Race and gender trends in computer science in the Silicon Valley from 1980-2015

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Abstract:

We analyze race and gender trends in the Silicon Valley technology industry from 1980 to 2015, with a focus on computer science. In the technology industry, there has been a rapid growth of Asians among professionals and, to a lesser extent, among managers, coincident with a decrease in the proportion of Whites, particularly White females. There continues to be low participation of Hispanics and Blacks, especially Black females. These race trends are even more salient among programmers; in addition, we document a stable or increasing gender gap across all races in the programmer labor force and in computer science higher education. However, these demographic shifts are not always consistent with either a pipeline argument that there are insufficient supplies of potential underrepresented programmers or a wage difference explanation. Findings suggest that policies to increase the number of programmers in underrepresented groups should differ by race and gender groups.

JEL Codes: I23; I24; J15; J16; J21; J24

Keywords: race; gender; technology; computer science; labor market; worker supply; higher education

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1. Introduction

There have been dramatic changes in the racial and gender composition of the Silicon Valley technology workforce over the past several decades. The technology industry has traditionally been a White male-dominated industry, although it appeared to be changing in the 1980s with the growing participation of White females in professional jobs and management (Carnoy & Gong, 1996). This trend has not continued, and other patterns have emerged. In the current paper, we analyze race and gender in the technology industry from 1980 to 2015. We then take a closer look at programmers, one of the most salient occupations in technology. In addition to describing changes in the race and gender of the programmer workforce, we examine the supplies of potential programmers in higher education and programmer wages. These analyses provide a heuristic for understanding race and gender gaps in the high technology industry and how these gaps may have different policy implications.

Race and gender are important concerns in the increasingly influential field of technology, demonstrated by several recent high-profile lawsuits that have alleged racial or gender discrimination in the technology workplace (Fiegerman, 2017). These cases align with a growing body of research that suggests that while gender and race disparities have been widely documented in Science, Technology, Engineering & Math (STEM) (Beede et al., 2011; Landiva, 2013; U.S. Equal Employment Opportunity Commission, 2016), these gaps may be particularly severe in computer science, one of the major disciplines in STEM. Although the proportion of females earning degrees in STEM has risen in most STEM fields, computer science remains one of the STEM disciplines with the lowest proportion of women (National Science Foundation, 2017). Furthermore, the gender wage gap is smaller in STEM compared to non-STEM jobs, but Computer & Math has the highest gender wage gap among the STEM fields (Beede et al., 2011). In addition, while there has been increasing representation of Blacks and Hispanics in STEM degrees (National Science Foundation, 2017), these minorities have relatively low representation in computer occupations compared to in other STEM occupations (Landiva, 2013).

Given the growing prominence of computer science[3], it is important to have an accurate representation of the gender and race trends in the education and career trajectories in this field. Prior literature has tended to focus on STEM more broadly, although there is growing concern about diversity in computer science (Google Inc. & Gallup Inc., 2016). Thus, this paper provides a more detailed analysis for the software developer occupation ("programmers"), the largest of the STEM occupations (Landiva, 2013). Although we cannot point to causes of the diversity gaps in technology, we explore two common explanations for these differences, the supply of potential programmers and wages, to understand differences in representation of race and gender groups among programmers.

We explore the programmer pipeline as a potential factor for demographic differences in the programmer workforce. Many papers have used or critiqued a "leaky pipeline" metaphor for STEM workers (Metcalf, 2010 for review). Whether or not the pipeline is the most appropriate metaphor, gender and racial disparities have been observed in the supply of STEM labor, from attitudes and exposure to technology in junior high and high school (Google Inc. & Gallup Inc., 2016; Riegle-Crumb et al., 2011; Quinn & Cooc, 2015) to enrollment and persistence in STEM

[3] It is estimated that more than half of Science, Technology, Engineering & Mathematics (STEM) jobs will be in computer science-related fields by 2018 (Smith, 2016)

courses in higher education (Katz et al., 2003; Griffith, 2010). Higher education is the most common transition into the workforce and thus a critical juncture for understanding the demographics in the workforce. Therefore, we examine race and gender trends in computer science in higher education, which we use as a proxy for the numbers of potential programmers by race and gender.

In addition to the pipeline analysis, we also examine whether wage differences can be another factor in the demographic trends observed. Wage differences by race and gender have been well-documented in the overall labor market (Altonji & Blank, 1999) and in the technology labor force (Beede et al., 2011; American Institute for Economic Research, 2014). Although it is difficult to attribute wages to observable characteristics such as race or gender (see Altonji & Blank, 1999 for review), wages have been suggested as a potential source of racial differences in the technology labor market (Salzman, Kuehn & Lowell, 2013) We focus our wage analysis on a specific occupation, programmers, to minimize biases across occupations. The programmer wage data are limited to Whites and Asians due to the sparse numbers of Hispanic and Black programmers, and even so, the analyses should be interpreted with caution.

We find that the technology industry has become increasingly Asian and decreasingly White, and that there has been pervasive low representation for Hispanics and Blacks. There are several differences in the demographics of managers versus professionals in technology (for example, less Asian representation among managers). Race and gender changes are even more dramatic among programmers; Asian males have become the predominant group of programmers. We also document increasing masculinization of computer science, both in the labor force and in degree completions. The higher education analysis shows that low representation of certain groups may originate at different points prior to labor force entry. Lastly, there is some evidence of wage gaps by race and gender, although it is difficult to make conclusive claims.

Section 2 describes the data used in the analyses. Section 3 provides a broad overview of the demographic trends in the technology industry in the Silicon Valley with comparisons to other major industries. Section 4 provides an analysis of the demographic trends for programmers. Section 5 analyzes the race and gender trends for computer science in higher education. Section 6 discusses wage trends for White and Asian programmers. Section 7 concludes.

2. Data description

The labor force analyses use microdata from the 5% sample in 1980, 1990 and 2000 U.S Censuses and the 1% samples of the 2010 and 2015 American Community Surveys[4]. To examine the technology sector, we limit the sample population to the geographic region most salient in technology: the Silicon Valley[5]. In addition, we limit the sample to individuals in the labor force, which excludes those who are younger than 16 years old, and only include full-time full-year (FTFY) workers, who are defined as individuals who usually work 35 hours a week or more and worked at least 50 weeks in the previous year[6]. All analyses are weighted by individual weights.

[4] The long form of the population census ceased in 2000

[5] This includes respondents in the following counties: Alameda, Contra Costa, San Francisco, San Mateo, Santa Clara and Santa Cruz. The Silicon Valley is not an official government designation and thus we use an inclusive geographic region in our analyses.

[6] The National Center for Education Statistics uses these definitions of full-time and full-year

In the introductory set of analyses, we look at patterns across industries in the Silicon Valley which enables us to compare trends in the technology industry to other major industries. Specifically, we create the following exclusive industry categories: Manufacturing, High Services, and Technology (analyses in this paper leave out other industry categories)[7]. We also categorize types of occupations into Managers and Professionals[8], leaving out other occupation categories.

We then restrict our analyses to a specific occupation, software developers[9] ("programmers"). Although there have been re-classifications of technology occupations in the census, the programmer occupation has remained stable since the census began recording information on technology professions in 1970, and it is easily comparable across years (Beckhusan, 2016). Programmers are part of the professional occupation category, although they span across industries.

Since research has demonstrated that much of the gender wage gaps are due to differences between occupations or industries rather than within, we use this narrow occupation to minimize potential differences between occupations and obtain a more conservative estimate of any wage gaps (Petersen & Morgan, 1995). Wage data are restricted to Whites and Asians due to low numbers of observations in wage data for Hispanics and Blacks. The hourly wages are restricted to positive wages (i.e. reported wages of 0 are dropped) of full-time, full-year workers and are constructed by dividing the annual income from occupation by the number of weeks per year and number of hours per week worked[10].

To construct the dataset of race and gender in computer science higher education, we combine data from the Integrated Postsecondary Education Data System (IPEDS) with data from the Open Doors surveys (Open Doors). We use IPEDS completion data for computer science degrees, including race and gender data, from 1985-2015 (earliest available data is 1985) for California[11] and include national data for context. We then combine these data with country of origin data from the Open Doors surveys for non-resident alien students whose race is not identified. This combination creates degree completion numbers by race and gender for computer science undergraduate and graduate degrees.

The absolute percentages of race and gender provide one important perspective on the demographic trends in the technology industry. However, these percentages do not account for

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[7] We define an industry as belonging to the technology industry if the industry is listed as "Computers and related equipment" (#322), "Radio, TV, and communication equipment" (#341), "Electrical machinery, equipment, and supplies, nec" (#342), "Guided missiles, space vehicles, and parts" (#362), "Scientific and controlling instruments" (#371), "Computer and data processing services" (#732), "Engineering, architectural, and surveying services" (#882) or "Research, development, and testing services" (#891) in the harmonized industry variable (ind1990). Manufacturing industries were industries with the codes 100-392 in the harmonized industry variable (ind1990), excluding those in the computer category. High services industries were industries with the codes 700-712, 721,732, and 812-893 in the harmonized industry variable (ind1990), excluding those in the computer industry.

[8] Occupations are categorized as Manager with the codes 004-022 in the harmonized occupation category (occ1990). These do not include management-related occupation such as accountants or HR specialists and include executives (there were too few executives to be a separate category). Occupations are categorized as Professionals with the codes 043-200 (Professional Specialty list), 229 (programmers), and 23-37 (Management-Related occupations) in the harmonized occupation category (occ1990). All other occupations are categorized as "Other" in these analyses (includes occupations such as cook, bookkeeper, waiter, office clerk, etc.).

[9] We use the harmonized occ1990 occupation category of 229 (programmers) which is defined as computer software developers and computer scientists/analysts (occ1990)

[10] 2015 data uses intervalled data; the average is used for that year.

[11] We recognize that the Silicon Valley technology labor market may be a national market, but restrict the higher education analysis to California for comparability.

overall representation of each demographic group within higher education or the labor force as a whole. We calculate ratios for each race-gender group of the group's representation in the occupation or completing a CS degree relative to its representation in the labor force or in higher education as a whole, based on the ratio of representation measure constructed by Lewis and colleagues (Lewis et al, 2009). A ratio of 1 indicates equal representation, greater than 1 indicates overrepresentation and less than 1 indicates underrepresentation.

3. Technology Trends from 1980-2015

Silicon Valley context

The Silicon Valley has become synonymous with high technology and is the focal region of analysis in this paper. Over the past several decades, the technology labor force has become increasingly concentrated in this area. In 2015, 2% of the national full-time full-year labor force was located in the Silicon Valley, yet 7.5% of the technology labor force and 10% of programmers were in the Silicon Valley.

