 12 to 29 months for those in eligible STEM fields.[22] Our analyses indicate that from 1999 to 2009, about 30% of foreign-born students initially entered the U.S. labor market under the OPT program. [23]

Fee for F, M and J Nonimmigrant Students and Exchange Visitors." http://www.ice.gov/sevis/factsheet/090104_fs.htm). After receiving the SEVIS I-901 receipt, the student can apply for a visa at any US Embassy. To maintain the F visa, an individual must refrain from unauthorized employment and maintain a full course load.

[21] The mechanics of adjusting to OPT program are as follows: a foreign student who wishes to work in the U.S. labor market must apply to the Designated School Office of his/her school within the 60 days of graduation. Designated School Officials renews his/her Form I-20, by making appropriate notation in SEVIS, then send it out to the U.S. Citizenship and Immigration Services (USCIS), with the application fee paid by the student. The amount of the fee is currently $380. When the Employment Authorization Document (Form I-765) is issued by USCIS, the student becomes eligible to work.

[22] A further administrative change extended the number of designated STEM programs from about 200 to nearly 400 in May 2011 and June 2012. For further details of the program, and the impact of these policy changes on the stay rate and labor market outcomes of foreign students, see Demirci (2013).

[23] To find the transition rates of foreign students into U.S. labor market through the OPT program, we compare the number of OPT beneficiaries in a year to the number of foreign graduates of U.S. colleges in the previous year. From 1999 to 2009, this transition rate has been around 0.3, which implies that three tenths of students enter the U.S. labor market initially under the OPT status (Figure 6).

In addition to the OPT program opportunity, a U.S. degree versus a foreign degree confers other potential advantages to entering the U.S. labor market. These include an information advantage, as U.S. employers may be more knowledgeable about and confident in hiring individuals with U.S. degrees, and an access advantage, as employers may find it more convenient to interview U.S.-based students or graduates. Furthermore, universities screen applicants before offering them admission, which is information useful to the employers and a good signal for prospective job-seekers. For their part, foreign-borns who want to work in the U.S. may recognize and exploit these advantages. U.S. employment is especially attractive to those from developing countries like India and China, where the same college degrees/skill sets tend to yield lower wages than they would in the U.S. (Clemens, Montenegro and Pritchett 2008; Clemens, 2013).

Although student visas can ease access to U.S. labor markets, demand is restricted by the prerequisite skills for admission and the capacity to finance the course of study. Because costs of attendance differ across program levels (BA, MA, PhD) and types, we expect – and observe – that the feasibility of student visas differs across country of origin and by level of study. Also, the demand for post-secondary education in the U.S. may be influenced by both the option value of U.S. education and the lack of educational opportunities in home countries. In the next two sections, we assemble evidence from U.S. higher education and labor market data that is consistent with the option value interpretation in the context of the IT industry from 1993 to 2010.

4. U.S. Enrollment and Degree Attainment: Cyclicality and Foreign Expansion

The last three decades have seen substantial changes in the number of foreign students coming to the U.S. for post-secondary education, the primary countries of origin, and the destination institutions, as established in data collected by the U.S. Department of Education (DOE) and the Institute of International Education (IIE).[24] While there is a rising trend in foreign enrollment since the 1980s, computer science degrees for foreign-born students closely follow labor market cycles.

Overall Trend in Foreign Enrollment

Figure 3 shows total enrollment of graduate and undergraduate students from abroad at U.S. colleges and universities from 1954 to 2011.[25] Since 1980, the average annual growth rate in foreign enrollment for graduate programs has been somewhat greater, at 1.9%, than the average rate for undergraduate programs, but since 2005 enrollment has grown faster for undergraduate (4.6%) than for graduate (2.5%) programs. While foreign students represent a relatively small share of undergraduate enrollment (3.3% in our sample of 4-year public and private non-profit institutions in 2011), they are a much larger share of enrollment in graduate programs. According to the National Science Foundation's (NSF) Survey of Earned Doctorates data, temporary visa holders accounted for 29% of all doctorate degrees awarded in 2011, 34% of doctorates in S&E fields, and 56% of doctorates in engineering (Science and Engineering Indicators, 2014).

[24] The DOE distinguishes enrollment and degrees conferred for all students at the level of the institution, further disaggregating by level of enrollment and field of degrees. The IIE has gathered data on the internationally mobile student population since 1948, and provides counts of students by country of origin studying in the U.S. at the undergraduate and graduate levels. Unfortunately, data providing enrollment by country of origin at the institution level is not available.

[25] The year corresponds to the fall year of the academic year. For example, 1954 corresponds to the 1954/55 academic year.

In the most recent decade, the post 9/11 dip in enrollment is clearly evident, and would be more marked if we were able to disaggregate by new entrants. While it is often conjectured that the more stringent visa requirements initiated after 9/11, along with a perceived hostile environment, stifled foreign enrollment, some evidence indicates that the decline started before 9/11 in response to contracting economic opportunities in the U.S.[26] Still, in the period since the collapse of the financial markets in 2008, enrollment of foreign students in U.S. higher education has continued on an upward trajectory, rising 14.6% in the 2008-11 interval among undergraduates and 6.0% among graduate students. As we show below, persistent growth is driven by countries less affected by the recent global financial crisis, such as China.

Trends by Country of Origin

The relatively steady increase in the enrollment numbers for all foreign students disguises substantial variation by region and country of origin. Table 7 presents leading source countries for U.S. enrollment in 1993 and 2011 for undergraduate and graduate levels. As shown in the top panel, China led the way in 2011 undergraduate enrollment, with nearly 75,000 students, followed by South Korea (38,232) and Saudi Arabia (14,344). Including India, Canada, Vietnam, and Japan, the top 7 sending countries account for about 56% of total undergraduate foreign enrollment in 2011. This pattern of enrollment differs markedly from 1993, when Japan was the leading source country and China did not crack the top 7 sending countries.

[26] Recessionary conditions which limited U.S. job opportunities and continued growth in higher education abroad placed downward pressure on demand for U.S. degree programs. Lowell and Khadka (2011) document the post 9/11 decline and find a 20% decrease in F visas issued between 2001 and 2002, a more modest decline in 2003, and then a period of rebound beginning in 2004. Lowell and Khadka emphasize that, consistent with retrenchment in temporary student enrollment in the mid-1980s, visa declines are most closely aligned with changes in economic conditions, rises in real tuition costs at U.S. universities, and eroding post-degree job prospects in the U.S.

The bottom panel of Table 7 shows that China and India led the way sending graduate students to the U.S. in both 1993 and 2011. Notably, these two countries have experienced appreciably growth over the 1993-2011 interval, with U.S. graduate enrollment increasing by a factor of 2.4 for China and by a factor of 2.1 for India. The nature of Chinese and Indian enrollment at the graduate level has changed somewhat over time, shifting from enrollment nearly exclusively at the PhD level to enrollment dispersed between PhD and master's programs and professional degrees. Participation among students from Taiwan in U.S. graduate education y dropped dramatically (about 45%) between 1993 and 2011, perhaps reflecting some maturation in the university structure in Taiwan.

Country-of-origin participation in U.S. higher education has changed over time and by undergraduate and graduate enrollment, as shown in Figure 4. For countries whose development trajectories have been steep over the period, such as China and India, evidence suggests that growth in enrollment at the doctorate level precedes growth at the undergraduate or master's levels. A significant reason for this may be that PhD programs in the U.S offer substantial financial aid (in terms of teaching and research positions) unavailable to foreign students at the pre-doctorate level. Yet, as we discuss in detail below, doctorate education is a relatively small component in graduate education. For affluent western economies with well-developed home country education systems, such as Germany and Canada, undergraduate and graduate enrollment are near the same scale and exhibit modest variation over our period of analysis.

In understanding the demand for enrollment at different levels of U.S. education, it is important to consider the barriers created by cost of attendance. Not only must foreign students pay international rates for tuition and fees, but must demonstration the ongoing capacity to meet all costs of attendance in order to obtain the F visa. While these costs may be prohibitive for

foreign-born undergraduates without generous home country support or affluent parents, [27] foreign doctoral-level students of modest means can take advantage of the substantial financial support often available for U.S. doctoral study. Overall, the IIE data show that about 82% of foreign undergraduate students finance their studies through "personal and family funds,"[28] while only about 5% of foreign doctoral students rely on their own sources as the primary means of educational support.

Degrees Conferred: Trends by Field for U.S. and Foreign Students

Examining degree outcomes provides an indication of the skills that foreign-born and native students bring to the labor market – either in the U.S. or elsewhere. Foreign-born students are more likely than their U.S.-born counterparts to choose S&E fields of study, and they comprise a substantial share of the graduates from U.S. programs in these fields.

Figure 5 focuses on the fields of computer science (CS) and engineering, showing trends over time in degrees awarded at the bachelor's, master's, and PhD levels. A first point of observation is that in 2012 more than 40% of the degrees awarded at the graduate level (master's and PhD) were to temporary residents, demonstrating a substantial increase since the mid-1980s, while degrees awarded to temporary residents remain a fairly modest share of bachelor's degrees in these fields.

In particular, there has been a marked increase in the number of master's degrees awarded to temporary residents in these fields since the mid-1990s. The number of master's

[27] To be sure, a small number of the "super-elite" colleges and universities in the U.S. are able to offer need-blind admission and full financial aid to international undergraduate students; these institutions include, MIT, Harvard, Princeton, Dartmouth, Williams, and Middlebury, with most of these institutions opening aid to international students around the year 2000. See http://www.edupass.org/finaid/undergraduate.phtml for a list of universities that offer significant financial aid (both need-based and merit, but not athletic) to international students.

[28] *Open Doors 2007* "Table 15 International Students by Primary Source of Funding 2005/06 & 2006/07."

degrees in CS awarded to foreign-born students increased from 5,007 in 1995 to 12,087 in 2012, while the number in engineering increased from 9,699 to 17,583. The increase in master's degrees in CS and engineering accounts for 37% of the total increase in master's degrees awarded in this period and dwarfs the increase in the number of PhD and bachelor's degrees awarded to temporary residents over this period.[29] The importance of master's degrees awarded to the foreign born from U.S. institutions to the supply IT workers is also apparent in Table 6, which shows an estimated 63% (122,619 in total) of foreign-born master's degree recipients from U.S. universities had student visas as their first visa, relative to about 21% (or 30,802) of bachelor's recipients.

