IMMIGRANTS AND NATIVES IN THE U.S. SCIENCE AND ENGINEERING WORKFORCE, 1994-2006

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ABSTRACT

Between 1994 and 2006 the foreign born-to-native S&E ratio (FSE/NSE) doubled. I decompose this change into a migration effect (which accounts for migration in general), a proportional college effect (which accounts for the relative proportions of college graduates among migrant and native workers) and a proportional S&E effect (which accounts for the relative proportions of S&Es among migrant and native college-educated workers.) Results show that the migration effect explains about three-quarters of the increase in FSE/NSE during the entire period under study. The proportional S&E effect was largest in 1995-1998, years of sustained economic growth, suggesting that the friendliest immigration policy toward scientists and engineers is a booming economy. Conversely, a slower economy (2000-2006) is correlated with a declining importance of skilled migration in general, and of the migration of scientists and engineers in particular. Increases in the annual cap on H-1B visas in 1999 and again in 2001 were of little consequence: if the foreign born-to-native S&E ratio had been determined by the immigration of scientists and engineers alone, it would have actually decreased in 1998-2001, even as government took action to promote precisely this type of migration.

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INTRODUCTION

All developed countries, as well as the leading emerging economies, fiercely compete for highly skilled workers (Hawthorne 2005; Iredale 2000; Regets 2001; The Economist 2006.) This competition spans across all fields of knowledge, but it is particularly noticeable in science and engineering (S&E) occupations. Since the 1990s the United States has received increasing numbers of foreign born scientists and engineers, and has repeatedly modified immigration legislation to facilitate this flow. Since 1994, as I will show below, the foreign born-to-native ratio among college-educated workers in S&E occupations has nearly doubled. This dramatic increase results from the interplay of changes in six populations or subpopulations: employed natives, employed college-educated natives, college-educated natives in S&E occupations, and their foreign born counterparts in all three cases. Below I present a decomposition analysis that is useful to describe how changes in these components led to the observed change in the overall ratio. Results shall be helpful to understand substantial processes at work and inform debates on skilled migration in the somehow controversial S&E field.

SKILLED MIGRATION

Most research on immigration to the United States focuses on low-skilled labor migration. This is understandable because, compared to natives, immigrants are disproportionately in the low-skilled category, dramatically so among the undocumented (Bean & Stevens 2003; Borjas 1999.) The immigration debate in the United States is largely about the flow of relatively unskilled foreign labor, in particular of the undocumented type. Skilled migration is largely legal and far less controversial. It is also sizable. As of 2003, the U.S. Census Bureau estimated the foreign born population at 33.5 million. Of those aged 25 and older, 27.3% (about 7.4 million individuals) had a bachelor's degree or higher, matching the proportion of college graduates among natives of the same age (Larsen 2004.)

The United States issues work visas to skilled individuals under various visa categories, of which the following four account for over 90% of all visas for skilled workers: H-1B (for professionals in specialty occupations), F1 (academic students), J1 (exchange visitors), and L1 (intracompany transfers.) In 2005, 703 thousand new visas were issued under these four categories. With data from the Immigrant Visa Control and Reporting Division of the Department of State, Figure 1 shows visas issued under these four categories during the period 1996-2005. The trend on all four visas was upward until 2001. In the aftermath of the terrorist attacks of September 11 of that year, student visas (F1) and specialty worker visas (H-1B) declined markedly. Both began to rise again in the last two years of the series.

Figure 1 about here

Of the visa categories for skilled workers listed above, the H-1B is the one that most directly targets scientists and engineers and the one that has been the focus of most debate. The H-1B was introduced in 1990, when the Immigration Act of that year divided the old H1 visa, reserved for individuals of distinguished merit and ability for temporary work in the U.S., into two types. The H-1A visa was assigned to foreign nurses in response to shortages in that profession, and the H-1B was assigned to non-nursing skilled labor (Meyers 2006.) Employers wishing to hire a foreign born professional under the H-1B program must file a labor condition application with the Department of Labor, attesting to posting the application at the job site, a lack of a strike or lockout, working conditions consistent with those of comparable workers, and payment of the prevailing wage for the position requested. Foreign workers can be on H-1B status for up to six years[1], and can only work for the employer who sponsored them.

H-1B visas are subject to an annual cap set by Congress. The cap was raised in FY 1999 and again in FY 2001, returning to the original 65,000 in FY 2004.[2] The cap

[1] Unless they have applied for adjustment of status to lawful permanent residency, in which case their H-1B visas are extended until their permanent residency cases are adjudicated.

[2] Fiscal year (FY) x begins on October 1st of year x-1 and ends on September 30th of year x.

applies to new visas only (not to renewals) and is also shown in Figure 1. Exemptions to the cap were introduced in 2000 benefiting skilled foreign workers hired by universities, nonprofit organizations and government research laboratories, and again in 2005, assigning 20,000 extra visas to foreigners who earn a masters or doctoral degree from a U.S. university.

To legally remain in the United States on a permanent basis, a foreign born individual needs to be granted lawful permanent residency (LPR), usually referred to as a green card. The two major classes of admission into LPR status are family-based and employment-based. The latter is largely reserved for skilled workers and their spouses and children—of course, many eligible skilled foreigners are alternatively granted LPR status on family-based preferences. In 2005, employment-based LPR was granted to 244,877 individuals—this number includes not only skilled workers but their spouses and children as well.

In short, to the more than 7 million foreign born college graduates present in the country, new work visas are issued each year for about 700 thousand more. In addition, thousands of green cards are granted to skilled individuals as well. These numbers cannot simply be added together year after year to track the total of skilled immigrants: Many visa holders will return to their home countries, and many of those who are granted LPR are only adjusting their status, generally from one of the visa categories listed above, after being in the country for a number of years (Batalova 2006.) In any event, it is clear that skilled migration is sizable, and increasingly significant.

MIGRATION OF SCIENTISTS AND ENGINEERS

Of all highly skilled fields, S&E has received most attention from migration researchers (Espenshade, Usdansky & Chung 2001; North 1995; Stephan & Levin 2001). Research on the effects of the immigration of scientists and engineers has explored a variety of topics, listed below.

Economic issues

Researchers have addressed questions concerning productivity, wages, labor conditions, and possible displacement of natives from certain jobs or occupational sectors. The evidence shows that both patents and academic papers authored by foreign born scientists and engineers are more widely cited than those authored by their native colleagues. In addition, foreign-educated individuals are more likely to have made exceptional contributions to the sciences. Together, these findings suggest that highly skilled immigrants have been beneficial for U.S. science (Stephan & Levin 2001). Wage trends, however, motivate concern. Controlling for changes in the composition of the science and engineering workforce, Espenshade, Usdansky and Chung (2001) estimated that real average earnings grew during the 1970s and 1980s but declined between 1990 and 1997. Thus, while unemployment in the sector remained low, Espenshade and his colleagues worried that labor supply may have reached a saturation point that conspired against further wage increases in the late 1990s. More recent data suggests, however, that S&E wages have been growing at roughly the same pace as wages of all professionals combined. Yet they continue to lag far behind those of physicians and surgeons (Ellis 2006.)

Based on wages, awarded S&E degrees, and occupational trends in the S&E workforce, some observers believe that the claimed shortages of information technology (IT) skilled labor, which motivated expansions of the H-1B visa program, were likely overstated (Espenshade 2001; Teitelbaum 2003; Watts 2001). It is argued that legal constraints imposed on H-1B visas, which allow the visa holder to work only for the employer that sponsored the visa, contribute to contain wage increases, as the immigrant worker remains captive of the sponsor at given levels of wages (Watts 2001). To reduce the possibility of manipulating the system for the advantage of an industry and to the detriment of American workers, the H-1B program is subject to multiple regulations to ensure that labor conditions, including wages, match those prevailing in the industry, and that American workers are not displaced from job positions opened to the foreign born (Lowell 2000).