However, it is important to acknowledge demographic differences between the Silicon Valley labor force and the national labor force. Nationally, the percentage of White males declined from 1980 to 2015 (57% to 37%) and the percentage of White females was relatively stable at 27%, whereas every other race-gender group made gains, particularly Hispanics and Asians (Appendix A1). During this time period in the Silicon Valley, the percentage of White males in the labor force halved from 48% to 24%, the percentage of White females decreased from 25% to 16%, and the percentage of Blacks also declined. Meanwhile, the representation of Hispanics and Asians increased, more than doubling from 1980 to 2015 for Hispanics and more than tripling for Asians. Hispanics and Asians represented over half of workers in the Silicon Valley in 2015, compared to about 30% nationally.

In addition, the percentage of foreign workers is particularly high in the Silicon Valley. Nationally, the percentage of foreign workers has been increasing, from about 3% in 1980 to 8.5% in 2015, and even higher in the technology industry (11%). Meanwhile, in the Silicon Valley, the percentage of foreign workers started at 7% in 1980 and increased to 18% in 2015. Foreign workers comprised nearly a quarter (24%) of the technology labor force in 2015. Although the countries of origin for technology workers were more broadly distributed in 1980, by 2015, the most represented countries were India (46%) and China (17%).

Major Industries in Silicon Valley

For an overview of the significance of technology in the Silicon Valley, we compare the technology labor force to those of two other major industries, manufacturing and high services, from 1980-2015, extending similar analyses by Carnoy & Gong (1996). There are common changes across these three industries in labor force educational attainment, race and gender, yet the technology industry has shifted towards a more Asian and less female labor force than the other industries.

Manufacturing, high services and technology represented over half of the labor force across all industries in the Silicon Valley from 1980-2015 (Appendix A2). Although the technology industry is not the largest industry in terms of labor force, its proportion of the total labor force increased over the past few decades. Technology's share of the labor force increased from 14% in 1980 to a high of 20% in 2000, declining to 18% in 2015.

The occupations within these industries can be categorized broadly into managers, professionals, and other workers. The proportions of the labor force in these occupations have changed dramatically over the past several decades (Appendix A3). The percentage of workers who were managers or professionals increased steadily in all three industries such that managers and professionals constituted almost half of workers in the manufacturing industry, almost two-thirds of workers in the high services industry and more than four-fifths of workers in the technology industry by 2015. The proliferation of both managers and professionals was especially salient in the technology industry, where the number of managers more than quadrupled and the number of professionals nearly quadrupled from 1980 to 2015. Managers made up almost a quarter (24%) and professionals were 58% of the technology industry in 2015.

During this time period, the level of education among workers increased (Appendix A4). Notably, the proportion of workers with undergraduate degrees increased in each occupation category in all three industries, primarily from 1980 to 1990. The proportions of managers and professionals with graduate degrees also generally increased, although these increases came after an initial decline from 1980 to 1990. By 2015, the vast majority of both managers (89%) and professionals (91%) in the technology industry held at least a bachelor's degree, and almost half of managers (45%) and professionals (48%) had graduate degrees.

There was a marked shift in the racial and gender composition of the workforce in these industries over the decades (Appendix A5). Although Whites were the majority race of workers across these three industries in 1980, the percentages of managers and professionals who were White steadily declined while the percentages of Asian managers and professionals dramatically increased in all three industries.

Whites represented 80-90% of managers in the three industries in 1980, but declined to 55% in manufacturing, 57% in high services and 52% in technology in 2015. Meanwhile, the percentage of Asian managers quadrupled in high services (5% to 21%) and increased to nearly eight times their starting percentages in manufacturing (4% to 32%) and technology (5% to 39%); these increases were particularly evident in 2000 and later years. The percentages of Hispanic managers increased from 5% to 6% in manufacturing, 6% to 13% in high services and 4% to 6% in technology. The percentages of Black managers were low over these industries and years.

Similar trends exist for professionals in these industries, although the representation of Whites decreased even more dramatically for professionals than for managers in manufacturing and technology. Approximately four-fifths of professionals across the three industries were White in 1980, but just under half of professionals in manufacturing, 53% in high services and 36% of professionals in technology were White in 2015. Meanwhile, the percentages of Asian professionals quadrupled in the manufacturing and technology industries and tripled in high services. In the technology industry, the percentage of Asian professionals overtook that of Whites by 2010, and Asians represented over half of all professionals (54%) in 2015. The percentages of Hispanic professionals increased in manufacturing and technology and doubled in high services (7%, 5% and 10% in 2015, respectively). The percentages of Black professionals, like Black managers, remained similarly low in all three industries and declined in the manufacturing industry.

In addition to these racial trends, the gender composition of the labor force within these industries also shifted (Appendix A6). The trends are more similar for the manufacturing and technology industries than the high services industry, which started out with and continued to have greater female representation in the labor force than the other two industries. Females

represented less than one-fifth of managers in the manufacturing and technology industries in 1980, climbing to 35% in manufacturing and 31% in technology by 2015. The percentage of female professionals increased in all three industries during this time. Accordingly, the technology industry had the lowest female representation in both managerial and professional jobs among all three industries by 2015.

In summary, the technology industry shares several demographic trends with the other major industries in the Silicon Valley. The managerial and professional labor force in these industries has become more educated, less White and more female. While the racial and gender distributions were similar across these industries in 1980, the technology labor force became much more Asian and less female than the other two industries by 2015.

Technology Industry

An analysis of race and gender in the technology industry reveals similarities in the trends for managers and professionals within the industry (Figure 1). There have been increases in the numbers of managers and professionals across all races, especially for Asian males and females. The dominant race shifted from White to Asian, while Hispanics and Blacks remained a relatively low percentage of the technology labor force. In 1980, White males were the largest group in both occupation categories, representing 75% of managers and 69% of professionals in technology (Table 1). These percentages decreased each decade, to 38% of managers and 29% of professionals in 2015. White males remained the largest group among managers but fell to second among professionals in 2015.

The next largest groups of managers and professionals in 1980 were White females followed by Asian males. These two groups followed different trajectories throughout the next several decades. White females represented 15% of managers and 12% of professionals in 1980; their percentages declined to 13% of managers but almost halved to 7% of professionals. Thus, the increase in White female representation among managers and professionals in technology found in Carnoy and Gong (1996) in the 1980s to 1990s did not continue and appears to have reversed for White females in the early 2000s. Meanwhile, Asian males comprised 4% of managers and 10% of professionals in 1980. However, Asian males became an increasingly larger percentage in both occupational categories, becoming the second largest group among managers (25%) in 2015. Asian males overtook White males in the professional occupations by 2010 and remained the largest group (39%) of professionals in 2015.

The percentages of managers and professionals who were Asian females were low in 1980. Asian females started at 1% of managers and 2% of professionals yet steadily increased their numbers until they represented 14% of the managers and 15% of professionals in 2015. By 2015, White and Asian females represented similar percentages of managers (13% and 14%, respectively), although the percentage of Asian females was double the percentage of White females in professional occupations (7% and 15%, respectively).

Although the numbers of Hispanics and Blacks in technology increased over this time period, the representation of Hispanic and Black managers and professionals within the technology industry started out low and remained low, particularly for Blacks. The percentages of Hispanic males and females among managers increased (3% to 4% and 1% to 2.5%, respectively), and the percentage of Hispanic males among professionals increased as well during this time (3% to 4%). Meanwhile, the percentage of Black males among managers halved while the percentage for Black females increased; however, Blacks represented less than 1% of managers by 2015. The percentages of Black males and females among professionals stayed almost constant, together comprising about 2% of professionals.

The ratios of representation show a consistent narrative with the distribution of race and gender groups in technology (Table 2). Only White males, Asian males and Asian females were overrepresented relative to their representation in the workforce during any of the years of analysis. White males were the only overrepresented group of managers (1.56) in 1980; this figure fluctuated somewhat, but ended higher at 1.60 in 2015. Meanwhile, the ratio of representation for Asian males steadily increased. Even though they were underrepresented in 1980 (0.79), Asian males became overrepresented by 2000 (1.26) and this ratio increased to 1.48 by 2015. Asian females were underrepresented in 1980 but became increasingly more represented, ending around par (1.02) in 2015. Meanwhile, White female, Hispanics and Blacks stayed underrepresented from 1980 to 2015, although there was some change during this time period. White females became more represented among managers, at about par in 1990 and 2000, while Hispanics and Blacks were underrepresented among managers throughout this entire time period. Hispanic and Black females increased in their respective representations from 1980-2015, but Hispanic and Black males' ratios of representation fell.

The ratios of representation were somewhat different for professionals in the technology industry. White males (1.44) and Asian males (1.87) were overrepresented in 1980; however, the overrepresentation of White males decreased while the overrepresentation of Asian males increased from 1980 to 2015. White and Asian females began similarly underrepresented (0.5 and 0.6, respectively) but the representation of White females declined after 1990 while the representation of Asian females generally increased from 1980 to 2015. The ratios of representation for Hispanic male and female professionals decreased from 1980-2015 but increased for Black male and female professionals over this time; however, these groups are underrepresented with respect to their labor force representation throughout this time period.

These two methods of describing the racial and gender composition show a dramatic change in the technology labor force over the past several decades. The percentage of managers and professionals who were White males declined, while the percentages and ratios of representation of Asians greatly increased, more so among professionals rather than among managers. Hispanics made some gains within the manager occupations, although their representation among professionals stayed constant. Although their numbers increased from 1980-2015, Hispanics and Blacks had a consistently low presence as managers or professionals in technology, especially when considering their overall representation in the labor force.

4. Programmer analysis

Workforce

This section focuses specifically on programmers, a key occupation among technology workers. The number of programmers in the Silicon Valley increased by over an order of magnitude in just several decades, from about 10,000 in 1980 to over 140,000 in 2015.

Educational attainment began and remained high in this profession (Appendix A7). In 1980, educational attainment was primarily split between those with some college (31%), an undergraduate degree (33%) or a graduate degree (26%). The share of programmers with at least an undergraduate degree increased over time, particularly between 1980 and 1990. In 1990, half of programmers had undergraduate degrees and a fifth had graduate degrees. There was a large increase from 1990 to 2000 for those with graduate degrees; this proportion continued to increase

through 2015; roughly equal percentages of programmers held undergraduate (46%) and graduate (48%) degrees by 2015.

Education levels were similar between genders (Appendix A8). However, there appear to be differences in educational attainment by race (Appendix A9). Asians had the highest levels of education in 1980; 75% of Asian, 58% of White, 41% of Hispanic and 31% of Black programmers held at least an undergraduate degree. By 2015, nearly all programmers across races held at least an undergraduate degree. Over the decades, the level of education increased for all races. By 2015, over half of Asian and Black programmers, about a third of White programmers and a quarter of Hispanic programmers held graduate degrees. However, the standard errors for Blacks are very large and thus the point estimates are not distinct from Hispanics or Whites.

The percentage of foreign workers began lower for programmers than in the overall technology industry, from 7% in 1980 to 39% in 2015. By 2015, the countries of origin were overwhelmingly India (58%) and China (17%). All races except Hispanics experienced an increase in the percentage of foreign programmers from 1980 to 2015 (Appendix A10).

