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Hearing on:
"Immigration Reforms Needed to Protect Skilled American Workers"

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Mr. Chairman and members of the committee, thank you for inviting me to speak on the topic of "Immigration Reforms Needed to Protect Skilled American Workers," and in particular on high-skill labor demand and supply, and the size and impact of the high-skill guestworker labor force. My analysis draws on several decades of workforce research on technology industries, globalization, and several recent in-depth studies of science, technology, engineering, and math (STEM) labor supply and currently, on STEM educational pathways and attainment. This research was conducted with my colleagues Leonard Lynn at Case Western Reserve University, Lindsay Lowell at Georgetown University, and Daniel Kuehn at American University, and has been funded by the Sloan Foundation, the National Science Foundation (NSF) and the Kauffman Foundation.[1]

Assessing approaches to immigration reform for high-skill workers involves, at the core of the issue, understanding whether the nation benefits from technology firms using their current levels of high-skill guestworkers and the likely impact of various legislative changes proposed such as those in I-Squared, The SKILLS Act, and S.744. Let me start with a point on which nearly all are in agreement: guestworkers can be an important source of labor market adjustment and can contribute to U.S. industry and productivity. ***Thus,*** the issue is *not* about whether or not to have guestworkers; it is about determining the right number and the policies governing their work conditions. In terms of high-skill guestworkers, primarily on H-1B and L visas, determining the right number, or evaluating whether increases or decreases in the number are best for the economy, and impact on the American worker, we want to know: Is there a shortage that impedes business productivity and growth and national prosperity? Answering this question depends fundamentally on examining the evidence about three issues:

(1) The adequacy of supply of U.S. STEM graduates and workers[2];

(2) The size of current and proposed guestworker flows;

(3) Impact on U.S. workforce, on innovation capacity, and on the nation.

When considering the issues of whether there are enough U.S. students and workers to fill STEM jobs, whether industry has a real labor shortage or is just dissatisfied with the time and effort it takes to find the workers it wants, or is dissatisfied with the wages it needs to pay to get the workers it wants, let me say that there is no single study that conclusively answers those questions; our measures are often imprecise or at an aggregate level that may not address the situation in each and every firm or industry. What we want to consider, thus, is what is indicated by the *preponderance of evidence*, and what are the *most direct and relevant measures* of the demand for, and impact of, STEM guestworkers.

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[1] The projects are supported through grants from the Alfred P. Sloan Foundation, the National Science Foundation, (Human and Social Dynamics Program, #SES-0527584; Social Dimensions of Engineering, Science, and Technology #0431755); and the Kauffman Foundation. Expert research assistance and analysis was provided by David Hersh and Susan Ferrara. The views expressed are those of the author and should not be attributed to Rutgers University, the J.J. Heldrich Center or the E.J. Bloustein School, the National Science Foundation, the Alfred P. Sloan Foundation, or the Kauffman Foundation. This research was conducted with my colleagues Leonard Lynn at Case Western Reserve University, Lindsay Lowell at Georgetown University, and Daniel Kuehn at American University. Author's papers cited and excerpted are available at policy.rutgers.edu/STEM

[2] "U.S. workers" and domestic workers/workforce denotes both native and immigrant workers, and both citizen and permanent resident (green card) workers; that is, from a labor market perspective, the labor pool is segmented into those workers in the U.S. who comprise the labor pool directly available to employers as distinct from the guestworker labor pool, which is available only through policies and conditions set by Congress.

My colleagues and I have examined the key questions using multiple methods, data, and indicators—from fieldwork and interviews at firms in the U.S. and globally, to analysis of large, national datasets. The preponderance of evidence is quite clear that:

(1) The U.S. supply of top performing graduates is large and far exceeds the hiring needs of the STEM industries, with only half of new STEM graduates finding jobs in a STEM occupation (and only a third of all STEM graduates in the workforce holding a STEM job);

(2) All market indicators, such as wages and employment rates suggest that, with few exceptions, an ample supply of labor is available given current and projected demand (demand for computer science graduates, as stated by the information technology (IT) industry, can be met by just half to two-thirds of the current annual supply of U.S. graduates);

(3) Guestworker supply is large and highly concentrated in the IT industry; it is likely a factor in the flat wage levels in the IT industry and perhaps for a substitution of young, entry-level guestworkers for experienced, incumbent, U.S. workers;

and most importantly,

(4) The *predominant* function of IT guestworker visa programs is to facilitate the offshoring of IT work—that is, the ability of firms to move IT work from the U.S. to offshore locations is highly dependent on their supply of H-1B and L visas for their companies. These are companies such as IBM, Accenture, Deloitte, Ernst & Young, as well as the internationally based firms such as Infosys, Wipro, and TCS.

The second, and growing use of guestworkers is by product firms and U.S.-based service firms to staff their workforces for largely domestic-based projects. The largest H-1B visa sponsors among these would include Microsoft, Google, Intel, Oracle, Apple, and Amazon (Top 100 H-1B Visa Sponsors, 2013). There are then a number of smaller firms that provide, in aggregate, significant staffing services both temporary and permanent. These firms supply guestworkers to a range of other firms and are more often identified as those offering substantially lower wages and engaging in substandard labor practices.

These findings suggest that:

(5) The large use of guestworkers by firms in each of these segments combine, in aggregate, to distort the STEM labor market, with the number of guestworkers equal to two-thirds of current entry-level and early-career hiring. It is high-skill guestworker policies, rather than market competition, that currently determine working conditions and job opportunities for U.S. STEM workers, with diminished opportunities for students and workers who wish to pursue a career in the IT industry.

(6) Current guestworker visa policies for students and new graduates appear to provide incentives to colleges and universities to establish master's degree programs that, as their business model, almost exclusively recruit foreign students into lower quality programs that provide easy entry into the U.S. labor market, further expanding the supply of entry-level STEM workers.

(7) Proposed high-skill guestworker legislation would expand the supply of guestworkers to levels greater than the total number of new technology jobs; that is, these visa changes would provide enough guestworkers to fill every new job opening in the IT workforce with a reserve

large enough to allow firms to legally substitute young guestworkers for their incumbent workforce, both directly and through expanded offshoring.

(8) "Green Cards for Grads" provisions in I-Squared and other bills would further distort the U.S. higher education system, providing incentives for colleges and universities to establish, or expand current master's degree programs as a "global services" business that offers a green card for the price of a graduate degree, and that are offered primarily or even exclusively for foreign students and directly or indirectly exclude U.S. students.

In sum, current policies and the proposed changes in visa and immigration policies that increase the supply of high-skill guestworkers are likely to exacerbate the already deteriorating labor force conditions and career prospects for STEM graduates and workers. Notably, it is only the IT industries that claim worker shortages whereas in nearly all other STEM fields there is an acknowledged need to address problems of oversupply and, in many science fields, poor career prospects for STEM graduates (e.g., National Institutes of Health, 2012; Stephan, 2012).

1. The Supply of STEM Graduates

The U.S. STEM workforce numbers about 7.5 to 8 million, or about 5 percent of the workforce. The computer occupations comprise about half (48.5%) of the STEM workforce at 3.7 to 4 million workers. According to the Bureau of Labor Statistics (BLS) projections for IT job growth, which is comprised of replacements (for those leaving the workforce because of retirements and job separations—layoffs and quits) and growth of the workforce, the IT industry needs approximately 124,000 new workers each year. Mircosoft's Washington representative and counsel Brad Smith (in his Congressional testimony) uses an earlier BLS projection of an annual increase of 122,000[3], and the trade organization Code.org, echoed by the Computing Research Association, use 150,000 as the expected annual demand for new IT workers (Harsha, 2014). Smith and these associations then assert that the BLS workforce growth estimates represent the demand exclusively for computer science graduates. Matched against annual computer science graduation of 67,000 in 2012, the claim of a supply shortage is made. It is these statistics and claims that are repeated widely.

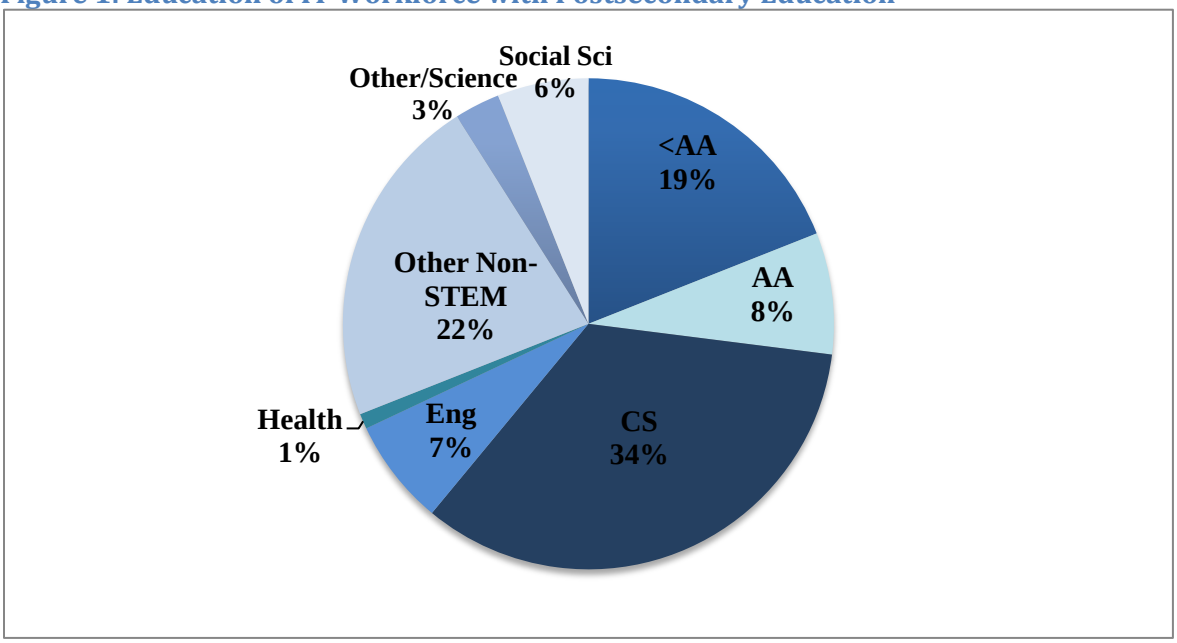
However, such claims misinterpret the BLS workforce projections for the computer occupations in asserting it is a demand only for computer science graduates. For example, Daniel Costa conducted a detailed study of these computer science shortage claims by Microsoft and other companies and shows the evidence does not support these claims because, among other reasons, "[i]t is a well-known fact that computer science graduates are not the only source of new hires in computing….less than one-fourth to less than one-half of workers in computing occupations have a computer science degree" (Costa, 2012). In fact, of those currently in computer occupations, only 14 percent hold a computer science degree and another 4 percent have electrical engineering degrees. Since that reflects the education level of the entire current IT workforce of all ages, it could understate the current cohort education levels.

Examining recent cohorts of all new entrants into IT occupations who have a postsecondary education, we find 34 percent have a bachelor's or master's computer science degree (See Figure 1); of just the pool of four-year college graduates entering computer occupations, 46 percent have a computer science degree.

[3] In a notable misstatement of the BLS projections, Brad Smith testified before the Senate Committee on the Judiciary in 2013 that, "The Bureau of Labor Statistics has projected approximately 122,000 new job openings each year in computing occupations requiring at least a bachelor's degree through the end of this decade. Yet nationally, our universities are only producing approximately 51,000 bachelor's degrees in computer science each year" (Smith, 2013). In fact, as clearly stated in the BLS projections, these openings are for computer occupations at all education levels and fields of study, of which about one-third are for those with at least a bachelor's degree in *any* field (U.S. Bureau of Labor Statistics, 2014). This misstatement has, however, been widely reported as evidence of "shortage" (e.g., Thoppil, et al., 2013).

About 36 percent of entrants into computer occupations do not have any four-year degree. Thus, we estimate that demand for new workers in computer occupations with a computer science degree as approximately 29 percent of the BLS projection of total demand for new workers (64% of new workforce entrants in computer occupations have a four-year degree and 46% of those have a degree in computer science, or 29% of all new workforce entrants). Using the actual educational composition of the computer occupations as an estimate of hiring demand by education and degree, the supply of computer science graduates needed to meet industry demand would be approximately 36,500 computer science graduates each year (based on the BLS projection of 124,000 new jobs; see U.S. Bureau of Labor Statistics, 2014). Figure 2 shows the historical graduation numbers of computer science graduates.

