

Immigration and the Tech Industry: As a Labor Shortage Remedy, for Innovation or for Cost Savings?

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Overview

An often-noted irony of the immigration debate in the United States is that most of the discussion is over two polar opposite ends of the labor market spectrum. On the one end are the unauthorized immigrants, typically low-skilled and with very limited education. On the other end are engineers, scientists and the like, all with at least bachelor's degrees and many with postgraduate degrees, hired by the tech industry. Proponents of the high end often distance themselves from the low end, claiming the immigrants are needed to maintain American technological edge. Critics of the high-end policies, on the other hand, claim the two types of immigration have a key point of commonality—employers' desire to save on labor costs.

It must be stated at the outset that I find the latter interpretation to be generally valid. Research on this issue is at the very confluence of my professional background. I am a computer science professor, was formerly a statistics professor, and worked years ago as a software developer in Silicon Valley. I thus can view the subject matter from both quantitative and qualitative viewpoints. Having studied it since 1993, I believe the preponderance of evidence strongly indicates that the primary motivation in the tech industry for sponsoring foreign workers for work visas and immigration is indeed cheap labor.¹

Consider the tech employers' stated reasons for hiring the foreign workers:

- American college students either cannot or will not study science, technology, engineering and mathematics (STEM).
- Rapid technological change causes shortages of the latest skill sets.
- Most importantly, employers need to hire from abroad in order to have “the best and the brightest” workers, people who will produce the innovations necessary for the firms (and the U.S.) to maintain technological dominance.

Yet it will be shown here that none of these claims is confirmed upon close inspection. That leaves cheap labor as the remaining explanatory factor. Analyses here will then confirm the cheap-labor factor.

It is of central importance to explain, however, that the major way in which the foreign workers serve as cheap labor is via their youth. Younger workers are generally cheaper than older workers, *ceteris paribus*, both in wages and in benefits, and the foreign workers as a group are younger than those of their American peers in similar jobs. As will be shown here, the young foreign workers are *also* cheaper than the young Americans. But the main cost savings are accrued when employers use high-end immigration policy as a means to avoid hiring the older American workers. This point is often overlooked, even by critics of the work visas, yet it is *the* core issue.

“Older,” it should be kept in mind, means over age 35 in this industry. Wages rise fairly rapidly in the early careers of tech workers, and by age 35, many are at salary levels that employers simply do not want to pay, even if the worker has the desired technological skill set. The employers then claim a shortage of workers, when what they actually mean is that there is a shortage at the level they wish to pay. As Peter Cappelli of the Wharton School of Business, University of Pennsylvania put it (albeit hyperbolically) “There is no shortage of diamonds, for example, because even though they are very expensive, you can buy all you want at the going price.”² The young foreign workers then provide a remedy to this “shortage.”

It should also be kept in mind that the usage of the foreign workers as cheap labor is in most cases fully legal. Major legal loopholes enable the underpayment of foreign workers relative to comparable Americans—for example, paying lower wages to young foreign workers than to young Americans—and nothing at all in immigration law forbids hiring young foreign workers in lieu of older Americans.

The results of all this have been:

- Suppressed wage growth.

- Greatly shortened careers.
- Avoidance of the field among the most talented American students.

These problems would be offset if the foreign workers tend to be outstanding talents, “the best and the brightest,” who are key to U.S. industry’s ability to innovate. I will address this question here as well, and show that the claims of outstanding talent are not supported by the data.

Unwarranted Focus on the Indian IT Staffing Firms

A major point that is important to discuss at the outset is that the analysis here will essentially exclude workers in the the Indian IT staffing firms, which hire H-1Bs and then rent them to other companies. (Here the term “Indian” will be shorthand for “Indian and Indian-American.”) It is common among analysts of the H-1B workforce to refer to the market as segmented, referring to two segments—mainstream U.S. firms and Indian IT staffing firms. The claimed nature of the segmentation is that the mainstream U.S. firms use the H-1B visa properly while the Indian firms abuse it.

This claim eventually made its way into Congress. During a controversial speech in the Senate in 2010, Senator Charles Schumer claimed that the majority of employers who use H-1B for cheap labor were the Indian IT staffing firms. The Indian community took offense and accused him of scapegoating, especially since he referred to the Indian firms as “chop shops” (Cha, 2010).

Although the criticism centered on Senator Schumer, his view that the Indian firms are the principal problem with the H-1B visa is widely held in DC. It was mentioned a number of times at a 2011 workshop attended by leading government policymakers (Hamuttal, 2011), and led to introduction of a bill being introduced in 2011 by Representative Zoe Lofgren. Her district includes Silicon Valley, and she has consistently been Congress’ staunchest supporter of the H-1B program. Close inspection of the bill revealed that many of its provisions were aimed at the Indian IT staffing firms.

Because of this view of Indian IT staffing firms, the analysis here will separate the Indian and U.S. firms, focusing specifically on mainstream U.S. firms. It will be shown that abuse is commonplace among the mainstream U.S. firms as well. The latter do tend to hire workers of much higher quality, but still often pay them less than Americans of the same high comparable quality would command in the open market.

Data Sets, Goals and Terminology

The primary data set is the 2003 National Survey of College Graduates.³ This data is especially useful because it not only contains the usual variables such as salary, educational level, age and so on, but also states whether a foreign-born person entered the U.S. on a student visa, and also what field of study she pursued while in school.

Also useful will be the Program Electronic Review Management (PERM) data, which consists of Department of Labor records of all employer-sponsored green cards.⁴ Note carefully that each record corresponds to an actual foreign worker, unlike the H-1B Labor Condition Application records.