Accordingly, a major demographic shift in the programmer workforce is the racial composition of programmers (Table 3). In 1980, over three-quarters of programmers (77%) were White and 16% were Asian. By 2010, Asians represented 59% of programmers while Whites represented 35% of programmers. Thus, Whites and Asians have been the vast majority (over 90%) of programmers, although the proportion has shifted towards an Asian advantage in recent decades.

When race and gender groups are examined, there is a clear transition from White males to Asian males as the dominant group of programmers. White males were the largest group of programmers in 1980 (56%) followed by White females (20%), Asian males (10%) and Asian females (6%). Hispanic males were 4% and Black males made up a little more than 2% while Hispanic and Black females each made up less than 1% of programmers. The percentages of White males and females steadily declined while the percentages of Asian males and females increased from 1980 to 2015. The percentage of White males decreased to 32% and the percentage of White females decreased to just 4%, while the percentage of Asian males more than quadrupled (44%) and the percentage of Asian females more than doubled (14%) during this time. Meanwhile, the low percentages of Hispanic and Black males and females declined even further, although it appears that their percentages have risen after the dip in 2010 (except for Black females).

In addition to these racial differences among programmers, there was a persistent gender gap in the programming occupation. Programmers were largely and increasingly male. In 1980, females were 28% of programmers; this percentage stayed stable in 1990, then declined until females represented 19% of programmers in 2015. This gender gap varied across race, which is shown by the ratio of males to females by race from 1980 to 2015 (Table 4). The male to female ratio increased for every race from 1980 to 2015. In 1980, Asians had the lowest ratio (1.58) while Hispanics had the highest (4.5). This gender ratio increased every time period for Whites, more than tripling from 2.76 in 1980 to 8.42 in 2015. The ratio for Asians doubled to 3.15 by 2015. The ratios for Hispanics and Blacks have spikes which may be due to the low numbers in these racial categories. The ratio for Hispanics in 2015 was similar to their starting ratio in 1980, although there was a large spike in 2010. The ratio for Blacks shows that there were more female than male programmers in 2010, although there was a large male to female ratio by 2015.

The numbers of programmers increased greatly from 1980 to 2015 for most race-gender groups. The numbers of Asian male and female programmers increased each decade, rising to over 60 and 30 times their initial numbers, respectively, from 1980 to 2015 (Table 5). All other race-gender groups increased from 1980 to 2000 but declined from 2000 to 2010. The numbers then rebounded from 2010 to 2015 in all race-gender groups except for Black females, who were the only group to decrease in number from 1980 to 2015. White females had the next smallest gains, increasing about 150%. White males, Hispanics, and Black males increased to about 5-8 times their starting numbers during this time.

The ratios of representation for each race-gender category illustrate the increasing White and Asian, largely male, trend among programmers (Table 6). The ratio of representation increased for White and Asian males but decreased for every other group during this time. In 1980, Asian males were the most overrepresented group (1.81), followed by Asian females (1.66) and White males (1.17). All other groups were underrepresented. The overrepresentation of White and Asian males increased while the overrepresentation of Asian females decreased through 2015. By 2010, the representation of Asian females was about par with their representation in the labor force. Meanwhile, White females and Blacks and Hispanics of both genders were underrepresented in 1980, and all ratios declined further by 2015.

The percentages of race-gender groups and the ratios of representation indicate several dynamics about racial and gender diversity among programmers. Over 90% of the programmer labor force in 1980 was White and Asian. The percentage of White females decreased, such that by 2010, 90% of programmers were White males or Asians. From 1980 to 2015, Asian males and females were the only groups to increase in percentage. White and Asian males increased in proportion of representation during this time, so although the percentage of White males decreased, White males became more overrepresented in the programmer profession over this time period.

Meanwhile, the percentages and representation of White females, Hispanics and Blacks fell. In particular, there was a dramatic decrease in the percentages of White and Black female programmers. White females went from 20% of programmers to 4% while Black females went from just under 1% to less than .1% of programmers from 1980 to 2015; the number of Black female programmers actually decreased from 1980 to 2015. There was also a drastic decrease in Hispanic and Black females' already-low ratios of representation. In 2015, Hispanic females' ratio of representation was 0.06 and Black females' ratio of representation was 0.03. Black females' diminutive presence in the programmer labor force appears to be shrinking even further.

5. Undergraduate and Graduate Degrees in Computer Science

It is important to understand racial and gender demographics at a critical step prior to the programmer labor force. This section discusses these dynamics for undergraduate and graduate degree completions in California, one important region for the pool of potential programmer candidates in the Silicon Valley. Although the potential technology labor force is not limited to this region, we use California as a comparable geographic area to the previous analyses of the technology labor force in the Silicon Valley. These analyses provide a description of the potential programmer pipeline by race and gender immediately prior to the labor force, which is a common rationale for disparities in the labor force.

As in the labor force, there has been an increasing presence of international students in U.S. higher education. Although international students have remained a relatively low percentage

of total degrees earned in the U.S., from 2.5% in the 1980 to 4.8% in 2015 (Institute of International Education, Inc., 2015), they are increasingly concentrated in the STEM fields, particularly at the graduate level. For example, more than half of doctoral degrees in Engineering and Computer/Information Sciences are obtained by international students (Desilver, 2015).

The countries of origin for these international students have become increasingly concentrated in Asia. The percentage of international students from Asian countries has increased from 29% of all international students in 1980 to 64% by 2015 (Appendix A11). Just several countries make up the bulk of these students: the most current Open Doors data indicates that over half of all international students (51%) are from China, India and South Korea (Institute of International Education, Inc., 2015).

Trends for undergraduate and graduate international students are similar, but there has been and continues to be a higher concentration of Asian international graduate students (Table 7). In 1986, 37% of international undergraduates were from Asian countries while 55% of international graduate students were from Asian countries. Both of these percentages increased dramatically by 2015, when 60% of international undergraduates and 72% of international graduate students were from Asian countries.

These data give an overview of the international nature of the higher education population which is then reflected in the U.S. labor force. Thus, the potential labor force in computer science includes a sizeable proportion of Asian non-citizens.

We use these data on international students to build the dataset of race and gender over time for those who completed a degree in computer science in California (Figure 2). The percentages of different race-gender groups show a more distributed demographic for degree completions than the labor force percentages. Furthermore, there are differences between the racial and gender distributions of bachelor's degree and graduate degree completions, which may reflect the more international population of those who obtain graduate degrees.

In California, the number of computer science bachelor's degrees started at 2,957 in 1985 then declined through 1995, rose through 2005, then declined sharply before rebounding to over 5,518 in 2015 (Table 8). The number of graduate degrees in computer science showed a steadier increase, starting at 764, with a small reduction in 2010 before increasing to 2,868 in 2015. These patterns were similar at the national level (Appendix A12). However, California had greater representation of Asians and Hispanics compared to nationally, particularly at the undergraduate level.

Whites represented 63% and Asians represented 24% of computer science bachelor's degrees in California in 1985. The percentage of Whites nearly halved while the percentage of Asians increased to 32% in 2015, although the percentage of Asian females decreased during this time. The percentage of Hispanics increased from 4% in 1980 to over 17% in 2015 and the percentage of Black males increased from 3% to 4%, although the percentage of Black females declined. More specifically, the representations of Whites, Asian females and Black females decreased while Hispanics, Asian males and Black males increased from 1985 to 2015.

The racial distribution at the graduate level in California began and remained less White and more Asian than at the undergraduate level. Whites represented just less than half (49%), Asians 28%, Hispanics 3% and Blacks 3% of graduate degrees in computer science in 1985. The percentages of White males and females declined (36% to 22% males, 12% to 7% females) while percentages for all other groups increased. The percentages of Asian males and females almost doubled from 1985 to 2015 (20% to 38% males, 8% to 16% females). The percentage of Hispanic males more than doubled, from 2% to 5% while the percentage of Hispanic females

increased more slowly, from 1% to almost 2%. The percentages of Black males went from 2% to 3% and the percentage of Black females increased from under 1% to 1%.

There appears to be a growing gender gap in computer science higher education at the undergraduate level; the percentage of CS undergraduate degrees completed by females nearly halved from 33% in 1985 to 17% in 2015 while the percentage in graduate degrees increased slightly from 25% to 28%. The ratio of males to females more than doubled for every racial group from 1985 to 2015 (Table 9). There were about 1.5 males per female for Asians and Blacks in 1985; for Asians, this increased to 3.6 and for Blacks, 5.9 males per female by 2015. Whites and Hispanics started with higher ratios in 1985 (2.4 and 2.2, respectively), and increased to almost 7 for Whites and 5.5 for Hispanics. At the graduate level, the male to female ratio increased for each racial group except Asians, but by comparatively moderate amounts.

The ratios of representation at the undergraduate level underscore the stark contrast between genders beginning in 2005 (Table 10). There was some fluctuation in earlier years, but males of all races were overrepresented while females of all races were underrepresented from 2005 to 2015. White males completing computer science undergraduate degrees have been increasingly overrepresented relative to their proportions of overall undergraduate degree completions since 1985, and Asian males' representation fluctuated more but ended higher in 2015 than in 1985. Unlike in the labor force, Black males became overrepresented in 1990 and Hispanic males were overrepresented in 1990 and 2005 onwards. Although Asian females were overrepresented in completing computer science undergraduate degrees in 1985, they were underrepresented beginning in 2000. Females from the other races were underrepresented during the all years of analysis from 1985-2015. Moreover, all females became more underrepresented than their initial representations by 2015.

The ratios of representation in graduate degree completions were similar to the undergraduate trends. One of the main differences is that Asian females were overrepresented throughout 1985-2015. Females from all other races were underrepresented throughout this time period, while males were generally overrepresented.

The trends in computer science degree completions appear different from employment trends among programmers. Notably, the percentages of both undergraduate and graduate completions for Hispanics and Blacks were generally higher than their corresponding percentages in the labor force (i.e. programmers with only undergraduate degrees and programmers with graduate degrees), and the gaps between their representation in degrees and in the labor force increased from 1990 to 2015.

In an illustrative exercise, we compare the percentages of race gender groups who obtain degrees in CS and their corresponding percentages in the programmer labor force. We restrict the labor force to younger workers (30 years and younger), although similar results hold for other age ranges or when using lagged data (i.e. labor market data from 5 years after higher education data). Hispanic males made up 5% of undergraduate CS degree completions and 4% of programmers with only undergraduate degrees in 1990 (Table 11). In 2015, the percentage of Hispanic males rose to 14% of undergraduate degree completions, yet represented only 7% of programmers in 2015. Similarly, Hispanic males made up about 2% of graduate degree completions and 3% of programmers in 1990 and increased to 5% of graduate degree completions yet dropped to just over 1% of programmers with graduate degrees in 2015. These percentages are smaller for Hispanic females and Blacks, yet generally follow the same pattern of representing a higher proportion of degrees than programmers in the labor force.