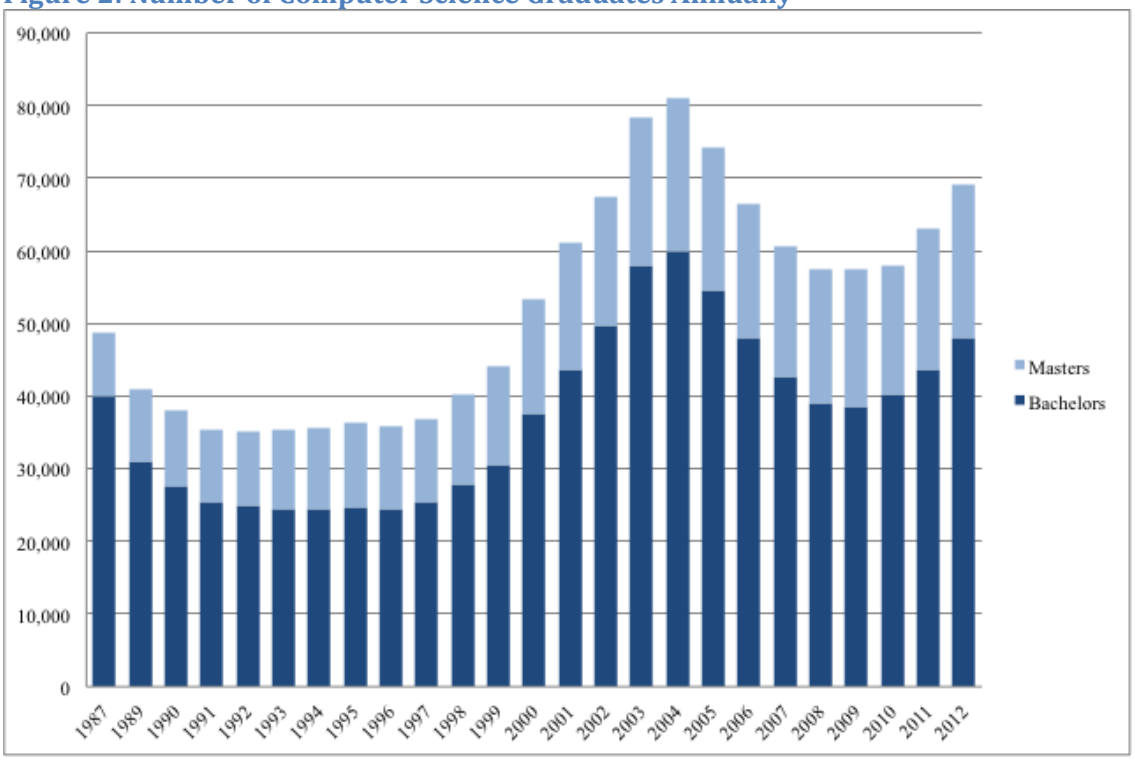
Figure 1: Education of IT Workforce with Postsecondary Education



Source: National Center for Education Statistics. (2013). 2003–2004 Beginning Postsecondary Students Longitudinal Study (BPS) [Restricted data file]. Washington, DC: U.S. Department of Education; tabulations by authors.

Current graduation rates indicate that projected employment demand specifically for computer science (CS) graduates can be met by about half of the current supply of 65,000 to 70,000 CS graduates (with at least a bachelor's degree) each year, and the balance of demand can be met by those graduating with a range of other degrees, as is the historical pattern. Even if current industry hiring is for a much greater level of computer scientists than historical hiring patterns, the current pool of graduates would provide sufficient numbers of computer scientists to meet industry demand. Our analysis of a large, nationally representative survey of a recent college cohort by the National Center for Educational Statistics finds that only two-thirds of computer science graduates went into IT jobs in 2009 (that would include all IT jobs, not just those for formally defined "computer occupations"). Of those not landing an IT job, half said they found a better job elsewhere. Fully one-third reported there were no IT jobs available (although this was the year after the start of the Great Recession, this is only slightly lower than the historical trend; Salzman, et al., 2013). Also worth noting is that an additional 64,341 students earned an associate degree or certificate in IT in 2012, also far exceeding the expected growth of 44,600 new IT workers with less than a bachelor's degree for work in the computer occupations (many of whom do not require an associate degree or certificate).

Figure 2: Number of Computer Science Graduates Annually



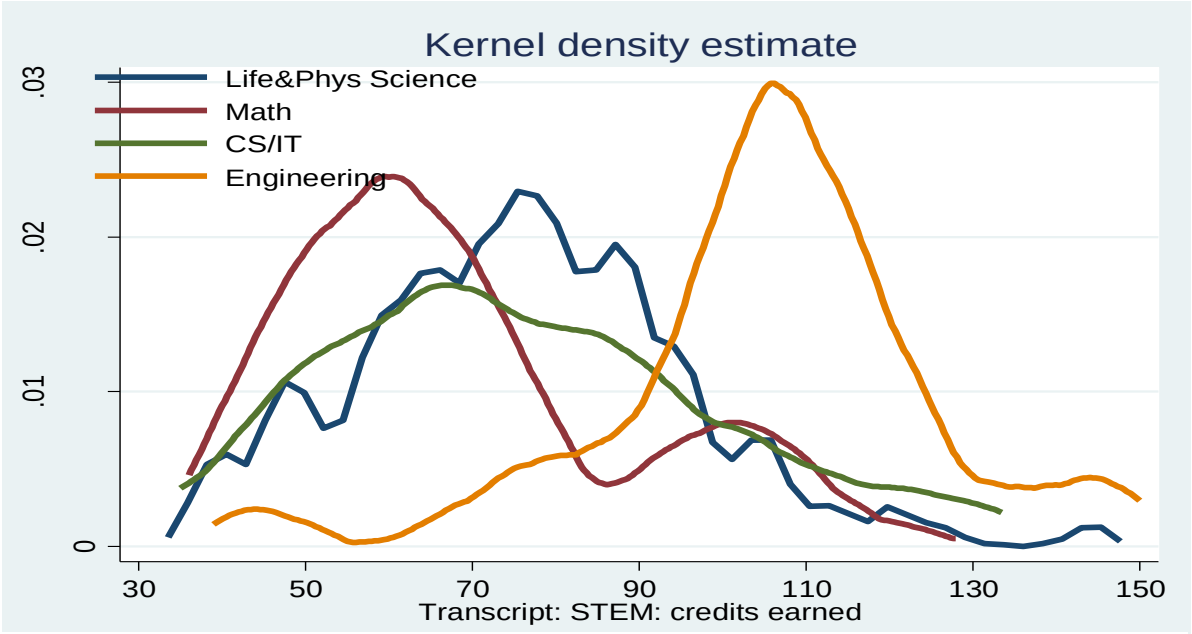
Source: National Center for Education Statistics, Higher Education, General Information Survey and Integrated Postsecondary Education Data, 1987–2012; tabulations by Daniel Kuehn, American University; David Hersh and Hal Salzman, Rutgers University.

STEM beyond IT

The demand for guestworkers and the various claims of "shortages" often discuss the labor market demand as a more general STEM workforce and industry problem. As noted above, guestworkers are predominantly employed in the IT industry, and are predominantly used to support offshore software development, with a second significant use to provide lower cost labor for positions in the U.S., either directly for software product firms or for their subcontractors and personnel staffing firms. If there really were a shortage of technical and scientific talent in the U.S., we should observe it in other STEM industries, not just in IT. In fact, most of the other STEM occupations and industries—science, engineering, and math—should have workforces that are more difficult to develop given the more demanding requirements and longer time period required for education and training. Of all the STEM fields, "T", which is almost exclusively computer science at the four-year college degree level, and math (also an IT "feeder" major) are the least demanding fields of all the STEM disciplines in terms of STEM credit hours.

Computer science and math majors take far fewer STEM credits than either science or engineering graduates, as can be seen in Figure 3, which plots the distribution of credit hours by major (of those graduating at four-year colleges). It should, thus, be easier to expand the number of computer science and math majors than science and engineering majors given current resources. It is hard to understand how such education or supply failures would occur only in a field that would appear to be the most readily responsive to market demand given the lower credit hour requirements (i.e., which provides easier entry during college since it would take fewer credits to fulfill the major requirements than either science or engineering).

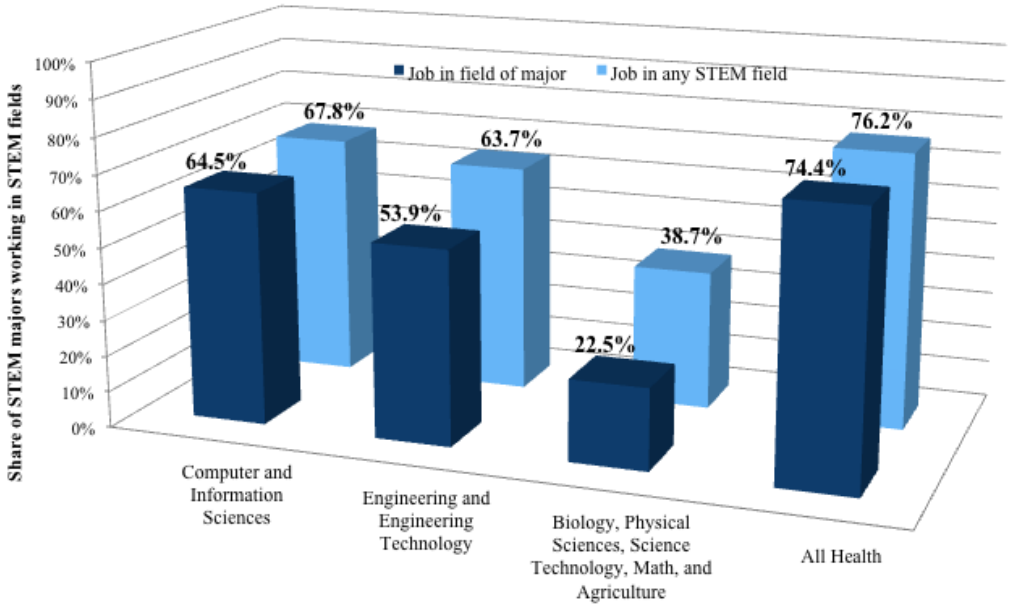
Figure 3: Credit Hours by Graduating Major



Source: National Center for Education Statistics. (2013). 2003–2004 Beginning Postsecondary Students Longitudinal Study (BPS) [Restricted data file]. Washington, DC: U.S. Department of Education; tabulations by authors.

Yet, science and engineering firms are not claiming they need guestworkers to address a shortage. In fact, study after study of science careers consistently find there is a glut of Ph.D. life scientists resulting in poor employment prospects for new graduates and postdoctoral scientists (e.g., Teitelbaum 2008, 2014; Stephan, 2012; Freeman, 2004; NIH, 2012). The National Institutes of Health (NIH) has developed a program to help new biomedical Ph.D.s find alternative careers in the face of "unattractive" job prospects in the field, where less than a quarter of Ph.D. graduates will find a career research and teaching position (NIH, 2012). The NIH Director's "Broadening Experience in Scientific Training" (BEST) program was launched three years ago in response to findings by many researchers and the NIH Advisory Committee to the Director Biomedical Workforce Task Force, which found few career opportunities for biomedical scientists in traditional science fields; this program is intended to address the oversupply of biomedical scientists by developing alternative career paths they can pursue. Overall, in the science fields, there are twice as many university graduates at the bachelor's degree level than the number who enter into a science occupation every year. Similarly, engineering schools graduate 50 percent more graduates than find jobs in engineering each year (see Figure 4); the one engineering area where there has been a shortage, petroleum engineering, is the exception that proves the rule (see discussion of petroleum engineers, below).