The PERM data are especially important in that they essentially exclude the Indian IT staffing firms, claimed by politicians to be the chief abusers of foreign worker programs. Professor Ronil Hira, who has studied the Indian IT staffing firms extensively, has found that such employers almost never sponsor their foreign workers for green cards (Hira, 2007). I am not taking the viewpoint that lack of green card sponsorship is “bad”; rather, the point is this means that analyses of the PERM data effectively remove the Indian IT staffing firms from consideration, and thus these analyses provide us with a view of the U.S. mainstream firms.

Finally, I consider the records of the annual Association for Computing Machinery (ACM) Dissertation Awards. Unlike (Hunt 2011), I chose not to analyze entrepreneurship and numbers of research papers published, as their value in assessing innovation is problematic.

Entrepreneurship and publications:

As will be shown later in this paper, Americans are crowded out of the CS/EE. Any study of immigrant entrepreneurship among the college educated must account for this, at least investigating whether the immigrants are more entrepreneurial on a *per capita* basis. The only such study I know of

for the college-educated is that of (Hunt, 2011).

Hunt did find a higher per-capita level of entrepreneurship among the immigrants. However, the difficulty with entrepreneurship is that one doesn't know what kind of business is involved. Berkeley researcher AnnaLee Saxenian found that 36% of the Chinese-immigrant owned firms are in the business of "computer wholesaling," meaning that they are simply assemblers of commodity PCs, with no engineering or programming work being done (Saxenian 1999). This certainly does not represent "best/brightest" innovation. And many Indian-owned tech firms are in the outsourcing business, again not the type of entrepreneurship that is relevant here. Lacking sufficiently detailed data, I did not investigate this aspect.

Though I did perform some analysis on research paper counts and found no difference between the immigrant and U.S. tech workers, it is not presented here. The consensus in academia is that such counts confuse quantity with quality, and thus form a poor measure (Patterson 1999; Hamermesh 2011). In addition, publication rates vary widely among research specialities, so that, for example, researchers in software publish much more frequently than those in algorithms. It is thus highly difficult to connect publication counts to innovation.

Note carefully that my references to "foreign" workers includes two major categories:

- Workers holding the temporary work visa known as H-1B.
- Workers being sponsored for permanent residence i.e. "green cards."

In the pattern typical in mainstream U.S. firms, a worker is in both categories, with the H-1B visa conferring right to work while the green card is pending. Since often data of a certain kind is available for one group but not another, I will often implicitly or explicitly treat characteristics of one group as a proxy for the other.

The term *American* can have varied meanings. I generally use it to refer to natives and naturalized citizens who immigrated via a mechanism other than employer sponsorship. In many cases, I will restrict the term to natives, for reasons that will be explained.

Fields of Focus

Instead of combining workers from all fields, as is done by most researchers, I focus on those who have degrees in computer science (CS) or electrical engineering (EE) who are working in those fields. The CS and EE fields are of interest as they are the two most common among foreign STEM workers, and there is broad overlap between the two fields. Many EE graduates, for example, work as software developers. University CS departments often have faculty with EE degrees and vice versa.

This restriction to field is key, as there are many pitfalls. Take the field of mathematics, for instance, say at a firm in the banking industry. Some mathematicians might work there as "quants" (modelers of equity or currency prices) at an exceptionally high salary, while others may work as analysts of server reliability, at a far lesser salary. Yet to the unwary researcher, both types of mathematicians would be treated as one. If the foreign mathematicians are disproportionately in the "quant" category, they would misleadingly look as if they are better paid than the Americans. As a CS professor (formerly a professor of electrical and computer engineering) and a former Silicon Valley software developer, I understand the qualitative side of the CS/EE labor market, and thus limit my analysis to that segment of the market.

Demographics

As noted, the H-1Bs are much younger than their coworkers. The figure below shows the age distributions of H-1Bs in computer science and electrical engineering, in the 2003 National Survey of College Graduates:

The computer-related H-1Bs—that is, software developers, database administrators and the like—predominate. During 2000-2009, 46% of H-1Bs were in this category, far more than in the second-largest category, university employment at 7%. Electrical engineers formed only 4% of the H-1Bs.

Computer-related H-1Bs are predominantly from India, with Indian nationals forming 64.8% of the total in 2001.5 Those from China were a distant second at 8.2%, followed by Filipinos at 2.3%

(Hoefer, 2001). It is interesting to look at a breakdown by major firm among green card sponsorees, with respect to the two largest nationalities:

group	% from China	% from India	total % ICs
Qualcomm	13.0%	66.4%	79.4%
eBay	6.8%	70.3%	77.1%
Cisco	10.0%	64.1%	74.1%
Oracle	6.7%	64.6%	71.3%
Intel	10.7%	58.8%	69.5%
Motorola	12.7%	46.8%	59.5%
HP	4.9%	55.6%	59.5%
Google	26.4%	30.0%	56.4%
Microsoft	12.9%	37.6%	50.5%

There is also an interesting trend in time, again among green card sponsorees. Below are the percentages for the two nationalities, among all CS/EE sponsorees:

year	China	India
2005	10.8%	31.2%
2006	9.6%	35.1%
2007	9.2%	36.7%
2008	8.0%	41.5%
2009	7.7%	43.6%

Claims of a Tech Labor Shortage

Starting with its first big campaign to convince Congress to expand the H-1B and related programs in 1998, the tech industry has asserted a tech labor shortage. Yet, other than one survey conducted by the industry trade group ITAA (ITAA, 1997), no study has ever confirmed the shortage claims. Studies by the Department of Commerce, the university computer science consortium known as the Computing Research Association, the Urban Institute's Robert Lerman, and the National Research Council (congressionally commissioned study), have all failed to confirm the ITAA claim of a tech labor shortage.