The differences between the percentages of degree completions in computer science and the labor force suggest that there may be differential rates of entering the programmer occupation. In general, Asians make up a higher proportion of the programmer labor force than their proportion of computer science degrees, while Hispanics and Blacks represent a larger proportion of degree completions than their proportions in the labor force. Whites have had decreasing representation in both degrees and in the labor force, yet have varied between greater or less representation than in the labor force at the undergraduate level. White females have higher representation among younger programmers than among undergraduate CS degree completions. At the graduate level, Whites have been a larger proportion of degree completions than their representations in the labor force. These trends indicate that certain groups, for example Hispanic males, do not appear to enter into the programmer labor force after degree completion, while other groups, such as White females, are choosing not to obtain undergraduate degrees in computer science.

There are other possible explanations for the observed gaps between the completion percentage and the labor force percentage. For example, the supply of potential programmers extends beyond state or national borders, or programmers may not necessarily complete degrees in computer science (Stackoverflow, 2015). There may be distinctions in degree quality that is not reflected in number of degree completions. However, these analyses suggest that certain groups, such as Hispanic males, may face barriers to the programmer occupation after higher education, whether these are internal (choosing not to go into programming) or external (facing discrimination in hiring).

6. CS occupation: Wage analysis

We next conduct a wage analysis to understand another significant component of the programmer labor force and explore whether wages can help explain race and gender distributions in the labor force. Because of the small sample sizes for Hispanics and Blacks, we restrict the wage analyses to White and Asian full-time full-year workers. We also limit the sample to 25-44 year olds, include only positive wages, and separate analyses into programmers with undergraduate degrees only and programmers with graduate degrees--this to provide less biased wage comparisons. We recognize that there may be other important variables that influence wages which may not be captured in the following analyses. For example, we do not divide the sample into domestic and foreign workers due to small sample sizes; however, a recent report indicates that race/ethnicity, not foreign status, appears to matter for wage gaps (American Institute for Economic Research, 2014).

Basic principles of supply and demand indicate that when there is an increase in supply (proxied by increased number of workers), wages should go down, all else equal. However, it is difficult to establish causality since wages and employment are determined simultaneously. We provide estimates of wage trends to help illuminate race and gender employment trends, understanding that these estimates do not address endogeneity.

As described in Section 4, the number of programmers increased steadily from 1980-2015, except for a dip between 2000 and 2010 for Whites. These increases were generally accompanied by increases in wages, with relatively flat wages during the 2000-2010 period (Table 12). We also showed that the supply of potential programmers grew for Whites and Asians from 1985-2015, except for White female undergraduate degree completions, in Section 5. Although there may be a variety of explanations, the increasing wages suggest an increase in

demand for programmers in most years. We next examine wages and labor force representation to discern different patterns by race and gender.

Wage patterns appear to differ by education level (Figure 3, Table 13). At the undergraduate level, White males consistently have the highest average hourly wage. The gap between White and Asian males appears to be relatively steady, although the difference is only statistically significant in 1980 and 2000. Meanwhile, White and Asian females appear to have similar wages during this period, although White females have slightly higher (but not statistically significantly different) wages most years. White female undergraduate degree completions was the only group with a decreased potential supply of programmers, which could contribute to the seemingly elevated wages for White females over Asian females. Finally, although the differences were not always significant in prior years, the gender gaps for both races became larger and statistically significant in 2015.

For those with graduate degrees, wages between Whites and Asians appeared to be closer for males and to the Asian advantage for females from 1980 to 2010. However, there was a large increase in wages for Whites (females especially) from 2010 to 2015, such that both Asian males and females had lower wages than White males (and qualitatively lower wages than White females, though not statistically significant) in 2015.

At both degree levels, there appears to be a gender gap among programmers. Females have lower average wages than their male counterparts although the difference is not always statistically significant. The gender gap appears to widen from 2010 to 2015 for those with only undergraduate degrees yet remains stable for Whites and narrows for Asians with graduate degrees. Meanwhile, there appears to be a widening race wage gap between White and Asian males, driven by larger gains in wages for Whites from 2010 to 2015. Although differences are not always statistically significant, the overall trends are consistent with other literature that shows that wages for Whites are higher than wages for other races in technology (American Institute for Economic Research, 2014). However, wages between White and Asian females are more comparable.

Although the data demonstrates that the relationship between wages and representation in the labor force is complex, employers should prefer to hire cheaper labor, ceteris paribus. However, it does not appear that cheaper labor is associated with greater representation in the labor force in this dataset except for in the case of the comparison between Asian and White males.

Lower wages for Asian males could help explain their greater representation among programmers, a common explanation for the rise of Asians in technology (Salzman et al., 2013). There is suggestive evidence that Asian males earn less than White males among programmers with undergraduate degrees, coinciding with greater representation of Asian males in the programming labor force. However, wages appear more comparable among those with graduate degrees, yet the pattern of participation of White and Asian males with graduate degrees among programmers is very similar to those with only undergraduate degrees. Thus, these data do not provide conclusive evidence of this theory that the employment of White and Asian males is driven by the lower wages paid to Asian males.

The differences between White and Asian female wages appear even less tied to their representation in the labor force, especially among those with graduate degrees. For those with graduate degrees, Asian females had slightly (but not statistically significant) higher wages than White females until 2015; however, the representation of White females steadily declined while the representation of Asian females slightly increased during this time period. Thus, the wage

patterns do not seem to account for the direction or magnitude of change in the labor force at the graduate degree level (Appendix A13 for details).

Gender wage gaps seem incongruous with representation in the labor force. Females have lower wages than males, yet males greatly outnumber their female counterparts. Although there may be other unobserved factors involved, higher wages for males may indicate greater demand for males over females.

The range of relationships between wage and labor force representation demonstrates that wages are not a simple explanation of the differences between races and genders in the programmer labor force.

7. Conclusion

This paper has documented major demographic changes in the Silicon Valley technology labor force from 1980 to 2015. The representation of Asians has dramatically increased over this time. White males are still the largest and most overrepresented group among managers in technology, although Asian males have overtaken this place among professionals. White females' participation in the technology work force has dramatically declined. Hispanics and Blacks have continued to have low representation in technology. Disparities in representation are even more acute among programmers. In addition, gender gaps among programmers appears to be growing across all races.

The analysis of race and gender in higher education shows that the pipeline of potential programmers varies by race and gender group, which could help explain race and gender differences in the programmer labor force. White females' share of degree completions in computer science declined from 1985 to 2015, which would support the argument that there are fewer potential White female programmers; White females seem to "leak" out of the pipeline prior to higher education. However, other groups do not necessarily align with this argument. In the most salient example, Hispanic males have become an increasingly large proportion of degree completions in computer science, yet their representation in the programmer labor force has declined. This may indicate a leak in the pipeline after obtaining degrees in computer science, although there are many other possible explanations for these findings. Nevertheless, it appears that certain groups such as Hispanic males may face barriers to working as programmers that other groups do not.

To examine another potential explanation of programmer race and gender trends, we estimated race and gender trends in programmer wages and in computer science higher education. The wage analysis provides suggestive evidence that females are persistently paid less than males and that Asian males are paid less than White males. Thus, lower wages for Asian males could help explain their rapidly increasing presence among programmers, particularly at the undergraduate level. However, the same is not true for females, who receive lower wages than their male counterparts yet are less represented in the labor force, which could signify a preference for male programmers.

These findings have implications for policies designed to attract underrepresented groups into technology. Different groups appear to leak out of the programmer pipeline at different points—for example, White females prior to higher education and Hispanic males after graduating with a degree in computer science. Therefore, policies designed to attract White females may need to focus on getting White females to major in computer science, while policies

designed to attract Hispanic males may focus on applying to jobs or convincing employers to hire more Hispanic with CS degrees.

Finally, although Asians have made tremendous gains in representation, there is evidence that they may receive lower wages than Whites and face some barriers to entering managerial jobs. Asians have increased rapidly in the professional occupations, including programmers, yet Asian males remain behind White males in the manager occupations. These patterns indicate that Whites are still the majority race among technology leadership, although this may change if the trends continue. The wage analysis suggests there is a race gap in favor of Whites, relatively steady for male programmers with undergraduate degrees but recently increasing for both genders with graduate degrees. These findings suggest that while demographics portray an important aspect of the diversity in technology, gaps are also present in leadership and wages.

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Table 1. Race and gender percentages by occupation and industry

Manufacturing

	Manager					Professional				
	1980	1990	2000	2010	2015	1980	1990	2000	2010	2015
White Male	75.34	61.2	53.47	50.58	38.75	61.35	49.73	41.7	35.9	31.9
White Female	13.99	21.18	21.25	18.03	16.22	20.66	22.96	22.5	12.4	17.65
Asian Male	2.77	6.25	8.44	12.89	20.53	6.64	11.35	14.77	21.52	22.21
Asian Female	1.19	2.91	4.55	7.17	11.08	2.49	6.12	8.87	18.18	17.76
Hispanic Male	4.19	3.92	4.33	4.9	2.92	3.14	4.06	3.88	4.57	4.98
Hispanic Female	0.71	2.36	2.55	2.77	3.47	2.4	1.68	2.38	2.55	1.7
Black Male	1.26	1.03	0.92	0.62	1.14	1.57	2.89	1.36	0.41	0.68
Black Female	0.32	0.71	1.35	0.58	1.44	1.11	0.82	1.3	0.47	0.38
Total	*25,300*	*31,430*	*26,226*	*28,299*	*31,152*	*21,680*	*34,318*	*31,413*	*36,588*	*45,997*

High Services

	Manager					Professional				
	1980	1990	2000	2010	2015	1980	1990	2000	2010	2015
White Male	48.16	36.38	33.22	27.42	27.58	46.4	39.33	33.4	24.25	24.37
White Female	34.64	40.78	36.91	30.19	29.2	33.89	35.28	31.43	30.73	28.55
Asian Male	3.15	4.72	5.2	7.94	8.54	4.22	5.52	8.65	11.87	11.73
Asian Female	2.2	4.75	6.86	10.94	12.7	4.32	7.31	10.11	15.37	16.68
Hispanic Male	3.39	2.58	3.63	5.95	4.79	2.59	2.41	3.13	4.21	3.22
Hispanic Female	2.25	3.99	4.77	7.38	7.84	2.37	3.73	4.19	6.07	6.6
Black Male	2.96	2.26	1.87	3.24	2.43	2.22	2.18	2.4	1.77	1.99
Black Female	2.63	4.09	4.6	3.68	3.32	3.32	3.78	3.4	3.03	3.61
Total	*41,860*	*63,881*	*79,598*	*107,248*	*122,287*	*108,880*	*165,937*	*212,168*	*299,836*	*342,862*

Technology

	Manager					Professional				
	1980	1990	2000	2010	2015	1980	1990	2000	2010	2015
White Male	74.73	58.2	49.27	43.92	38.39	68.74	55.4	41.8	32.27	29.04
White Female	14.9	23.85	20.76	11.87	13.35	12.48	17.9	12.92	8.43	7.27
Asian Male	3.79	8.25	15.03	24.18	24.92	9.91	14.5	25.63	36.13	39
Asian Female	1.07	2.6	5.36	10.41	13.58	2.21	5.02	10.39	13.38	14.73
Hispanic Male	2.8	2.3	2.74	3.32	3.82	3.25	2.74	3.47	3.75	4.08
Hispanic Female	0.99	1.56	2.35	2.59	2.55	0.97	1.16	1.29	1.02	1
Black Male	0.99	1.54	1.2	0.97	0.48	1.4	2.05	1.27	1.52	1.59
Black Female	0.33	1.24	0.77	0.65	0.48	0.55	0.97	0.79	0.71	0.5
Total	*24,300*	*45,127*	*74,089*	*76,895*	*97,912*	*61,540*	*103,301*	*178,010*	*183,742*	*240,501*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old). Percentages may not add up to 100% due to other races (left out of table).

