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Engineering Educational Opportunity

Impacts of 1970s and 1980s Policies to Increase the Share of Black College Graduates with a Major in Engineering or Computer Science

Catherine J. Weinberger

During the 1970s and 1980s, in the context of a national conversation about racial inequality, a constellation of overlapping policy efforts aimed to increase the number of black college graduates with engineering or computer science majors. These efforts can be roughly organized into two categories. The first was inspired by business leaders concerned about the absence of black Americans among top executives, and cognizant that many of the most influential industrial leaders had engineering training. This effort involved representatives of industry, private foundations, and educators from campuses across the United States, including the six engineering programs on historically black campuses, which were graduating the majority of black engineers at the time. The second came out of the desire to improve the future career prospects of graduates within a broader coalition of historically black colleges and universities (HBCUs),[1] including those with no engineering program. This second wave effort strove to expand opportunities for both men and women to study engineering, and led to new computer science programs at many HBCU campuses.

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1. For statistical purposes, HBCU is defined as an institution where the majority of students were black immediately before passage of the 1964 Civil Rights Act.

This chapter shows that these campaigns succeeded in raising the proportion of college-educated black men and women entering engineering and computer science fields. Initially, the change was particularly rapid among persons born near the six historically black engineering programs. These engineering programs were able to increase the number of black graduates quickly, relative to most other U.S. institutions. While there remain black-white gaps in engineering despite changes at engineering campuses across the country, the strengthening of the HBCUs decades ago contributed and continues to contribute to limiting this gap. The chapter also shows that the second wave effort to introduce computer science courses at HBCU campuses was so successful that black college graduates became more likely than the U.S. average to hold a computer science degree. Because there was little change in the relative propensity to major in math or other science fields, growing engineering and computer science participation led to a net increase in the representation of black college graduates among science, technology, engineering, and mathematics (STEM) majors.[2]

The chapter is divided into four sections. The first part describes historical features of the higher education infrastructure and details of national and local efforts to change. The second part presents my analysis of the impacts of these efforts on the number of black engineering and computer science graduates in each year, based on data describing the number and type of degrees conferred by each institution of higher education over the interval 1968–2011, collected by the U.S. Department of Education and the Engineering Manpower Commission. To establish a link between the geography of institution-level changes and the impacts on college students from different states, I draw on information about college major plus year and state of birth from the nationally representative American Community Survey (ACS) 2009–2013. The third part examines the occupations and earnings of college graduates in current ACS data to learn how changes in the number of black Americans with engineering and computer science education translated into current labor market outcomes. The fourth part concludes.

3.1 Historical Context of the Higher Education Infrastructure

Prior to the civil rights era, the most prevalent job opportunity for black college graduates was to teach in a segregated school, and educational offerings at HBCU campuses tended to reflect this reality (U.S. Office of Education 1942/1943; Weinberg 1977; Pruitt 1987). The separate-but-equal doctrine associated with the 1896 Supreme Court decision in *Plessy v. Ferguson* preserved racial segregation, which eventually led to the 1954 *Brown v. Board*

2. STEM is shorthand for science, technology, engineering, and mathematics. Here it includes biological and physical sciences, computer and information sciences, engineering, mathematics and statistics.

of Education ruling that separate is inherently unequal. The Civil Rights Act of 1964 provided further promise of access to education for black students, but systems of higher education remained separate and unequal, particularly in the South where HBCU programs remained poorly funded. No specific legal rulings addressed equitable funding for black college campuses or desegregation of undergraduate programs until a string of decisions in the far less familiar *Adams* case that spanned 1972–1983 eventually required nineteen states to submit plans of remedial action to the federal government (Pruitt 1987). The wording of this requirement recognized the unique role played by HBCU campuses as part of the U.S. educational infrastructure (Pruitt 1987).