Vivek Wadhwa, a former tech CEO who now writes about the tech industry, conducted his own survey in 2006 (Wadhwa, 2006). Rather than employing the indirect methods of the earlier studies, Wadhwa and his coauthors simply asked employers about their ability to hire the engineers they need. They found that acceptance rates of job offers were good, and that most job offers did not include

bonuses; both of these findings counterindicate the employer claims of having trouble filling their open positions. Echoing the Cappelli comment cited above, Wadhwa remarked that the industry's claim of a "shortage" is actually "a shortage of engineers below market price that work day and night like slave labor" (Overby, 2007).

In 2011, starting salaries for new computer science graduates were up only 3% from the year before (NACE, 2011), and wages of experienced workers in Silicon Valley had increased only 3% since 2009 (Carey, 2011). Interestingly, the online jobs board Dice.com gave anecdotal evidence of a shortage but then admitted that tech salaries had risen less than 1% in the past year. None of these figures indicates a shortage.

Claims of a Pipeline Shortage

The industry has also claimed a pipeline shortage—not enough American students majoring in STEM at the undergraduate level (ITAA, 1997) (NRC, 2001), and then insufficiently many of them going on to doctoral studies. Let us examine these claims.

The first claim was refuted in an extensive 50-page report by the Urban Institute (Lowell, 2007). The authors found that U.S. universities graduate more than enough STEM students each year to meet the demands of the economy.

This point was put into sharper focus in the 2011 testimony before the U.S. House Immigration Subcommittee, by Texas Instruments V.P. for HR Darla Whitaker (Whitaker, 2011). Ms. Whitaker stated that her firm does not sponsor workers holding only bachelor's degrees for H-1B visas, as the company has no shortage of American applicants.

Since Whitaker's statement that there is no shortage of bachelor's level engineering graduates was at odds with the image often purveyed by the industry, one of the congresspersons on the hearing panel asked her why these engineering students stop at the bachelor's degree level. She answered that the students are anxious to get into the labor market and start earning a living. That in itself raises questions that I will address below, but first one must ask a question that is almost never discussed--do we need so many PhDs in the first place?

For simplicity I will focus here on the PhD, the level usually cited the industry in its advocacy efforts to expand foreign worker programs. The industry lobbyists often cite the fact that 50% or more of the doctoral degrees at U.S. universities are awarded to foreign students. This is reflected in the NSCG data, comparing U.S. natives to former foreign students now working in the U.S.:

degree	% PhD among natives	% PhD among frmr. for.
CS	2.1%	13.9%
EE	4.4%	29.6%

There is a clear disparity here. However, one cannot conclude from these numbers that there is a shortage of American doctoral students in these fields. On the contrary, there are strong indications that we have been overproducing PhDs in these fields. These concerns began back in the mid-1990s, triggered by a Stanford study (Massy, 1995), and continue today.

Overproduction of Ph.D.'s in computer science in particular was a major theme in an article by Professor Anthony Ralston of the State University of New York at Buffalo. Ralston wrote of the underemployment issue:

[In the coming years] we are almost certain to continue to produce more--probably far more--Ph.D.'s in computer science than will be able to find the kinds of research jobs which attracted them to seek doctorates in the first place...[Though they still will find employment], does this justify the cost--to taxpayers, to government, to the students themselves--when the attainment of a Ph.D. adds little to the abilities of the candidates to do [these] jobs? (Ralston, 1996)

Then-CEO of Silicon Graphics, Forest Baskett, wrote that his PhD workers were quite good and that he did not believe there was a surplus of doctorates,, but he conceded (using the language of the Stanford report) that "...it is probably true that they don't have `jobs that really require a Ph.D.'"

It would be easy to dismiss the concerns at the time as being ill-timed Cassandra thinking just prior to the Dot Com boom. However, the issue is just as valid today.

A very illuminating example of this is the CIFellows program of the Computing Research Association, a consortium of the major computer science departments in North American universities. The initiative was launched in 2009 as a post doctoral employment program for new computer science PhDs, to remedy the fact that these graduates were having severe problems finding jobs--termed "crisis conditions in the labor market for computing researchers" in the external report commissioned by CRA to evaluate the program (SRI, 2010). Since CS had never been a field in which post doc work was common (CRA, 2011a), the advent of the CIFellows program was rather revolutionary, and dramatized the poor job market for CS PhDs.

Recently the CRA announced it would probably not continue the project past the 2011-2012 academic year, as the economy has recovered. Yet the situation for CS PhDs is still not good. Indeed, the CRA CIFellows Web page⁷ lists numerous open post doc positions. Given that the CRA defines a post doc as "a person who has recently completed his or her doctoral degree but has not yet found a permanent position on a faculty, in a research laboratory, or in industry" (CRA, 2011a), the CRA's listing of a plethora of open post doc jobs shows that the CRA in fact continues to believe we have a surplus of PhDs after all.