Table 2. Ratio of representation of manager/professional occupation categories within the technology industry to the overall labor force

	Manager					Professional				
	1980	**1990**	**2000**	**2010**	**2015**	**1980**	**1990**	**2000**	**2010**	**2015**
White Male	1.56	1.44	1.46	1.73	1.60	1.44	1.37	1.24	1.27	1.21
White Female	0.59	0.97	0.99	0.67	0.83	0.50	0.73	0.61	0.47	0.45
Asian Male	0.71	0.97	1.26	1.54	1.48	1.87	1.70	2.14	2.31	2.32
Asian Female	0.29	0.40	0.60	0.82	1.02	0.60	0.78	1.16	1.05	1.11
Hispanic Male	0.43	0.29	0.30	0.27	0.29	0.50	0.35	0.38	0.30	0.31
Hispanic Female	0.27	0.33	0.42	0.32	0.31	0.26	0.24	0.23	0.13	0.12
Black Male	0.25	0.42	0.40	0.37	0.18	0.35	0.56	0.42	0.58	0.60
Black Female	0.10	0.38	0.26	0.23	0.20	0.17	0.30	0.26	0.26	0.21

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Table 3. Programmers by race and gender percentages

	1980	1990	2000	2010	2015
White Male	56.16	53.99	41.38	31.96	31.51
White Female	20.35	18.38	8.49	3.96	3.74
Asian Male	9.59	11.26	31.5	46.12	44.26
Asian Female	6.07	8.4	11.06	12.92	14.05
Hispanic Male	3.52	3.37	2.58	1.92	2.34
Hispanic Female	0.78	1.04	0.83	0.16	0.5
Black Male	2.15	2.29	1.02	0.18	1.02
Black Female	0.98	0.98	0.67	0.57	0.07
Total	*10,220*	*24,264*	*77,532*	*88,137*	*143,286*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Table 4: Male to female ratio of programmers, by race

	1980	1990	2000	2010	2015
		Overall			
White	2.76	2.94	4.87	8.07	8.42
Asian	1.58	1.34	2.85	3.57	3.15
Latino	4.50	3.23	3.09	11.90	4.70
Black	2.20	2.35	1.53	0.33	15.51

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Table 5. Change in numbers of programmers

#	# in 1980	1980-1990	1990-2000	2000-2010	2010-2015	1980-2015
White Male	5,740	128%	145%	-12%	60%	687%
White Female	2,080	114%	48%	-47%	53%	158%
Asian Male	980	179%	794%	66%	56%	6371%
Asian Female	620	229%	321%	33%	77%	3147%
Hispanic Male	360	127%	144%	-15%	98%	829%
Hispanic Female	80	216%	155%	-78%	401%	790%
Black Male	220	153%	42%	-79%	794%	563%
Black Female	100	137%	118%	-3%	-81%	-6%

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Table 6: Ratio of representation for programmers compared to the overall labor force

	1980	**1990**	**2000**	**2010**	**2015**
White Male	1.17	1.34	1.23	1.26	1.32
White Female	0.81	0.75	0.40	0.22	0.23
Asian Male	1.81	1.32	2.63	2.94	2.63
Asian Female	1.66	1.30	1.24	1.01	1.05
Hispanic Male	0.54	0.43	0.28	0.15	0.18
Hispanic Female	0.21	0.22	0.15	0.02	0.06
Black Male	0.54	0.63	0.34	0.07	0.38
Black Female	0.30	0.30	0.22	0.21	0.03

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Table 7. Percentage of international students from region of origin, by academic level

	Africa		Asia		Europe		Latin America		Middle East		North America		Oceania		World Total #	
Year	UG	G	UG	G	UG	G	UG	G	UG	G	UG	G	UG	G	UG	G
1985-1986	11.3	9.5	37.2	54.8	9.2	11.1	17.7	8.0	17.5	11.4	5.8	4.2	1.3	1.0	149,200	132,430
1989-1990	8.0	5.4	42.7	64.9	12.4	11.0	17.2	6.9	12.3	7.0	6.0	4.1	1.4	0.7	137,560	169,820
1994-1995	5.2	4.0	52.2	64.8	14.7	13.2	13.2	7.2	7.3	5.8	6.1	4.3	1.2	0.7	228,184	195,166
1999-2000	8.2	3.8	47.0	62.2	16.1	14.2	15.2	8.6	7.1	6.1	5.2	4.5	1.1	0.7	249,786	225,383
2004-2005	9.2	4.2	48.6	65.1	13.1	11.6	16.5	8.1	5.8	5.5	5.7	4.9	1.0	0.6	247,255	269,933
2009-2010	7.3	4.1	56.9	68.6	10.3	8.9	12.5	7.3	6.9	6.5	5.1	4.1	0.9	0.5	274,431	293,885
2014-2015	4.7	2.7	59.9	71.8	9.1	7.9	10.2	5.7	12.0	8.4	3.3	2.9	0.8	0.5	398,824	362,228

Notes: For years 1979-80 & 1984-85 Open Doors data do not include breakdown of country of origin by academic level, so 1985-86 data is the earliest year used. Starting in 2009-10, Cyprus & Turkey were re-categorized from Middle East to Europe. However, due to the quality of data from prior to 1995-96 data, it is not possible to re-categorize these countries so Cyprus & Turkey were re-classified as Middle East a 2009-2010 and 2014-2015 in this analysis. Cyprus represents 211 undergrads and 296 graduate students while Turkey represents 3,656 undergraduates and 6,585 graduate students in 2009-10. Cyprus represents 187 undergrads and 155 graduate students while Turkey represents 3,242 undergraduates and 5,357 graduate students in 2014-15. North America consists of Canada and Bermuda (vast majority is from Canada).

Table 8. Percentage of degree completions in CS, by race and gender

	Bachelor's						
	1985	1990	1995	2000	2005	2010	2015
White Male	44.49	43.68	39.21	30.93	27.78	34.19	30.11
White Female	18.78	11.41	12.01	8.81	5.15	4.9	4.32
Asian Male	14.32	18.05	20.84	27.75	28.11	17.87	24.8
Asian Female	10.13	10.71	10.32	11.63	8.58	4.14	6.82
Hispanic Male	3.01	5.22	5.07	6.02	9.08	11.4	13.97
Hispanic Female	1.35	2.22	1.78	2.4	2.56	2.22	2.56
Black Male	1.72	2.54	2.89	2.83	3.38	3.6	3.73
Black Female	1.16	1.32	1.87	1.54	1.17	1.01	0.64
Unknown	0	4.04	5.53	7.56	13.48	19.20	8.90
total	2957	2798	2479	3506	5585	3594	5518
	Graduate						
	1985	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**
White Male	36.46	41.8	37.3	27.71	23.47	25.25	22.25
White Female	12.48	11.33	8.64	9.9	6.75	6.12	7.09
Asian Male	20.2	26.25	28.94	30.46	34.84	34.64	37.57
Asian Female	8.29	9.52	10.08	17.98	16.92	12.15	16.09
Hispanic Male	1.92	2.4	3.5	4.01	4.98	4.72	5.09
Hispanic Female	1.14	0.99	1.11	2.28	2.02	1.27	1.73
Black Male	1.9	2.15	1.98	2.27	2.6	2.92	3.11
Black Female	0.86	0.88	0.54	1.25	1.07	1.66	1.05
Unknown	0	4.78	7.83	4.13	7.26	10.72	4.85
total	764	1087	1188	1574	2425	2378	2868

Note: for degree completions in CS in California.

Table 9. Male to female ratios of CS degree completions

		1985	1990	1995	2000	2005	2010	2015
Bachelor's	White	2.37	3.83	3.26	3.51	5.39	6.98	6.98
	Asian	1.42	1.68	2.02	2.38	3.28	4.31	3.64
	Hispanic	2.23	2.35	2.86	2.51	3.55	5.13	5.47
	Black	1.50	1.92	1.57	1.83	2.86	3.58	5.89
Graduate	White	2.94	3.69	4.30	2.79	3.47	4.11	3.14
	Asian	2.44	2.74	2.87	1.69	2.06	2.85	2.34
	Hispanic	1.67	2.36	3.23	1.75	2.47	3.73	2.92
	Black	2.00	2.30	4.00	1.80	2.42	1.79	2.97

Note: for degree completions in CS in California

Table 10: Ratio of representation of CS degrees to All degrees

	Bachelor's						
Percentage	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**
White Male	1.28	1.46	1.54	1.55	1.54	1.95	1.92
White Female	0.50	0.33	0.39	0.33	0.21	0.22	0.22
Asian Male	2.27	2.47	2.21	2.72	2.72	1.71	2.44
Asian Female	1.85	1.48	1.02	0.96	0.67	0.33	0.57
Hispanic Male	0.87	1.35	0.93	0.93	1.42	1.64	1.45
Hispanic Female	0.39	0.50	0.27	0.25	0.24	0.20	0.16
Black Male	0.91	1.58	1.61	1.47	1.99	2.20	1.83
Black Female	0.49	0.60	0.68	0.47	0.38	0.36	0.18

	Graduate						
Percentage	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**
White Male	1.02	1.23	1.26	1.10	1.09	1.30	1.20
White Female	0.42	0.37	0.28	0.32	0.25	0.26	0.31
Asian Male	2.65	2.87	2.51	2.66	2.94	2.90	2.99
Asian Female	2.16	1.76	1.23	1.74	1.41	1.00	1.23
Hispanic Male	0.70	0.87	1.09	1.03	1.19	1.07	0.97
Hispanic Female	0.56	0.40	0.32	0.44	0.31	0.17	0.19
Black Male	0.84	1.17	1.08	1.11	1.31	1.42	1.37
Black Female	0.47	0.45	0.22	0.40	0.32	0.51	0.22

Note: Authors calculated numbers in May 2016, constructed from two data sources: IPEDS Completions data (1985, 1990, 1995, 2000, 2005, 2010) and Open Doors data (1985-86, 1989-90, 1995-96, 1999-2000, 2004-2005, 2009-2010) for degree completions in California. Non-citizens in the IPEDS data were re-categorized into these categories using region of origin data from the corresponding Open Doors year. There are "Unknown" racial/gender categories, thus columns do not add up to 100%. The ratios were calculated as the percentage of completions in Computer Science divided by the percentage of completion for all subjects for each race-gender category.