An examination of the institutional sources of master's degrees in CS awarded to temporary residents provides some insight into the nature of adjustment in the U.S. higher education institutions. First, there is substantial concentration of foreign students in a relatively modest number of programs, with 10 institutions awarding nearly 25% of the master's-level CS degrees earned by temporary residents (U.S. Department of Education, 2011). The largest producers include: Carnegie Mellon University (464), Illinois Institute of Technology (397), University of Southern California (377), Columbia University, (292) and University of Texas at Dallas (214). This list represents considerable heterogeneity in institutional ranking – only one (Carnegie Mellon) was ranked in the top-5 for CS in 2014 by U.S. News & World Report[30] – as well as the mix of public and private control, suggesting that it may be difficult to make strong

[29] While the number of Master's degrees in all fields to temporary students increased from 48,756 to 89,145; the number of Master's degrees in CS and engineering increased from 14,711 to 29,670. Thus the increase in CS and engineering, in the amount of 14,959, accounts for 37% of the total increase in Master's degrees. On the other hand, PhD degrees to temporary residents in CS and engineering increased by 2,728, and BA degrees increased by 2,886. Both of these figures are substantially smaller than the increase in Master's degrees.

[30] See: http://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-science-schools/computer-science-rankings The most highly ranked programs in computer science are: Carnegie Mellon University, Massachusetts Institute of Technology, Stanford University, University of California—Berkeley, and University of Illinois—Urbana-Champaign.

statements about the qualitative characteristics of CS degree receipt in the U.S. relative to foreign countries.

Much research has examined the adjustment of choice of major to changes in labor market conditions. A classic set of papers, including Freeman (1971, 1975, 1976) and Ryoo and Rosen (2004), models student enrollment as functions of their expectations of future earnings. These "closed economy" modeling approaches, in which the labor supply adjustments in a particular occupation are achieved by the transfer of workers from another occupation and the entrance of new workers from the domestic educational pipeline, were quite successful in predicting the supply–response in choice of major to demand shocks in S&E fields. Examining the response to recent U.S. IT booms in the supply of bachelor's degrees, Bound, Braga, Golden and Turner (2013) identified cycles of response with an approximately four-year lag, which produced peaks in 1986 and 2003. They found undergraduate degree adjustments to demand shocks more muted in the more recent period, owing to the flow of foreign-born high-skill workers into the IT labor pool.[31] Yet, as the U.S. higher education market is unquestionably "international" – particularly at the graduate level – an open question concerns the cyclicality of the foreign student enrollment.

Figure 5 shows that the share of temporary residents in each degree category appears to demonstrate more cyclicality than does the total level of degrees awarded. For example, the share of master's degrees awarded to temporary residents decreased by 15% in CS and by 10% in engineering between 2001 and 2007, before rebounding as the market picked up in recent years.

[31] Between 1975 and the local peak in 1986, CS and Electrical Engineering (EE) undergraduate degrees increased by 446%, from 15,285 to 68,307 based on data from the Department of Education's annual "Earned Degrees Conferred Surveys". Then, from 1995 to 2004, degree awards increased by a more modest – though still appreciable – 186%, from 42,348 to 78,747.

This greater cyclicality is consistent with the notion that foreign students are using a master's education in the U.S. to enter the labor market.

5. Foreign Born Degree Recipients and the U.S. Labor Market

Evaluating the impact of U.S. post-secondary degree acquisition on the U.S. labor market depends markedly on whether U.S. education – particularly among temporary visa recipients – leads to long-term work in the U.S. Our evidence, presented in more detail below, makes two striking points. First, "stay rates" for degree recipients are extraordinarily high – much higher than for other temporary visa recipients. Second, not only do we observe marked differences in cross-country flows into U.S. degree programs (as discussed in the prior section), but we see marked differences across countries in pathways to entering the labor market and in labor market performance.

Coming and Going

Gauging how country of origin differs with the location of highest degree receipt and how degree receipt links to persistence in the U.S. labor market helps to model the determinants of the decision among the foreign born to invest in U.S. higher education.

Persistence in the U.S. labor market following degree receipt is hard to measure. Here we present data from several sources that provide a sense of both high overall stay-rates and of high propensities to stay among advanced degree recipients. To begin, we consider the likelihood that those studying in the U.S. transfer from F visas to either permanent residency or temporary work permits (H-1B). While data are limited, in 2000, the most recent year in which the Department of Homeland Security (DHS) released the transition tables, 16,161 international students

adjusted from an F student visa to a permanent residency status , which comprises about 16% of the total number of international students graduating in 1999 (Yearbook of Immigration Statistics, 2001).[32] Using administrative data, Lowell and Avato (2013) estimate that approximately 31,000 H-1Bs were awarded to foreign students in 2003, a total that represents about 40% of the prior year's entire graduating class of international students earning master's and PhD degrees, and about 90% of all foreign graduates in science and engineering. An alternative measure, shown in Figure 6, presents the ratio of initial H-1B visas awarded to those who have been in the U.S. under another visa classification to the number of international graduates of U.S. universities. Our calculation indicates that, on average, about a half of each graduating class of international students, 1999-2009, changed from student (F) visa status to H-1B status.

For doctorate recipients, administrative data merges provide a much better measure of stay rates. Tabulations conducted by the Social Security Administration for Michael Finn (2012) link the NSF's Survey of Earned Doctorates (SED), a census of those receiving PhDs from U.S. institutions, to Social Security Administration data to identify how many of the foreign-born on temporary or permanent visas at the time they received their PhD continue to work in the U.S. at intervals of one, two, five, and ten years after degree receipt. Finn estimates that, in 2009, 64% of those who received their PhD five years earlier and 66% of those who received their PhD 10 years earlier continued to live in the U.S.

Stay rates for doctorate recipients tend to be somewhat higher in STEM fields than in other degree areas, and have been trending up over recent years. They also vary by country of origin, the strength of the degree holder's ties to the US, and their academic ability (indicated by

[32] This measure includes all types of transitions to permanent residency including those based on family green cards.

fellowship receipt) (Grogger and Hanson 2013). Focusing solely on PhD holders in STEM fields with temporary visas, Finn finds that 89% of those from China and 79% from India remain in the U.S. five years after receiving their PhD.[33]

Analyzing data from the National Survey of College Graduates, we also find considerable cross-country variation in U.S. degree receipt by educational level and, among high-skill foreign-born U.S. workers. This variation can be related to the likelihood that foreign-born degree-holding workers used the U.S. education market as a pathway to enter the U.S. labor market. Table 8 presents distributions for highest degree receipt and the proportions earning these degrees in the U.S. for foreign-born high-skilled workers from four origin areas: Europe, Canada, India and China. We note that U.S. workers from China are the most educated in terms of degree attainment, followed by workers from India. In 2010, 68% of Chinese-origin workers in all high-skill jobs and 81% in the IT sector held master's or PhD degrees; among those from India, 56% of workers overall and in the IT sector held advanced degrees. Comparable numbers for immigrants from Europe or Canada are appreciably lower (Table 8).

Workers from China are also distinguished by the extent to which the U.S. education market is the source of individuals' highest degree. As shown in the right side of Table 8, among master's degree holders from China currently working in all high-skill U.S. jobs, 83% to 86% received their highest degree from a U.S. institution across all years – and these proportions are higher in the IT sector. In contrast, among European-origin U.S. workers with advanced degrees in 2010, only 27% of those with a terminal master's degree and 36% of those with a PhD had

[33] However, for a number of other countries like Japan, South Korea, and Taiwan, Finn finds 5-year stay rates under 50%. An inference following Bound, Turner, Walsh (2009) is that persistence rates reflect market forces, not just visa availability. 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 U.S. unless they obtain employment in top research universities or labs.

received these in the U.S. That U.S. post-secondary degree receipt is a pathway to entry is validated by review of the data on visa at entry by country of origin. Overall, about 55% of all high-skill Chinese-origin U.S. workers (and about 64% of those who entered the U.S. on other than a permanent visa) first came to the U.S. on a student visa (authors' tabulations from NSCG: 2010).

An implication, then, is that entry on a temporary student visa is likely to be a strong proxy for persistence in the U.S. labor market. Without identifying causality, it is useful to consider the multiple mechanisms through which a U.S. education may lead to labor market persistence. First, self-selection may play an important role: that is, individuals with the most to gain from access to the U.S. labor market may be the most likely to invest in U.S. higher education, which comes at a non-trivial cost of both tuition and forgone earnings. Second, a higher education from the U.S. may be more valued by U.S. employers than one from abroad. U.S. employers may feel less sure about the quality of programs or the skill sets of graduates from foreign institutions. U.S. higher education credentials may serve as a low-cost screening function – helping firms to identify high-skill/high-quality candidates when the costs of vetting candidates from less familiar origins are likely to be prohibitive.

Valuing Skills: Differences by Degree Location

How country of origin and location of post-secondary education correspond to earnings in the U.S. labor market helps explain the incentives for immigration and degree completion in the U.S. We continue to focus on those employed in the IT sector because this set of occupations encompass well-defined skills subject to broadly similar demand shocks, but use the overall labor market for college-educated workers as a point of comparison.

We consider the earnings for foreign-born relative to native workers with the same degree qualifications and the differences associated with the location of highest degree (U.S. versus abroad) and timing of U.S. entry, distinguishing between those entering as young children and those entering as adults.[34] We use data from both the NSCG (1993, 2003 and 2010), which has the advantage of precisely measured location and timing of degrees, and the American Community Survey (ACS), which provides more limited education coverage but a much larger sample.

Focusing on the wage differentials in the high-skill sector for those arriving in the U.S. after high school, we analyze earnings differentials between those who completed all of their post-secondary training abroad and those completing their highest degree in the states. The sign and magnitude of this coefficient is indicative of several factors.