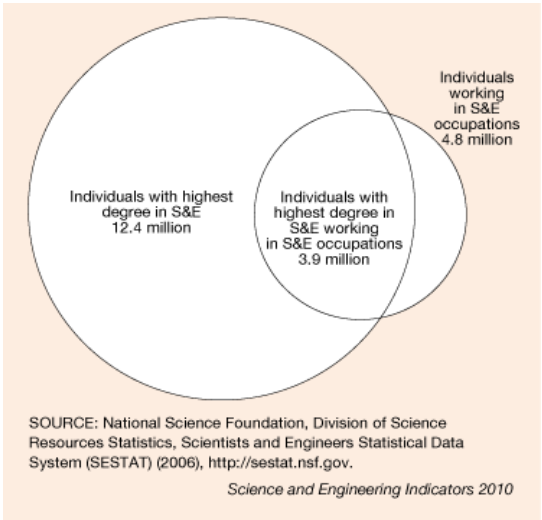
Figure 4: Occupational Field of STEM College Majors One Year After Graduation, 2009



Source: National Center for Education Statistics. (2013). 2003–2004 Baccalaureate and Beyond Survey (B&B) [Restricted data file]. Washington, DC: U.S. Department of Education; tabulations by authors.

If we examine the entire workforce, of all incumbent workers currently employed, a recent study by the U.S. Census Bureau finds that of those who have a STEM degree (excluding social sciences), only 36% are employed in a STEM field (U.S. Census Bureau, 2012). This is consistent with the NSF analyses of field of degree and occupation. Figure 5 shows the NSF analysis of degree holders and occupations, showing less than one-third of science and engineering degree holders are in a science or engineering occupation. Although some portion of the STEM degree holders who are not in a formal STEM job are no doubt working in jobs utilizing their STEM education, the evidence suggests there is still a very large supply of STEM educated workers available to STEM industries if there were demand for them. The evidence does not reflect a deficit in the number of STEM graduates in the workforce or in our current annual production rates of STEM graduates.

Figure 5: Highest Degree in S&E and Occupation



Rather than "shortages," the concern about the STEM workforce overall is about the worsening career prospects and indications that supply far in excess of demand weakens the labor market in these fields, motivating students to pursue careers elsewhere. This was the finding in the analysis of changes in the composition of STEM graduates going into STEM jobs over the past three decades. Findings show that although the overall supply remained strong, fewer of the highest performing students were going into STEM jobs (Lowell, Salzman, et al., 2009). Other STEM workforce researchers find similar outcomes and evidence supporting similar conclusions. Even the lead author of a widely-cited study that asserted the need for more STEM graduates, Tony Carnevale of Georgetown University's Center on Education and the Workforce said, "If you're a high performing math student in America, from a purely economic point of view, it's crazy to go into STEM" (Light and Silverman, 2011). And, in fact, many of the top students flock to Wall Street and corporate law firms and other non-STEM jobs.

It is thus curious that claims about "STEM shortages" only assert a need to fill IT jobs for which, paradoxically, the vast majority are not filled by STEM graduates. Nor do most IT jobs require the education or training of a STEM degree (which, in any case, is the least demanding of all STEM fields in terms of STEM credit hours). Moreover, these shortage claims rest almost entirely on employer reports about the difficulties they face in hiring but little substantiating evidence of a shortage.

Fieldwork research including ours (Lynn and Salzman, 2010; Salzman, 2000), finds that reports of hiring difficulties often reflect unrealistic expectations. Traditionally, during tight labor markets, such as before the dot-com crash, employers will hire good candidates who may not be "perfect," but the firms will invest in training them. However, recent studies of employer recruiting find a *decrease* in recruitment intensity and little evidence of efforts to address unmet hiring needs. Peter Cappelli (2012) of the Wharton School concludes that employers have become willing to wait, hoping for the perfect candidate, the "purple squirrel," believing that unemployment is high and there must be someone who will not require training. Because it is a slow economy, there is less urgency to fill positions quickly and a longer search time is possible.

Do Markets Work? The Case of Petroleum Engineering[4]

Petroleum engineering offers an important case of observed labor market shortages and the market response of firms and students. It is instructive to consider in light of current claims about market failure in the IT sector and industry's assertion that they are unable to obtain the needed supply of graduates from U.S. colleges and universities. This case is of further interest because, as noted above, engineering is the most demanding college major in terms of credit hours, technical content, and time to completion whereas computer science and math degrees have the lowest course hour distribution of the STEM fields, suggesting increases in engineering supply should be more difficult to achieve than in other fields.

In the 1970s, the building of the Trans-Alaska Pipeline and increased oil exploration in other regions led to rapidly increasing demand for petroleum engineers. By 2002, however, *Occupational Outlook* forecast an employment decline "because most of the petroleum-producing areas in the United States already have been explored" (BLS, 2004), and this continued to be the forecast through the 2008 edition of *Occupational Outlook*. In the most recent edition, 2014-2015 however, the BLS forecast changed to a projected employment increase of 26 percent over the coming decade because "petroleum engineers increasingly will be needed to develop new resources, as well as new methods of extracting more from

[4] This section is excerpted from Lynn, Salzman, and Kuehn (2015) "Dynamics of Engineering Labor Markets: Petroleum Engineering and Responsive Supply" in Freeman, R. and H. Salzman (eds.) *Engineering in a Global Economy* (forthcoming, 2015) NBER and University of Chicago Press.

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existing sources." The shift to greater exploration followed the 2008 oil price spike, which also increased the returns to investments in types of oil extraction that were previously cost-prohibitive (e.g., tar sands), thus increasing the demand for petroleum engineers, especially those with new skill sets.

The number of job openings began to exceed the number of graduates around 2002, even though there still had been no overall workforce growth. This was because of retirements and little hiring since the earlier oil boom and hiring expansion of the 1970s and 1980s. In some interviews with managers in oil companies in the mid-2000s, high levels of concern were found because the large cohort of engineers hired in the 1970s and 1980s was retiring just as the firms were launching large development and maintenance projects. This underlying demand was then exacerbated by the oil price spike, which intensified exploration efforts as higher oil prices made previously unprofitable exploration profitable.

The response to this confluence of events—little hiring for many years, a current workforce that was aging and retiring, and sudden increase in oil exploration—led to a classic textbook example of market disequilibrium. The earlier shortage had already led to increases in starting salaries, but with the oil price spike petroleum engineering starting salaries rose even further, becoming the highest of all fields of engineering for new bachelor's degree graduates (National Association of Colleges and Employers, 2010). Starting salaries jumped from an already high $43,674 in 1997 to $50,400 in 1999. Starting salaries rose further to $55,987 in 2003, $61,516 in 2005 (Bureau of Labor Statistics, 2004, 2006), and $86,220 in 2010 (National Association of Colleges and Employers, 2010).

In all these years, petroleum engineering salaries were higher than other engineering salaries but, until the spike in demand, the petroleum engineering starting salary premium was relatively small. For example, the 1997 $43,674 starting salary for petroleum engineers was only slightly greater than that for the second highest paid engineering field, chemical engineers, who received an average starting salary of $42,817. In 2010, however, the starting salary of $86,220 for petroleum engineers was much higher than that of the second highest field, still chemical engineering, which was only $65,142 (National Association of Colleges and Employers, 2010).

In response to this and other market signals the number of new petroleum engineering degrees awarded by U.S. universities more than tripled (*American Oil & Gas Reporter*, 2010). In just the period from 2007-2008 to 2010-2011, U.S. university petroleum engineering departments increased the number of Ph.D. graduates from 39 to 95. Texas A&M and Colorado School of Mines more than tripled their output of new graduates from 42 to 128 and 32 to 100, respectively. Reports from some petroleum engineering programs indicate an even greater increase in demand in subsequent years (TTU, 2010). The dramatic increase in petroleum engineering followed the steep rise in starting salaries, which in turn reflected an observable increase in industry demand. This would seem to be a clear textbook case of efficient and responsive market functioning. It seems to show that normal market mechanisms, namely wage increases, can dramatically and quickly increase supply. The immediate and dramatic increase is all the more remarkable given the credit hour and course demands of the engineering degree—further raising doubts about claims that colleges and universities are not able to graduate enough computer science students to meet market demand.

2.Guestworker Flows[5]

The H-1B nonimmigrant visa use is dominated by the IT sector. Under international trade law, the United States may not restrict the annual number of H-1B visas to fewer than 65,000 annually, but U.S. law has been amended to provide an additional 20,000 visas for foreign STEM graduates of U.S. universities, and there is no cap on the number of H-1Bs sponsored by nonprofit employers such as universities.

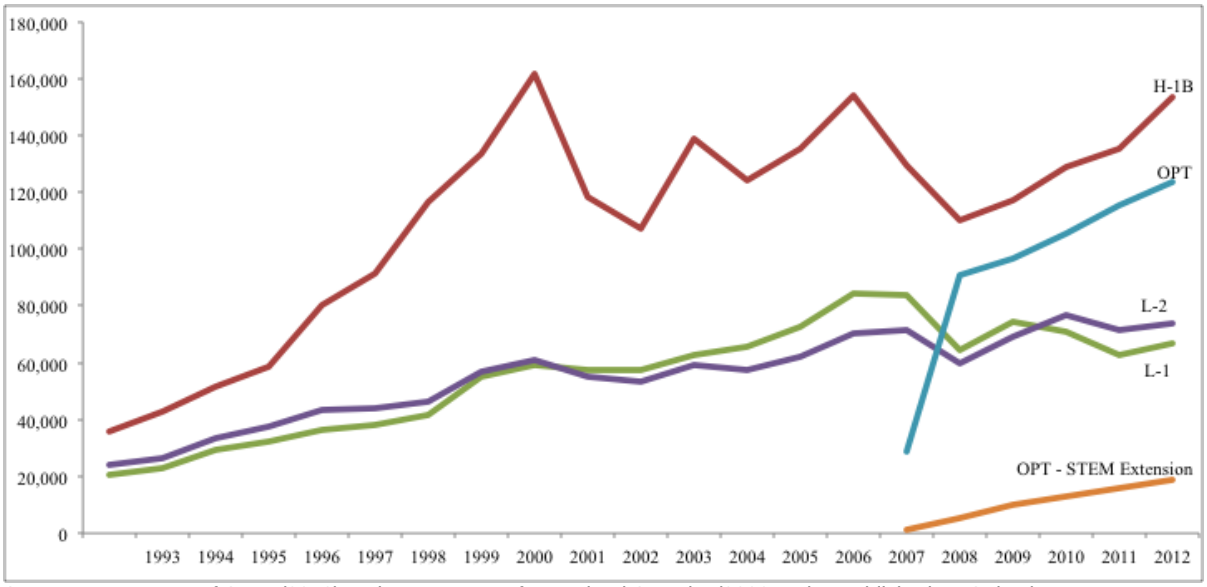
[5] This section is excerpted from Salzman, et al., (2013).

The next largest visa used by STEM employers is the L-1 visa for intracompany transferees. The L-1 has two categories, the L-1A for executives and managers (it permits work for up to seven years) and the L-1B for employees with "specialized knowledge" (it permits work for up to five years). Spouses and children of L-1 workers may be admitted with an L-2 visa, which grants the L-2 holder work authorization for the same amount of time as the principal L-1 holder. There are no caps on the L visa, and its use has increased over time.

An unknown but substantial proportion of foreign students on F-1 nonimmigrant student visas change status directly to the H-1B visa if sponsored by an employer, while many other foreign students first work after graduation through the Optional Practical Training (OPT) program. The permitted stay to work under the OPT was two years in the past, but it has been changed to 12 months. In 2008, however, the program was extended by 17 months for graduates in STEM fields, meaning that these graduates can work on OPT status for a total of 29 months.[6] Another temporary visa that often supplies workers for IT jobs is the O-1 visa for workers of extraordinary ability (10,590 total O-1 visas were issued in 2012).

Figure 6 shows the annual number of visas issued to guestworkers in the relevant visa categories, i.e., the H-1B, the L, and foreign-student OPT workers (see Appendix A for method and calculations). The number of workers hired in these visa categories has been growing over time. The H-1B trends reflect the booming demand during the dot-com bubble years and a congressional cap that was raised to 195,000 (it dropped down to 65,000 in 2003). The H-1B numbers dropped sharply after 2001, only to rise again up until the recession of 2008. Use by employers of all of the guestworker visa programs declined following the crash of the economy in 2008, but it has been increasing since that time. In FY2011, these guestworker visa programs totaled 372,000 workers.

Figure 6: Guestworker Visas Issued Annually, By Program or Visa Category, 1991-2011



Source: Department of State (2012) and Department of Homeland Security (2008 and unpublished DHS data).