Table 11. Race and gender percentages of young programmers

	Undergraduate					Graduate				
	1980	1990	2000	2010	2015	1980	1990	2000	2010	2015
White Male	49.41	44.42	33.85	29.73	29.35	40.62	46.52	25.27	12.2	14.86
White Female	23.53	24.37	5.32	2.34	5.66	28.13	15.55	2.76	2.49	3.04
Asian Male	10.59	12.63	43.67	54.41	38.67	12.5	24.01	48.97	68.45	54.25
Asian Female	10.59	11.02	11.63	5.49	13.6	12.5	11.46	18.35	12.1	18.79
Hispanic Male	3.53	3.19	2.45	0.61	7.32	3.13	2.46	0.97	0.74	1.22
Hispanic Female	0	0.61	0	0	0.57	0	0	0	0	0.65
Black Male	1.18	2.67	0.45	0	1.11	0	0	0.05	0	6
Black Female	1.18	1.09	0.14	0	0	3.13	0	0	1.03	0
Observations	1700	4608	11254	9374	18547	640	733	6273	7953	14573

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force who are 30 years old and under. This age restriction is to approximate the demographic of degree completers.

Table 12: Changes in wages and in the labor force

			1980-1990		1990-2000		2000-2010		2010-2015	
Undergraduate	Initial #	Initial wage	#	wage	#	wage	#	wage	#	wage
White Male	1,440	25.77	207%	5%	156%	47%	-19%	1%	58%	27%
White Female	580	23.33	262%	5%	11%	38%	-63%	-8%	94%	5%
Asian Male	260	21.52	352%	18%	716%	35%	53%	6%	39%	18%
Asian Female	140	22.48	719%	0%	181%	43%	16%	1%	66%	-9%

			1980-1990		1990-2000		2000-2010		2010-2015	
Graduate	Initial #	Initial wage	#	wage	#	wage	#	wage	#	wage
White Male	1,160	26.76	80%	12%	198%	35%	-14%	4%	89%	39%
White Female	360	18.94	21%	33%	177%	26%	-66%	0%	212%	55%
Asian Male	260	26.03	140%	31%	1587%	14%	67%	0%	47%	13%
Asian Female	220	20.52	178%	33%	493%	26%	34%	10%	75%	9%

Note: Sample for wage analyses and corresponding number of worker analyses are full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force with positive wages. The sample is further limited to workers between 25-44 years old.

Table 13. Wages of programmers, by race and gender
Undergraduate degree

		1980	1990	2000	2010	2015
White Male	Mean	25.77	26.97	39.72	40.00	50.98
	SE	0.60	0.76	1.24	1.80	3.05
	Obs	1,440	4,415	11,324	9,124	14,440
White Female	Mean	23.33	24.40	33.57	30.77	32.40
	SE	1.44	0.55	1.75	3.06	3.17
	Obs	580	2,097	2,321	860	1,667
Asian Male	Mean	21.52	25.36	34.13	36.10	42.54
	SE	1.15	0.88	0.90	1.04	1.86
	Obs	260	1,176	9,594	14,705	20,466
Asian Female	Mean	22.48	22.50	32.24	32.58	29.49
	SE	1.37	1.02	1.08	1.06	1.29
	Obs	140	1,146	3,224	3,730	6,176

Graduate degree

		1980	1990	2000	2010	2015
White Male	Mean	26.76	30.01	40.43	42.03	58.37
	SE	1.02	1.37	1.40	2.17	3.59
	Obs	1,160	2,089	6,222	5,356	10,117
White Female	Mean	18.94	25.25	31.88	32.02	49.59
	SE	1.74	1.21	1.42	2.20	9.00
	Obs	360	435	1,206	411	1,281
Asian Male	Mean	26.03	34.08	38.89	38.90	43.95
	SE	2.52	2.70	0.97	1.41	1.59
	Obs	260	623	10,507	17,510	25,658
Asian Female	Mean	20.52	27.22	34.25	37.58	40.99
	SE	1.67	1.03	0.80	1.22	2.25
	Obs	220	612	3,632	4,871	8,548

Note: Sample for wage analyses are full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force with positive wages. The sample is further limited to workers between 25-44 years old.

Figure 1. Manager and professional occupations in technology

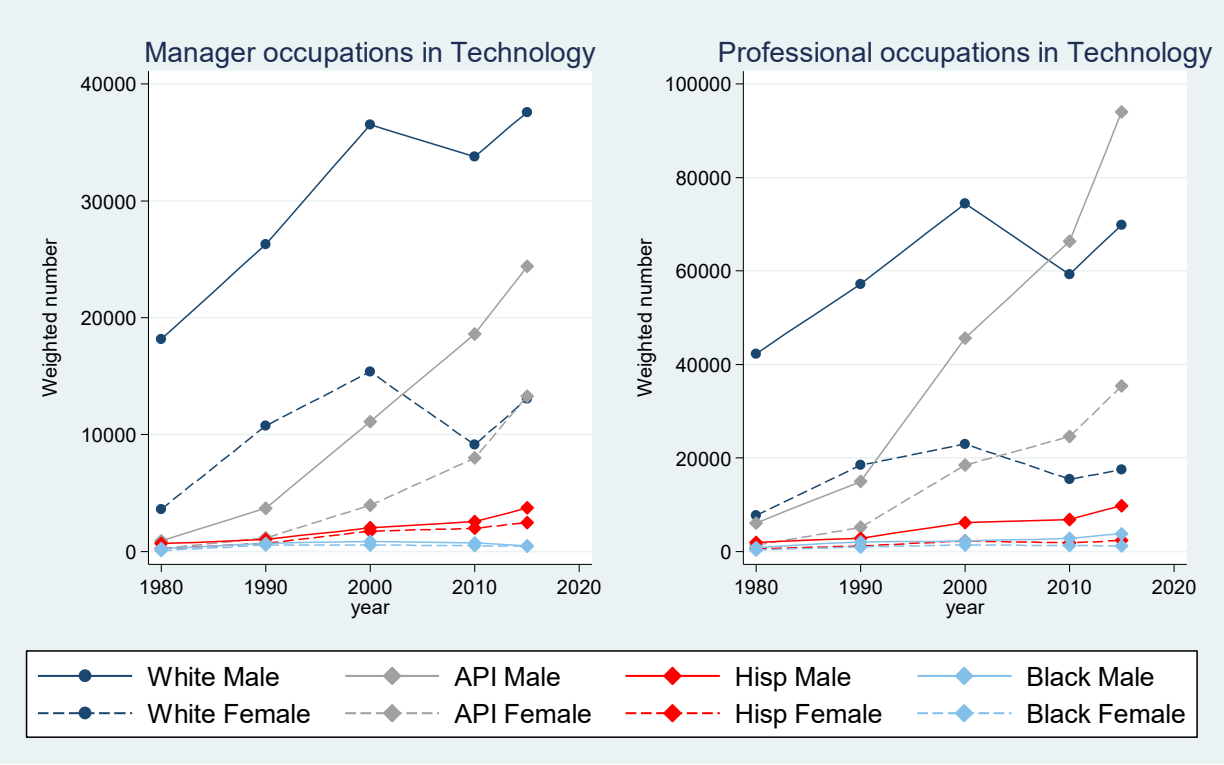


Figure 2. Percentage of degree completions in CS in CA, by race and gender

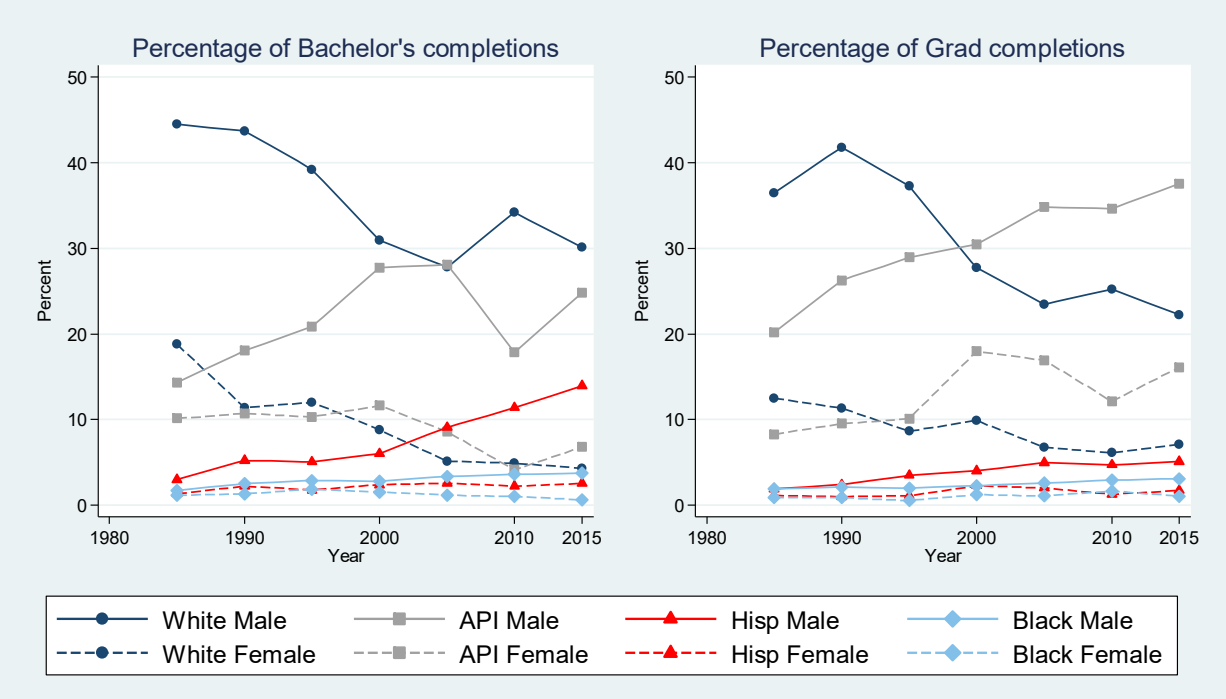
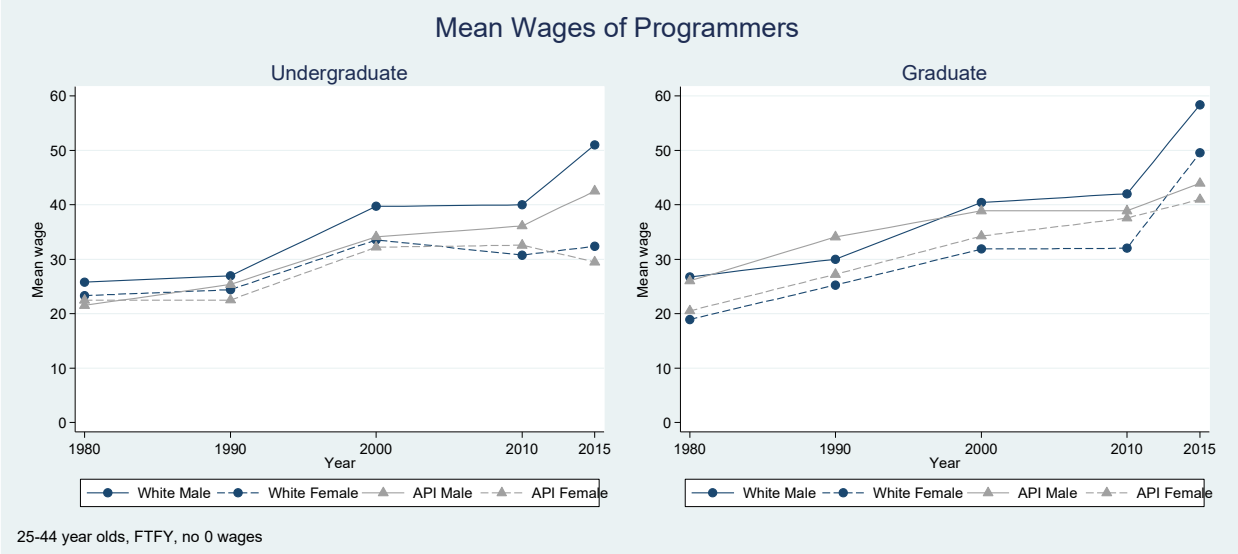