CIFellow Cindy Bethel wrote in the CRA's newsletter in 2011,

The CIFellows Project enabled me to gain new skills and to be more competitive in this challenging job market. This year when academic institutions were receiving 300-400 applications for one posted position, I was able to secure an Assistant Professor position in the Computer Science and Engineering department at a research-intensive university...In 2009, opportunities to find employment in computing research were extremely limited, and unfortunately that situation has not improved much today...(Bethel, 2011)

In other words, the overproduction of PhDs continues today. Indeed, the external report stated,

"Now that the computing research field is maturing, it will not be as easy for the labor market to absorb all newly-minted Ph.D.'s in computing research, and postdocs may help to create equilibrium in the research labor market" (SRI, 2010).

If the industry nevertheless believes that insufficiently many Americans pursue doctorates, the blame must be placed on the foreign worker programs, rather than advocating these programs as a remedy. The large number of foreign students swells the labor market and thus suppresses wage growth, and thus in turn making it financially unattractive for American students to pursue a PhD.

I will return to this point in a later section, but the evidence suggests that the industry finds this wage suppression attractive, and does not actually desire an increase in domestic enrollments.

H-1Bs As Cheap Labor: Type I

There are (at least) two ways that employers save money via the H-1B program:

- *Type I savings*: Involves paying H-1Bs less than comparable U.S. citizens and permanent residents.
- *Type II savings*: Involves hiring younger H-1Bs in lieu of older Americans over age 35.

As discussed in the Overview section above, Type II savings is the more important of the two types, but I first cover the Type I case, as it is also of major interest.

In the following, the reader should keep in mind two central points to be demonstrated here:

- (a) Most employers who use H-1Bs for cheap labor do so *in full compliance with the law*, through the use of loopholes. The problem lies not in fraud or violation of the law, but in the law itself.
- (b) Use of H-1B to reduce labor costs pervades the entire tech industry, including the mainstream U.S. firms. It is not limited to the Indian-owned IT staffing firms.

The legal prevailing wage, and (non-)relation to skill sets:

A key issue in our analyses will be the legally required prevailing wage, and its (non-)relation to

technological skill sets.

Employers are required to pay H-1B workers, and those being sponsored for a green card, the prevailing wage for the given occupation at the given experience level, in the given geographical region. However, the problem is that the legally defined prevailing wage is typically well below the true market wage, as follows.⁸

Employers claim that they hire foreign workers because they have special value in some way, such as experience in a scarce technological skill or extraordinary talent. Since I will deal with the talent issue in another section, I focus on skills here.

The employer claims that the H-1Bs are hired for their special skill sets were exemplified in a 2004 article that highlighted Sutter Health, a

Northern California hospital network:

Sutter has about 25 H-1B visa holders, people whom CIO John Hummel describes as specialists with hard-to-find skills related to medical IT systems. "I don't need [Microsoft OS] NT engineers. I need some very specific [medical] informatics skills," Hummel says. "I've scoured the country, and I can't find that expertise" (McGee, 2004)

In 1998 testimony, Sun Microsystems, a leader in pushing Congress to expand the H-1B program, made a similar statement regarding a shortage of workers with OS kernel skills (Alvares, 1998). The immigration lawyer lobby has given testimony along these lines as well, such as (AILA, 1998) and (Cooper, 2011).

In the open market, employers would have to pay a premium for these rare technological skills. For example, (Matloff, 2003) cited premiums ranging from 16 to 24%. (Drapier, 2011) reported (UK) premiums of 20% for iPhone and Android developers, and even up to 70% for Ruby, Hadoop and HTML5. Those who know Hadoop (a cloud computing platform) can get 25% more salary, according to (Darrow, 2012).

Yet these premiums for skill sets are not factored into the prevailing wage. The latter is merely the average salary for a generic worker who does not possess "hot" skills. In determining prevailing wage, the Department of Labor (DOL) offers employers two options—either use a private salary survey, or utilize DOL's automated system, the Online Wage Library (). Though an employer can do better (in the sense of obtaining a lower prevailing wage) with a private survey, most choose the DOL system instead, as DOL considers it "safe harbor," i.e. automatic acceptance. The employer logs on to the DOL Web page (<http://www.flcdatcenter.com>), where he is asked the worker's occupation, experience level (I through IV) and geographical location. The employer is not asked whether the worker has skill, say, in Hadoop or any other skill.

In other words, *the legal prevailing wage is below market value*, and the employer of the H-1B gets a special-value worker for the price of an average one, thus less than what he would need to pay a similar special-value American. This point will be central in the analyses below.⁹

Recognition of the fact that the legally required wage is below the real market wage has been occasionally recognized by government. An employer survey conducted by the GAO (GAO, 2003) found that some employers readily admitted to paying H-1Bs less than Americans, but noted that they were nevertheless paying the legally required wage, thereby illustrating that the latter is indeed below the market wage. Representative Zoe Lofgren has remarked that the Department of Labor found that the average wage for computer systems analysts in her district was \$92,000, while the legal prevailing wage was \$52,000 (Thibodeau, 2011).¹⁰

Previous research:

The industry has vehemently denied underpaying the H-1B workers. Indeed, the question as to whether holders of the H-1B work visa are paid less than comparable Americans has been the subject of controversy in the research literature, even in the case of academic studies. (I will limit the presentation here to academic work, as it is peer-reviewed.)

My research for CS/EE estimates the underpayment at 15-20 percent (Matloff 2003). A study of earlier data even calculated the pay gap for engineering to be 33 percent (Ong 1997). Hunt, analyzing

all college graduates, with no restriction on field, found that the group of interest here—those who first arrived as foreign graduate students—were making significantly less than comparable natives (Hunt 2009).ⁱ On the other hand, Mithas and Lucas (Mithas 2010) found that foreign IT workers are actually paid 2.3 percent more than comparable Americans.