Policy considerations

It is clear that legislation on *temporary* migration is more malleable and subject to change on a more regular basis than legislation on lawful permanent residency. In addition, temporary ("nonimmigrant") visas require shorter processing and adjudication time than green cards. As a consequence, employers wishing to hire highly skilled foreigners have made extensive use of nonimmigrant visa categories. For scores of highly skilled immigrants these visa categories have become intermediate steps between entry into the United States and eventual LPR status (Batalova 2006; Lowell 2000, 2001; North 1995). However, while the use of nonimmigrant visas has consistently grown over time (as shown in Figure 1), avenues to permanent residency have not changed much and skilled foreign born workers wishing to adjust to LPR status are subject to a variety of requirements and long delays resulting from processing backlogs. In view of this, especially as debate on illegal immigration dominates the political scene, some observers call for "comprehensive" immigration reform to address the migration not only of unskilled laborers but of skilled ones as well (Rosenblum 2006.)

Structural issues

Beyond debates on whether a shortage of IT or other skilled labor really exists, observers worry that solutions proposed to prevent future shortages ignore the nature of incentives in the U.S. educational and occupational structure. From the point of view of U.S. natives, graduate degrees in S&E require ever longer educational paths and produce relatively low returns when compared with suitable alternatives (Teitelbaum 2003.) Other observers, focusing on the outsourcing of skilled technical jobs, point out that what ultimately matters is not so much where jobs are located, but where cutting-edge research is located. From this point of view, highly-skilled migration should be welcomed and facilitated, at the same time that higher education in science should be made more economically attractive to American students (Wadhwa et al. 2007.)

Data limitations

Anyone who studies highly skilled migration to the United States quickly runs into severe data insufficiencies. This is true even if the focus is on legal migration only, and whether one looks at temporary or permanent visas. To begin, it is really impossible to know how many new foreign born workers on nonimmigrant visas enter the U.S. each year. Data from the Department of State provide the number of visas issued, but no follow-up on whether those visas were indeed used to enter the country. In turn, the Department of Homeland Security records admissions, not people, so that its figures for any given year exceed the number of actual new migrants by an unknown margin.

Second, the government does not publish records on the departure of foreigners, let alone by skill levels. Third, as adjustment of status from temporary skilled work visas to LPR becomes ubiquitous, data on the proportion of new permanent residents who are status-adjusters became severely incomplete in FY 1998 and fully unavailable in FY 2003 (Batalova 2006.) In short, even though highly skilled immigrants are in the country legally, and even though every person who enters (or leaves) the country legally must pass through computerized checks at the port of entry (or departure), our best estimates on the foreign born skilled population come from surveys, such as the CPS, and from the population census, once every ten years, rather than from visa statistics or entry/departure records.

THE FOREIGN BORN-TO-NATIVE S&E RATIO

Consistent high levels of skilled migration led the foreign born-to-native S&E ratio to increase steadily during the period under study, 1994-2006. Defining scientists and engineers as college-educated individuals in S&E occupations, the ratio between foreign born and native scientists and engineers increased from 0.16 in 1994 to 0.30 in 2005. Or, equivalently, there were 6.2 natives in S&E occupations per migrant in S&E occupations in 1994, but only about 3.3 in 2005 (estimation details below.)

The period under study, 1994-2006, includes several years of economic growth and a roaring stock market associated with what has been dubbed the dotcom boom[3] (or, alternatively, the dotcom bubble; see Cassidy 2002, Sheeran & Spain 2004.) August 9, 1995, the day of the Netscape Initial Public Offering (IPO) is conventionally identified as the beginning date of the dotcom boom. March 10, 2000, the day the NASDAQ index peaked, marked the beginning of the end. During the rest of 2000 and in 2001 the NASDAQ index consistently declined and large numbers of Internet startups and other companies linked to the IT industry went bankrupt. After the collapse, an economic slowdown ensued, deepened by the terrorist attacks of September 11, 2001. The annual GDP growth rate, which peaked at 7.3 percent in 1999 and had never fallen below 3

[3] I will use the term "dotcom boom" to refer to these years of rapid economic growth, even though economic growth was widespread and should not be credited to any particularly industry. My preference for the term reflects the influential role of the Internet and telecoms sectors during those years and the fact that they were, and remain, primary employers of scientists and engineers.

percent since 1992, declined to 2.1 percent in 2000 and did not reach 3 percent again until 2006.

During the years of the dotcom boom, as I will show below, employment of college graduates in S&E occupations grew significantly. Toward the end of the last century, claiming a shortage of talented labor, lobbying efforts by the IT industry succeeded in persuading Congress to raise the annual cap on H-1B visas from 65,000 to 115,000 in FY 1999. As the economy roared and the IT industry overheated, the new cap was quickly reached and Congress raised again the cap, now to 195,000, effective FY 2001. However, almost simultaneously, the dotcom boom came to an end and the economy slowed down. The new cap proved unneeded and it was never reached (see Figure 1). In FY 2004, Congress returned the cap to its pre-1999 level.

Given this economic background, it seems reasonable to expect the foreign born-to-native S&E ratio to have grown most significantly during the years of economic growth than afterward, when skilled immigration must have slowed down together with the economy. In addition, one would expect increases in the ratio to be associated with increases in the H-1B cap, since the purpose of these increases was, essentially, to allow for the immigration of ever larger numbers of foreign professionals for the IT industry.

Besides expectations on the general trend concerning the ratio, one can draw expectations regarding the proportion of the growth in the foreign born-to-native S&E ratio actually explained by the immigration of scientists and engineers—as opposed to, say, migration in general, migration of professionals in general, or variations in the native S&E workforce. Consistent with expectations on the general trend, it seems reasonable to expect actual immigration of scientists and engineers to have a larger influence during the years of the dotcom boom and following increases in the H-1B cap than during the most recent years of the period under study.

The decomposition analysis below reveals to what extent each of these expectations matches the actual empirical record. In short, we will see that the dramatic growth in the foreign born-to-native S&E ratio was a result, first and foremost and regardless of the subperiod of focus, not of the specific immigration of scientists and engineers, but of general migration growth. Second, we will see that this growth was in effect more rapid, and the effect of the actual immigration of scientists and engineers was largest, during the early years of the economic boom. Third, we will find, perhaps surprisingly, that increases in the H-1B cap are of relatively little consequence when it comes to explain the increase in the foreign born-to-native S&E ratio.

METHOD

The initial formula for the decomposition analysis is:

$$\frac{\mathrm{FSE}}{\mathrm{NSE}} = \frac{\mathrm{F} \times \frac{\mathrm{FC}}{\mathrm{F}} \times \frac{\mathrm{FSE}}{\mathrm{FC}}}{\mathrm{N} \times \frac{\mathrm{NC}}{\mathrm{N}} \times \frac{\mathrm{NSE}}{\mathrm{NC}}} \qquad (1)$$

where, for any given year, F indexes the foreign born, N indexes natives, SE stands for scientists & engineers, and C indicates college degree or higher. The equation refers to the employed workforce only. We can rewrite this as:

$$\frac{\mathrm{FSE}}{\mathrm{NSE}} = \mathrm{m} \times \mathrm{c} \times \mathrm{se} \qquad (2)$$

In words, in any given year, the ratio of foreign born-to-native scientists and engineers is the product of the migrant[4]-to-native worker ratio (*m*); the ratio between the proportions of college-educated workers among the foreign born and among the native workforce, or proportional college ratio (*c*); and the ratio between the proportions of scientists and engineers among foreign born college-educated workers and among college-educated native workers, or proportional S&E ratio (*se*). With data for each year of the period 1994-2006, using a technique developed by Das Gupta (1993), I decompose the *change* in FSE/NSE between *any* pair of years in the series into effects attributable to *m*, *c* and *se*, which I label, respectively, the migration effect, the proportional college effect, and the proportional S&E effect.

Each of these effects reports how the ratio between foreign born and native scientists and engineers (FSE/NSE) would have changed if only the factor in question had changed while the other two remained constant. For example, the migration effect shows the change in FSE/NSE that would have still happened even if *c* and *se* had not changed at all; or, in other words, the change in FSE/NSE attributable to migration in general. It must be noted that, unlike regression, a decomposition technique does not address causality. Instead, it provides a nuanced description, not affected by random error, of the trend under study.

[4] I will use the terms migrant and foreign-born interchangeably.