Figure 3. Mean hourly wages of programmers, by race and gender



Appendix A1. Race and Gender percentages among full-time, full-year labor force (National and Silicon Valley)

National

	1980	1990	2000	2010	2015
White Male	57.20	50.60	46.15	38.71	37.46
White Female	26.97	29.95	29.72	28.69	27.03
Asian Male	0.95	1.56	2.03	3.00	3.30
Asian Female	0.61	1.13	1.51	2.41	2.56
Hispanic Male	3.40	4.35	5.67	8.77	10.04
Hispanic Female	1.60	2.42	3.27	5.70	6.26
Black Male	4.96	4.86	4.73	4.97	5.31
Black Female	3.80	4.56	4.89	5.79	5.81
Total	*59,566,700*	*72,885,681*	*83,525,143*	*96,064,364*	*105,922,797*

Silicon Valley

	1980	1990	2000	2010	2015
White Male	47.80	40.37	33.70	25.32	23.94
White Female	25.09	24.48	21.07	17.79	16.18
Asian Male	5.31	8.54	11.95	15.67	16.83
Asian Female	3.66	6.47	8.94	12.77	13.33
Hispanic Male	6.48	7.88	9.25	12.42	13.27
Hispanic Female	3.69	4.78	5.60	7.98	8.28
Black Male	3.99	3.63	3.00	2.61	2.67
Black Female	3.29	3.28	3.01	2.76	2.41
Total	*1,280,840*	*1,649,805*	*1,799,712*	*1,983,485*	*2,348,018*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Appendix A2. Industries by year (Percent)

	1980	1990	2000	2010	2015
Manufacturing	14.37	12.11	8.61	7.42	7.00
High Services	24.67	26.06	27.06	33.27	31.13
Technology	14.48	14.84	19.63	16.32	17.61
All other industries	46.48	46.98	44.70	42.99	44.26
Total number (weighted)	*1,280,840*	*1,649,805*	*1,799,712*	*1,983,485*	*2,348,018*

Note: Includes only full-time (over 35 hours/week) full-year (50+ weeks of work in the previous year) workers in labor force (16+ years old)

Appendix A3. Percentage of Workers in Occupations within Industries

		1980	1990	2000	2010	2015
Manufacturing	Manager	13.75	15.73	16.92	19.23	18.94
	Professional	11.78	17.18	20.26	24.87	27.97
	Other	74.47	67.09	62.82	55.9	53.08
	Observations	*184,000*	*199,757*	*155,022*	*147,127*	*164,443*
High Services	Manager	13.25	14.86	16.34	16.25	16.73
	Professional	34.46	38.59	43.56	45.43	46.9
	Other	52.29	46.56	40.1	38.32	36.37
	Observations	*315,940*	*430,019*	*487,088*	*659,990*	*731,033*
Technology	Manager	13.1	18.43	20.98	23.75	23.68
	Professional	33.17	42.18	50.4	56.76	58.18
	Other	53.73	39.39	28.63	19.49	18.14
	Observations	*185,520*	*244,893*	*353,204*	*323,736*	*413,409*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old). Includes all education levels

Appendix A4. Education levels by Occupation & Industry

	Manufacturing									
	Manager					Professional				
	1980	1990	2000	2010	2015	1980	1990	2000	2010	2015
Less than HS	5.93	3.92	2.94	3.93	1.77	1.94	1.65	1.24	0.39	0.88
	0.67	0.5	0.47	1.69	1.03	0.42	0.36	0.3	0.28	0.45
High school grad	18.34	10.72	6.68	9.94	5.13	9.96	6.17	5.36	2.41	3.89
	1.1	0.82	0.72	2.93	1.75	0.91	0.62	0.61	0.88	0.91
Some college	29.64	28.35	25.43	23.79	17.82	26.48	24.35	21.74	12.06	11.12
	1.29	1.21	1.28	3.26	2.47	1.35	1.12	1.13	2.1	1.77
College graduate	24.66	37.98	39.99	36.92	38.04	34.5	45.95	44.91	48.66	45.22
	1.21	1.3	1.48	3.5	3.19	1.44	1.29	1.38	3.11	2.59
Graduate degree	21.42	19.03	24.96	25.42	37.24	27.12	21.88	26.75	36.48	38.89
	1.16	1.03	1.31	3.08	3.26	1.36	1.06	1.2	2.98	2.51
Total	*25,300*	*31,430*	*26,226*	*28,299*	*31,152*	*21,680*	*34,318*	*31,413*	*36,588*	*45,997*
	High Services									
	Manager					**Professional**				
	1980	1990	2000	2010	2015	1980	1990	2000	2010	2015
Less than HS	4.11	1.94	1.16	1.17	0.75	1.3	0.61	0.69	0.87	0.55
	0.45	0.28	0.2	0.43	0.24	0.16	0.09	0.09	0.25	0.13
High school grad	17.15	9.1	5.97	5.81	4.98	6.52	3.76	3	2.5	2.53
	0.83	0.55	0.41	1	0.76	0.34	0.23	0.19	0.37	0.35
Some college	26.66	29.58	24.63	20.53	18	17.52	16.98	16.27	13.2	11.1
	0.97	0.87	0.76	1.47	1.34	0.52	0.45	0.4	0.73	0.63
College graduate	21.83	33.46	39.41	43.18	42	18.59	33.4	34.89	34.72	38.76
	0.91	0.9	0.85	1.85	1.59	0.53	0.56	0.51	1.05	0.99
Graduate degree	30.24	25.91	28.83	29.3	34.27	56.06	45.25	45.16	48.7	47.07
	1.01	0.84	0.78	1.61	1.53	0.69	0.6	0.54	1.09	1
Total	*41,860*	*63,881*	*79,598*	*107,248*	*122,287*	*108,880*	*165,937*	*212,168*	*299,836*	*342,862*
	Technology									
	Manager					**Professional**				
	1980	1990	2000	2010	2015	1980	1990	2000	2010	2015
Less than HS	1.65	1.16	0.44	0.3	0.27	0.62	0.44	0.43	0.09	0.24
	0.37	0.23	0.12	0.17	0.17	0.15	0.1	0.09	0.07	0.09
High school grad	8.89	4.59	2.73	1.59	1.25	7.99	2.78	2.78	1.69	1.82
	0.81	0.48	0.29	0.57	0.39	0.49	0.24	0.2	0.4	0.42
Some college	26.09	25.74	15.63	9.14	9.44	26.29	20.51	16.3	10.54	6.94
	1.27	0.98	0.64	1.17	1.02	0.8	0.61	0.43	0.84	0.61
College graduate	25.27	36.28	43.07	42.45	44.01	28.01	45.36	44.48	40.93	42.74
	1.25	1.06	0.87	1.99	1.79	0.82	0.75	0.59	1.36	1.22
Graduate degree	38.11	32.22	38.14	46.52	45.03	37.08	30.91	36.01	46.74	48.27
	1.4	1.03	0.86	2.02	1.77	0.88	0.69	0.57	1.36	1.23
Total	*24,300*	*45,127*	*74,089*	*76,895*	*97,912*	*61,540*	*103,301*	*178,010*	*183,742*	*240,501*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Appendix A5. Race by Occupation & Industry

	Manufacturing									
	Manager					Professional				
	1980	**1990**	**2000**	**2010**	**2015**	**1980**	**1990**	**2000**	**2010**	**2015**
White	89.33	82.39	74.71	68.61	54.96	82.01	72.69	64.19	48.3	49.55
Asian	3.95	9.17	12.98	20.05	31.61	9.13	17.47	23.64	39.7	39.96
Hispanic	4.9	6.28	6.88	7.67	6.39	5.54	5.74	6.26	7.11	6.68
Black	1.58	1.74	2.26	1.2	2.59	2.68	3.72	2.65	0.88	1.07
Total	*25,300*	*31,430*	*26,226*	*28,299*	*31,152*	*21,680*	*34,318*	*31,413*	*36,588*	*45,997*
	High Services									
	Manager					Professional				
	1980	**1990**	**2000**	**2010**	**2015**	**1980**	**1990**	**2000**	**2010**	**2015**
White	82.8	77.16	70.13	57.61	56.78	80.29	74.61	64.83	54.98	52.92
Asian	5.35	9.47	12.06	18.88	21.24	8.54	12.83	18.76	27.23	28.41
Hispanic	5.64	6.57	8.41	13.33	12.63	4.96	6.15	7.32	10.28	9.81
Black	5.59	6.35	6.48	6.93	5.75	5.55	5.96	5.79	4.8	5.59
Total	*41,860*	*63,881*	*79,598*	*107,248*	*122,287*	*108,880*	*165,937*	*212,168*	*299,836*	*342,862*
	Technology									
	Manager					Professional				
	1980	**1990**	**2000**	**2010**	**2015**	**1980**	**1990**	**2000**	**2010**	**2015**
White	89.63	82.06	70.03	55.8	51.74	81.22	73.3	54.72	40.7	36.31
Asian	4.86	10.85	20.38	34.59	38.5	12.12	19.52	36.01	49.5	53.83
Hispanic	3.79	3.87	5.1	5.91	6.37	4.22	3.89	4.76	4.78	5.08
Black	1.32	2.78	1.97	1.62	0.96	1.95	3.02	2.07	2.24	2.09
Total	*24,300*	*45,127*	*74,089*	*76,895*	*97,912*	*61,540*	*103,301*	*178,010*	*183,742*	*240,501*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Appendix A6. Gender by Occupation & Industry (Percentage female)