A key aspect of these studies is the data set. Mithas and Lucas, for example, based their analysis on a reader survey of a magazine for IT managers, not mainstream engineers and programmers. Also, the average age in their sample was about a decade older than among H-1Bs in general, thus again indicating that the Mithas and Lucas study may not be generalizable to the mainstream. Though Hunt corrects for field of highest degree (but not current profession), her data set is extremely broad, with unknown consequences to the analyses.

An even more important issue is that in attempting to determine whether H-1Bs are paid less than comparable Americans, the key word is *comparable*. As discussed above, “hot” technological skills command a wage premium in the open market, so the only truly accurate analysis would be to compare, say, H-1B Android developers to American Android developers (of the same age, education and so on). Thus, ideally researchers' statistical analyses should include a variable for experience with “hot” skills. Yet such data is not available, and if, say, Android programmers are disproportionately foreign, as the industry claims, the analysis would misleadingly make the foreign workers appear to be doing well relative to the Americans.

Analysis based on limitation on mobility:

Second, foreign workers have a lower *reservation wage* in economics terms—they are willing to work for lower pay than what comparable Americans would earn. As pointed out above, immigrant status, i.e. a green card, is a form of highly-valued nonmonetary compensation for the foreign workers. And even those who do not stay permanently will have valuable American work experience when they return home. These considerations result in a lowered reservation wage, so the foreign worker may earn less than his American peer even at the time of hire.

Unfortunately, this also renders H-1Bs who are being sponsored for green cards essentially immobile, unable to allow other employers to compete for her services. During the lengthy period of the green card process, often six years or more, the worker dare not switch to other employers, as it would entail starting the green card process again. Her employer thus may not give her raises as large or as frequent as those her American peers are receiving (NRC, 2001).¹¹

Basic economic theory then implies that the foreign workers, not being free agents in the labor market, will on average not get the best salary deal. In other words, *they will on average be paid less than comparable Americans*.

These points were confirmed and quantified in (Mukhopadhyay, 2012). The authors compared immigrants to immigrants (in general, not just in STEM), a very direct approach and found that “acquisition of an employer-sponsored green card leads to an [average] annual wage gain of about \$11,860.” The lead author explained the cause of the deficit in a press interview (Wharton, 2012):

"Employers know they have these workers over a barrel," Mukhopadhyay said. "They aren't going to demand a raise during those six years, even if they deserve it, and they aren't going to move on to another company, because they know doing those things will jeopardize their chances of getting their green cards in time."

Mukhopadhyay said there are regulations to try to prevent employers from paying lower wages to those here on work visas than they pay to U.S. natives, but, "there are ways around the regulations, and obviously, employers are aware of these loopholes and are using them. Some of these loopholes have been documented extensively in the popular media."

As noted, the Indian IT staffing firms only rarely sponsor their foreign workers for green cards, so the Mukhopadhyay analysis effectively excludes them.

Even Mithas and Lucas, cited above as finding that the H-1Bs are paid more than Americans, recognize this basic point:

Possession of a green card provides greater bargaining power...for an IT professional compared to someone with a[n H-1B] work visa because...employers typically hold work visas, which

makes it difficult for an IT professional to easily change his or her employer...

And indeed the authors found that workers with green cards earned more than H-1Bs.¹²

Analysis based on the below-market nature of the prevailing wage:

As shown earlier, the legally required prevailing wage is typically well below the true market wage. Here I will use this fact to present further analysis that the foreign workers are paid less than comparable Americans.

Toward this end, I looked at the PERM data, 2005-2010, consisting of records of all employer-based applications for worker green cards. For each worker I calculated the wage ratio (WR), meaning the ratio of their salary to the prevailing wage. Since the latter is below market level, a value of WR near 1.00 indicates underpayment of the worker. Note that by law, DOL will not approve any application for which WR is below 1.00.¹³

Here are the WR values for occupations of interest:

Worker Category	Median.Wage Ratio
Software Engineers	1.01
Electrical Engineers	1.00
Computer Scientists	1.04

Thus most foreign workers were being paid at or near the prevailing wage. Since that latter value is low, we see that *most foreign workers are paid less than comparable Americans*.

Type II Savings

As seen above, employers do tend to pay H-1Bs lower wages than they pay comparable Americans. Since this is due largely to the mobility limitations discussed earlier, many well-meaning reformers have proposed as a remedy awarding automatic green cards to newly-graduated foreign student who earn STEM degrees at U.S. universities. This eliminates (or reduces) the period of *de facto* indentured servitude, thus ameliorating the Type I salary savings problem.

But this thinking overlooks the central issue, which is that Type II savings—hiring young foreign workers in lieu of older (age 35+) Americans—is the primary reason why employers hire foreign workers. As seen below, Type II is where the major cost savings occur, and as noted earlier, the H-1Bs tend to be markedly younger than their American colleagues. This makes the H-1Bs cheaper. The proposals for permanent resident status are thus just as harmful to American workers as is the H-1B work visa, because the vast majority of new foreign graduates are *young*.

To see the scale involved, consider a comparison of wage distributions in Figure 1 among new computer graduates and all software engineers, as of 2005, shown below (Matloff, 2006).

worker group	25th Wage Percentile	Median Wage	90th Wage Percentile
new computer science graduates	\$45,000	\$50,664	\$61,500
all software engineers	\$65,070	\$82,120	\$120,410

Thus, then, the potential for labor cost reduction via H-1B is even greater for Type II than for Type I. Once again, note that this data essentially excludes the Indian IT staffing firms.