[6] The government's rationale for the 17-month extension was to "reduce some of the hardship imposed by the H-1B visa cap." At the time the extension was created, the H-1B cap for the fiscal year was reached quickly, and the OPT program was intended to allow employers to keep STEM graduates employed in the country while they waited for an H-1B visa to become available (Thibodeau 2008).

The predominant employers of guestworkers are either in the IT industry or in non-IT industries but with IT occupations to fill. For the H-1B workers, about 50 to 60 percent are approved for employment in formally defined IT occupations.[7] There are no official, detailed statistics on the occupational categories of L-1 visa holders, but a 2006 study by the Department of Homeland Security (DHS) Office of the Inspector General (OIG) concluded that the evidence suggested the L-1 visa was effectively "The Computer Visa." The study noted that, although "the L-1 visa program is not specifically tailored for the computer or information technology industries, the positions L-1 applicants are filling are most often related to computers and IT." In addition, "...nine of the ten firms that petitioned for the most L-1 workers were computer- and IT-related outsourcing firms that specialize in labor from India...[and] almost 50 percent of the L-1B (specialized knowledge) petitions...named beneficiaries…born in India" (DHS 2006, 4). Other analysts have also concluded that the L-1 visa is primarily used for the IT industry and IT occupations, and that the number of all L visas has been steeply increasing since the Inspector General's report in 2006. There are no publicly available data on the number of L-2 visa holders (for spouses of L-1 visa holders) who have been granted employment authorization by DHS or where they are employed. There are also no publicly available occupational or employer data on initial OPT visas (the maximum 12-month work permit provided to all college graduates on an F-1 visa), but data was obtained on the 17-month OPT-STEM extension applicants for 2008 through early 2013. This analysis found the vast majority (77 percent) were for IT occupations and/or IT firms (the other major group is biomedical and pharmaceutical industries). Because these guestworker programs are clearly used most intensively by the IT industry and for IT occupations, the focus of this analysis is on the IT workforce to identify the role of guestworkers and potential workforce impacts.

The H-1B and F-1/OPT guestworker visa categories are primarily for workers with at least a bachelor's degree, though the H-1B category does permit use of experience as a degree equivalent.[8] Except for L-1 visas granted under a "blanket" petition, which requires the worker to possess a college degree, the main L-1 visa categories do not have a college degree requirement; they require only that the worker be coming to fill a managerial/executive position (L-1A) or a position requiring specialized knowledge (L-1B). However, the 2006 DHS OIG report suggested that the L visa is more likely to be used by employers to import workers with a foreign college degree of three years instead of the U.S. standard of four years, than to hire those without a college degree at all. The L-2 spousal/child visa has no education, degree, or skill requirement (but the spouse may work, unlike, say, the spouse of an H-1B visa holder). Given the wide range of educational levels in the IT workforce, guestworkers at many different education and skill levels could be employed in the IT sector. The combined number of annual IT guestworker entrants (of those with work visas eligible for employment) for FY2011 is thus conservatively estimated to range from 134,000 to 228,000.

The crucial question is: How significant is the flow of guestworkers into the IT labor market? We first look at this flow as consisting of the pool of eligible IT workforce entrants. Ideally we would want to know how many job openings were filled by guestworkers and how many were filled from the domestic labor pool (again, the domestic labor pool comprises both citizens and permanent residents). Unfortunately, the data on job openings in the IT field are not available; the best data available to address this question measure job tenure of those in IT occupations.[9] We examine the number of IT workers who

[7] The IT occupations are those classified by the Bureau of Labor Statistics; some analyses classify workers based on the business of their employer, whether or not they hold a formal IT occupation. This leads to some inconsistency in estimates of "IT workers." In general, occupational analyses include only IT occupations, and the industry analyses use all workers in IT firms. This guestworker analysis examines both occupation and industry, as noted in the figures.

[8] See Immigration and Nationality Act, Section 214(i); 8 USC 1184(i).

[9] Jobs that started in the last year are a reasonable proxy for new hires in the absence of new hire data. Job tenure information is taken from the January 2012 Current Population Survey's "Job Tenure" supplement, and should therefore serve as a reasonable proxy for jobs started in 2011 (data are available on new hires and job openings by industry, but not occupation; these data will be reviewed below).

began their jobs in the year 2011 and were still employed in January 2012, and we compare that to the number of guestworkers who were approved for initial work in 2011. While the annual entry of guestworkers could be taking IT jobs that were opening due to turnover, as well as those newly created, we cannot ascertain these two types of jobs openings from these data. Because these are the only reliable data available on new guestworker entrants, as well as on total new IT jobs, we compare these two measures to gauge the relative supply of guestworkers in the IT sector.[10]

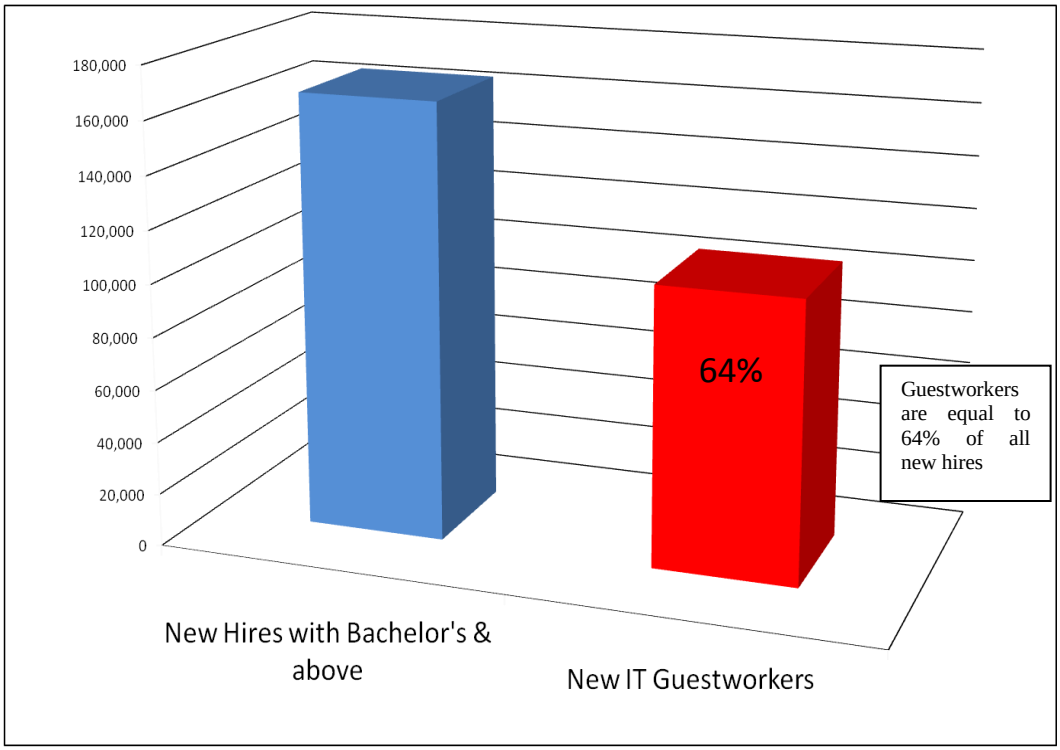
We estimate that during FY2011, 372,516 high-skill guestworkers were issued visas to enter the U.S. labor market, and, of these workers, between 134,000 and 228,500 were available for IT employment. We use the mid-range estimate of 160,755 IT guestworkers for the year FY2011.

Hiring and Age/Education of the IT Workforce

In January 2012, 698,412 workers reported that they started an IT job over the course of 2011. These estimates of the number of potential new guestworkers in IT fields equal, at the mid-range estimate of 160,755, almost a quarter of all new hires in these occupations. However, as discussed earlier, the IT workforce is comprised of workers with a wide range of skills and education, while the high-skill guestworker programs are specifically designed to limit this guestworker population to those with particular skills and/or a college degree. In fact, the data on high-skill guestworkers show that nearly all have at least a bachelor's degree. We thus examine the characteristics of the new guestworkers and jobs held by workers with similar educational backgrounds and age groups. The population of IT workers with a college degree (bachelor's and above) who started their jobs during 2011 is 483,692. Of these, the 160,755 guestworkers represent approximately a third of all new IT jobs (specifically, we estimate the number of guestworkers to range from a low of 28 percent to a high of 47 percent of the number of all IT jobs in 2011 that were filled by a college graduate hired in that year). One-third (34.3 percent) of workers who began their IT jobs in 2011 were under the age of 30; among guestworkers approved for H-1B visas for initial employment in 2011, the under-30 share was 57 percent (DHS 2012). An even higher share of F-1/OPT guestworkers are likely to be under the age of 30, since it is a benefit extended to recent college graduates. A more detailed analysis of the age distributions of U.S. workers beginning their IT jobs during 2011 and H-1B guestworkers approved for initial employment shows striking differences: more than half (52 percent) of new U.S. IT hires were over the age of 35, compared to only 18 percent of H-1B new workers. If we examine IT new hires and IT guestworkers under the age of 30—the population of entry-level and early-career workers—we find that the number of new guestworkers in 2012 was equal to nearly two-thirds (64%) the number of *all* new hires under age 30 in the United States (Figure 7).

[10] An alternative measure would be to divide the annual change in the population of temporary workers by the annual change in the total workforce. But we cannot do that here because the only estimates available at this time are the annual entry numbers. An estimate based on employment change for H-1Bs was conducted for the late 1990s, and it found that the H-1B visa averaged 20 percent of total employment growth during that decade. During the peak years of H-1B entries, however, growth in the H-1B workforce was over half of total IT employment growth (Lowell 2001, 131-62).

Figure 7: New IT Hires/Guestworkers Ages 30 & Below



Source: Authors' analysis of Current Population Survey Job Tenure Supplements microdata; Department of State (2012), Department of Homeland Security (2008 and unpublished DHS data).

3. Who Uses Guestworkers and What is Their Role? How U.S. Guestworker Policy Supports Offshoring of IT Work

The predominant demand for guestworkers is in the IT industry and, within the IT industry, it is by the offshoring companies. The use of guestworkers is required to support offshore IT development because a portion of the project team (often estimated as about one-third of the entire project team) is dedicated to managing the customer account in the United States, to do requirements analysis, quality assurance, implementation, and liaise with the offshore team. Without this onshore team, it would be nearly impossible for a company to do offshore development. It is thus not the case, as often asserted, that without guestworkers firms would move their work offshore. It is, in fact, quite the opposite: without guestworkers, conducting work offshore would be much more difficult and the cost savings would be substantially reduced. This finding is based partly on fieldwork (Salzman, 2000; Salzman and Biswas, 2001), but also comes directly from the statements of offshoring companies in their U.S. Security and Exchange Commission (SEC) filings (10-K and 20-F forms).

Infosys, one of the larger Indian IT consulting and services firms, and one of the larger users of H-1B visas in 2013, states that provisions in the early drafts of Senate legislation (no longer in current versions such as I-Squared) that would "…require employers to pay higher wages & conduct U.S. worker recruitment, and limit number of H-1B and L-1 workers in a company's U.S. workforce and ability of company to place H-1B and L-1B workers at third party worksites…" would lead to a situation where the "…cost of doing business would increase" (Infosys, 20-F, 2014). The result of such legislation would be that, "Any restriction on ability to deploy trained offshore resources at client locations may require Infosys *to replace existing offshore resources with local resources*, or hire additional local resources,

potentially *at higher wages*." [emphasis added] This is because, according to Infosys, the "…majority of professionals in the U.S. hold H-1B visas or L-1 visas; *ability of our technology professionals to engage in work-related activity abroad depends on ability to obtain the visas and permits*."[emphasis added] Further, "Reliance on work visas for a significant number of technology professionals makes Infosys particularly vulnerable to such changes and variations as it affects our ability to staff projects with technology professionals who are not citizens of the country where the work is to be performed."

It is worth noting that nowhere does Infosys state that it would be unable to find sufficient workers in the U.S. and who are eligible to work (i.e., U.S. citizen, permanent resident, or current holders of work visas) but, rather, that it would raise their costs and require them to change their business model to one relying on U.S. hiring.