A decomposition analysis necessarily begins with a standardization technique.[5] In this case, I standardize the ratio in question (FSE/NSE) for all factors except (one at a time) *m*, *c*, and *se*. For example, the series for FSE/NSE standardized for all factors except *m* shows what FSE/NSE would have been, in each year of the period under study, if only *m* had varied, while *c* and *se* remained constant. After this is done, the effects introduced above are simply calculated as differences between standardized ratios. For example, the migration effect for the subperiod 2000-2006 is calculated as the difference between FSE/NSE standardized for all factors except *m* in 2006 minus FSE/NSE standardized for all factors except *m* in 2000. There are two consistency conditions. First, the sum of all three effects for any given pair of years must equal the difference between the two observed values of FSE/NSE for those same years. Second, the sum of the effects for subperiods within a period must equal the effect for the total period (for example, the migration effect for 2000-2006 must equal the sum of the migration effects for 2000-2004 and 2004-2006.)

In formulas, for any given number of years, one must first calculate all the pairwise standardized FSE/NSE, *ignoring the other years* (Das Gupta 1993:8). For example, for years 1 and 2, FSE/NSE standardized for all factors except *m* is:

$$Year\ 1 = \left[\frac{c_2 se_2 + c_1 se_1}{3} + \frac{c_2 se_1 + c_1 se_2}{6} \right] m_1 \qquad (3)$$

$$Year\ 2 = \left[\frac{c_2 se_2 + c_1 se_1}{3} + \frac{c_2 se_1 + c_1 se_2}{6} \right] m_2 \qquad (4)$$

Afterward, the standardization formula that meets the two consistency conditions is (Das Gupta 1993: 105-106):

$$\alpha_{1.23\ldots N} = \frac{\sum_{i=2}^{N} \alpha_{1.i}}{N-1} + \frac{\sum_{i=2}^{N} \left[\sum_{j \neq 1,i}^{N} \alpha_{i.j} - (N-2)\, \alpha_{i.1} \right]}{N(N-1)} \qquad (5)$$

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[5] For full details on the decomposition technique the reader may consult Das Gupta (1993). Summaries longer than the one presented here are provided by Smith, Morgan and Koropeckyj-Cox 1996, and Sana 2008.

… where $\alpha_{i.j}$ represents FSE/NSE standardized for all factors *except α* for the comparison between year *i* with year *j*, *ignoring the other years*. If α is, for example, the migrant-to-native worker ratio *m*, the standardization refers to FSE/NSE standardized for *c* and *se* (as in formulas 3 and 4). $\alpha_{1.23...N}$ refers to FSE/NSE standardized for all factors except *α* in year 1, *in the presence of the other years*, given N years.

DATA

As described above, only six series of data are needed: total number of workers, of college-educated workers, and of college-educated workers in S&E occupations, each of these for US natives and for the foreign-born, for each year of the period 1994-2006. I use the Merged Outgoing Rotation Groups (MORG) from the Current Population Survey (CPS). The CPS is a household survey conducted monthly by the Census Bureau for the Bureau of Labor Statistics (BLS) to measure labor force participation, employment and related variables. The CPS collects data on nativity since 1994, which sets the first year of the analysis. Every household that enters the CPS is interviewed each month for 4 months, then ignored for 8 months, then interviewed again for 4 more months. The MORG data sets, available from the National Bureau of Economic Research, are annual data files that include only those households which were in their 4th and 8th interview each month. Since the 4th and 8th interviews are a year apart, in the MORG extracts no household is recorded twice in the same survey year.

Ordinarily, migration researchers who use the CPS work with the March Annual Social and Economic Supplement (ASEC) because it includes a larger number of variables and a larger sample size than the monthly basic survey (see Schmidley & Robinson 2003.) For the present analysis, however, point estimates for each of the six series listed above suffice, and all the necessary data are available in the basic monthly survey, so that using the ASEC is not necessary. Furthermore, producing estimates using the MORG extracts appears advantageous: by comparison with any monthly CPS (including the ASEC supplement) the extracts contain households interviewed throughout the year, reducing the effect of occasional large sampling errors in any given month.[6]

When producing annual CPS estimated counts of attributes present in the basic, or monthly, CPS survey, researchers often calculate averages from the twelve monthly surveys for the year in question. Because each month in the MORG extracts covers one-fourth of all CPS households surveyed that month, each MORG annual data set has about three times as many households as the average monthly CPS. After adjusting weights, my estimated counts of a given subpopulation in any given year produced with the MORG extracts may differ very slightly from counts estimated from annual averages of twelve CPS surveys.[7]

Comparability issues

Comparability between estimates from different years of the survey is affected by a change in the population controls used to produce the sample weights and by a revision of the U.S. Standard Occupational Classification (SOC) used to code occupations.

CPS data are weighted to produce population totals. The weights depend on "population controls," derived from population projections benchmarked to the last census, adjusted for omission, limited to the civilian non-institutionalized population, and distributed by demographic characteristics including age, sex, race, Hispanic origin and residence, but not nativity (U.S. Bureau of the Census 2002, Appendix D.) In other words, estimates of population totals that can be obtained from the CPS ultimately depend on population projections prepared by the Census Bureau. The 2000 census

[6] As stated by Schmidley and Robinson (2003:3): "Groups such as the foreign born who are not represented in the sample strata and non-randomly distributed across the United States may be over or under represented from month to month depending on the location of the housing units selected for inclusion in the sample."

[7] For the estimated total of the employed population, the difference between the estimates published by the BLS (based on annual averages of monthly CPS surveys) and my MORG-based estimates ranges from -0.17% (2001) to +0.12% (1997). Using annual averages of the monthly CPS, the BLS has only been publishing estimates of the employed population broken by nativity since 2002. For the employed native population, the largest difference between published CPS estimates and my MORG-based estimates is of -0.18% (2005). For the employed foreign-born population, it is +0.26% (2003). Available estimates of the foreign-born population and subpopulations within it for prior years are typically based on the March supplement and are therefore far less comparable with estimates obtained from the MORG extracts.

revealed that the projections based on the 1990 census were underestimated, especially with respect to the Hispanic population. Using 2000 census results, the CPS population controls were corrected. Schmidley and Robinson (2003) show estimates of the foreign-born population based on the old and the new weights for the monthly CPS surveys from October 1999 to December 2002. The result is a consistent increase in the estimate of the foreign-born when the new weights are used. Proportionally, the increase among the foreign-born that results from the new weights was found to be much larger than the proportional increase recorded for natives.

The MORG data files provide both the 1990-based weights and the 2000-based weights for the years 2000 to 2002. Table 1 shows that, in effect, the new weights result in a larger estimate for all six data series, and the increases are proportionally much higher for the three foreign-born subpopulations: The largest percent increase among natives is 0.70% for the college-educated in 2002, while the lowest percent increase among the foreign-born is of 6.82% for the college-educated in 2000. Table 2 shows the actual effect of the revision of weights on the ratios needed as input for the decomposition analysis. The effect is clearly much larger on the migrant-to-native worker ratio (*m*) than on the other two ratios. In turn, the proportional S&E ratio (*se*) is affected positively while the effect for the proportional college ratio (*c*) is negative. In essence, this would translate into a very large, and ultimately artificial, migration effect in the year 2000.

Table 1 about here

Table 2 about here

To avoid this outcome I decided to adjust all six series backward from 1999 through 1994 (originally estimated using the 1990-based weights,) while using the 2000-based weights beginning in 2000. An extra increase of, say, 7% in the foreign-born population due to the revision of weights in the year 2000 is almost certainly artificial if one attributes the entire 7% increase to 1999-2000, but it is most likely genuine for the period encompassed in between the two censuses: 1990-2000. The question is when this unexpected increase took place, or rather how much of it took place in each year. I decided to smooth the effect of the revision of weights, for all six populations under study, by distributing it evenly through the period 1990-2000.[8]

The U.S. Standard Occupational Classification (SOC) was introduced in 1977, and revised in 1980, in time to be used for data processing of 1980 census results. By the mid-1990s, the 1980 SOC was being criticized as fragmented, outdated, and lacking information on skills (Bureau of Labor Statistics 1999.) In 2000, a new SOC revision was introduced. In the MORG data sets, occupations are coded using the 1980 SOC through 1999, and using the 2000 SOC afterward. However, to allow comparability and for evaluation purposes, the 1980 codes are also available in 2000, 2001, and 2002.