- *Perceived quality of U.S. versus foreign post-secondary education.* While it is widely acknowledged that the U.S. universities represent a disproportionate share of the most highly-ranked options at the doctorate level, the extent to which undergraduate or master's preparation abroad differs from the U.S. is far from clear.
- *Improved job search*: Foreigners graduating from U.S. institutions may be in a better position to search for U.S. jobs than are those living abroad, and this advantage is likely to show up both in terms of increase employment prospects and higher wages.
- *Better employer screening*: Employers may be better able to evaluate transcripts and academic performance at U.S. universities relative to foreign institutions, while also finding degree information to be more trustworthy when presented by U.S. institutions.

[34] We find that foreign-born individuals who arrive in the U.S. at relatively young ages earn a labor market premium relative to those arriving at older ages, on the order of 0.17-0.18 log points, while also garnering a premium relative to natives among IT workers. This is a net-effect which includes the potential for substantial assimilation and the likely selection by family circumstances. The same broad pattern holds for all college educated workers. We report parallel regressions for all workers in the Appendix.

- Foreign-born individuals entering the U.S. labor market directly may be "selected" differently from those continuing on from the post-secondary system, with the former group having to be more distinguished in quality to gain work in the U.S.

While we are unable to distinguish these effects empirically, we are able to provide an estimate of the net effect. Among foreign-born IT workers, those who received their highest degree abroad earned – on average in recent years – a modest premium over those who received their highest degree in the U.S. The magnitude of this effect differs somewhat over samples and time periods analyzed. First, in the NSCG, which requires three years of residence in the U.S. by sample construction, the effect changes from a negative coefficient of -0.0607 in 1993 (in log-points, with the negative sign indicating foreign-borns who received their highest degree from abroad earned less than foreign-borns who earned their highest degree from the U.S.) to positive coefficients of 0.0622 and 0.0956 in 2003 and 2010, respectively (see Panel B of Table 9).

Examining the ACS over the last decade, we find a differential between degrees granted abroad and in the U.S. of -0.0095 for the 2001-2010 period and 0.0242 for 2008-2010. This range of coefficients suggests no difference or a modest positive earnings advantage for the foreign-born in being educated abroad. That these modest effects shifted over time suggests that the composition of foreign-born IT professionals by country of origin changed somewhat over this period, along with the perceived quality of degree receipt in the U.S. and abroad.

It is worth noting that these results for the IT sector are somewhat different from those found in the high-skill labor market at large, where both parallel regressions and evidence from prior research (e.g. Zeng and Xie, 2004) indicate a substantial premium for U.S. relative to foreign post-secondary education for foreign-born workers. Indeed, we find an overall penalty for foreign education of nearly -.233 in the most recent NSCG and about -.172 log points in the

ACS over the most recent decade (see top panel of Table 9).[35] The implication is that, across all high-skill occupations, the foreign born with U.S. degrees out earn not only other immigrants with degrees from abroad but also US-born workers. This result could be explained by U.S. employers applying greater selectivity in hiring the foreign born, or by their perception that post-secondary education received by U.S.-trained immigrants is of higher quality than education received abroad.[36]

Two factors may help explain the difference in results found in all job sectors versus in IT occupations. First, location of degree may matter less in IT fields than in other occupations. Second, the changing composition of foreign-born IT professionals by country of origin may have an effect. Hunt (2013) and others note that the returns to English language fluency – associated with a U.S. post-secondary experience – may be smaller in IT than in other fields, which could dampen the wage advantage of a U.S. degree in IT jobs. Moreover, consistent with the lack of a penalty for IT workers, Peri and Sparber (2009) suggest that U.S. natives and foreign-borns educated in U.S. institutions may find it easier to transfer their skills from IT fields to management positions and other occupations.

Country-specific factors may also play a role in the differential effects of a U.S. education among all foreign-born high-skill workers versus foreign-born IT workers. Using data from the NSCG and the ACS (Table 10), we disaggregate the foreign-born place of education effect by country of origin. It is striking that foreign-born IT workers educated in European

[35] Using the NSCG allows for the observation of field of study in addition to location of degree. As shown in the additional rows of Table 9A (and Appendix Table 11), the estimated effects of the "location" of degree receipt change only modestly with the inclusion of field of study and occupation fixed effects.

[36] It is noteworthy that even as the Appendix Table 9A results include fixed effects for occupation (Columns 3,6, and 9), when we limit the analysis to those in the IT profession we see a decided change in the interaction between "Foreign Born" and "Foreign Degree Receipt", with this coefficient ceasing to be negative and significant after 1993. As we discuss in the next paragraph, two factors are at play: first, location of degree may matter less in IT fields than in other occupations and, secondly, the composition of foreign-born IT professionals by country of origin changes somewhat over this period.

countries and Canada appear to benefit from degrees from abroad, while those from China face a disadvantage. For IT workers from India, place of post-secondary training has virtually no effect.

Given the significant contribution made by foreign workers – particularly workers from China and India – to the U.S. IT labor market over the last two decades, it is striking that the penalty for foreign education is dramatically attenuated in the IT sector relative to all high-skill workers (see Tables 10 A & B). One might ask why young people from India, China, and other countries would continue to pursue degrees in the U.S. given a low, nonexistent, or negative earnings advantage and the relatively high out-of-pocket costs. One explanation is that while U.S. degrees may not provide a strong wage advantage, they do provide improved access to the U.S. labor market given the U.S. visa system. The OPT program allows an extended window of opportunity to look for jobs and H-1B visas can be extended for obtaining an advanced degree – increasing in both cases the potential for employment in the U.S.

In sum, we find variation by country of origin in the labor market penalty/premium for foreign degree receipt. At the extremes, workers from China pay a penalty and those from European countries receive a premium. Such differences likely reflect the combination of differences across countries in the quality of home-country university options and home-country labor market opportunities which affect selection into the U.S. labor market. Because student visas are not subject to a numerical cap and the foreign born who receive U.S. degrees are advantaged in the award of temporary work visas, studying in the U.S. is likely to improve U.S. employment prospects even if the obtained degree confers no wage premium and costs more than one available from their country of origin.

6. Concluding thoughts and Implications for Policy

The key takeaway from this analysis is that U.S. higher education institutions and U.S. immigration policy both play a critical role in determining the flow of high skill immigrants to the U.S. labor market. About 9.5% of the current high-skill labor force is comprised of those entering the U.S. on student visas and then transitioning to temporary or permanent work visas. In occupations like IT, the share is higher still at 15.7%. Focusing on just those workers under the age of 35 – the cohort more likely to be affected by the restrictive H-1B visa policy of the last decade – we find a magnified effect for U.S higher education, with 16.7% of all current high-skill workers and 26.4% of IT workers entering the U.S. on student visas (authors' tabulations from NSCG:2010). And focusing still more on foreign-born IT workers who did not arrive in the U.S. at young ages on permanent visas, we find the share receiving their highest degree from U.S. institutions is yet higher.

The flow of foreign-born students to U.S. higher education institutions and – potentially – the U.S. labor market depends on home-country economic conditions and education options, labor market opportunities in the U.S., and the supply side of the U.S. higher education market. Rosenzweig (2006) proposes two models for foreign student mobility: a "constrained domestic schooling model" in which foreign students seek education in the U.S. due to a lack of home country options; and a "migration model" in which foreign students enroll in the U.S. to increase the probability that they will find employment in the U.S. when they graduate.[37] To the extent

[37] Using a cross-section of data, Rosenzweig finds that the number of foreign students is positively related to the number of universities in a home country, and negatively related to the home country "skill-price", the market wage for a given skill level. Rosenzweig concludes that the migration model is the correct model, meaning foreign students come to the U.S. for education for an option value to enter the U.S. labor market. However, Hwang (2009) uses a panel of data from an alternate source, and finds a positive relationship between a home country's skill-price and enrollment in the U.S. She also performs a survey of foreign students at Harvard, from which 35.8% respondents revealed that their primary reason for studying in the U.S. was a lack of high-quality options in their home country. In addition, only half of respondents expressed the desire to work in the U.S. after graduation, and only 22% wished to work in the U.S. long term. Rosenzweig and Hwang do not disaggregate foreign students into

that foreign students come from countries with large wage differences with the U.S. labor market and their enrollment rates are sensitive to the U.S. labor market conditions rather than the expanding education opportunities at the home country, the "migration model" is fairly important.

In this paper, we emphasize that there is substantial interaction between visa policies providing access to the U.S. labor market and education decisions of foreign born students if the motivation for U.S. education is as described in the "migration model". More restrictive work visa policies may boost the option value of gaining employment subsequent to graduation for those with the weakest home-country options to the extent that the likelihood of employment with a U.S. degree, particularly at the advanced level, is quite high relative to having a degree from abroad.[38]

Simply put, our analyses point to the interpretation that demand among foreign students for U.S. higher education is high not because of the relative value of the degree itself, but because studying in the U.S. is a pathway to employment in the U.S., effectively lowering search costs, increasing networking opportunities, and providing a more easily interpretable skill set.[39] On the market demand side, U.S. employers may prefer U.S.-trained workers because choosing workers from domestic institutions reduces their search and recruitment costs and the uncertainty in skill assessment. Given the high returns in the U.S. labor market for S&E degrees,

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education levels, i.e. undergraduate versus graduate, yet we would expect demand determinants are likely very different for undergraduate, Master's, professional, or doctorate level students.

[38] Kato and Sparber (2013) test how decreasing H-1B visa quotas for most countries in the mid-2000s affected foreign enrollment. They find that not only do smaller quotas decrease foreign enrollment, but these restrictions also decrease the average quality of foreign interested in applying to U.S. institutions. Kato and Sparber's results are consistent with the migration model proposed by Rosenzweig, as applicants become less likely to secure employment in the U.S. after graduation. However, their results may be confounded by the fact that the U.S. student visa program also suffered from additional restrictions and delays in the years following the 9/11 attacks in 2001. Kato and Sparber's results are also limited to the undergraduate level.

[39] We do not intend to imply that foreign students only motive for studying in the U.S. involves hopes that doing so will increase their employment prospects in the U.S. Our claim is only that employment prospects are an important motivating factor, especially in IT.

students from India and China are willing to pay for education in the U.S. and increasingly have the means. In turn, U.S. educational institutions value foreign students at least in part for tuition revenues (Bird and Turner, 2013). It is for this combination of reasons that there is an expansion of degree programs at the sub-doctoral level provided by U.S. educational.