Another large IT offshoring company, Wipro, discusses proposed restrictions on guestworker visas as well. They note it would affect their "…ability to compete for and provide services to clients in U.S." because they might not be able to "…continue to be able to obtain any or a sufficient number of H-1B and L-1 visas for our onsite employees on the same timeframe as we currently maintain." Interestingly, Wipro discusses as a potential risk to their business growth and revenue the increased scrutiny of L visa workers by United States Citizenship and Immigration Services, noting specifically that it would limit use of labor that is "…essentially an arrangement to provide labor for hire rather than in connection with the employee's specialized knowledge." It would seem the implication is that such enforcement would curtail current practices.

It is not just the Indian offshore firms that note the impact of potential restrictions on use of guestworkers. The U.S. consulting firm Accenture, also a large H-1B employer with a large offshore operation, notes in its 10-K that if it is "…unable to deploy needed talent because of increased regulation of immigration or work visas, including limitations placed on number of visas granted, limitations on type of work performed or location in which work can be performed, and new or higher minimum salary requirements, could be more difficult to staff employees on client engagements and increase costs." Worth noting is that the problem appears to be one of costs and difficulty in offshore staff working in the U.S., but not a potential "shortage" of workers.

Cognizant, a New Jersey based IT consulting company with large offshore development operations, reports that the "…U.S. Congress has recently considered and may consider in the future extensive changes to U.S. immigration laws regarding admission of high-skilled temporary and permanent workers. *If such provisions are signed into law, cost of doing business in the U.S. would increase*...[and would]… *impair ability to staff projects with professionals who are not citizens of the country where the work is to be performed*." Their report further notes that, "…Any inability to travel could cause us to incur additional unexpected costs and expenses or could impair our ability to retain the skilled professionals we need for our operations." [emphasis added]

This review of selected company SEC filings about "Quantitative and Qualitative Disclosure About Market Risk" finds that companies that use offshore software development (both U.S. and non-U.S. firms) have business models that depend upon access to large numbers of guestworker visas. Further, that these guestworker visas provide a cost advantage over hiring from the U.S. labor force, as noted throughout the SEC disclosures. Importantly, there is no mention by U.S. or non-U.S. companies that guestworker visas provide labor that would otherwise be unavailable in the U.S., only that using U.S. workers would increase costs and make offshoring less profitable and potentially uncompetitive with firms that did development work solely or largely in the U.S.

It should be noted that there are a few companies that have decided to develop IT services firms that are based exclusively on domestic sourcing, namely hiring from the U.S. labor pool rather than using guestworkers, and on conducting the development work wholly within the U.S. (Thibodeau, 2012). These

are companies such as Nexient[11], led by Neeraj Gupta, Rural Sourcing Inc.,[12] founded by Monty Hamilton after he left Accenture consulting, and Brian Keane who founded Ameritas Technologies[13] after he left the IT services business his father founded and that Brian developed into an offshoring company, which was later sold to an offshoring firm. These firms demonstrate there are alternatives to offshoring in this industry that could expand if there were changes in guestworker policy that did not continue the current distortion of the market.

4. Impacts

Historical trends in wages

The impact of guestworkers on the labor market and wages can be assessed through a number of different measures. As noted earlier, we are examining multiple measures to understand dominant trends and whether multiple measures are consistent in indicating labor market impacts. We first examine several different measures of wages: by occupation, by industry, by geographical region. Then we examine wages, guestworker supply, and computer science graduate trends. Beginning in the 1990s, wages and employment rose steeply to a peak during the dot-com boom. (This trend has been reviewed in recent research by Costa, 2012; Lazonick ,2009; Lazonick, et al., 2014; and Matloff, 2013 as well as by other researchers in recent years.) Through the 1990s and until 2004, we observe the expected relationship between unemployment and wages; in the 1990s unemployment was low and wages grew strongly, both signs of growing demand for IT workers. After the bursting of the dot-com bubble, a period of high unemployment was accompanied by a tapering off of IT wage growth. However, starting around 2004, a different pattern emerges. Although the recovery of the 2000s brought down unemployment and increased employment, wage growth never resumed. These flat wages do not appear to reflect a level of unmet demand.

A more detailed analysis of the IT industry has been undertaken by Lazonick (2009),[14] who focused on four key information and communication technology areas: semiconductors, software publishing, computer programming, and computer system design, with data up to 2006. Figure 8 updates the data to 2010.[15] Lazonick's analyses also examine the employment and wage trends in different industry segments

[11] Nexient describes the company as: "…is the pioneer in onshore agile software development services. Launched in 2009, the company today has over 60 scrum teams across 5 US based delivery centers supporting dozens of Fortune 500 and high growth mid-market enterprises."

[12] Rural Sourcing describes its business model as one that "…utilizes software development centers in tier 2 cities within the same country or geographic domain as the project. …providing efficient and knowledgeable US teams working in an Agile software development environment. This methodology enables us to build development, management and consulting teams catered to an organization's needs without creating unnecessary overhead and additional management priorities…."

[13] Ameritas's business model is developed on their mission, stated as: "We believe strongly that our domestic outsourcing services bring greater convenience and higher responsiveness to dynamic business needs. Add our relentless focus on quality, and our drive to continually improve productivity and cost effectiveness, and the result is a superior customer experience that easily surpasses other outsourcing options….[and provides "value to clients" because it can deliver services where] "Ability to outsource projects not suited for offshore delivery…[and where they can] Demonstrate a commitment to US job creation; American job creation; Rebuild US IT capabilities by developing domestic outsourcing capabilities and growing the pool of trained and experienced resources."

[14] See Lazonick (2009, 18-20, 57-66). Lazonick uses U.S. Census Bureau County Business Patterns data to chart employment and real wages by industrial classification, by state and zip code from 1994. The latest available data are for 2010 (http://censtats.census.gov/cbpnaic/cbpnaic.shtml). Updated charts in Lazonick, et al., 2014.

[15] SIC classifications for 1994–1997 and NAICS classifications for 1998–2010:

- Semiconductor and related devices: SIC 3674, NAICS 334413
- Software publishing: SIC 7372, NAICS 511610 and 334611

and regions, with particular focus on the high-tech regions of Silicon Valley in California, the Route 128 corridor in Massachusetts, and the cities of Dallas and Austin in Texas. The trends in each of these labor markets show similar patterns: steep increases in employment and wages during the dot-com boom, a collapse in 2001, and then increases in employment and wages in some industry segments and regions (but still well below the peaks of 2000) until the crash of 2008.[16]

There are important differences in trends by region and occupation. Policy discussions about the IT and guestworker labor markets tend to focus on Silicon Valley and big product companies like Apple. But as the following figures show, the Silicon Valley pattern in employment and wage levels is not representative of the industry as a whole. For example, a sharp increase in computer system design employment in Silicon Valley in 2010 was primarily the result of the dramatic growth of employment at Apple in response to the success of the iPhone and the launch of the iPad, but significant employment and compensation increases were not observed in other locations.

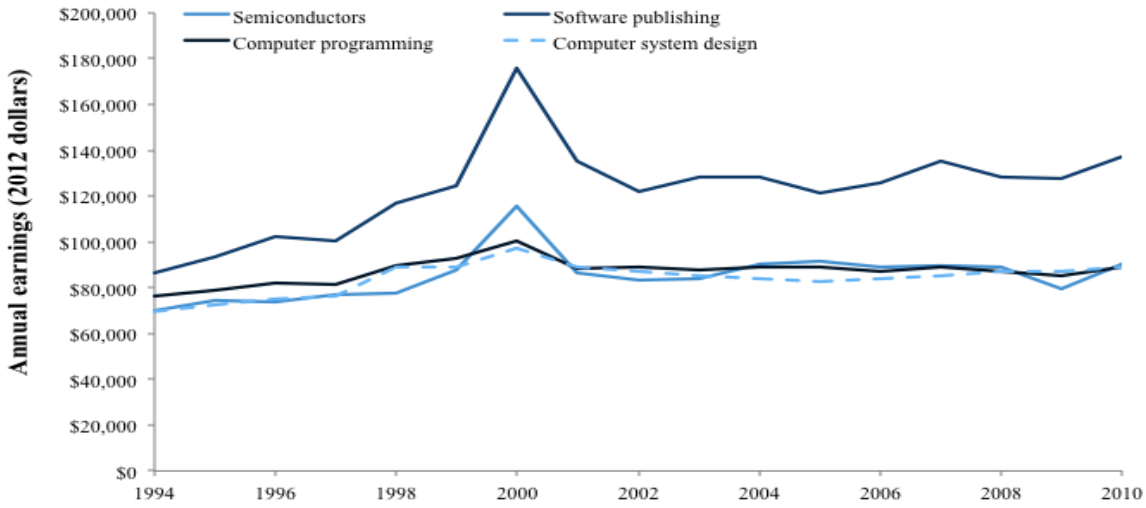
Programming employment exhibited the strongest growth during the dot-com boom and again before the 2008 recession, but computer design and semiconductor employment experienced no recovery. Programming is the lower paid and generally lower skilled of the occupations, and there is a secular decline in wages over the past decade; in many cases they even fall below the lowest levels reached after the dot-com crash (Figure 8).

Even in the dynamic technology regions of Silicon Valley, Route 128, Dallas, and Austin, the local earnings data shown in Figure 9 for workers in computer programming and computer system design reveal no signs of the rising wages that would be expected to occur if employers were hiring in a market that had a limited supply of workers.

- Computer programming services: SIC 7371, NAICS 541511
- Computer system design: SIC 7373 plus half of 7379, NAICS 54152.

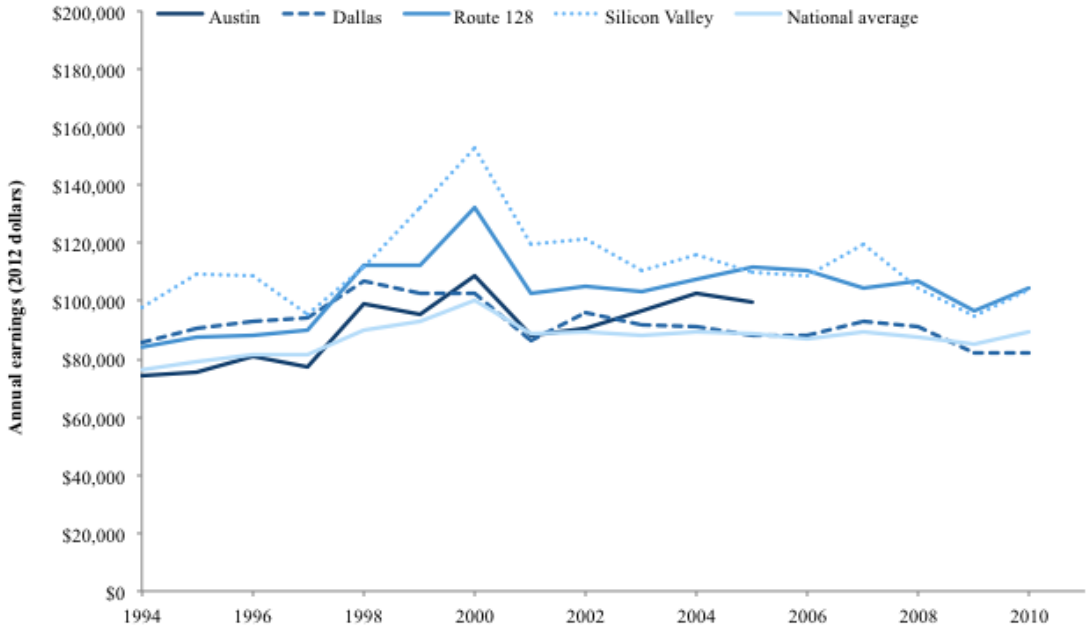
[16] These figures, with data through 2006, appear in Lazonick (2009); the figures included here are updated and graciously provided to the author by William Lazonick.

Figure 8: Earnings by industry: Average Annual Earnings of U.S. Employees in Semiconductors, Software Publishing, Computer Programming, and Computer System Design, 1994-2010



Source: Lazonick (2009), updated by Lazonick using U.S. Census Bureau County Business Patterns data and provided to the authors (Salzman, et al., 2013); also in Lazonick, et al., 2014.