The industry lobbyists acknowledge that the H-1Bs tend to be younger, but claim that that is because only new graduates have the latest skills, which older workers could acquire only after undergoing

training. Yet there have been a number of instances in which U.S. firms such as Pfizer, Nielsen, Wachovia, and the Bank of America have reportedly laid off American tech workers, replacing them with foreign workers, and forcing the Americans to train their foreign replacements (Hira, 2010). Clearly it was the foreign workers that lacked the skill set, not the Americans.

The industry's own lobbying report used to convince Congress to expand the H-1B program in 1998 (ITAA, 1997) showed that the skills issue is merely a pretext to avoid hiring the older, i.e. more expensive workers. Allowing an IT worker to acquire new skills makes him a flight risk:

“You take a \$45,000 asset, spend some time and money training him, and suddenly he's turned into an \$80,000 asset,” says Mary Kay Cosmetics CIO Trey Bradley. That can lead to another problem. New graduates trained in cutting edge technologies become highly marketable individuals and, therefore, are attractive to other employers.

In other words, the real issue is not acquiring the skills, but that workers possessing the skills are more expensive. Obviously Bradley did not want to pay that higher price, and the ITAA message here is that the H-1B program provides a cheap alternative.

Former tech CEO (and current supporter of establishing an automatic green card program for STEM foreign students) Vivek Wadhwa has spoken on this a number of times, saying for example,

...even if the [older] \$120,000 programmer gets the right skills, companies would rather hire the younger [i.e. cheaper] workers. That's really what's behind this (Lehrer 2009).

Back in 1998 Congress, accepting the industry's claim that older tech workers' employment difficulties are due to lack of newer skills, added a user fee that employers of H-1Bs must pay, to go into a retraining fund. This failed to reduce H-1B usage (Vaas 2000), not surprising in light of the Wadhwa remark above--even if the skills issue were not a pretext, in the end a retrained expensive older programmer would still be an expensive older programmer. So, when the employers run out of younger Americans (often before that), they turn to hiring younger H-1Bs. The visa program has, in other words, become a vehicle for rampant age discrimination in the industry.

The skills issue is treated in detail in (Matloff, 2003; Matloff, 2006).

The Best and the Brightest?

I now turn to the other question that arises frequently in discussions of H-1B: Are industry claims that H-1Bs tend to be “the best and the brightest,” key to America's ability to innovate? My approaches consist of regression analyses on salary, patenting activity and work in research and development (R&D), followed by an analysis of CS dissertation awards.

In the three regression analyses, I look at the 2003 NSCG data, restricting to the following groups. I cover every full-time, nonmanagerial, nonsales worker who satisfies the following conditions:

- had his/her highest degree in the CS/EE field
- was working full time in a U.S. position in CS/EE as of 2003
- if foreign-born, originally entered the U.S. on a foreign student visa

In addition, to avoid complications involving the exploitation of H-1Bs, in the case of my salary analyses on the NSCG data I imposed an additional condition on the foreign-born:

- was a U.S. citizen (naturalized) or permanent resident as of 2003

Note that we thus are comparing U.S. natives to former foreign students now working in the U.S. For simplicity, I will refer to the natives as “Americans,” but it must be noted that many of the former students have naturalized and are now Americans too.

Note also who is excluded. First, the analyses exclude those who entered the U.S. on a work visa, so as to concentrate on mainstream U.S. firms and exclude the Indian IT staffing firms.

Also excluded are those who immigrated under family qualifications and the like. Some researchers have found U.S. education to be an important variable, which may play a role in the American cultural propensity for innovation. The easiest way to study this is to restrict to U.S. natives.

Wage Analysis

I ran a regression analysis, in order to assess how salary is affected by age, education level, region and original F-1 status. The latter is an indicator variable regarding the type of visa a person first held upon entering the U.S., with the variable being equal to 1 if the person came here as a foreign student, 0 otherwise.ⁱⁱ Similarly, there is an indicator variable for having a master’s degree (without a PhD), one for a doctorate, and one for working in a high cost-of-living region. (Those with just a bachelor's degree are indicated by the presence of 0 values in the master's and PhD variables.)

The regression equation was

$$\begin{aligned} \text{mean wage} = & \\ & \beta_0 + \beta_1 \text{ age} + \beta_2 \text{ age}^2 + \beta_3 \text{ MS} + \beta_4 \text{ PhD} + \beta_5 \text{ highCOL} + \beta_6 \text{ origF1} + \\ & \beta_7 \text{ acad} + \beta_8 \text{ gov} \end{aligned}$$

Here are the results:

OLE-object

OLE-object

I place regression coefficient values that are statistically significant at the 5% level in bold face. The estimated coefficient for the former foreign students, **-5278.43**, is negative and statistically significant. In other words, the former foreign students working in CS are earning significantly less than the Americans.

Rather than merely reporting the results of statistical significance tests, I also report margins of error, i.e. radii of approximate 95% confidence intervals for the coefficients. Use of margins of error, i.e. confidence intervals, rather than significance tests, yields more informative results (Freedman 1998; Kaye 2000).

The regression results for the EE case are as follows:

OLE-object

Here the coefficient for former foreign student status was not significantly different from 0.

Looking at the two regression results, we see that no “best and brightest” trend was found for the former foreign students. On the contrary, in the CS case the former foreign students appear to be somewhat less talented on average than the Americans.