Our analyses indicate that post-secondary policies that affect opportunities for study in the U.S., such as student visa restrictions or increases in the direct costs for educational programs, will have a substantial effect on the flow of high-skill workers to the U.S. labor market. In turn, elasticity in the supply of U.S. graduate programs – particularly in science and engineering – to meet foreign demand is likely to affect the level and composition of high-skill immigration to the U.S.

Future changes in the supply of U.S. higher education could have dramatic effects on the flow of high-skill foreign born workers to the U.S. economy. For example, U.S. universities may be able to expand opportunities for graduate study – in particular, in master's-level S&E programs –by using technology to increase the scale of programs while reducing marginal costs. On the other hand, continued fiscal contractions, particularly at public universities, may force the shuttering of doctorate programs, which would narrow a channel of entry for foreign graduate students.

Of course, the demand side of foreign flows to the U.S. higher education market also merits attention in projections. Two factors may serve to reduce demand for post-secondary study in the U.S.: the development of university capacity abroad and a decreasing earnings advantage in the U.S. labor market. Particularly at the graduate level, where students from abroad are a large constituency, a large decline in the foreign demand for U.S. degree programs would have a substantial effect on the U.S. market for higher education.

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Table 1: Representation of foreign-born among all workers and IT workers, by year and age-group

Panel A: All Workers					**Change from**
	1993	**2003**	**2010**	**Total**	**1993 to 2010**
Native	23,784,160	31,992,012	37,422,597	93,198,770	13,638,437
Foreign Born	2,437,745	4,864,934	6,943,759	14,246,438	4,506,014
Total	26,221,905	36,856,946	44,366,356	107,445,208	18,144,451
% Foreign Born, by Age group					
25 to 34	9%	14%	15%		
35 to 44	10%	16%	20%		
45 to 54	10%	12%	16%		
above 54	8%	11%	12%		
Total	9%	13%	16%		

Panel B: IT Workers					**Change from**
	1993	**2003**	**2010**	**Total**	**1993 to 2010**
Native	943,192	1,476,963	1,627,328	4,047,483	684,135
Foreign Born	174,204	540,480	749,613	1,464,297	575,409
Total	1,117,396	2,017,443	2,376,941	5,511,780	1,259,544
% Foreign Born, by Age group					
25 to 34	16%	34%	35%		
35 to 44	17%	29%	37%		
45 to 54	14%	19%	27%		
above 54	13%	16%	19%		
Total	16%	27%	32%		

Source: National Survey of College Graduates (NSCG) -1993, 2003 and 2010

Panel A: Sample restricted to all full-time college-educated workers, that are 25 years or older.

Panel B: Sample restricted to those working in the IT industry or related occupations, and are 25 years or older

Table 2. Distribution of college-educated foreign -born and US-born workers, by highest degree achieved and year (Panel A: All workers; Panel B:IT workers only)

Panel A: All Workers

	Natives			
	1993	**2003**	**2010**	**1993-2010**
Bachelor's	15,526,091	20,556,119	23,871,814	59,954,023
Percentage of total	65	64	64	64
Master's	5,822,671	8,402,498	10,214,300	24,439,469
Percentage of total	24	26	27	26
PhD	812,200	1,050,539	1,122,285	2,985,024
Percentage of total	3	3	3	3
Professional Degrees	1,623,199	1,982,857	2,214,199	5,820,254
Percentage of total	7	6	6	6
Total	23,784,160	31,992,012	37,422,597	93,198,770
	100	100	100	100

	Foreign Born			
	1993	**2003**	**2010**	**1993-2010**
Bachelor's	1,394,163	2,767,936	4,046,264	8,208,363
Percentage of total	57	57	58	58
Master's	618,548	1,362,724	1,970,894	3,952,166
Percentage of total	25	28	28	28
PhD	207,833	379,256	528,096	1,115,184
Percentage of total	9	8	8	8
Professional Degrees	217,201	355,019	398,506	970,726
Percentage of total	9	7	6	7
Total	2,437,745	4,864,934	6,943,759	14,246,438
	100	100	100	100

Panel B: IT Workers

	Natives			
	1993	**2003**	**2010**	**1993-2010**
Bachelor's	694,431	1,077,515	1,236,683	3,008,628
Percentage of total	74	73	76	74
Master's	223,737	361,020	358,024	942,780
Percentage of total	24	24	22	23
PhD	22,052	32,541	27,390	81,983
Percentage of total	2	2	2	2
Professional Degrees	2,973	5,887	5,231	14,091
Percentage of total	0	0	0	0
Total	943,192	1,476,963	1,627,328	4,047,483
	100	100	100	100

	Foreign Born			
	1993	**2003**	**2010**	**1993-2010**
Bachelor's	92,767	265,431	374,171	732,370
Percentage of total	53	49	50	50
Master's	68,359	239,426	330,448	638,233
Percentage of total	39	44	44	44
PhD	12,786	34,636	44,638	92,061
Percentage of total	7	6	6	6
Professional Degrees	292	987	355	1,634
Percentage of total	0	0	0	0
Total	174,204	540,480	749,613	1,464,297
	100	100	100	100

Source: National Survey of College Graduates (NSCG) -1993, 2003 and 2010

Panel A: Sample restricted to all full-time college-educated workers, that are 25 years or older.

Panel B: Sample restricted to those working in the IT industry or related occupations, and are 25 years or older

Table 3. Distribution of all college-educated foreign-born workers earning highest degree in U.S., by age and year (Panel A: All workers; Panel B: IT workers only)

Panel A: All Workers				**Panel B: IT Workers**			
Percentage of Degrees earned in U.S.				**Percentage of Degrees earned in U.S.**			
Bachelor's Highest degree				***Bachelor's Highest degree***			
	1993	**2003**	**2010**		**1993**	**2003**	**2010**
25 to 34	74%	61%	59%	**25 to 34**	86%	50%	52%
35 to 44	53%	54%	45%	**35 to 44**	62%	57%	41%
45 to 54	41%	43%	47%	**45 to 54**	56%	56%	50%
above 54	42%	37%	33%	**above 54**	47%	48%	63%
Master's Highest degree				***Master's Highest degree***			
	1993	**2003**	**2010**		**1993**	**2003**	**2010**
25 to 34	87%	78%	69%	**25 to 34**	92%	72%	73%
35 to 44	77%	73%	69%	**35 to 44**	82%	74%	60%
45 to 54	75%	70%	67%	**45 to 54**	78%	74%	79%
above 54	70%	70%	64%	**above 54**	74%	62%	66%
PhD Highest degree				***PhD Highest degree***			
	1993	**2003**	**2010**		**1993**	**2003**	**2010**
25 to 34	76%	81%	77%	**25 to 34**	83%	85%	95%
35 to 44	73%	67%	62%	**35 to 44**	85%	69%	78%
45 to 54	74%	65%	59%	**45 to 54**	84%	63%	63%
above 54	60%	62%	60%	**above 54**	68%	61%	67%
Professional Highest degree				***Professional Highest degree***			
	1993	**2003**	**2010**		**1993**	**2003**	**2010**
25 to 34	65%	80%	68%	**25 to 34**	100%	0%	0%
35 to 44	52%	54%	49%	**35 to 44**	0%	0%	100%
45 to 54	32%	44%	46%	**45 to 54**	100%	0%	100%
above 54	34%	29%	29%	**above 54**	0%	57%	0%

Source: National Survey of College Graduates (NSCG) -1993, 2003 and 2010
Panel A: Sample restricted to all full-time college-educated workers, that are 25 years or older.
Panel B: Sample restricted to those working in the IT industry or related occupations, and are 25 years or older

Table 4. Distribution of Bachelor's degree and Master's degree workers aged 25-34 by Field of Highest Degree

Panel A: All Workers

	Bachelor's Highest Degree													
	Computer/Math		**Life Sciences**		**Physical Sciences**		**Social Sciences**		**Engineering**		**S&E Related**		**Non S&E Fields**	
	1993	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**
Foreign-Born	10%	13%	5%	5%	3%	2%	11%	11%	16%	11%		12%	56%	46%
Natives	5%	4%	4%	6%	2%	1%	11%	15%	8%	6%		7%	70%	61%

	Masters's Highest Degree													
	Computer/Math		**Life Sciences**		**Physical Sciences**		**Social Sciences**		**Engineering**		**S&E Related**		**Non S&E Fields**	
	1993	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**
Foreign-Born	13%	14%	5%	5%	3%	2%	7%	7%	26%	19%		11%	47%	42%
Natives	4%	3%	3%	2%	2%	1%	7%	7%	8%	4%		12%	75%	72%

Panel B: IT Workers

	Bachelor's Highest Degree													
	Computer/Math		**Life Sciences**		**Physical Sciences**		**Social Sciences**		**Engineering**		**S&E Related**		**Non S&E Fields**	
	1993	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**
Foreign-born	31%	55%	1%	1%	1%	2%	4%	3%	43%	27%		6%	19%	6%
Natives	35%	37%	1%	2%	2%	1%	4%	8%	29%	18%		4%	30%	31%

	Master's Highest Degree													
	Computer/Math		**Life Sciences**		**Physical Sciences**		**Social Sciences**		**Engineering**		**S&E Related**		**Non S&E Fields**	
	1993	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**	**1993**	**2010**
Foreign-born	32%	41%	0%	1%	1%	1%	2%	0%	49%	40%		7%	16%	10%
Natives	28%	43%	1%	1%	1%	2%	3%	2%	40%	22%		4%	27%	27%

Source: National Survey of College Graduates (NSCG) -1993, 2003 and 2010

Panel A: Sample restricted to all full-time college-educated workers, that are 25 years or older.