With regards to the present study, the changes in the SOC affect the number of college-educated workers in S&E occupations. Classification changes affect the number of scientists and engineers in a number of ways: through new occupations (i.e. without a correlate in 1980) that can be classified as S&E; through the splitting of old codes into new occupations, some but not all of which are to be classified as S&E; through the grouping of old codes into a new overarching code which may lead to loss or gain of S&E occupations depending on the criteria used to assign the new code; and so on (for a detailed analysis of the 2000 SOC equivalencies with the 1980 SOC and the effect of the resulting changes on the S&E workforce see Ellis 2007.) Given that an important share of the substantial changes in the U.S. occupational structure between 1980 and 2000 relates to the spectacular growth of the IT industry, it may not be surprising that the effect of the new classification is to increase the number of workers in S&E occupations.

The effect is much larger among the foreign-born than among natives. Comparing estimates using the 2000 SEC with those obtained using the 1980 SEC results in an increase of 15% (for 2000 and 2001) and 19% (2002) of foreign-born scientists and engineers, more than doubling the proportional increase among natives, of 7% (in 2000) and 6% (in 2001 and 2002.) Unlike the choice I made for the adjustment of weights backward through 1994, I did not make any adjustments on estimates of S&E workers produced with the 1980 SOC for several reasons. First, the period involved is longer (1980-2000) and an even-distribution assumption may be

[8] Thus, a 10% increase as a result of the revision of weights in 2000 would translate into a 4% increase over the figure estimated for 1994, a 5% increase on the 1995 figure, and so on.

unsound; second, it is uncertain what share of the change is genuine and what is only a result of reclassification of occupations; finally, even knowing what part of the change is a genuine increase in S&E occupations for a given year would not suffice, as assumptions would still be required on genuine increase year by year.

Instead of adjusting the series, I conducted two separate analyses. In one I used 1980 SOC codes for 1994-1999 and 2000 SOC codes since 2000, and in the other one I used 1980 SOC codes through 2002 and 2000 SOC codes starting in 2003. In both cases, it is important to keep in mind that the annual increase in S&E occupations recorded when the 2000 SOC codes are adopted should not be interpreted as a genuine sudden spike. The dual exercise is useful, as I will show below, because changes up to 2000, 2001 or 2002 can be considered using the analyses that preserves 1980 SOC codes through 2002, while for changes beginning in 2000 we can focus on the analyses that uses 2000 SOC codes since 2000.

Definition of Scientists and Engineers

For the purposes of this study, I define scientists and engineers as employed college-educated workers in S&E occupations. This operational definition leaves aside the unemployed, those without college degrees, and, more importantly, a large number of people with training in S&E but with jobs that are not classified as S&E jobs. Using data from the National Science Foundation, Kannankutty and Burrelli (2007) show that, in 2003, only 20.1 percent of U.S.-born trained scientists and engineers were working in S&E occupations, while 24.8 percent were working in S&E-related occupations. Among the foreign-born, the corresponding figures were 30.5 and 23.9 percent.[9] In other words, the majority of people with training in S&E are not employed in S&E occupations. I decided to focus on the employed for ease of processing (the MORG data does not allow for the allocation of educational credentials to specific fields) and for certainty of measurement: persons with S&E training working on something else may not be in S&E occupations for a myriad of reasons. Thus, my focus is on actual S&E jobs that require higher education skills, and on the national origin of those who hold those

[9] The remainder were working in non-S&E occupations (37.6% of natives and 29.8% of the foreign-born,) were unemployed (2.7% and 4.2%) or were not in the labor force (9.8% and 11.6%.)

jobs.

Appendix A lists my selection of S&E occupations using 1980 SOC codes and using 2000 SOC codes. My list is slightly shorter than that used by a recent study on foreign-born scientists and engineers (Lowell 2005), which included not only professional but also technical occupations—and which did not impose a college degree constraint either. A downside from the reclassification of occupations in 2000 stems from the grouping of all postsecondary teachers into a single code (see Ellis 2007.) Had the discrimination by discipline, present in the 1980 SOC, been maintained, I would have been able to include postsecondary teachers of S&E specialties. As this is impossible in 2000, postsecondary teachers in 1980 were not included either.

RESULTS

Basic Trends

Table 3 shows the input data for the decomposition analysis. As explained in the Data section, figures from 2000 onwards are very similar to those published by the Bureau of Labor Statistics for the available series. Figures through 1999 are slightly less comparable because of the adjustments that I made to smooth the effect of the revision of CPS weights. At first glance, Table 3 shows the remarkable growth of the foreign-born working population: while there were 9.1 native workers for each foreign-born worker in 1994, there were only 5.5 in 2006. The 2.63 million U.S.-born scientists and engineers in 1994 outnumbered their foreign-born counterparts by a factor of 6.2. In 2006, there were only 3.1 U.S.-born scientist and engineers per foreign-born peer.

Table 3 about here

The growth of each of the six subpopulations can be better appreciated in Figure 2, which shows indices based in 1994 for all of them. The figure also shows the effect of the reclassification of occupations: for the two series on S&Es, estimates from data coded using the 1980 SOC are shown through 2002, while estimates from data coded using the 2000 SOC are shown from 2000 onward. The second series clearly produces higher estimates than the first one for the overlapping years 2000-2002. More generally, Figure 2 shows that all three foreign-born subpopulations grew at much higher rates than all three U.S.-born subpopulations. In addition, for both the foreign-born and natives, it is clear that the subpopulation of S&Es grew faster than the subpopulation of college graduates, which in turn grew faster than the overall working population.

Figure 2 about here

Ratios

Table 4 shows the series of ratios needed for the decomposition analysis, which are calculated from Table 3. The goal is to decompose the change in FSE/NSE, that is, the ratio between foreign-born and native scientists and engineers. As defined earlier, this ratio is the product of the other three ratios shown: the migrant-to-native worker ratio (m), the migrant-to-native proportional college ratio (c) and the migrant-to-native proportional S&E ratio (se). The column that corresponds to the latter is based on estimates obtained using 1980 SOC through 1999 and 2000 SOC afterward. The last column shows the ratio for the years 2000-2002 when 1980 SOC codes are used instead.

Table 4 about here

In order to visualize the rate of change in each of these ratios, Figure 3 presents indices for all of them, where 1994=100. The figure shows that the FSE/NSE ratio grew faster than any of its three components during the period under study, followed by the migrant-to-native worker ratio (*m*), the proportional S&E ratio (*se*), and the proportional college ratio (*c*), which in fact decreased, indicating that the proportion of college graduates among native workers grew faster than the same proportion among the foreign-born—both proportions grew, as it can be seen in Table 3.

Figure 3 about here

Since the H-1B program represents a prominent entry gate for IT professionals, it is interesting to relate the index corresponding to the proportional S&E ratio with the dotcom boom and changes in the H-1B cap. Arguably, since it considers not only S&E jobs but also college degrees, the proportional S&E ratio is the most appropriate indicator to measure competition or substitution between foreigners and natives in skilled S&E occupations.

The proportional S&E ratio grew between 1995 and 1998, that is, during the first years of the dotcom boom. A slight decline occurred in 1999 despite the substantial cap increase that went into effect that year (from 65,000 to 115,000), suggesting that the large increase in S&E jobs held by foreigners did not result in displacement of professional natives from S&E occupations[10]. As the 115,000 cap was maintained in 2000, the proportional S&E ratio increased very slightly, a relative increase far lower than the annual increases registered between 1995 and 1998, again suggesting that substitution of foreigners for natives in S&E occupations, if it took place at all, must have been only marginal at that time. Together with a new rise of the H-1B cap (to 195,000), the year 2001 also saw the definite demise of the dotcom boom and the subsequent mild but persistent recession—and, in the last quarter of the year, the terrorist attacks of September 11 and their immediate aftermath. The substantial increase in the proportional S&E ratio in 2001 most likely reflects the relative flexibility (or rigidity) of labor contracts: while foreign-born workers on nonimmigrant visas such as the H-1B are tied to sponsoring employers, native workers can rapidly switch employer and even industry. In other words, at the end of the dotcom boom, native professionals in S&E occupations either quit earlier, or were dismissed earlier, than their foreign-born counterparts—as shown in Table 3, the number of college-educated natives in S&E occupations did indeed decline in 2000-2001, while the number of foreigners continued to increase. By 2002 job loss (or job turnover) reached the foreign-born as well, resulting in a decline in the proportional S&E ratio, which continued into 2003.