Salary and Language

(Hunt 2011) speculated that the reason her analyses found Asian immigrants lagging behind the Europeans in salary was language. However, this does not seem to explain the salary results in our previous sections.

The tech industry is famously meritocratic for engineering workers. (For managerial jobs and venture capital, the field is considered to be much less meritocratic.) Workers produce tangible product of crucial value to the firms, and if you successfully write the code or design the chips, you are rewarded. Professor Joyce Tang found that language skills were not a barrier to Asian immigrant engineers, even for those who wish to obtain academic positions (Tang 2000). My logistic regression analysis on the 2000 PUMS census data (not presented here) shows that among immigrant Chinese engineers and programmers, English skill has no statistically significant impact on the probability of earning a high salary, defined to be above \$150,000. The dominant H-1B group, the Indians, typically grow up with English, and often dazzle U.S. professors with language skills exceeding those of the American students.

Patent Activity

There have been a number of recent studies on immigrant patenting in the tech area. Several have attracted considerable attention (Wadhwa 2007; Hunt 2010; Kerr 2010). However, they are not very useful in the present context, as their findings essentially boil down to stating, “Immigrants are numerous in the tech field, and thus they are also numerous in patent activities.”

None of these studies addresses the central question relevant here, which is whether the foreign workers programs are raising our average level of tech talent. The relevant question is whether the immigrant tech workers are more prone to patenting on a per capita basis, especially after education and other variables are taken into account. As discussed earlier, due to the internal brain drain, this per-capita issue is crucial; are the immigrants of higher quality than those they are displacing?

With that in mind we turn again to the NSCG data. We no longer restrict to U.S. citizens and permanent residents, but remove those in academia and government, where patenting rates are lower. The table below displays the regression analysis in the CS case, expressing mean number of patent applications filed in terms of age, education and original F-1 status:

OLE-object

The coefficient for original foreign student status, -0.44 is significantly different from 0 at the 5%

level. In other words, on average the former foreign students are producing about a half a patent fewer per person than are Americans of the same age and educational level.

On the other hand, in EE the former foreign students' patenting activity is not significantly different from the Americans:

OLE-object

In summary, the former CS students apply for somewhat fewer patents than do their American peers, while in EE the foreign and American groups have the same mean numbers of patents.

Again, the data certainly do not show a "best and brightest" tendency among the former foreign students.

R&D Work

Presumably much (though by no means all) of the innovation in the tech industry comes from those working in research and development (R&D) positions. It is thus of interest to investigate the proportions of U.S. versus immigrant workers who hold such jobs. Fortunately, the NSCG data include a variable for this status.

Here I used a logistic regression model for the probability of working in R&D with the following results for CS:

OLE-object

The former foreign students in CS are significantly less likely to be working in R&D than the Americans.

Here are the results for EE:

OLE-object

Here again, the former foreign students are less likely than comparable Americans to be working in research and development.

So, as with wages, we find that not only are the former foreign students not of especially high talent level, they are on average less talented than the Americans.

Dissertation Awards

The previous sections involved analysis of wages, presuming that the top innovators in a firm would also get top wages (among non-managerial workers). My analyses in this and succeeding sections will more directly address the innovation issue. In this section, we look at awards for top PhD dissertations.

Each year, the Association for Computing Machinery (ACM) selects one or more dissertations in computer science for its ACM Doctoral Dissertation Awards. These awards by definition select the very top innovator or innovators. The ACM's press release for its 2010 award, for instance, stated:

Craig Gentry has won the 2009 Doctoral Dissertation Award from ACM...for his breakthrough scheme that solves a central problem in cryptography... His dissertation... adds a crucial layer of safety and privacy to the online world in settings ranging from banking and healthcare to networks and cloud computing. This approach allows users to outsource the processing of data without giving away access to the data...

I thus compare the percentage of foreign students among the awardees to the percentage of foreign students among all doctorates earned in computer science, to assess whether foreign students disproportionately win the award.

The NSCG data show that 51% of the CS PhDs in the U.S. as of 2003 had originally entered the U.S. as foreign students. The Computing Research Association's annual Taulbee Survey shows that of the CS PhDs granted between 1994 and 2007 (mainly in the U.S., but including Canada as well), 48% went to international students.

When the ACM first started its dissertation awards program in 1978, there were fewer Chinese foreign students, an important group, so I did not include those earlier years. Instead, I took 1985 as my starting point, following the lead of Orleans, who viewed the influx of Chinese foreign students as having hit a kind of steady state by then (Orleans 1988).iii

During the period 1985-2009, a total of 29 dissertation awards were given to students at North American universities (28 in the U.S., one in Canada). Of these, 14 went to foreign students. This fraction, 0.48, has a margin of error of 0.19, and is not statistically different from the figures of 0.51 and 0.48 stated above for the proportion for former foreign students among CS PhDs.

Thus foreign students earned the dissertation award roughly in proportion to the presence in the doctoral student population, again indicating that the foreign students are similar to, rather than more talented than, their American classmates.

For STEM in general, an earlier study cited by researcher David North found that their U.S. Doctoral degrees tended to be from the academically weaker universities (North 1995). The lower the ranking of the school, the higher the percentage of international students.

Summary on the Talent Issue:

Though there are indeed some truly outstanding individuals, I find no evidence of general outstanding talent among the former foreign students. Indeed, on some measures, the former foreign students appear to be weaker than the Americans.

Impact of Tech Immigration on the U.S.