Panel B: Sample restricted to those working in the IT industry or related occupations, and are 25 years or older

Table 5. First Visa Status

Panel A: All Workers

	Permanent Resident Visa		Temporary Work Visa		Temporary Student/Training		Dependent Visa		Other Temp Visa	
Age group	**2003**	**2010**	**2003**	**2010**	**2003**	**2010**	**2003**	**2010**	**2003**	**2010**
25 to 34	41%	36%	14%	14%	24%	27%	15%	19%	5%	4%
35 to 44	38%	33%	13%	22%	26%	21%	13%	17%	9%	7%
45 to 54	46%	35%	12%	16%	23%	25%	9%	11%	10%	12%
above 54	52%	49%	8%	11%	23%	19%	7%	7%	10%	14%

Panel B: IT Workers

	Permanent Resident Visa		Temporary Work Visa		Temporary Student/Training		Dependent Visa		Other Temp Visa	
Age group	**2003**	**2010**	**2003**	**2010**	**2003**	**2010**	**2003**	**2010**	**2003**	**2010**
25 to 34	25%	16%	32%	39%	30%	35%	11%	9%	2%	1%
35 to 44	29%	22%	23%	46%	32%	23%	9%	7%	7%	3%
45 to 54	34%	28%	13%	23%	34%	36%	8%	7%	11%	6%
above 54	40%	34%	14%	12%	37%	30%	3%	6%	6%	19%

Source: National Survey of College Graduates (NSCG) - 2003 and 2010

Panel A: Sample restricted to all full-time college-educated workers, that are 25 years or older.

Panel B: Sample restricted to those working in the IT industry or related occupations, and are 25 years or older

First-Visa status not available for the 1993 survey.

Table 6. First Visa Status by Highest Degree (2010 survey)

Panel A: All Workers

Bachelor's Highest Degree

	Location of Highest Degree		
	Abroad	**US**	**Total**
Permanent Resident Visa	772,412	850,052	1,622,464
Percentage of total	35	59	45
Temporary Work Visa	599,500	35,604	635,104
Percentage of total	27	2	17
Temporary Student/Training	181,701	262,412	444,113
Percentage of total	8	18	12
Dependent Visa	335,297	204,367	539,663
Percentage of total	15	14	15
Other Temp Visa	300,842	93,183	394,024
Percentage of total	14	6	11
Total	2,189,752	1,445,617	3,635,368
	100	100	100

Master's Highest Degree

	Location of Highest Degree		
	Abroad	**US**	**Total**
Permanent Resident Visa	171,686	358,184	529,870
Percentage of total	27	32	30
Temporary Work Visa	207,964	61,751	269,715
Percentage of total	33	6	15
Temporary Student/Training	68,443	520,075	588,518
Percentage of total	11	47	34
Dependent Visa	86,683	127,957	214,640
Percentage of total	14	12	12
Other Temp Visa	102,883	42,209	145,092
Percentage of total	16	4	8
Total	637,658	1,110,177	1,747,835
	100	100	100

Panel B: IT Workers

Bachelor's Highest Degree

	Location of Highest Degree		
	Abroad	**US**	**Total**
Permanent Resident Visa	30,595	75,265	105,860
Percentage of total	16	52	31
Temporary Work Visa	132,600	12,744	145,344
Percentage of total	68	9	43
Temporary Student/Training	11,901	30,802	42,703
Percentage of total	6	21	13
Dependent Visa	9,696	15,106	24,801
Percentage of total	5	11	7
Other Temp Visa	8,873	9,493	18,365
Percentage of total	5	7	5
Total	193,664	143,409	337,073
	100	100	100

Master's Highest Degree

	Location of Highest Degree		
	Abroad	**US**	**Total**
Permanent Resident Visa	12,052	29,724	41,776
	12	15	14
Temporary Work Visa	68,301	22,003	90,303
	67	11	30
Temporary Student/Training	9,778	122,619	132,397
	10	63	44
Dependent Visa	7,707	16,656	24,363
	8	9	8
Other Temp Visa	4,522	4,351	8,873
	4	2	3
Total	102,359	195,352	297,711
	100	100	100

Source: National Survey of College Graduates (NSCG) – 2010

Panel A: Sample restricted to all full-time college-educated workers, that are 25 years or older.

Panel B: Sample restricted to those working in the IT industry or related occupations, and are 25 years or older

Table 7. Leading Countries of Origin for U.S. Enrollment, 1993 and 2011

Undergraduate Enrollment					
2011			1993		
1	China	74,516	1	Japan	31,960
2	South Korea	38,232	2	Canada	13,149
3	Saudi Arabia	14,344	3	South Korea	12,521
4	India	13,509	4	Malaysia	11,289
5	Canada	12,866	5	Taiwan	11,067
6	Vietnam	11,244	6	Hong Kong	10,427
7	Japan	9,359	7	Indonesia	7,982
Leading Country Total		174,070			98,395
Top 7 as % of total		56.27%			46.10%
TOTAL		309,342			213,610
Graduate Enrollment					
2011			1993		
1	China	88,429	1	China	36,370
2	India	59,014	2	India	27,533
3	South Korea	21,260	3	Taiwan	24,623
4	Taiwan	12,007	4	South Korea	15,785
5	Canada	11,190	5	Canada	8,455
6	Turkey	6,198	6	Japan	7,755
7	Saudi Arabia	6,133	7	Thailand	5,621
Leading Country Total		204,231			126,142
Top 7 as % of total		67.98%			62.70%
TOTAL		300,430			201,030

Source: IIE Open Doors

Table 8: Distribution of Highest-Degrees achieved, and its location by Country of Birth

	Degree distribution				% Highest Degrees from US		
	Bachelor's	Master's	PhD	Prof	Bachelor's	Master's	PhD
				Europe			
All Workers							
1993	54%	27%	10%	8%	70%	68%	55%
2003	53%	30%	10%	7%	62%	61%	47%
2010	53%	30%	12%	5%	56%	50%	49%
IT workers							
1993	58%	35%	7%	0%	71%	58%	44%
2003	53%	38%	9%	0%	59%	49%	46%
2010	54%	38%	8%	0%	46%	27%	36%
				Canada			
All Workers							
1993	58%	23%	8%	11%	75%	82%	81%
2003	61%	22%	8%	10%	60%	77%	65%
2010	60%	23%	7%	10%	51%	74%	59%
IT workers							
1993	75%	20%	5%	0%	78%	70%	79%
2003	80%	16%	3%	1%	42%	57%	76%
2010	64%	22%	13%	1%	45%	69%	100%
				India			
All Workers							
1993	37%	37%	13%	13%	23%	69%	69%
2003	44%	41%	8%	7%	21%	57%	67%
2010	44%	42%	7%	7%	19%	58%	70%
IT workers							
1993	26%	62%	12%	0%	37%	84%	83%
2003	41%	55%	4%	0%	14%	60%	66%
2010	44%	54%	2%	0%	17%	62%	78%
				China			
All Workers							
1993	43%	34%	17%	5%	43%	86%	88%
2003	30%	43%	22%	4%	43%	84%	77%
2010	32%	37%	27%	5%	47%	83%	70%
IT workers							
1993	30%	54%	16%	0%	67%	97%	94%
2003	19%	65%	16%	0%	45%	88%	79%
2010	19%	58%	23%	0%	50%	86%	79%

Source: National Survey of College Graduates (NSCG) – 1993, 2003 and 2010

All workers: Sample restricted to all full-time college-educated workers, that are 25 years or older.
IT workers: Sample restricted to those working in the IT industry or related occupations, and are 25 years or older

Table 9A: Coefficient on Foreign Born and Educated Abroad for Various Specifications, All workers

	NSCG			Census-ACS			
Specification	1993	2003	2010	1990	2000	2001-2010	2008-2010
Base Specification (see footnote)	-0.0858***	-0.191***	-0.223***	-0.0444***	-0.137***	-0.173***	-0.172***
	(0.0107)	(0.0204)	(0.0470)	(0.0087)	(0.0059)	(0.0066)	(0.0088)
Base Specification with field of study dummies	-0.0698***	-0.192***	-0.225***				
	(0.0107)	(0.0203)	(0.0459)				
Base Specification with field of study and occupation dummies	-0.0605***	-0.178***	-0.211***				
	(0.0104)	(0.0198)	(0.0441)				

Source: National Survey of College Graduates (1993, 2003 and 2010); Census (1990 and 2000) and ACS (2001 to 2010)
Note: Weighted regressions for all college-educated full-time workers.
The Census/ACS does not report location of institution for degrees. Based on age of immigration and educational qualifications, and comparing it to the NSCG tabulations, it was estimated whether the individual obtained their degree from inside or outside the US. The ACS regressions are estimated separately for each year, the average coefficient values are reported for the period of interest in this table. See Appendix for the full set of estimation results.
The base specification includes a constant, dummy variables for foreign born, foreign born and immigrated after 18, highest degree levels, sex, and age groups.

Table 9B: Coefficient on Foreign Born and Educated Abroad for Various Specifications, IT workers

	NSCG			Census-ACS			
Specification	1993	2003	2010	1990	2000	2001-2010	2008-2010
Base Specification (see footnote)	-0.0607**	0.0622**	0.0956*	0.0128	-0.0610***	-0.0095	0.0242
	(0.0253)	(0.0276)	(0.0518)	(0.0194)	(0.0117)	(0.0123)	(0.0202)
Base Specification with field of study dummies	-0.0506**	0.0593**	0.0878*				
	(0.0248)	(0.0277)	(0.0513)				

Source: National Survey of College Graduates (1993, 2003 and 2010); Census (1990 and 2000) and ACS (2001 to 2010)
Note: Weighted regressions for IT workers (Computer or Information Scientists; and Electrical or Computer Hardware Engineers) The Census/ACS does not report location of institution for degrees. Based on age of immigration and educational qualifications, and comparing it to the NSCG tabulations, it was estimated whether the individual obtained their degree from inside or outside the US. The ACS regressions are estimated separately for each year, the average coefficient values are reported for the period of interest in this table. See Appendix for the full set of estimation results. The base specification includes a constant, dummy variables for foreign born, foreign born and immigrated after 18, highest degree levels, sex, and age groups.