	Manager					Professional				
	1980	**1990**	**2000**	**2010**	**2015**	**1980**	**1990**	**2000**	**2010**	**2015**
Manufacturing	16.28	27.37	30.27	29.3	34.56	26.94	31.68	36.58	35.62	38.84
Total	*25,300*	*31,430*	*26,226*	*28,299*	*31,152*	*21,680*	*34,318*	*31,413*	*36,588*	*45,997*
High Services	42.09	53.83	54.79	53.89	55.59	44.34	50.41	50.93	56.57	57.51
Total	*41,860*	*63,881*	*79,598*	*107,248*	*122,287*	*108,880*	*165,937*	*212,168*	*299,836*	*342,862*
Technology	17.28	29.42	29.99	26.13	31.1	16.35	25.11	26.07	24.41	24.14
Total	*24,300*	*45,127*	*74,089*	*76,895*	*97,912*	*61,540*	*103,301*	*178,010*	*183,742*	*240,501*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Appendix A7: Educational attainment of programmers

	1980	1990	2000	2010	2015
Less than HS	1.17	0.85	0.51	0	0
	0.55	0.33	0.12	0	0
High school grad	8.41	3.75	1.77	1.52	1.23
	1.26	0.6	0.24	0.52	0.32
Some college	31.31	25.46	13.26	6.91	5.01
	2.06	1.36	0.6	1.01	0.62
College Grad	33.07	49.72	47.28	45.82	45.51
	2.08	1.56	0.9	2.08	1.58
Graduate degree	26.03	20.22	37.18	45.75	48.25
	1.96	1.23	0.87	2.07	1.59
Total	*10,220*	*24,264*	*77,532*	*88,137*	*143,286*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old). Standard errors are displayed below point estimates.

Appendix A8: Educational attainment of programmers, by gender

	MALE					FEMALE				
	1980	**1990**	**2000**	**2010**	**2015**	**1980**	**1990**	**2000**	**2010**	**2015**
Less than HS	0.82	0.96	0.45	0	0	2.07	0.57	0.74	0	0
	0.61	0.43	0.13	0	0	1.18	0.47	0.29	0	0
HS grad	7.65	3.62	1.62	1.4	1.46	10.34	4.05	2.32	2.06	0.23
	1.39	0.72	0.26	0.49	0.39	2.53	1.06	0.61	1.73	0.23
Some college	32.24	27.68	13.66	7.62	5.42	28.97	19.97	11.81	3.87	3.24
	2.44	1.67	0.69	1.19	0.73	3.77	2.26	1.19	1.48	1.06
Bachelor's	32.79	46.51	47.58	45.33	45.21	33.79	57.66	46.18	47.94	46.81
	2.45	1.84	1	2.27	1.71	3.93	2.79	1.86	4.64	3.64
Grad school	26.5	21.22	36.69	45.66	47.91	24.83	17.75	38.95	46.13	49.72
	2.31	1.48	0.96	2.25	1.72	3.59	2.15	1.82	4.59	3.62
Total	*7,320*	*17,277*	*60,930*	*71,594*	*116,322*	*2,900*	*6,987*	*16,602*	*16,543*	*26,964*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Appendix A9: Educational attainment of programmers, by race

	White					Asian				
	1980	**1990**	**2000**	**2010**	**2015**	**1980**	**1990**	**2000**	**2010**	**2015**
Less than HS	0.77	0.46	0.48	0	0	2.5	0.67	0.18	0	0
	0.44	0.21	0.18	0	0	2.45	0.67	0.11	0	0
HS Graduate	8.95	3.66	2.27	3.13	2.92	2.5	2.01	0.68	0.38	0
	1.48	0.66	0.38	1.19	0.84	1.75	1.35	0.24	0.38	0
Some College	31.97	28.81	17.9	13.38	9.61	20	10.25	4.56	1.97	2.34
	2.36	1.66	0.94	2.27	1.45	4.49	2.06	0.55	0.74	0.53
College Graduate	32.99	47.31	50.19	48.71	49.95	40	58.66	45.27	44.41	41.37
	2.36	1.82	1.24	3.12	2.55	5.52	3.42	1.4	2.79	2.09
Graduate Degree	25.32	19.76	29.16	34.79	37.53	35	28.41	49.3	53.24	56.29
	2.22	1.44	1.13	2.9	2.44	5.37	3.12	1.41	2.8	2.1
Total	*7,820*	*17,558*	*38,663*	*31,664*	*50,511*	*1,600*	*4,770*	*32,996*	*52,034*	*83,552*
	Latino					**Black**				
	1980	**1990**	**2000**	**2010**	**2015**	**1980**	**1990**	**2000**	**2010**	**2015**
Less than HS	0	5.61	3.71	0	0	0	4.29	2.91	0	0
	0	5.36	1.7	0	0	0	3.03	2.1	0	0
HS Graduate	9.09	12.34	6.77	8.41	1.5	25	3.28	0.99	0	0.45
	6.13	4.6	2.51	7.91	1.51	10.83	3.23	0.99	0	0.49
Some College	50	30.65	32.58	23.96	6.48	43.75	35.81	50.11	15.69	0
	10.66	7.21	5.03	10.22	3.72	12.4	9.01	6.99	16.69	0
College Graduate	27.27	45.61	41.13	49.18	66.07	12.5	54.22	35.65	0	37.18
	9.5	7.85	5.15	11.48	8.42	8.27	9.4	6.91	0	18.32
Graduate Degree	13.64	5.79	15.82	18.45	25.95	18.75	2.4	10.33	84.31	62.37
	7.32	2.92	3.74	7.84	8.03	9.76	2.38	3.43	16.69	18.4
Total	*440*	*1,070*	*2,643*	*1,832*	*4,058*	*320*	*793*	*1,307*	*663*	*1,552*

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Appendix A10. Percentage of programmers who are foreign workers

	1980	1990	2000	2010	2015
White	3.32	4	14.24	14.42	17.53
Asian	22.5	22.56	53.2	49.56	53.57
Hispanic	13.64	18.41	23.46	22.33	12.64
Black	0	0	11.25	12.37	32.02

Note: Only full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force (16+ years old).

Appendix A11. Region of origin of all degrees for foreign students (Undergraduate, Graduate, and other)

Year	Africa	Asia	Europe	Latin America	Middle East	North America	Oceania	TOTAL
1979-1980	12.6%	28.5%	7.9%	14.8%	29.2%	5.4%	1.4%	286,340
1984-1985	11.6%	42.0%	9.7%	14.2%	16.5%	4.7%	1.2%	342,110
1989-1990	6.4%	53.8%	11.9%	12.4%	9.6%	4.8%	1.0%	386,850
1994-1995	4.6%	57.8%	14.3%	10.4%	6.7%	5.2%	1.0%	452,635
1999-2000	5.9%	54.4%	15.2%	12.1%	6.8%	4.7%	0.9%	514,723
2004-2005	6.4%	57.5%	12.7%	12.0%	5.5%	5.1%	0.8%	565,039
2009-2010	5.4%	63.1%	10.8%	9.5%	6.4%	4.1%	0.7%	690,923
2014-2015	3.4%	64.3%	8.2%	8.9%	11.7%	2.8%	0.7%	974,926

Notes: In 2009-10, Cyprus & Turkey were re-categorized from Middle East to Europe. However, due to the quality of data from prior to 1995-96 data, it is not possible to re-categorize these countries so Cyprus & Turkey were re-classified as Middle East in this analysis. Cyprus represents 211 undergrads and 296 graduate students while Turkey represents 3,656 undergrads and 6,585 graduate students in 2009-10. North America consists of Canada and Bermuda (vast majority is from Canada).

Table A12. CS degree completions, by race and gender percentages

Bachelor's	1985	1990	1995	2000	2005	2010	2015
White Male	52.85	51.58	49.7	46.36	46.61	51.32	47.8
White Female	29.04	17.33	15.86	14.09	9.79	9.01	8.66
Asian Male	4.33	7.13	9.93	12.32	11.27	8.04	11.01
Asian Female	2.9	3.72	4.47	5.83	3.88	2.21	3.36
Hispanic Male	1.92	3.36	4.42	4.58	5.62	6.74	8.4
Hispanic Female	1.19	1.84	2.07	2.19	1.99	1.6	1.87
Black Male	3.07	4.24	5.37	5.27	6.84	7.09	7.15
Black Female	3.02	4.2	5.22	4.62	4.59	3.26	2.45
total	39,121	27,259	24,719	36,565	56,150	40,973	62,023

Graduate	1985	1990	1995	2000	2005	2010	2015
White Male	48.34	41.37	38.31	30.26	30.89	29.35	25.2
White Female	18.95	15.12	11.56	11.73	9.81	8.82	8.88
Asian Male	15.77	19.95	26.23	26.64	26.48	27.36	31.39
Asian Female	6.06	7.19	10.04	15.42	12.16	11.08	14.72
Hispanic Male	2.36	2.43	3.44	3.97	4.28	4.87	4.57
Hispanic Female	0.88	0.67	1.1	1.91	1.73	1.75	1.82
Black Male	3.24	2.6	2.97	3.21	4.07	4.75	4.74
Black Female	1.55	1.32	1.68	2.25	2.48	2.95	2.61
total	7,349	10,146	11,294	15,209	20,091	19,961	33,948

Note: for degree completions in CS in the U.S.

Appendix A13. Race and gender distribution of programmers, by education level

With undergraduate degrees

	1980	1990	2000	2010	2015
White Male	56.69	45.86	39.87	30.5	30.5
White Female	22.83	21.78	8.17	2.88	3.52
Asian Male	10.24	12.21	33.78	49.16	43.23
Asian Female	5.51	11.9	11.35	12.47	13.05
TOTAL	2540	9628	28401	29913	47340

With graduate degrees

	1980	1990	2000	2010	2015
White Male	55.24	55.03	27.56	18.21	20.88
White Female	17.14	11.46	5.34	1.4	2.64
Asian Male	12.38	16.41	46.54	59.52	52.95
Asian Female	10.48	16.12	16.09	16.56	17.64
TOTAL	2100	3796	22576	29417	48454

Note: Sample is restricted to the same sample as the wage analyses: full-time (at least 35 hours of work a week) full-year (at least 50 weeks in previous year) workers in labor force with positive wages between 25-44 years old.