In short, with the exception of 2000-2001, the proportional S&E ratio increased most dramatically during the booming years 1995-1998, before the H-1B cap was ever altered. The 2000-2001 sudden increase in the ratio seems to have been a consequence

[10] It is useful to recall here that 1999 recorded the highest GDP growth rate (7.3%) of the period under study, exceeding the already impressive 6.3% reached in 1998, the second highest.

of the different timing of exit from the S&E workforce of migrants and natives, rather than a result of the new H-1B cap of 2000.[11]

Decomposition

Table 5 presents observed and standardized foreign-born-to-native S&E ratios for each year of the period 1994-2006. The left panel uses the 1980 SOC for the classification of scientists and engineers through 1999, and the 2000 SOC from 2000 on. The right panel extends the 1980 SOC through 2002, and applies the 2000 SOC starting in 2003. To obtain the effects, consider the figures on the left panel for 1994 and 2006. In 1994 the observed FSE/NSE was 0.161, and in 2006 it was 0.319, for an increase equal to 0.158. The difference between the ratio standardized for all factors except *m* (that is, standardized for *c* and *se*) for those same years is 0.310 – 0.191 = 0.119. This figure is the migration effect and indicates that, if the proportional college ratio and the proportional S&E ratio had not changed, the growth in migration alone would have increased FSE/NSE by 0.119, or 75% of the observed increase of 0.158. Similar calculations lead to a slightly negative proportional college effect (0.246 – 0.255 = -0.009) and a positive Proportional S&E effect (0.268 – 0.219 = 0.049)—the negative proportional college effect indicates that, if migration and the proportional S&E ratio had not changed, FSE/NSE would have actually fallen between 1994 and 2006, albeit very slightly.

Table 5 about here

Table 6 presents the computed effects for a selection of pairs of years within the

[11] A disclaimer is in order. Recall that hires by universities, nonprofit organizations and government research laboratories were exempted from the H-1B cap in 2000, and that 20,000 additional H-1B visas were introduced in 2005 for foreigners who hold graduate degrees from U.S. universities. Recall as well that postsecondary teachers of S&E specialties are not classified here as S&Es due to changes in SOC codes (see Data section above.) What this means is that, for example, growth in the number of foreign S&Es employed as faculty in American universities which was made easier by the cap exemption introduced in 2000, is not detected by the present analysis—but the corresponding increase in foreign college graduates is. In short, the reader will benefit from thinking in terms of industry and private sector rather than government or higher education. The former are, by far, more frequent employers of foreign S&Es than the latter.

period under study. Except for the pair corresponding to the whole period (1994-2006) the top panel presents pairs of years in which only the 1980 SOC codes were used to identify scientists and engineers. With the same exception as in the top panel, the bottom panel shows pairs of years in which the 2000 SOC codes were used.

Table 6 about here

Results are instructive. The effects recorded for the whole period, regardless of what SOC codes are used for the years 2000-2002, tell a clear story: about 75 percent of the observed increase in FSE/NSE corresponds to the migration effect. As stated above, this means that in the absence of changes in the proportional college ratio and the proportional S&E ratio, 75% of the increase in FSE/NSE would have been observed anyway due to the increase in migration alone. Yet, 31-32 percent of the increase in FSE/NSE throughout the period is explained by the proportional S&E effect, that is, by an increase in the proportion of college-educated workers in S&E occupations among the foreign-born relative to that among natives.

During the 1990s (see 1994-1999 in the top panel) the increase in FSE/NSE is also mostly explained by the migration effect, but not as dramatically as for the whole period (52%), followed again by the proportional S&E effect, which now explains 40% of the change in FSE/NSE. If one considers the period 1995-1998, when the proportional S&E ratio grew most rapidly, the migration effect (now 47%) is nearly matched by the proportional S&E effect (45%). If the whole dotcom period is considered (1995-2001) the migration effect explains 63% of the observed change in FSE/NSE, while the proportional S&E effect accounts for 30% of it. The lowest proportional S&E effect is recorded for 1994-2002 (only 21% of the observed change in FSE/NSE). If we focus on the period 1998-2002, which includes the two increases in the H-1B cap, the proportional S&E effect is actually negative, mostly as a consequence of the job loss recorded in 2001-2002. Yet, if we look instead at 1998-2001 we still see a slightly negative proportional S&E effect.

In the new century (see 2000-2006, bottom panel) virtually the entire observed change in FSE/NSE would still have happened as a consequence of migration alone even if the proportional college ratio and the proportional S&E ratio had not changed; 20% of it would have taken place if only the proportional S&E ratio had changed, and the ratio would have shrunk (by 20% of the observed change) if only the proportional college ratio had changed. The table shows that most of the increase in FSE/NSE between 2000 and 2006 occurred in the second half of this period, as the effects of 9/11 and the subsequent economic slowdown on skilled migration began to subside. In 2003-2006 the proportional S&E effect explains 31% of the observed increase in FSE/NSE and the proportional college effect accounts for a negative 11%. In other words, the migration effect alone still accounts for the bulk of the observed change: 80%. If one looks into a short period such as 2000-2003, in which the change in FSE/NSE was very small, the effects become a little too volatile because of the small figures involved.

A chart of standardized remittances offers the full view of what happened during the period under study. Figure 4 shows the three series of standardized FSE/NSE, where 2000 SOC codes are used for the classification of scientists and engineers in 2000-2002. Displacements along the vertical axis show the migration, proportional college, and proportional S&E effects that correspond to subperiods along the horizontal axis (Smith et al. 1996). Recall that the effect from one factor is computed from the series of FSE/NSE standardized for the other two factors, so that the slopes of the curves show the periods in which each factor by itself would have produced an increase or a fall in FSE/NSE.

Figure 4 about here

The most obvious result is that the migration effect was positive throughout the full range of years. In contrast, the proportional S&E effect was slightly negative in the first year of the series, in 1998-1999 (just as the H-1B cap was raised for the first time,) and in 2001-2003[12]; the proportional college effect, in turn, was generally more

[12] When 1980 SOC codes are used through 2002, the FSE/NSE ratio standardized for *m* and *c* shifts downwards in 2000-2002 (alternative chart available from the author.) This results from the underestimation of S&E occupations by the 1980 SOC classification. Consequently, the proportional S&E effect becomes strongly negative in 1999-2000 and sharply positive in 2002-2003. Since by 2000 the 1980 SOC classification was certainly outdated, the chart shown should better reflect real processes at work: a positive proportional S&E effect in 2000-2001 and a negative one in 2001-2003 reflect both changes in the H-1B visa cap and the end of the dotcom boom.

moderate and it was negative more often than positive. Focusing on the slopes, we can also identify two subperiods during which the proportional S&E effect roughly matched the migration effect: 1995-1998 and 2000-2001.[13] This finding parallels observations made above concerning the proportional S&E ratio. First, the proportional S&E effect rivals the migration effect not as a consequence of H-1B cap increases, but before they ever happened, during the first half of the dotcom boom (1995-1998). Second, the proportional S&E effect matches the migration effect the year of the dotcom collapse, as natives were able to switch to other jobs and industries before foreigners did, or else were dismissed before foreigners were.

CONCLUSIONS

Defining scientists and engineers as college-educated workers in S&E occupations, the foreign born-to-native S&E ratio (FSE/NSE) nearly doubled between 1994 and 2006, from 0.16 to 0.30. The analysis presented here takes a close look at this ratio and how it came to change during the period under study. Results are telling. Before turning to them, however, a quick review the meaning, and usefulness, of the various estimated effects is in order.

I decomposed the change in FSE/NSE into three effects. The migration effect refers to the change in FSE/NSE that would have been observed if only the ratio between migrant and native workers had changed, keeping constant the proportions of college graduates and the proportion of college graduates in S&E occupations among both migrants and natives. Conceptually, this subsumes the effect of migration alone. Part of the increase in the number of foreign born scientists and engineers is simply a result of massive immigration, even if no change happens in the relative distributions of skills among immigrants and natives. The second effect, which I labeled proportional college effect, refers to the change in FSE/NSE that would have been recorded if only the relative proportions of college graduates among migrants and natives had changed. In essence, this is a simplified skills effect that does not take into account the distribution of these skills among fields. Finally, since only college graduates can be scientist and

[13] While a cursory look may suggest that this is the case in 2003-2005 as well, the corresponding calculations show that the migration effect more than doubled the proportional S&E effect during that subperiod.

engineers (as I defined them) the last effect is attributable to changes in the proportions of scientists and engineers among eligible workers only. This is the proportional S&E effect, which represents the change in FSE/NSE that would have occurred if only the migrant-to-native ratio between the proportion of scientists and engineers among college graduates had changed. This effect is, therefore, at the core of the issue. It ultimately tells us to what extent changes in the migrant-to-native S&E ratio is attributable to the immigration of scientists and engineers per se.