Table 10A: Coefficient on Country of Birth and Educated Abroad for Various Specifications, All workers

	NSCG			Census-ACS			
Country	1993	2003	2010	1990	2000	2001-2010	2008-2010
				Base Specification (see footnote)			
China	-0.270***	-0.174**	-0.459***	-0.232***	-0.237***	-0.242***	-0.225***
	(0.0462)	(0.0761)	(0.1230)	(0.0175)	(0.0123)	(0.01058)	(0.0153)
India	-0.181***	-0.281***	-0.380***	-0.168***	-0.224***	-0.138***	-0.119***
	(0.0278)	(0.0468)	(0.1030)	(0.0185)	(0.0115)	(0.0124)	(0.0191)
Europe	0.0754***	0.00937	-0.031	0.0163	-0.0422***	-0.056***	-0.038***
	(0.0216)	(0.0432)	(0.0796)	(0.0115)	(0.0093)	(0.0078)	(0.0111)
Canada	0.376***	0.447***	0.316	0.106***	0.186***	0.133***	0.134***
	(0.0503)	(0.0965)	(0.2800)	(0.0235)	(0.0192)	(0.0148)	(0.0217)
Others	-0.0911***	-0.289***	-0.251***	-0.0642***	-0.154***	-0.230***	-0.237***
	(0.0176)	(0.0315)	(0.0716)	(0.0087)	(0.0065)	(0.0057)	(0.0078)
				Base Specification with field of study			
China	-0.250***	-0.146*	-0.430***				
	(0.0464)	(0.0759)	(0.1300)				
India	-0.148***	-0.248***	-0.349***				
	(0.0277)	(0.0458)	(0.0964)				
Europe	0.0489**	-0.0235	-0.0546				
	(0.0217)	(0.0433)	(0.0812)				
Canada	0.350***	0.418***	0.252				
	(0.0497)	(0.0975)	(0.2690)				
Others	-0.0827***	-0.287***	-0.232***				
	(0.0175)	(0.0317)	(0.0709)				

Source: National Survey of College Graduates (1993, 2003 and 2010); Census (1990 and 2000) and ACS (2001 to 2010)
Note: Weighted regressions for all college-educated full-time workers.
The Census/ACS does not report location of institution for degrees. Based on age of immigration and educational qualifications, and comparing it to the NSCG tabulations, it was estimated whether the individual obtained their degree from inside or outside the US. The ACS regressions are estimated separately for each year, the average coefficient values are reported for the period of interest in this table. See Appendix for the full set of estimation results.
The base specification includes a constant, dummy variables for foreign born, foreign born and immigrated after 18, highest degree levels, sex, and age groups.

Table 10B: Coefficient on Country of Birth and Educated Abroad for Various Specifications, IT workers

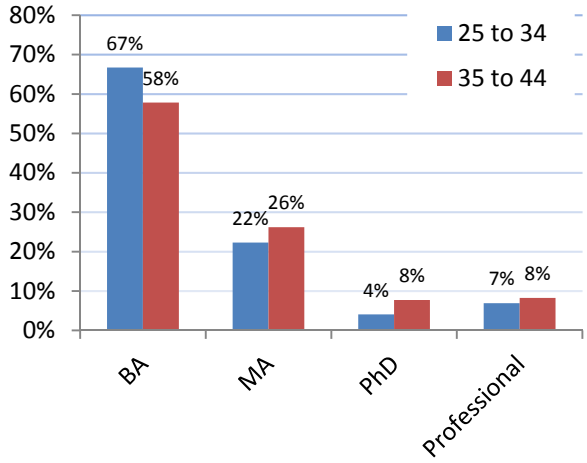
	NSCG			Census-ACS			
Country	1993	2003	2010	1990	2000	2001-2010	2008-2010
			Base Specification (see footnote)				
China	-0.0417	-0.039	-0.137	-0.0902***	-0.137***	-0.048	-0.076
	(0.0879)	(0.0779)	(0.2180)	(0.0315)	(0.0197)	(0.0187)	(0.0259)
India	-0.0717	-0.025	-0.0372	-0.0152	-0.0603***	0.006	0.018
	(0.0663)	(0.0475)	(0.0704)	(0.0331)	(0.0175)	(0.0236)	(0.0349)
Europe	0.0693*	0.173***	0.174**	0.0189	-0.00029	-0.013	0.000
	(0.0402)	(0.0604)	(0.0681)	(0.0305)	(0.0222)	(0.0188)	(0.0298)
Canada	0.222	-0.108	0.0947	0.076	0.202***	0.08	0.134**
	(0.1580)	(0.1420)	(0.1190)	(0.0661)	(0.0530)	(0.0369)	(0.0643)
Others	-0.0672	0.0626	0.113	0.0528**	-0.0709***	-0.026	-0.026
	(0.0467)	(0.0646)	(0.0857)	(0.0213)	(0.0176)	(0.0140)	(0.0216)
			Base Specification with field of study				
China	-0.0316	-0.0186	-0.123				
	(0.0895)	(0.0733)	(0.1940)				
India	-0.0757	-0.038	-0.0179				
	(0.0656)	(0.0486)	(0.0713)				
Europe	0.0598	0.148**	0.185***				
	(0.0394)	(0.0602)	(0.0697)				
Canada	0.192	-0.128	0.119				
	(0.1490)	(0.1320)	(0.1240)				
Others	-0.0574	0.0628	0.107				
	(0.0467)	(0.0652)	(0.0872)				

Source: National Survey of College Graduates (1993, 2003 and 2010); Census (1990 and 2000) and ACS (2001 to 2010)
Note: Weighted regressions for IT workers (Computer or Information Scientists; and Electrical or Computer Hardware Engineers)
The Census/ACS does not report location of institution for degrees. Based on age of immigration and educational qualifications, and comparing it to the NSCG tabulations, it was estimated whether the individual obtained their degree from inside or outside the US. The ACS regressions are estimated separately for each yer, the average coefficient values are reported for the period of interest in this table. See Appendix for the full set of estimation results.
The base specification includes a constant, dummy variables for foreign born, foreign born and immigrated after 18, highest degree levels, sex, and age groups.

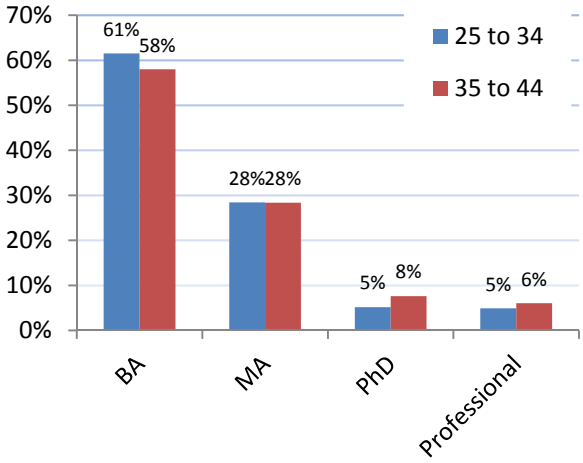
Figure 1. Distribution of U.S. workers by nativity, sector (All vs. IT), highest degree, and age group, 1993 and 2010

Panel A: All Workers

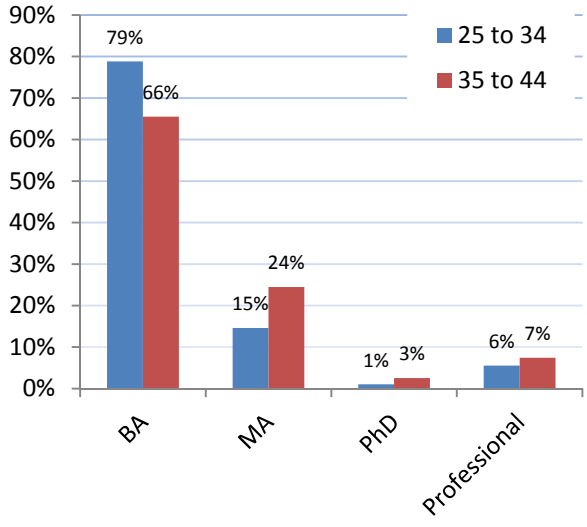
Foreign Born 1993



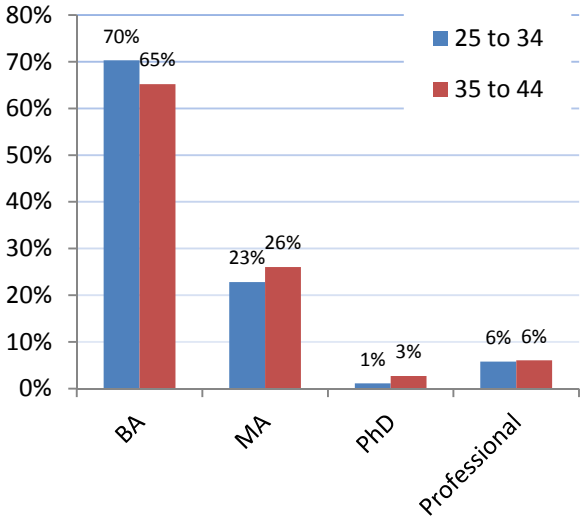
Foreign Born 2010



Native Born 1993



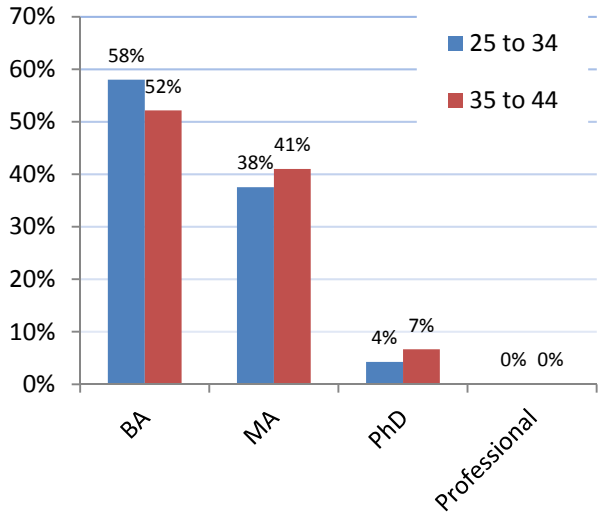
Native Born 2010



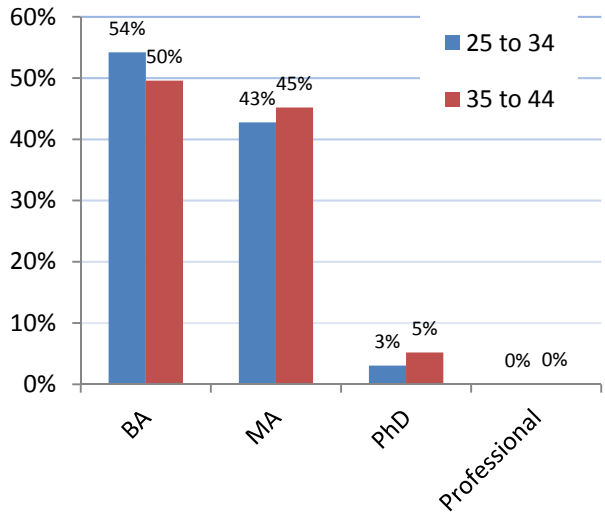
Source: National Survey of College Graduates (NSCG) – 1993 and 2010
Sample restricted to all full-time college-educated workers, that are 25 years or older.