The higher-education landscape in the United States was largely in place by the early nineteenth century (Goldin and Katz 1999). While the *Adams* case was being argued, black students in most southern states had limited access to engineering education. During the 1960s and 1970s, only six of the HBCU campuses housed an accredited engineering program. These were four public land-grant universities, which enrolled primarily in-state students: Prairie View A&M in Texas, Southern University and A&M College in Louisiana, North Carolina A&T State University, and Tennessee State (formerly Agricultural and Industrial) University,[3] plus Howard University in Washington, D.C., and Tuskegee in Alabama, HBCUs with a somewhat wider geographic pull.[4] No federal statistics on the number of black engineering graduates were collected until 1968, but it was estimated that at least one-half of black engineers in the United States were trained at one of these six HBCU campuses (HBCU6) during the 1960s and earlier (Pierre 1972).[5]

On many HBCU campuses, a commitment to support the intellectual development of students regardless of prior academic preparation is viewed as a legacy of the historic mission to teach emancipated slaves how to read. During the 1970s and 1980s a group of HBCU campuses organized to expand educational opportunities in engineering, computer science, and other technical fields, "to prepare their students for expanded career choices" (Trent and Hill 1994). Contemporaneous observers describe an encouraging pedagogical environment that exemplifies the heart of what education can be: "They take students who may not have been well prepared in high school for careers in the 'hard sciences' and graduate them with degrees in science and engineering" (Trent and Hill 1994). The success of

3. For historical background on the establishment of land grant universities, see Weinberg (1977). It is notable that the majority of the HBCU engineering campuses began as agricultural and technical, mechanical, or industrial campuses.

4. All six campuses offered engineering degrees by 1960; one has been training engineers since 1912.

5. The exact share is impossible to determine because educational statistics on new degrees conferred by race were not collected before 1968. My estimate of two-thirds, given later in this chapter, is based on three different bodies of data. It exceeds the estimate of at least one-half mentioned at the time.

both early and current educational programs at HBCU campuses has been well documented. While college-completion rates tend to increase with the selectivity of an institution, HBCUs have graduation rates far higher than comparably selective colleges (Kane 1998). Other superior student outcomes include shorter time to graduation, and encouragement and academic support to pursue more challenging and remunerative college majors compared to students with observably similar characteristics at other colleges (Trent and Hill 1994; Ehrenberg and Rothstein 1994; Nettles 1988; Kane 1998; Sibulkin and Butler 2005; Weinberger and Joy 2007). The supportive HBCU environment is described in interviews with students who took courses at both an HBCU campus and another institution of higher education (Fries-Britt, Burt, and Franklin 2012), and also by the former dean of the Howard University School of Engineering (Pierre 1972). As summarized by Slaughter (2009), historically black schools of engineering provide an environment "in which success is encouraged, supported, and expected."

In contrast, the first black students who enrolled at Georgia Tech in the early 1960s recall an unsupportive educational environment.[6] Relying on primary historical documents and interviews, Bix (2013) notes that these students faced social barriers with profound implications for their academic development including difficulty finding lab partners, exclusion from fraternities and their valuable files of prior years' exams, a "ring of empty seats around me in class," and threats of physical violence that rendered the library inaccessible (Bix 2013). It is telling that the first black student to persist to graduation had transferred from, and continued to find social support within, a nearby HBCU campus. Landis (2005, 6)—who visited dozens of engineering campuses throughout the 1970s and 1980s—reported that, despite the best of institutional intentions, "At university after university, minority engineering students have told me that white students won't form laboratory groups with them, act surprised when they do well on tests, and intentionally leave the seats next to them vacant." Today's STEM undergraduates report similar experiences: "there was no one willing to be my lab partner. . . . They don't think I'm capable enough or know the material. What it means is I study alone" (Abcarian 2017). Landis (2005) argues that fostering strong social support and a collaborative learning environment is key to successfully retaining capable black engineering students. The successful programs he developed are based on his own experiences as the member of an academically oriented fraternity while he was an engineering student at MIT (Landis 2005). Highlighting the importance of social support, Treisman (1992) observed in the 1970s that academically talented black students at UC Berkeley did not learn as much calculus as ethnically Chinese classmates because of their tendency to study alone rather than with groups of friends. Successful programs of social and

6. Since that time, Georgia Tech has graduated thousands of black engineers.

academic engagement and support, based on models inspired by these and other educators, are thriving on many engineering campuses today.