The first and most important finding presented above is that the migration effect explains about three-quarters of the increase in FSE/NSE during the entire period under study, with the proportional S&E effect accounting for another 31 or 32 percent—the proportional college effect was negative. What this ultimately means is that immigration policy intending to facilitate the immigration of skilled workers, who did indeed come to the U.S. in large numbers, was of limited consequence (as far as the foreign born-to-native S&E ratio goes) given the equally impressive rise in unskilled migration. In other words, the increase in FSE/NSE had little to do with the actual immigration of college-educated workers in general or scientists and engineers in particular. We can fairly attribute 75% of the increase in FSE/NSE during 1994-2006 to what we could call the force of migration alone.

The only subperiod during which the proportional S&E effect nearly matched the migration effect (45% vs. 47% of the total change in FSE/NSE) was 1995-1998, that is, during the first half of the dotcom boom and before the annual cap on H-1B visas was ever increased. The interpretation of this result is quite informative: a booming economy, without major changes in immigration policy toward the skilled, created auspicious conditions for the (disproportional) immigration of scientists and engineers. Stated this way, the friendliest immigration policy toward scientists and engineers is a booming economy, with no need to alter immigration regulations.

Prompted by claims of a shortage of talented labor by representatives of the then thriving IT industry, Congress took active part in reshaping immigration policy towards the highly skilled by increasing the annual cap on H-1B visas in 1999 and again in 2001. The latest cap increase was largely inconsequential because by 2001 the dotcom boom came to an end and recession took over, so that the proportional S&E effect for 1998-2002 was largely negative. Even excluding 2002, the proportional S&E effect was still slightly negative in 1998-2001. In words, if the foreign born-to-native S&E ratio had been determined by the immigration of scientists and engineers alone, it would have actually decreased even as government took action to promote precisely this type of migration. This does not mean that scientists and engineers did not come to the U.S. during those years. It means that the other factors considered (proportion of college graduates among migrants and natives, general migration alone, and so on) cancelled out the effect of the actual immigration of scientists and engineers on the ratio under study. This result is also a welcome reminder that H-1B visas are not the only avenue of entry for foreign born skilled workers, including scientists and engineers. Family-based green cards, for example, are often assumed to be mostly for unskilled workers, but quite a few foreign professionals marry American citizens or lawful permanent residents and obtain their green cards through their spouses. After all, even if there is an employer willing to sponsor, the processing of a family-based lawful permanent residency application is simpler and faster than the employment-based alternative.

Starting in 2001, the economy slowed down considerably. In the period 2000-2006, the proportional S&E effect declined to 20 percent of the total change in FSE/NSE. Migration alone now explains the entire change in FSE/NSE, as the proportional college effect is largely negative. This finding mirrors what I reported for the period 1995-1998. With care taken not to infer causality (inappropriate in a decomposition analysis) it appears that a slower economy is correlated with a declining importance of skilled migration in general, and of the migration of scientists and engineers in particular—the reader must recall that the focus is on ratios between migrant and native subpopulations; as shown in Table 4, all ratios actually increased in the period 2000-2006.

Finally, turning the focus of attention to the proportional college effect, we notice (as shown in Table 6) that this effect became largely negative in 2000-2006. Coupled with a positive proportional S&E effect, this suggests that, while the proportion of college-educated natives is on the rise—and more so than the same proportion among migrants—American college graduates are not embracing (or else are being kept out of) S&E occupations. Relatively speaking, they are either leaving or losing jobs to foreign born scientists and engineers. This question cannot be answered with decomposition tools, but since all observations in this sample are employed, those not employed in S&E

occupations are employed elsewhere. We do therefore see job substitution. Legal safeguards are in place to ensure that H-1B holders face working conditions comparable to the industry average, including prevalent wages. While there has certainly been fraudulent use of the H-1B program by individuals and firms for the purpose of replacing American workers with immigrants, it seems reasonable to suspect that in most cases natives are turning to other occupations voluntarily, starting with the majors they choose in college. As has been noted by various observers, careers in S&E simply do not offer, from the point of view of natives, incentives comparable to other professions.

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Table 1
Workers, College-educated Workers, and College-educated Workers in Science & Engineering Occupations, Foreign-born and Native, 1994-2006. Differences in Estimates with 2000 vs 1990 weights, 2000-2002

Weights and	Foreign Born			Native		
Year	All workers	College+	S&E	All workers	College+	S&E
1990 weights						
2000	16,933,420	4,622,783	860,908	118,318,147	32,563,204	3,454,499
2001	17,511,211	4,902,623	927,714	117,766,953	32,934,605	3,324,413
2002	17,532,899	5,031,618	871,356	116,708,065	33,593,496	3,149,100
2000 weights						
2000	18,142,945	4,938,092	932,984	118,737,301	32,740,065	3,459,166
2001	18,870,326	5,240,615	1,002,727	118,299,564	33,117,843	3,329,191
2002	18,986,413	5,389,513	947,058	117,463,505	33,828,228	3,162,829
Difference 2000 weigths - 1990 weights						
2000	1,209,525	315,309	72,076	419,154	176,861	4,667
2001	1,359,115	337,992	75,013	532,611	183,238	4,778
2002	1,453,514	357,895	75,702	755,440	234,732	13,729
Difference 2000 weigths - 1990 weights (percent)						
2000	7.14	6.82	8.37	0.35	0.54	0.14
2001	7.76	6.89	8.09	0.45	0.56	0.14
2002	8.29	7.11	8.69	0.65	0.70	0.44

NOTES
Figures shown are point estimates from CPS-MORG files.
College+ stands for college degree or higher.
S&E is short for science and engineering occupations.
Each column category is fully included in the previous one, so that College+ are all workers, and S&Es are all college-educated workers.

Science and Engineering Occupations were determined using the 2000 revision of the Federal Standard Occupational Classification (SOC).

Table 2
Effect of Revision of Weights on the Ratios Used in the Decomposition

Weights and year	Ratio		
	m	c	se
w/1990 weights			
2000	0.143	0.992	1.755
2001	0.149	1.001	1.875
2002	0.150	0.997	1.847
w/2000 weights			
2000	0.153	0.987	1.788
2001	0.160	0.992	1.903
2002	0.162	0.986	1.879
Percent increase			
2000	6.76	-0.49	1.87
2001	7.28	-0.91	1.53
2002	7.59	-1.14	1.74

Table 3
Workers, College-educated Workers, and College-educated Workers in Science & Engineering Occupations, Foreign-born and Native, 1994-2006.

	Foreign Born			Native		
Year	All workers	College+	S&E	All workers	College+	S&E
1994	12,185,031	3,039,015	423,296	111,270,846	28,111,442	2,632,534
1995	12,332,259	3,025,423	409,280	113,045,546	29,052,260	2,675,316
1996	13,938,023	3,635,099	541,058	113,399,873	29,626,951	2,698,951
1997	15,128,797	3,970,964	641,335	115,229,484	30,433,200	2,860,877
1998	16,036,941	4,269,717	712,858	116,756,568	31,426,013	2,944,570
1999	16,652,728	4,602,194	770,989	118,217,548	32,293,184	3,052,771
2000 (1980 SOC)	18,142,945	4,938,092	814,059	118,737,301	32,740,065	3,224,924
2000 (2000 SOC)	18,142,945	4,938,092	932,984	118,737,301	32,740,065	3,459,166
2001 (1980 SOC)	18,870,326	5,240,615	874,070	118,299,564	33,117,843	3,138,926
2001 (2000 SOC)	18,870,326	5,240,615	1,002,727	118,299,564	33,117,843	3,329,191
2002 (1980 SOC)	18,986,413	5,389,513	794,232	117,463,505	33,828,228	2,982,838
2002 (2000 SOC)	18,986,413	5,389,513	947,058	117,463,505	33,828,228	3,162,829
2003	19,680,492	5,581,328	979,197	118,049,867	34,722,556	3,407,824
2004	20,260,877	5,690,171	983,595	119,108,182	35,582,588	3,417,707
2005	21,007,539	5,994,568	1,063,326	120,921,414	36,200,512	3,535,121
2006	22,178,527	6,423,152	1,135,432	122,338,885	37,168,282	3,554,102

NOTES
Figures shown are point estimates from CPS-MORG files.
College+ stands for college degree or higher.
S&E is short for science and engineering occupations.
Each column category is fully included into the previous one, so that College+ are all workers, and S&Es are all college-educated workers.