Figure 9: Earnings by Geographical Region: Average Annual Earnings of Full-Time Computer Programming Employees in Austin, Dallas, Route 128 Corridor, and Silicon Valley, 1994-2010



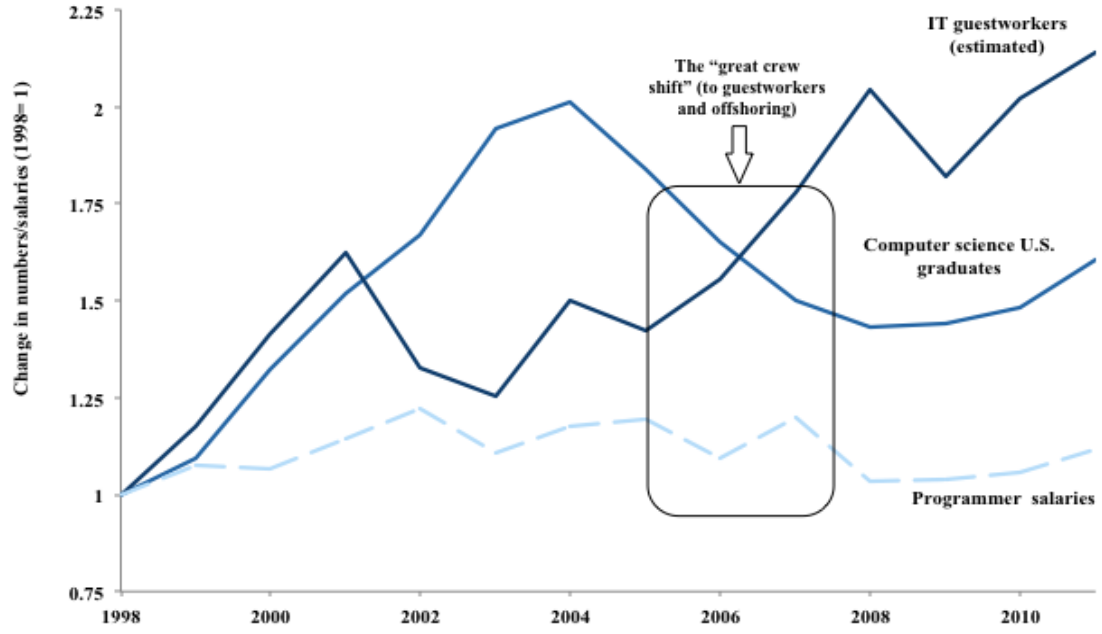
Source: Lazonick (2009), updated by Lazonick using U.S. Census Bureau County Business Patterns data and provided to the authors (Salzman, et al., 2013); also in Lazonick, et al., 2014.

H-1B workers and IT wages

The overall wage trends, as shown above and detailed in Salzman et al., (2013) and Lazonick (2009), and many other studies demonstrate a pattern of largely stagnant wages that suggest a sufficient, and perhaps ample supply of workers in most regions and computer occupations. As the example of petroleum engineers shows, a tight labor supply will be reflected in wage increases and a consequent increase in supply. Conversely, as a Brookings report observes, "it is likely that the extra supply of foreign-born workers does bring downward pressure on the wages of incumbent workers, as research suggests" (Rothwell and Ruiz, 2013).

In examining wage and both domestic and guestworker supply, we can observe several trends that may explain the flat salaries shown in the analysis in the previous section. As shown in Figure 10, in the late 1990s through early 2000s wages were increasing as was the number of computer science graduates and guestworkers. This was due to the high demand created by Y2K remediation work and the growing dot-com bubble as well as general IT growth. When the dot-com bubble burst, wages fell and both U.S. computer science graduate enrollments and guestworker numbers declined (with a lag in graduates because those already enrolled at the time of the crash completed their degrees in the subsequent two to three years). However, as the IT industry recovered, we observe sharp increases in the number of guestworkers but a continued decline in U.S. computer science graduates and continued declines and stagnation of salaries. It was during this period that there was the great "crew shift" to using guestworkers both in the U.S. and a significant increase in offshore IT development, which relies on guestworkers in the U.S. and transfer of work to offshore teams. All these factors would suggest there was a fundamental structural change in the IT labor market that allowed firms to have an ample workforce supply without having to raise wages.

Figure 10: Change in Programmer Salaries and in Numbers of U.S. STEM-related Graduates and IT Guestworkers, 1998-2011



Note: Optional Practical Training (OPT) visa numbers for 2009, 2010, and 2011 are estimated based on the 2008 total reported by the Department of Homeland Security. The initial OPT estimates use the OPT-extension ratio to initial

OPT in 2008, and OPT-STEM extension statistics for 2007–2013 are used to estimate 2009, 2010, 2011 initial OPT visas. Source: Department of State (2012) and Department of Homeland Security (2008 and unpublished DHS data).

Table 1 shows a preliminary analysis of the U.S. workforce and H-1B workforce in the same IT occupations. There is substantial average wage savings gain by using H-1B workers, which we estimate now comprise over 40 percent of the current, total workforce in these occupations (the data on the U.S. workforce provides detailed occupational breakouts but the H-1B data combine these two computer occupations). What is remarkable is that these workforce averages, which are for all workers in these occupations with a bachelor's degree or higher, are lower for the H-1B workforce yet ithe H-1B workforce is a workforce comprised of nearly twice the proportion of workers with a master's degree. *That is,* despite a workforce composed of a substantially greater number of workers with a postgraduate degree (nearly twice the proportion of the domestic workforce), their average wages are *lower*. In a preliminary analysis of wages and education, Lowell and Salzman (in preparation) find that, as would be expected in the labor market, U.S. workers with a master's degree receive higher wages than those with a bachelor's degree, and it is a wage premium that increases among older workers with a master's degree. However, in the H-1B workforce there is, on average, no wage premium for a master's degree. That is, for most H-1B workers with a master's degree, they do not earn more than an H-1B worker with a bachelor's degree. The implications of this finding are discussed in more detail in the next section.

Table 1: U.S. and H-1B wages and workforce

	% Masters	Annual Average Salary	Number of Workers		
Domestic Workforce					
Computer scientists and systems analysts	25%	$79,895	234,239		
Computer programmers	21%	$79,185	225,292		
H-1B workforce			**1st & 3rd Year Approvals**	**Estimated 6 Year Population**	**Est. Percent of Domestic IT Workforce**
Computer Sci/Systems Analyst & Programmers (combined)	45%	$75,873	78,113	195,283	42.5%

Source: DHS H-1B data; calculations by authors (Lowell and Salzman, forthcoming).

5. "Green Cards for Grads"

In response to the "handcuff" provisions of H-1B visas (e.g., employer sponsorship that limits mobility), various policies such as those in the I-Squared Act would increase the speed, ease, and availability of green cards for STEM graduates. The justification is that, by providing free labor market mobility to workers, they can obtain market wages and that they won't be "sent home" after receiving a U.S. education. This is presumed to provide a benefit to the U.S. as well as preventing them from "competing against us" by going to work in another country. Although a well-intentioned response to the documented abuses of the H-1B program, the I-Squared and other green card proposals do not appear to consider the evidence about the impact of the current H-1B, CPT, OPT, and OPT-extension programs on higher education and impact in the STEM labor market.

First, although the assertion that "we're educating them and then sending them home" is widespread and oft-repeated, there is scant evidence available to accurately assess this claim, but that evidence which is

available suggests quite the opposite is occurring. The one study that did examine Ph.D. graduates found there has been no change in the return rate (Finn, 2012). One informal follow up that was done of cases reported in the media found none had, in fact, been compelled to leave because of an inability to obtain a visa (Matloff, 2014). Matloff concludes: "The lobbyists' claims that we are losing outstanding technological talents to our competitor nations due to low visa caps is just false. There must be some examples somewhere, but the examples given by the advocates themselves just don't support their claims." In earlier work that Leonard Lynn, Pamela Meil, and I conducted of technology entrepreneurs in India and China (Lynn, et al., 2012), we found that those returning had all done so because they wanted to live and work in their home country (often after many years, and professional success, in the U.S.). That is, the "pull" factors to home country seem to be the primary motivating factor rather than "push" factors in the U.S.

Second, the "loss" of graduates is often described as the potential loss of the next Google founder, or other innovator. This claim is not based on any evidence, the cases cited are anecdotal and often not illustrative of the claim (e.g., Google's co-founder, Brin, immigrated as a child with his family leaving the dissolving Soviet Union) and, importantly, fail to consider the evidence about the predominant types of students and jobs the colleges and visa programs support. That is, these guestworker programs are largely to support offshore development work and generally for routine programming work, not the innovation work that makes headlines. Moreover, the very notion that sequestering talent in the U.S. can either feasibly prevent global migration or doing so would further US "competitiveness" is a case of old generals fighting the last (cold) war. The globalization of industry requires a much different strategy that leverages global migration for national prosperity and advances the global commons of innovation (see Lynn and Salzman, 2004, 2006, 2015, for discussion).

Third, and perhaps most importantly, the incentives provided by easy U.S. labor market entry through colleges and universities as now exists with the CPT, OPT, OPT-extension, and H-1B programs have led to growth of graduate programs that, at the extreme are fraudulent programs (Bartlett, Fischer, and Keller 2011), but in the main have grown to target foreign students as part of a business model to generate revenue rather than provide a high quality, graduate-level education. These are programs in lower tier schools and programs in higher ranked schools but are structured to serve foreign students with a lower quality education. The institutions with some of the highest ratios of OPT-STEM extension awards to enrollments (Stratford University, University of Bridgeport, and Northwestern Polytechnic University; see Table 2) were found by a 2011 *Chronicle of Higher Education* investigation to target foreign students as the primary population for their programs (Bartlett, Fischer, and Keller, 2011).

These colleges specialize in acquiring student visas and (for students with F-1 visas) OPT employment authorization for their students. In addition to tuition, students are often charged up to $3,000 in fees for obtaining the work authorization. At some universities, such as Tri-Valley University in California, the authors of the *Chronicle* study report that students do not even attend classes; the business model was "selling permission to live and work in the United States on student visas." Institutions specializing in acquiring OPT employment authorization for their students that do not act as egregiously as Tri-Valley University still keep their instructional expenses down with substantial reliance on online education, or they hold classes only occasionally throughout the semester.

Table 2: Universities with the largest number of OPT approvals, 2010---2012

	OPT Approvals (fiscal 2012)	Cumulative OPT Approvals Through fiscal 2010	IT and Computer Science Share of OPTs (fiscal 2012)	IT and Computer Science Completions (2010-2011)
Silicon Valley University	181	546	95.6%	N/A
University of Bridgeport	160	1,378	16.9%	62
Lamar University	124	452	2.4%	16
Texas A&M University-	114	492	33.3%	7

Kingsville				
Northwestern Polytechnic University	110	704	48.2%	118
University of Houston-Clear Lake	109	321	56.9%	188
Stratford University	107	1,834	95.3%	343
San Jose State University	106	674	34.9%	357
Illinois Institute of Technology	102	781	48.0%	299
International Technological University	95	412	36.8%	155

Note: IT and computer science completions include all computer science majors and all computer software engineering majors. Discrepancies between IT and computer science completions and IT and computer science OPTs may result from differential reporting to different agencies for different major categories (for example, reporting "software engineering," which is counted here simply as “engineering”). Source: Authors' analysis of Optional Practical Training (OPT) application data, and National Center for Education Statistics, Higher Education, General Information Survey and Integrated Postsecondary Education Data System.

The data on OPT and OPT-STEM extension use by universities, and the investigation of both abuse and legal but questionable practices by universities suggest there is a need for more research and consideration of the impact of expanding this type of program. The types of changes proposed in I-Squared not only would expand the numbers of guestworkers but, by granting permanent residency, would also increase the incentives for foreign students to enroll in, and for colleges to expand these programs. Moreover, there would be potentially quite dramatic impact on the labor market if colleges and universities expand with essentially no limits to increases of student and graduate flows that would be encouraged by changes such as those proposed in I-Squared. Abuses have been found in some college programs responding to high foreign- student demand for entry into the U.S. IT labor market. These colleges also appear to be serving the labor demand of some firms that hire students without even minimal college-level education and without much, if any, apparent IT experience or background. In other segments of the college market, even in well-established schools, there appears to be extensive use of the OPT extension (suggesting that there are students who are unable to find regular employment even a year after graduating or that their employers either have not prioritized their employment in H-1B applications or they did not win an H-1B visa in the annual lottery), and programs are expanding by targeting foreign student enrollments. Providing permanent residency for STEM graduates could have quite significant impacts on the education system as well as the labor market.