3.1.1 The 1970s Intervention

The beginning of the nationwide effort to increase opportunities for black students to enter engineering is attributed to a speech "Needed: Revolutionary Approaches Leading to Minority Management Development," by General Electric (GE) executive J. Stanford Smith in 1972.[7] The speech was given to a group of corporate executives and forty-four engineering school deans at the GE Management Development Center in Crotonville, NY, during a five-day conference on "Strategic Considerations in Engineering Education" (Lusterman 1979; Blackwell 1981). It emphasized that the majority of top leaders in industrial management began their careers with engineering study, and accumulated many years of engineering experience before rising to leadership, and made the case that integrating top management twenty years in the future would require immediate action to increase the supply of black engineers (Smith 1973). Lusterman's (1979) account, written shortly afterward, describes how GE analysts, charged with figuring out how to meet hiring goals, determined that there was a bottleneck in the supply chain that should be remedied. Lusterman (1979) reports that the audience was "startled" by Smith's presentation of GE's analysis, and his call for "an undertaking of staggering proportions that requires revolutionary action." A representative of the Alfred P. Sloan Foundation and a science advisor to President Nixon were also in attendance.[8] In concluding, Smith—an industry leader with a family legacy of advocacy for educational opportunity—called for a national effort to rectify inequities in engineering education, with cooperation of the business and education communities, foundations, and professional societies (Lusterman 1979; Blackwell 1981).[9] Senator Humphrey felt the speech was so important that he summarized its main points in a brief oration addressed to President Nixon, and had the text of the entire speech (with revised title) entered into the U.S. Congressional Record, following his own remarks (Humphrey 1973). The Crotonville speech continues to be referenced by those working to rectify inequities in access to engineering education.

Although many inspiring speeches are delivered to little long-term effect,

7. Soon after the passage of the 1964 Civil Rights Act, there were some modest efforts to increase the number of black engineering graduates. Some companies seeking additional engineers donated funds to improve capacity and quality at the HBCU6 campuses, and to establish "dual degree" programs between other HBCU campuses and engineering schools prepared to accept transfer students after the first two or three years of study (Pierre 1975; Lusterman 1979). But these efforts were insufficient to change the majority of educational institutions.

8. Lucius P. Gregg completed a master's degree at MIT after graduating with distinction from the Naval Academy in 1955 (Williams 1999; Schneller 2008).

9. J. Stanford Smith's mother served on the advisory board of the Mary McLeod Bethune School for Negro Girls; his daughter was influenced by discussions about educational equity around the family dinner table, and continues to advocate for educational opportunity as a scholar and professor (Witherell 2009; College of Lewis and Clark 2012).

the Crotonville speech began conversations that affected private and public policy. Discussions between GE representatives and the educators in attendance led to deeper understanding of broad challenges, including the need to improve in K–12 education (Pierre 2013, 2015). As the scope of the necessary effort became clear, Lindon Saline, director of the GE Management Development Institute, enlisted the participation of Percy Pierre, who attended the Crotonville conference as the Dean of Engineering at Howard University. After approaching several organizations without success, this pair persuaded the Commission on Education of the National Academy of Engineering to host a Symposium on Minorities in Engineering, and pulled in financial sponsors including the Sloan Foundation (NAE 1973; Slaughter 2009; Pierre 2013, 2015). At this symposium, held four months after Smith's Crotonville speech, consensus was reached on building a national organization and extending the institutional support of the National Academy of Engineering toward this effort, with the cooperation of GE and other corporations (Slaughter 2009; Pierre 2013, 2015). The Academy created the National Advisory Council for Minorities in Engineering (NACME), with GE Chairman Reginald Jones as its first chair (Pierre 2013).[10] Soon afterward the Sloan Foundation committed 20 percent of its resources over five to seven years ($12–$15 million) toward this national effort, and asked Percy Pierre to serve as program officer to oversee Sloan's multimillion-dollar investment, which he agreed to do half time while continuing as dean of engineering at Howard University (Lusterman 1979; Blackwell 1981; Pierre 1975, 2012, 2015). Pierre (1975) later reported that the Sloan Foundation was interested in funding such an effort several years earlier, but was waiting for a sign that they would not have to work alone. J. Stanford Smith's speech and the rapid organizational energy that followed soon afterward provided the signals that the Sloan Foundation had been waiting for (Pierre 1975; Pierre 2013).