Weights: For 2000-2006, 2000-based weights were used. For 1994-1999, 1990-based weights were used and the totals were adjusted to smooth the effect of the revision of weights in 2000 (see text.)

Table 4
Ratios used in the Decomposition

Year	FSE/NSE	m	c	se*	se w/occ80**
1994	0.161	0.110	0.987	1.487	
1995	0.153	0.109	0.955	1.469	
1996	0.200	0.123	0.998	1.634	
1997	0.224	0.131	0.994	1.718	
1998	0.242	0.137	0.989	1.782	
1999	0.253	0.141	1.012	1.772	
2000	0.270	0.153	0.987	1.788	1.674
2001	0.301	0.160	0.992	1.903	1.760
2002	0.299	0.162	0.986	1.879	1.671
2003	0.287	0.167	0.964	1.788	
2004	0.288	0.170	0.940	1.800	
2005	0.301	0.174	0.953	1.816	
2006	0.319	0.181	0.953	1.849	

FSE / NSE: Migrant-to-Native S&E Ratio
m: Migrant-to-Native worker Ratio
c: Migrant-to-Native Proportional College Ratio
se: Migrant-to-Native Proportional S&E Ratio

* 1980 SOC codes for 1994-1999, and 2000 SOC codes for 2000-2006.
** The last column shows the se ratio when the 1980 SOC codes are used for 2000-2002.

Table 5
Foreign-born-to-Native Scientist and Engineer Ratio, 1994-2006.
Observed and Standardized

	With 1980 SOC through 1999				With 1980 SOC through 2002			
	Observed	FSE / NSE standardized for all factors except:			Observed	FSE / NSE standardized for all factors except:		
Year	FSE / NSE	m	c	se	FSE / NSE	m	c	se
1994	0.161	0.191	0.255	0.219	0.161	0.187	0.250	0.218
1995	0.153	0.192	0.248	0.217	0.153	0.187	0.243	0.216
1996	0.200	0.211	0.258	0.236	0.200	0.206	0.252	0.236
1997	0.224	0.224	0.257	0.248	0.224	0.219	0.252	0.247
1998	0.242	0.234	0.256	0.256	0.242	0.229	0.251	0.256
1999	0.253	0.240	0.262	0.255	0.253	0.235	0.256	0.255
2000	0.270	0.261	0.256	0.258	0.252	0.255	0.250	0.241
2001	0.301	0.273	0.257	0.275	0.278	0.267	0.252	0.254
2002	0.299	0.277	0.255	0.272	0.266	0.270	0.250	0.240
2003	0.287	0.285	0.249	0.258	0.287	0.279	0.244	0.258
2004	0.288	0.290	0.243	0.260	0.288	0.284	0.237	0.260
2005	0.301	0.297	0.246	0.262	0.301	0.291	0.241	0.263
2006	0.319	0.310	0.246	0.268	0.319	0.304	0.241	0.268

Table 6
Selected Decomposition Pairs for the Change in the Foreign-born-to-Native S&E Ratio, 1994-2006

Period	Total change in FSE/NSE	Migration effect	Proportional College effect	Proportional S&E effect
Using 1980 SOC through 2002				
1994-2006	0.159	0.118	-0.009	0.050
1994-1999	0.092	0.048	0.007	0.037
1995-1998	0.089	0.042	0.008	0.040
1995-2001	0.125	0.080	0.009	0.037
1994-2002	0.105	0.083	0.000	0.022
1998-2002	0.024	0.041	-0.001	-0.016
1998-2001	0.036	0.038	0.001	-0.003
1994-2006	100%	74%	-6%	32%
1994-1999	100%	52%	7%	40%
1995-1998	100%	47%	9%	45%
1995-2001	100%	63%	7%	30%
1994-2002	100%	79%	0%	21%
1998-2002	100%	169%	-3%	-66%
1998-2001	100%	104%	3%	-7%
Using 2000 SOC from 2000 on				
1994-2006	0.159	0.119	-0.009	0.049
2000-2006	0.050	0.049	-0.010	0.010
2003-2006	0.032	0.026	-0.003	0.010
2000-2003	0.018	0.024	-0.006	0.000
1994-2006	100%	75%	-6%	31%
2000-2006	100%	99%	-20%	20%
2003-2006	100%	80%	-11%	31%
2000-2003	100%	135%	-36%	1%

Figure 1: Visas issued under selected categories and H-1B visa cap, 1996-2005

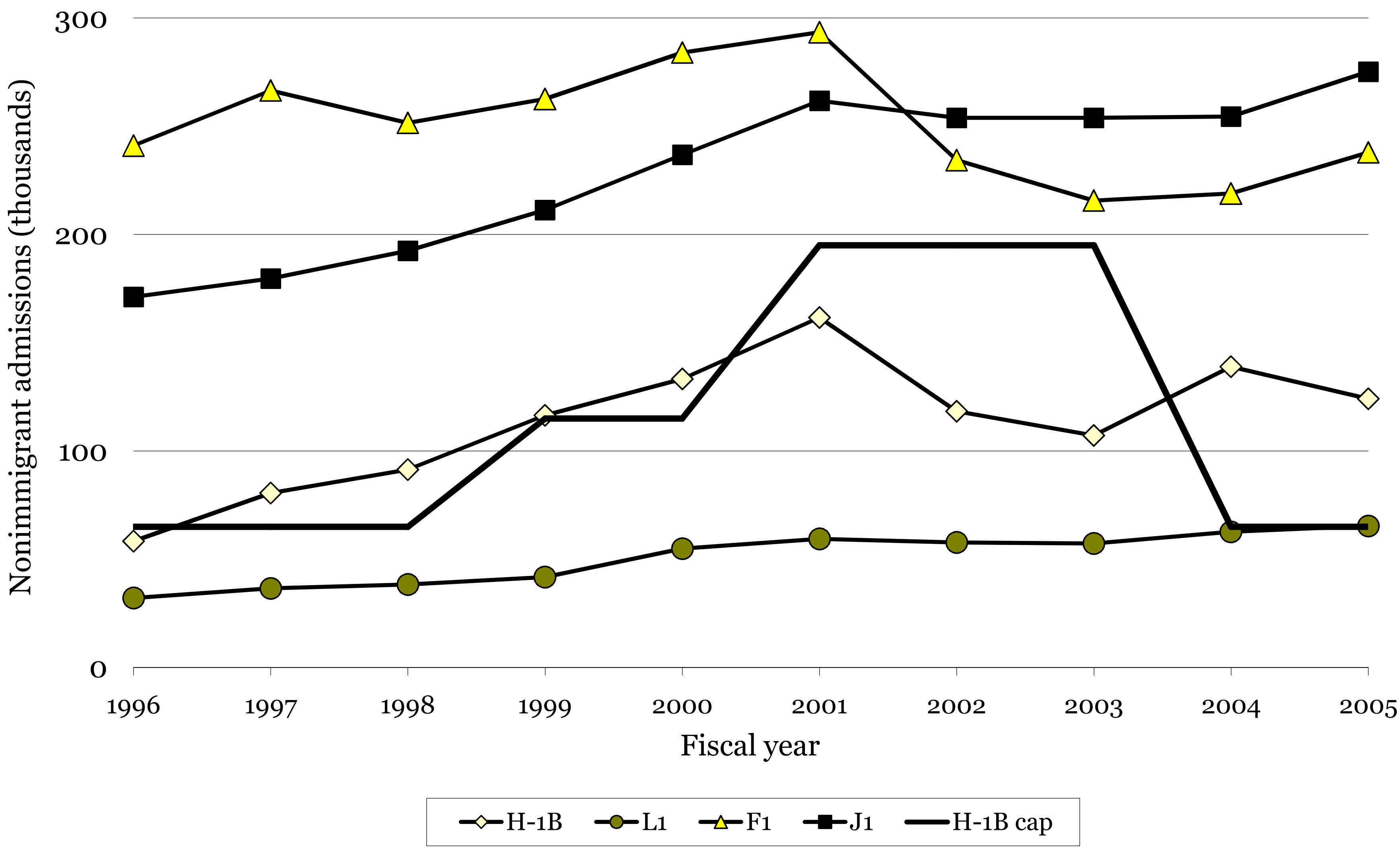

Figure 2. Working Population: Total, College-educated, and College-educated in Science and Engineering Occupations, Foreign-Born and Native, 1994-2006 (1994=100)