Tables 3 and 4 show colleges, grouped by Carnegie Class, that have the largest percentage of their computer science masters students on a student F-visa. As these charts show, these are colleges that appear to have programs largely if not almost exclusively serving foreign students. These enrollment patterns reflect a business model for these colleges; master’s degree programs generate high revenue and because entry into the U.S. labor market is relatively easy, it becomes a means of expanding the labor supply. Interestingly, the preliminary analysis finds that the vast majority of H-1B IT workers with a master’s degree have little to no wage premium over an IT worker with a bachelor’s degree, suggesting that these master’s degree programs are not providing students a master’s level education but rather the entry-level skills into the IT field (U.S. students with master’s degrees in computer science do have a wage premium over U.S. bachelor’s degree students).

Table 3: Master Computer Science Degrees Awarded to Students on F-Visas

	Total MS /CS degrees	F-Visa Graduates	F-Visa graduates as percent of all graduates	% of all FV grads
Research Universities-Very High Research Activity	7,448	3,921	53%	41.9%
Research Universities-High Research Activity	4,579	2,567	56%	27.4%
Master's Colleges and Universities	5,854	2,152	37%	23.0%
Doctoral/Research Universities	2,341	619	26%	6.6%
Not Classified	411	17	4%	0.2%
Special Focus Institutions-Other	308	76	25%	0.8%
TOTAL	**20,941**	**9,352**	**45%**	**100%**

Source: National Center for Education Statistics, Higher Education, General Information Survey and Integrated Postsecondary Education Data System, 2012. Analysis by Hal Salzman and David Hersh, Rutgers University.

Table 4: Universities with Highest Percentage of F-Visa Graduates in Computer Science

Carnegie Classification	University/College	Number of F-Visa Graduates	FV/US Ratio	F-Visa graduates as percent of all graduates
Doctoral/Research Universities	Texas A & M University Kingsville	49	24.5	96%
Doctoral/Research Universities	Indiana State University	24	24.0	96%
Doctoral/Research Universities	Texas A & M Univ.- Corpus Christi	38	12.7	93%
Doctoral/Research Universities	Central Michigan University	30	3.3	77%
Doctoral/Research Universities	Sam Houston State University	12	3.0	75%
Doctoral/Research Universities	University of North Carolina at Charlotte	95	2.5	71%
Doctoral/Research Universities	Illinois State University	13	1.9	65%
Doctoral/Research Universities	Marquette University	5	1.7	63%
Doctoral/Research Universities	Oakland University	13	1.6	62%
Doctoral/Research Universities	University of Nebraska at Omaha	39	1.3	57%
Doctoral/Research Universities	University of San Francisco	32	1.2	54%
Research U.-High Research Activity	Texas Tech University	45	22.5	96%
Research U.-High Research Activity	Louisiana Tech University	11	11.0	92%
Research U.-High Research Activity	Rutgers University Newark	11	11.0	92%
Research U.-High Research Activity	University of Texas at Arlington	40	10.0	91%
Research U.-High Research Activity	University of Missouri Kansas City	51	8.5	89%
Research U.-High Research Activity	Kansas State University	27	6.8	87%
Research U.-High Research Activity	Wichita State University	47	6.7	87%
Research U.-High Research Activity	New Mexico State University	13	6.5	87%
Research U.-High Research Activity	Illinois Institute of Technology	221	6.3	86%
Research U.-High	University of Akron Main	29	5.8	85%

Research Activity	Campus			
Research U.-High Research Activity	University of Texas at Dallas	252	4.8	83%
Research U.-High Research Activity	University of Louisiana at Lafayette	41	4.6	82%
Research U.-High Research Activity	SUNY at Binghamton	72	4.5	82%
Research U.-High Research Activity	Old Dominion University	26	4.3	81%
Research U-Very High Research Act.	University at Buffalo	164	10.9	92%
Research U-Very High Research Act.	University of Houston	88	8.0	89%
Research U-Very High Research Act.	Louisiana State University and Agricultural & Mechanical College	23	7.7	88%
Research U-Very High Research Act.	University of Arizona	73	6.1	86%
Research U-Very High Research Act.	Stony Brook University	102	6.0	86%
Research U-Very High Research Act.	University of Illinois at Chicago	48	6.0	86%
Research U-Very High Research Act.	Indiana University Bloomington	69	4.9	83%
Research U-Very High Research Act.	University of Southern California	349	4.8	83%
Research U-Very High Research Act.	Washington State University	9	4.5	82%
Research U-Very High Research Act.	University of Nebraska Lincoln	18	3.6	78%
Research U-Very High Research Act.	University of Missouri Columbia	14	3.5	78%
Research U-Very High Research Act.	Wayne State University	26	3.3	76%
Master's Colleges and Universities	Maharishi University of Management	116	38.7	97%
Master's Colleges and Universities	Monmouth University	22	22.0	96%
Master's Colleges and Universities	Northwest Missouri State University	72	18.0	95%
Master's Colleges and Universities	University of Maryland Eastern Shore	17	17.0	94%
Master's Colleges and Universities	Valparaiso University	17	17.0	94%
Master's Colleges and Universities	Bradley University	46	15.3	94%

Master's Colleges and Universities	Western Kentucky University	29	14.5	94%
Master's Colleges and Universities	University of Texas at Tyler	13	13.0	93%
Master's Colleges and Universities	Oklahoma City University	24	12.0	92%
Master's Colleges and Universities	University of Bridgeport	62	10.3	91%
Master's Colleges and Universities	University of Houston Clear Lake	150	9.4	90%

Source: National Center for Education Statistics, Higher Education, General Information Survey and Integrated Postsecondary Education Data System, 2012. Analysis by Hal Salzman and David Hersh, Rutgers University.

In summary, any expansion of foreign student entry into the U.S. labor market in IT is likely to exacerbate rather than remediate the current, negative impacts of large guestworker flows on the labor market. Further, and very importantly, it is likely to exacerbate what appears to be growth of a college and university business model of providing entry into the U.S. labor market that would otherwise be difficult to obtain; the provisions of the I-Squared legislation could expand the numbers of master's degree programs that are primarily offering degrees as the cost of obtaining a green card, easy entry into the U.S. labor market, and perhaps a moderate level of skill and education. The evidence suggests the impact would be depressing wages, as is currently reflected by the lack of a wage premium for H-1B master's degree holders and growth of degree programs that exclude U.S. students, either indirectly (as evident in the colleges with high concentration of F-visa graduates) or directly, as in the case of California State University-East Bay, which stopped admitting state residents into its graduate programs and admitted almost exclusively international students into its computer science program (which is about 90 percent international students; Jaschik, 2012,Matloff, 2012). This was the University's explicitly stated strategy to increase revenue to make up for budget deficits by excluding state residents who would pay lower tuition rates than out-of-state and international students. As the chart above suggests, this appears to be a "global services" business model pursued by a number of colleges and universities across the country.

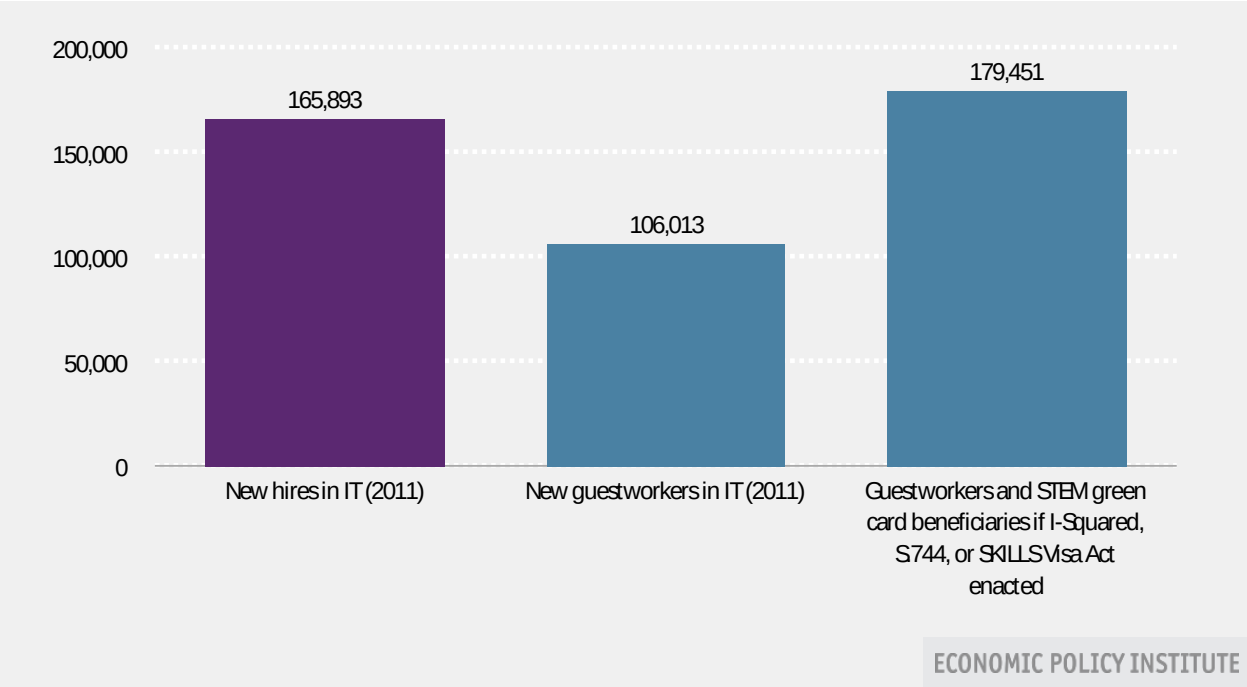
6. Summary and Concluding Remarks

Analysis of the data finds that high-skill guest worker programs supply the preponderance of all new hires for the IT industry. The inflow of guest workers is equal to half of all IT hires each year and fully two-thirds of annual hires of workers younger than 30.

As the wage analyses show, wages in IT jobs have been stagnant for over a decade while guestworkers have steadily increased, now comprising 40 percent or more of all current workers in some computer occupations. The evidence strongly indicates that the current levels of guestworker supply are a key factor in the depressed wages of U.S. IT workers, by both providing a large supply of entry-level and early-career workers that can be legally substituted for U.S. workers and, in particular, substitute younger guestworkers for older incumbent workers (again, this is permissible within the current law). Important to note is that the large supply of guestworkers is required by IT services firms for them to profitably support offshore development. That is, as stated in these companies' SEC filings, without a large supply of guestworkers they would be unable to move IT work offshore at competitive rates. At the very least, they would have to hire U.S. workers for the portion of their workforce on assignment in the U.S. (and the growth of "domestic sourcing" firms suggests alternative business models are viable).

As increases in the supply of guestworkers are being debated and proposals developed to speed the path to green cards, U.S. colleges are already graduating more than twice as many STEM graduates than the number of STEM openings generated by our economy each year. In short, the overwhelming evidence does not support a need for the escalating numbers of new guestworkers called for in the I-Squared legislation, S. 744, or The SKILLS Act. As Figure 11 shows, increases of the magnitude proposed would supply guestworkers for more than 100 percent of the industry's hiring needs. Such increases can only exacerbate current trends of stagnant wages and poor career opportunities in IT and STEM fields. In particular, the likely impact of large-scale guestworker programs, which stand to hurt all STEM graduates, will have especially negative impacts on minorities who are underrepresented in high tech, as well as other, recently arrived foreign-born workers who compete most with newcomers.

Figure 11: College-Educated Workers in Information Technology Jobs Under 30 Years Old and Current and Proposed Guestworkers in IT



Summary: Labor Markets and the Economy[17]

Markets are supposed to reflect demand through the price mechanism of markets. In the case of labor, the "price" is wages. How can it be then, that if the IT industry is experiencing labor shortages, wage levels in this highly profitable industry are no higher than they were in the last millennium? How can an industry expect to attract the best workers without raising wages? Is there what economists call a "market failure" here? As the evidence presented suggests, STEM labor markets do work as expected. In the case of petroleum engineers—a field that is more demanding in terms of course credit hours than computer science, and thus greater constraints to rapid change in supply— shortages led to wage increases which, in turn, led to near tripling of graduates. There is no plausible explanation for the observed IT labor market trends and outcomes other than, quite simply, large supplies of guestworkers that allow many firms to swap out higher paid, high-skill domestic workers for lower paid guestworkers, as found by many researchers.