The salient issue here is that due to the cheap labor issue tech immigration has suppressed wage growth, crowded out mid-career U.S. workers, and discouraged America's own "best and brightest" from staying in the field or entering it in the first place.

The financial crash of 2008 makes long-term comparison difficult, but recent data counterindicates shortage claims. The National Association of Colleges and Employers (NACE) tracks salaries of new graduates. They report that computer science starting salaries just kept pace with inflation from 2010 to 2011, with a 1% increase (NACE 2011a). Though EE was an exception with a 4.4% advance (after

a dip of 1.2% the previous year), overall engineering starting salaries essentially stayed flat since 2010, with a 0.3% increase. In turn, the 2010 salary levels were actually 0.5% lower than in 2009 (NACE 2011b).

The foreign worker programs are directly and indirectly displacing Americans. In other words, these programs are causing an internal brain drain from technology fields in the U.S.

In some cases, the displacement has been direct, with mainstream firms firing Americans and replacing them with workers on H-1B and L-1 visas, and requiring the Americans to train their foreign replacements as a condition for severance pay (Hira 2010). However, most displacement is less direct, with foreign workers being hired in lieu of Americans.

The impact is particularly acute on those who are older—which in the tech field, means over age 35. Employers prefer to hire the younger, thus cheaper, H-1Bs instead of the older, thus more expensive, Americans..

The tech industry's hiring focus on the young has been well documented (NRC 2001; Brown 1998; Brown 2009). (The NRC suggested that this was due to older workers having out-of-date skill sets, an assertion to be countered below.) Microsoft admits that “the vast majority of Microsoft hires are young, but that is because older workers tend to go into more senior jobs and there are fewer of those positions to begin with” (emphasis added) (Wadhwa 2008), a very telling slip.

As discussed before, it appears that we are producing too many PhDs in CS. But if we value having Americans with doctorates, it must be noted that the foreign worker programs have caused displacement of American students at the graduate level. The influx from abroad has hindered salary growth at that level, hence making pursuit of graduate degrees unattractive to U.S. students.

The displacement of Americans at the PhD level was actually projected by a federal agency. In the late 1980s, the Policy Research and Analysis division of the National Science Foundation, our government's central science agency, complained that PhD salaries were too high. In an unpublished report, PRA proposed a remedy in the form of importing a large number of foreign students, stating,

These salary data show that real PhD-level pay began to rise after 1982, moving from \$52,000 to \$64,000 in 1987 (measured in 1984 dollars). One set of salary projections show that real pay will reach \$75,000 in 1996 and approach \$100,000 shortly beyond the year 2000...

[Thus, to] the extent that increases in foreign student enrollments in doctoral programs decline or turn negative for reasons other than state or national policies it may be in the national interest to actively encourage foreign students. One way to do this is to ensure that foreign students have equal access to graduate student support funds provided through federal agencies. Another approach is to grant permanent resident status or immigrant status to foreign students successfully completing PhD degrees at U.S. Institutions (Weinstein 1998).

Note carefully that the PRA projected that the resulting stagnant salaries for PhDs would drive the American students away:

A growing influx of foreign PhDs into U.S. labor markets will hold down the level of PhD salaries...[The Americans] will select alternative career paths...by choosing to acquire a "professional" degree in business or law, or by switching into management as rapidly as possible after gaining employment in private industry...[as] the effective premium for acquiring a PhD may actually be negative.

It is not clear whether the PRA report represented official NSF policy. However, we see that at the least, the NSF was aware that an increase in foreign students would suppress wages and thus

drive American students away from PhD programs. This forecast proved accurate, as did the projection that American students would shift to business and law.

The adverse impact of the foreign students on U.S. engineers has been noted by a team of Berkeley researchers (emphasis added):

...high-tech engineers and managers have experienced lower wage growth than their counterparts nationally... Why hasn't the growth of high-tech wages kept up?...Foreign students are an important part of the story...Approximately one-half of engineering PhDs and one-third of

engineering MSs were granted to foreign-born students in the mid-1990s (Brown 1998; Brown 2009).

Former Fed chair Alan Greenspan has also advocated the use of the foreign worker programs to keep tech salaries low (Greenspan 2008).

One result of these trends has been to discourage young people from pursuing a career in the tech industry. A *Forbes Magazine* article cites the disturbing effects of stagnant salaries and offshoring:

Between 2003 and 2006 the percentage of graduates from MIT going into financial services rose from 13% to almost 25%...One can hardly blame these young hires. Financial firms offer considerably higher pay, better career prospects and insulation against off-shoring, than traditional science and engineering companies...

This same phenomenon holds even within the tech industry itself. The PERM data show that Microsoft pays its financial analysts and lawyers much more than it pays its engineers. Young people see these market signals and respond accordingly.

Even Professor Ed Lazowska, a former chair of the CRA and a perennial advocate of the view that we have a shortage of tech workers, recognizes this impact of the foreign worker programs. In an Internet discussion, he wrote,

"If, 15 years ago, entry-level engineers and computer scientists had been paid what entry-level lawyers and financiers were getting paid, then it's reasonable to guess that today, 15 years later, we would have lots more entry-level engineers and computer scientists. So, if the question is 'Do US companies offshore and hire H-1B's because of the need for talent, or because of the cost of talent?' the answer is 'yes.'"

I have always strongly supported bringing in the world's "best and brightest," but the data show that only a small percentage of those brought in under foreign worker programs are in that league. Reform of the system is needed to focus on the truly outstanding talents, possibly by granting automatic green cards to those with salary offers in the 90th percentile range.

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