Panel B: IT Workers

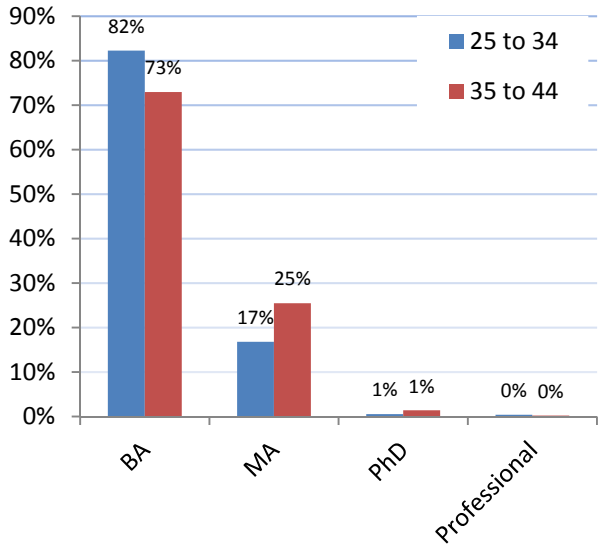
Foreign Born 1993



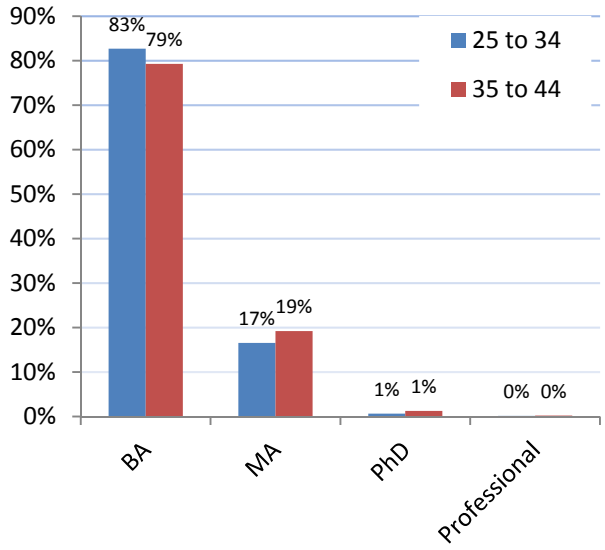
Foreign Born 2010



Native Born 1993

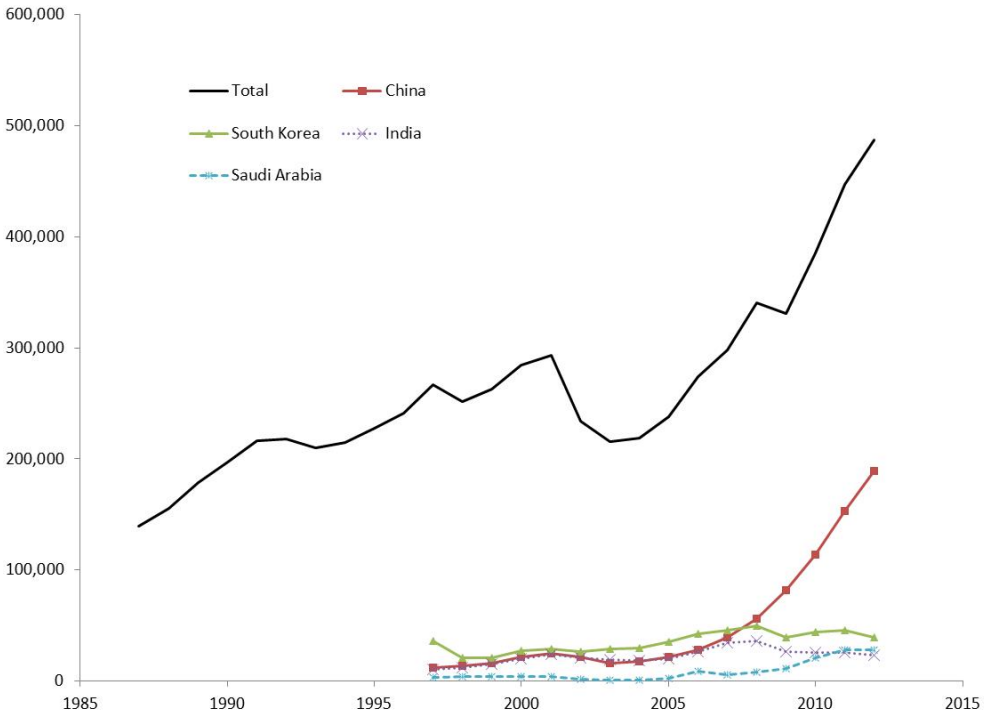


Native Born 2010



Source: National Survey of College Graduates (NSCG) – 1993 and 2010
Sample restricted to those working in the IT industry or related occupations, and are 25 years or older.

Figure 2. Trends in F student visas issued, overall and by select nationality



Source: Department of State, "Nonimmigrant Visa Issuances by Visa Class and by Nationality " and "Nonimmigrant Visas by Individual Class of Admission"; see http://travel.state.gov/visa/statistics/nivstats/nivstats_4582.html

Figure 3: Trends in foreign enrollment in U.S. higher education by education level, 1954-2011

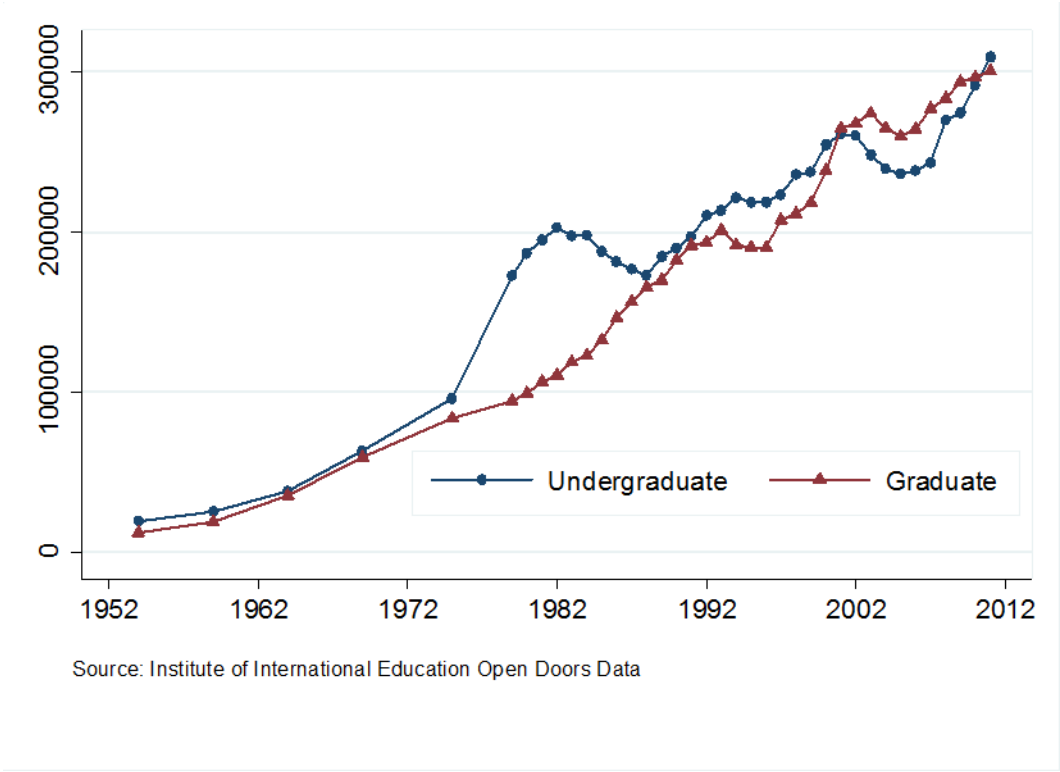
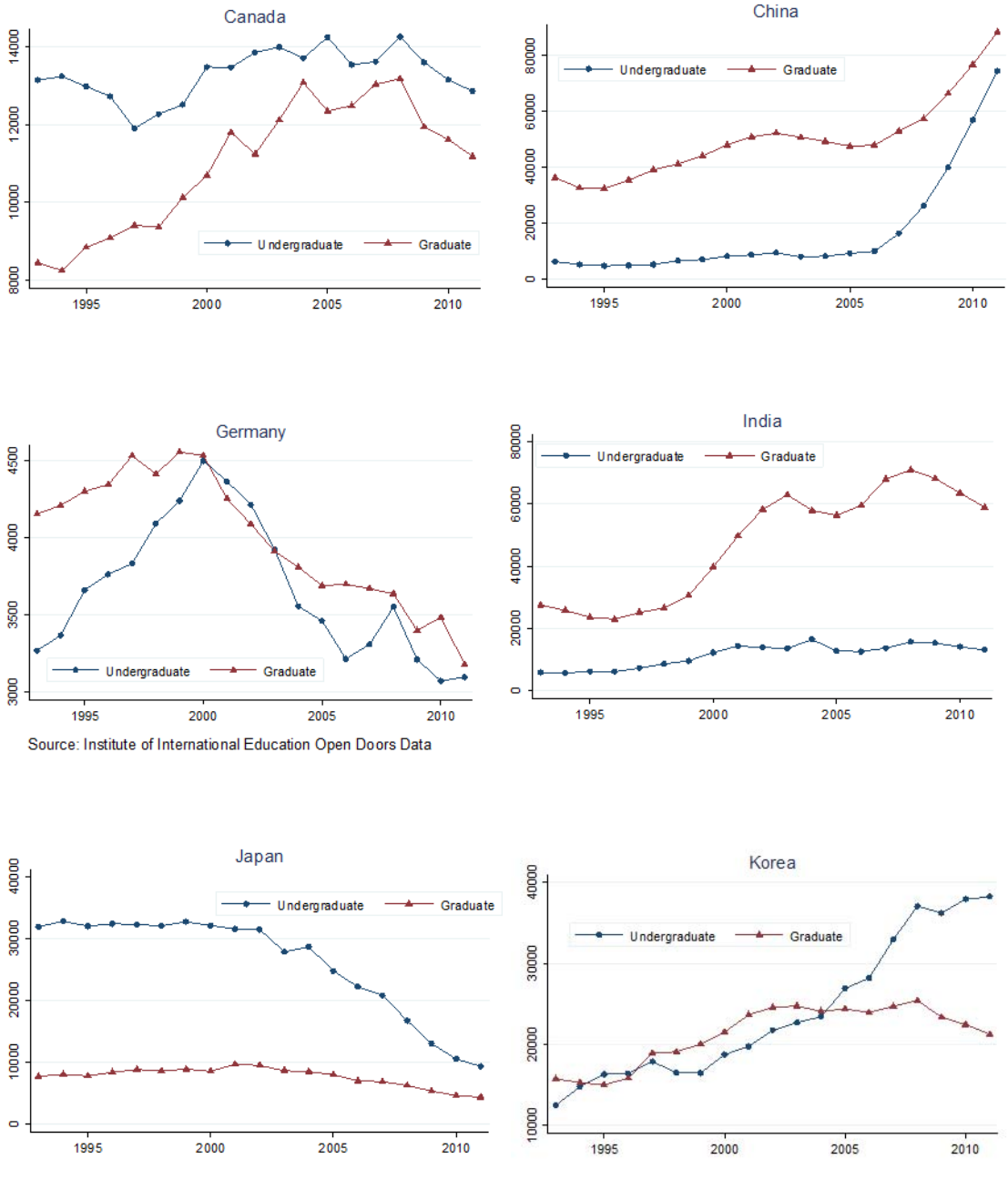