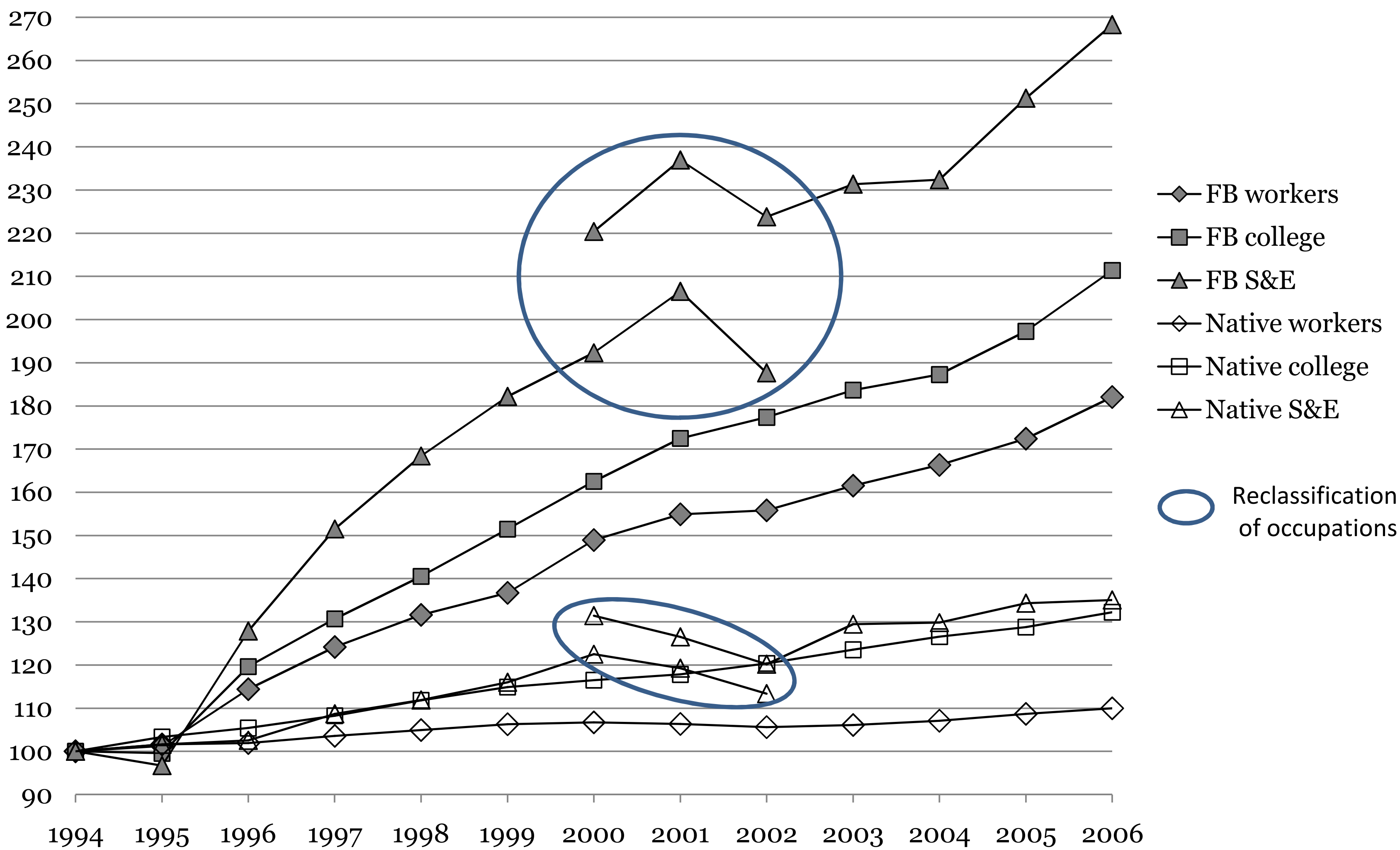

Figure 3. Ratios Used in the Decomposition. Indices with 1994=100

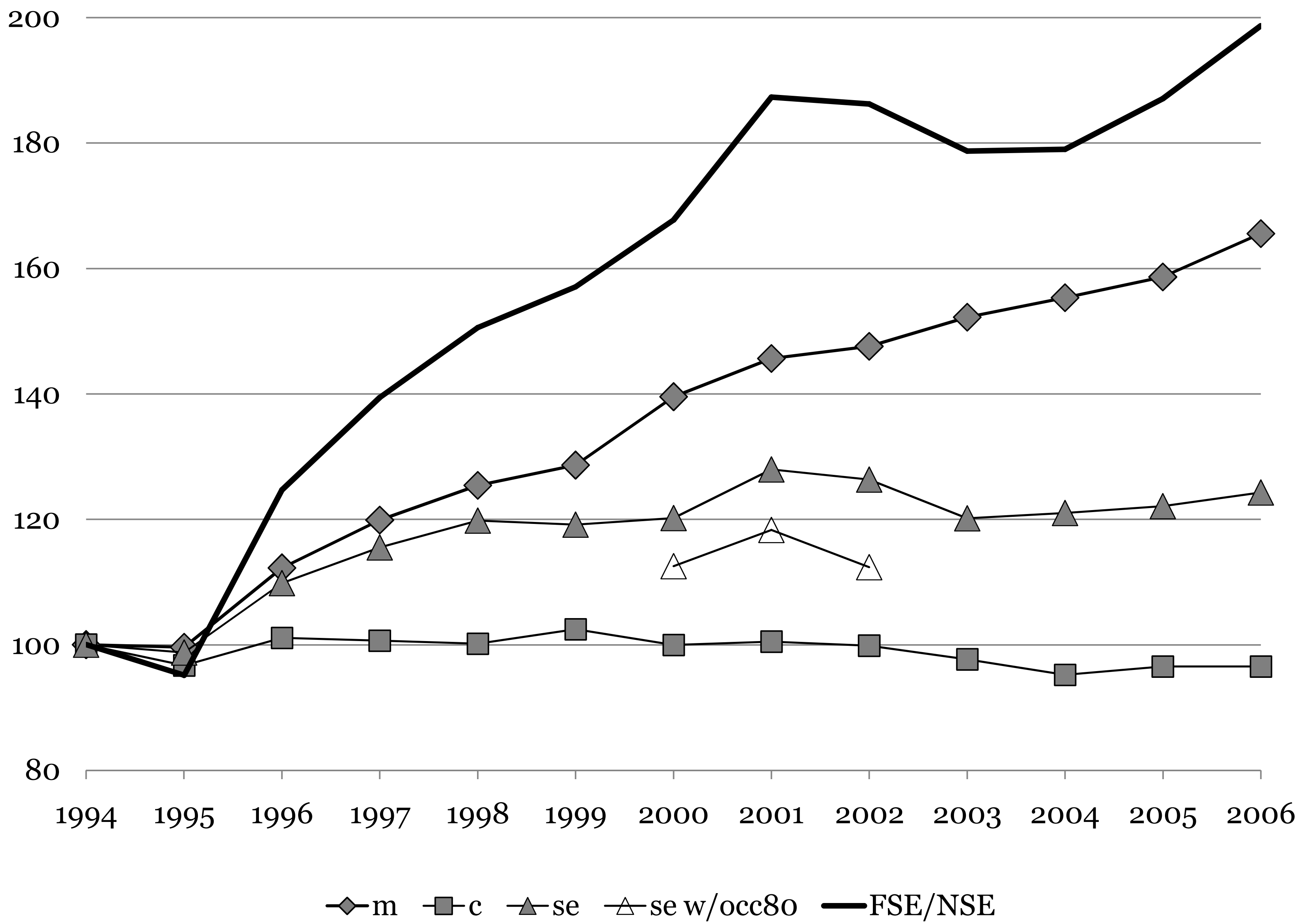

FIGURE 4. Migrant-to-Native Science & Engineering Ratio, 1994-2006
Standardized Effects (Version R00)