[17] This summary is draws on and excerpts from Salzman, Lowell, Kuehn, 2013b; http://www.pbs.org/newshour/making-sense/the-bogus-high-tech-worker-sho/

All the evidence suggests the IT labor market is still bound by the usual dynamics of supply and demand. When we look at the trends of the past 20 years, we see that when wages increase, the number of computer science graduates increases. When wages fall, the number of graduates falls. When the supply of guestworkers increases, wages stay flat, and too many domestic students must find employment in other fields.

Some commentators argue that this last result is good for the economy: science and engineering skills are now being used in millions of non-STEM jobs. But an alternative view is that far too many domestic STEM graduates are in jobs that do not fully use their education, which represents a loss of our greatest source of innovators. Moreover, students observing these trends pursue careers outside of STEM fields, putting their talents to work in industries such as finance and law but not contributing to the innovation that drives the long-term and sustainable strength of the nation.

Yes, employers claim they have thousands of unfilled job openings, but the evidence is hardly compelling. Only about half to two-thirds of engineering graduates find engineering jobs and fewer than half of graduating Ph.D. scientists find career jobs. At the largest IT jobs website DICE.com, about half of the advertisements are for contract, short-term, and part-time jobs—not the types of jobs that U.S. graduates will find attractive nor the types of jobs that will allow these graduates to pay off student loans, much less enter the middle class. Those on the front lines of IT now tell students that given the industry's stagnant wages and unstable career tracks, better students should seek jobs elsewhere. An extensive survey of a recent college cohort by the National Center for Educational Statistics corroborates their advice. Only two-thirds of computer science graduates went into IT jobs in 2009. Of those not landing an IT job, half said they found a better job elsewhere. Fully one-third reported there were no IT jobs available.

This was also the finding in the analysis of changes in the composition of STEM graduates going into STEM jobs over the past three decades (Lowell, et al., 2009). We found that although the overall supply remained strong, fewer of the highest performing students were going into STEM jobs.

Meanwhile studies by Peter Cappelli of the Wharton School and by Burt Barnow of George Washington University find a *decrease* in the intensity of firms' recruitment efforts since the recession and an *increase* in pickiness about whom they are willing to hire. Again, the inference seems obvious: the supply of potential workers is already plentiful relative to employer demand. This should be the evidence that guides current legislation rather than anecdotal accounts and thin claims about the need for guestworkers and the U.S. falling behind in the global high-tech talent search.

H-1B guestworkers are concentrated in computer programmer and system analyst jobs. But most of these are commodity-like production jobs in IT services, doing back office programming for companies. A disproportionate number of H-1Bs provide onshore customer management for offshore programming teams. Ironically, without the visas, much of the programming work couldn't have been offshored in the first place.

There may be highly innovative guestworkers, but most are in jobs far away from the innovation frontier. Ron Hira at Howard University found that few of the largest H-1B employers could be considered technology innovators, with most generating very low levels of patents. So an often-heard argument for a massive increase in guestworkers—that we'll gain a few key innovators for America—is in reality a high stakes lottery with few winners but, like most lotteries, many losers. Large increases in the number of guestworkers will not ensure that we admit, among the tens of thousands of guestworkers, the few geniuses who could make a decisive contribution relative to American workers. If the intent of guestworker and immigration policy is to attract the high performing students and workers with potential to innovate and make substantial contributions to the economy, a much different set of polices is needed than those currently proposed.

In Conclusion

Currently, U.S. colleges graduate far more scientists and engineers than find employment in those fields every year—about 200,000 more—while the IT industry fills as much as two-thirds of its entry-level and early-career positions with guestworkers. At the same time, IT wages have stagnated for over a decade. We cannot expect to build a strong STEM workforce and encourage domestic innovation by developing policies that undermine the quality of STEM jobs. Before asking government to intervene in labor markets by handing out more guestworker visas and green cards to STEM graduates, we should ask for audits of shortage claims and workforce impacts as a first step toward developing evidence-based policy on this issue, an issue critical to the nation's future.

In sum, current immigration policies and the proposed changes that increase the supply of STEM guestworkers are likely to accelerate the already deteriorating career prospects for STEM graduates and workers. Considering the evidence, it would be wise for us to be concerned about the state of technology careers when making government policies that will fundamentally distort the market. We cannot expect to build a strong STEM workforce and encourage American innovation by developing policies that undermine the quality of STEM jobs.

Appendix A [18]

Estimating the Number of Annual Guestworker Entrants to the IT Workforce

In order to estimate the number of guestworkers who are available to work in the IT sector, we need to know the number in each visa category who have been entering IT jobs. Data show that the majority of H-1Bs are employed in IT jobs, and that large shares of both L-1 visa holders and foreign students working on the OPT visa can be found in IT jobs. Although it is not known the extent to which the L-2 spousal/child visa is used for IT or STEM fields, we include it here because IT recruiters are targeting this group of visa holders in advertisements, and there has been a sharp increase in the number of L-2 visas issued. As explained below, a range is calculated in which the lower bound is based on minimal STEM workers being drawn from the L categories and none being drawn from the other visa categories (though there is likely some flow from these other groups, as there are nearly 400,000 employment-eligible visas issued each year in categories such as J-1, J-2, E-2, and O-1). As such, we can be reasonably certain that these are conservative estimates, erring on the side of undercounting rather than overcounting the number of guestworkers available to enter the labor force.

The occupational and industry data are available only for the H-1B visa petitions approved by DHS and for the OPT-STEM extension visa, though there are estimates of the industry employment of L-1 guestworkers, as discussed above. DHS also provides detail on the H-1B population by education and age. We use these figures to develop estimates of the total number of guestworkers entering annually into the IT workforce.[19]

The only common data available for most guestworkers are the State Department's tallies of annual visas issued, but DHS releases data on employer petitions for H-1B workers. A total of 192,990 H-1B petitions were approved in FY2010, of which 76,627 were for "initial employment"; the balance were for renewals. In FY2011, DHS reported there were 105,395 initial employment H-1B petitions approved for which occupation was known; another 1,150 initial employment H-1B petitions were approved but occupation was not known. The State Department, which issues the actual visas, reports significantly more H-1B visas than there are DHS petitions. The number of visas issued in a given year may exceed the number of H-1B petitions approved by DHS because a petitioner approved in one year might not apply for, or be issued the actual visa, until the following year. The State Department visa statistics are used because the data are reliable and can be obtained for other visas. In FY2011, 51,570, or 49 percent of the initial H-1B employment visas, were identified by DHS as "computer-related occupations" (DHS 2012). The percentage of H-1B guestworkers in IT has been reported as significantly greater in the past two years than the 49 percent in IT in previous years, according to industry watchers and knowledgeable experts, and the DHS statistics report only the number of H-1B petitions approved for work in IT occupations, not the number working for IT employers but in non-IT occupations. Thus, there is evidence that the actual share of new H-1B guestworkers in the IT field is larger than the reported 49 percent and appears to be growing.

There are no detailed statistics on the 70,728 issued in FY2011, but, as noted above, the OIG investigation and knowledgeable experts both estimate that a higher percentage work in the IT industry

[18] This appendix is excerpted from Salzman, et al., 2013.

[19] The term "guestworker labor pool" is used to denote the group of people who are newly eligible entrants; they are part of the flow rather than the stock of workers. The only data available are the number of visas issued in a given year, and some of those visa holders may not start work in the year the visa is issued; however, there are also new workforce entrants issued visas in prior years, minimizing any net differences. These estimates are broad enough to be minimally affected by any net differences, and labor markets, particularly wages, are largely affected by the size of the pool of available workers rather than by the number actually employed. Thus, the size of the pool, even if larger than the actual number of new labor force entrants, is as important as the actual flow of workers entering the labor force.

than is the case for the H-1B population (it has been suggested that the expansion of L visas is disproportionately used by the IT industry). Applying the same distribution, of 49 percent, as a conservative estimate (i.e., it would tend to undercount rather than overcount the number) would yield 35,280 guestworkers on L-1 visas in IT jobs (in range estimates, 21,000 is used as the lower bound and 53,000 as the upper bound for L-1 IT guestworkers in FY2011).

The L-2 visa count is 69,233 for FY2010 and 76,949 for FY2011 (in FY2011, the number of L-2 visas was greater than the number of L-1 visas issued). One would expect a lower proportion would be in the IT industry, but since there is some correspondence between the education and occupations of L-1 visa holders and the education and occupations of their spouses and adult children (who are eligible for L-2 visas), the number of L-2 visa holders in IT would be nontrivial. Further, because the IT industry is composed of such a wide range of education levels and backgrounds, the L-2 pool could be used throughout the IT occupational range even if the person was not formally trained in IT. It has also been noted that there has been an increase in recruitment ads targeting L-2 visa holders for the IT industry. We will include 30,000 L-2 visa holders in the upper bound and 10,000 as the lower bound of this segment of the guestworker IT pool.[20]

The number of F-1/OPT guestworkers has been increasing, from approximately 70,000 in 2008 to an estimated 89,000 in 2010.[21] An analysis of the occupation and industry/employers for all of the 14,499 OPT-STEM extension approved petitions in FY2011 was conducted. This analysis included all those employed in an IT occupation and STEM graduates working for an IT company. The findings show that 77 percent, or 11,103, of OPT-STEM extension guestworkers in FY2011 were in IT. To estimate the *initial* OPT IT guestworker population, a range of 35 percent to 65 percent of the total initial OPTs issued was used (it is lower than the OPT-STEM extension rate since initial OPT visas are also provided to students outside of STEM).

[20] As noted above, estimates of guestworkers drawn from the several other employment visas or spousal employment visas are not included—totaling nearly 400,000 employment-eligible visas issued in FY2011—but presumably some number of these visa holders are also entering the IT industry; the L-2 visa holders are included because observers have noted that IT recruiters are specifically advertising for L-2 visa holders.

[21] Initial OPT data are not routinely provided, and a single source for series data has not been identified; only the OPT-STEM extension data were obtained (released to a third party via the Freedom of Information Act). OPT data are listed in other sources, such as the 2008 DHS Interim Final Rule establishing the 17-month STEM OPT extension ("Extending Period of Optional Practical Training by 17 Months for F-1 Nonimmigrant Students With STEM Degrees and Expanding Cap-Gap Relief for All F-1 Students With Pending H-1B Petitions," 73 F.R. 18944, 18950, April 8, 2008); *"Currently, DHS estimates, through data collected by SEVP's Student and Visitor Exchange Information System (SEVIS), that there are approximately 70,000 F-1 students on OPT in the United States. About one-third have earned a degree in a STEM field." The r*egulation is available at http://www.gpo.gov/fdsys/pkg/FR-2008-04-08/pdf/E8-7427.pdf.

Table A1: Annual Guestworker Visa Issuances, Estimated Total and Estimated Number Approved for Employment in IT, 2010-2013

Visa Program	**2010 Total**	***For IT Workforce***	**2011 Total**	***For IT Workforce***	**2012 Total**	***For IT Workforce***	**2013 Total**	***For IT Workforce***
H-1B	117,409	*57,530*	129,134	*63,276*	135,530	*66,410*	153,223	*75,080*
L-1	74,719	*36,612*	70,728	*34,657*	62,430	*30,591*	66,700	*32,683*
L-2	69,233	*17,308*	76,949	*19,237*	71,782	*17,945*	74,104	*18,526*
OPT	96,916	*38,766*	105,357	*42,143*	115,303	*46,121*	123,328	*49,331*
OPT-STEM extension	9,984	*3,994*	12,961	*5,184*	15,827	*6,330*	19,034	*7,613*
Total	**368,261**	***154,210***	**395,129**	***164,497***	**400,872**	***166,888***	**436,389**	***181,674***

Source: Department of Homeland Security reports and data provided through a third party and obtained via Freedom of Information Act. The initial OPT estimates use the OPT-extension ratio to initial OPT in 2008, and the OPT-STEM extension statistics for 2007–2013.

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