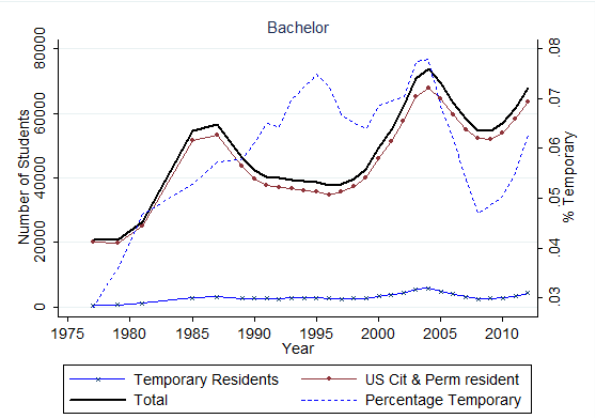
Figure 4: Trends in foreign enrollment by select countries of origin, 1993-2011



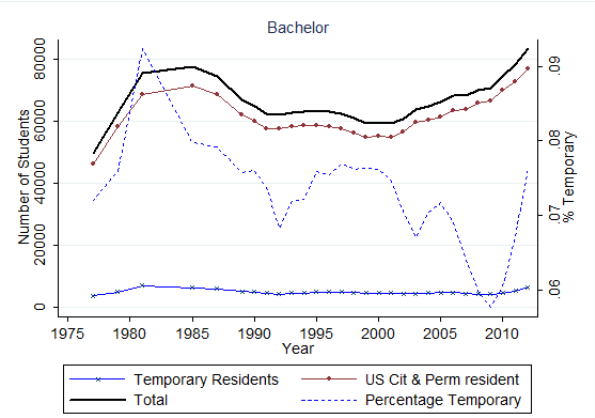
Source: Institute of International Education Open Doors Data.

Figure 5. Trends in U.S. degrees conferred by field and level

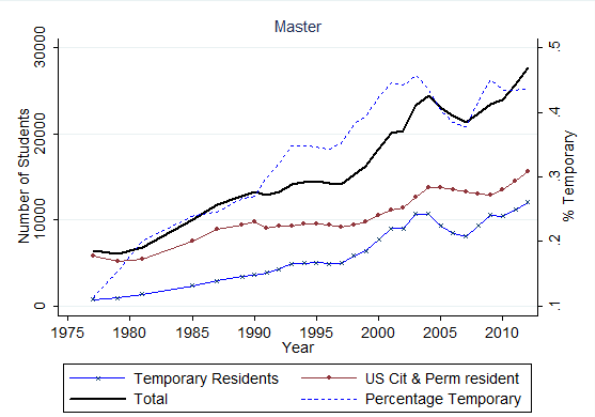
Computer Science



Engineering



Computer Science



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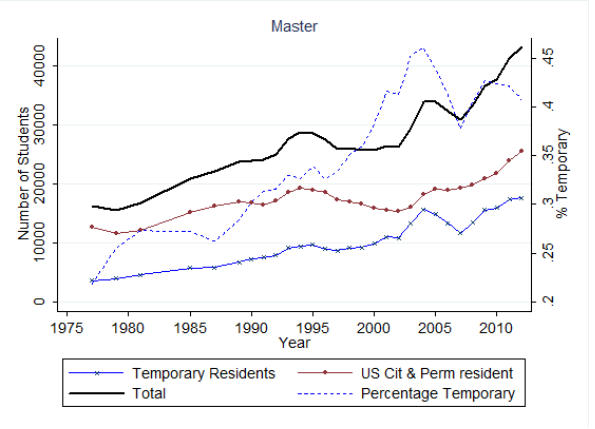
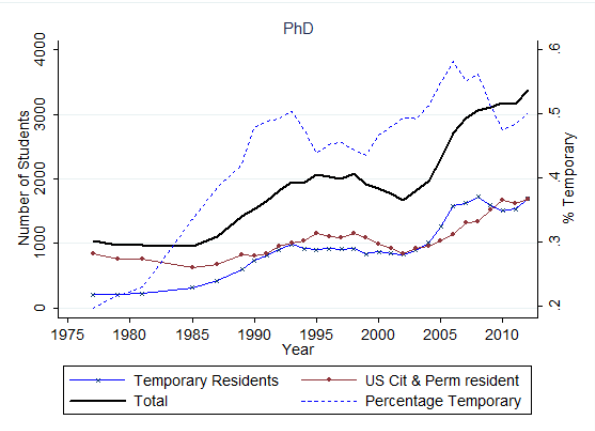
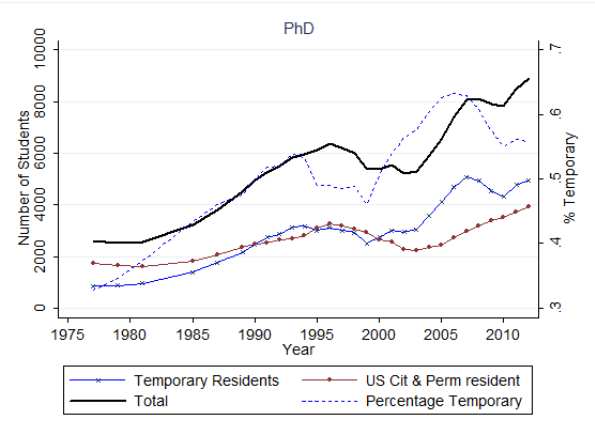


Computer Science

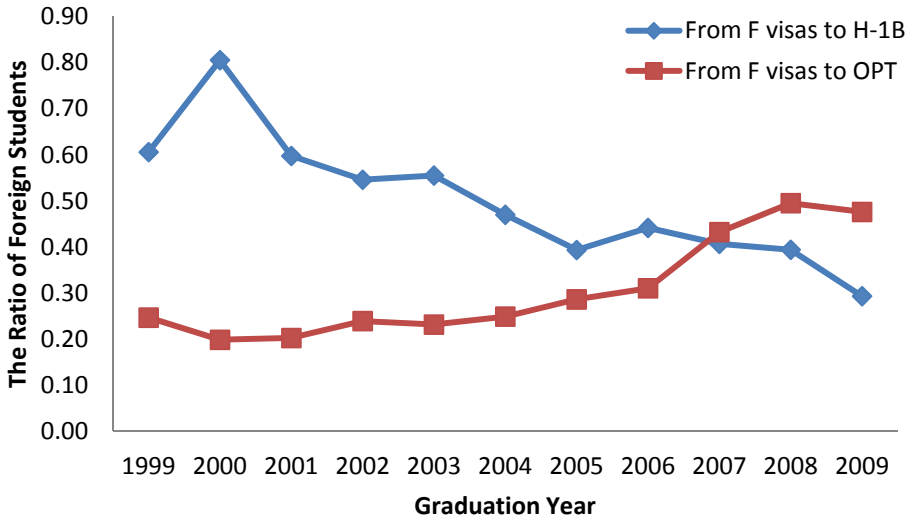


Engineering



Source: Integrated Post-Secondary Data System (IPEDS) Completions Surveys by Race.

Figure 6: Trends in the transitions from student visas to temporary work visas



Source: 2000-2010 Characteristics of H-1B Specialty Workers Reports of the USCIS, 2000-2010 Open Doors Report of the Institute of International Education, and 1999-2009 Completion Surveys by Race of the Integrated Post-Secondary Data System. The ratio of initial H-1B petitions processed to aliens in the U.S. (OPT beneficiaries) to the number of foreign graduates of U.S. universities in that class of graduation is an approximation of the transition rate from F visas to H-1B (or OPT) for each year of graduation.