Over the next year, the newly formed Planning Commission for Expanding Minority Opportunities in Engineering met regularly under the leadership of Professor Louis Padulo of Stanford University, who had previously established a dual degree program between Georgia Tech and nearby HBCU campuses.[11] This group—seventeen representatives of industry, academia, government, and other organizations recruited by the Sloan

10. The National Action Council for Minorities in Engineering that exists in 2016 came from the 1980 merger of the original NACME organization with two closely intertwined organizations, the Minority Engineering Effort (ME3), and the National Fund for Minority Engineering Students (NFMES). While the focus of NACME is on undergraduate education, other organizations formed during this effort focus on graduate level (the National Consortium for Graduate Degrees for Minorities in Engineering, or GEM) and K–12 education (Mathematics, Engineering, Science Achievement, or MESA).

11. According to his web page, Dr. Padulo established the Georgia Tech dual degree engineering program soon after earning a PhD from that institution, while a professor at Morehouse by invitation of Dr. King (Padulo 2015).

Foundation—produced a "Blueprint for Action" that treated the effort as an engineering problem, and recommended approaches to overcome obstacles (PCEMOE 1974; Pierre 1975; Blackwell 1981; Pierre 2013). Suggested mechanisms included funding to expand and improve programs at the HBCU6 institutions, funding to establish additional dual degree partnerships between HBCU and engineering campuses, thousands of undergraduate minority engineering scholarships, expanded support for the transition to graduate school, incentives for individual engineering programs to begin or expand recruitment efforts, and efforts to improve precollege math and science preparation across the nation (PCEMOE 1974; Pierre 1975; Lusterman 1979; Blackwell 1981). The Blueprint report was quickly endorsed by NACME (Pierre 2013). An edited volume of sixteen articles by twenty-one authors gives a sense of the teamwork inspired by the early effort (Saline 1974) that in short order translated recommendations into action as social activists, educators, and engineering corporations reconfigured the opportunity structure in engineering.

The resulting efforts to expand the pool of qualified black engineers were well funded (Blackwell 1981; Lusterman 1979). In addition to the Sloan Foundation's seed money, major engineering employers donated millions of dollars both to the emerging national organizations and to individual university campuses (Lusterman 1979). Donations by potential employers to educational institutions cemented relationships that paid off when it was time to recruit new graduates (Pierre 2012). The donations toward equitable engineering education were also encouraged by the newly formed Equal Employment Opportunity Commission (EEOC) as one of the hallmarks of an EEOC-compliant federal contractor.[12] The large total value of all donations can be surmised by surviving documentation: a 1973 advertisement in *Black Enterprise* states that IBM placed twenty-five full-time engineers in teaching positions at black colleges and donated a large quantity of equipment as well, and a 1986 NACME publication itemizes several million dollars in donations made by a veritable who's who of American industry (IBM 1973; Miranda and Ruiz 1986). Money was distributed both as scholarships to individuals and also in the form of institutional support for minority engineering programs through an "Incentive Grants" program that required institutions to set and meet goals for minority engineering enrollment and graduation (Blackwell 1981, 1987; Miranda and Ruiz 1986). By 1983, nearly half of all U.S. engineering programs were actively recruiting minority students (NACME 1986; Miranda and Ruiz 1986; Blackwell 1987).

Through the 1990s, opportunities for black students to enroll in engi-

12. This is suggested by an observation made by Pierre (1972, 2) that "It is explicitly included in the Executive Order establishing affirmative action that activity by companies to increase the supply of black engineers is part of what the Labor Department must look for. So this is one reason, I think, why we have noticed this interest today."

neering programs continued to grow rapidly. In the southern states, several historically black campuses added accredited engineering programs: Alabama A&M, Florida A&M, University of the District of Columbia, Morgan State (Maryland), Hampton University (Virginia) between 1979 and 1992, joined by Jackson State (Mississippi), South Carolina State, Virginia State, and Norfolk State (Virginia) in the most recent decade.[13] Meanwhile, representation of black engineering students at other institutions continued to expand, so that the addition of new HBCU programs was matched by equally strong trends toward inclusion at engineering programs across the country. While the national effort to train black engineers did not meet the ambitious goals set out by early activists, it produced real and sustained change. Blackwell (1981, 1987), who wrote a book with one chapter devoted to the entry of black professionals into each of ten occupations, concluded that the engineering effort was the most successful among all the professions. More recently, Conrad (2006) has noted substantial variation across geographic regions in the representation of black college graduates in high tech occupations.

3.2 Analysis of the Impacts of the Intervention

3.2.1 Access to Engineering Education

To see how the national effort just described affected the flow of black students into engineering majors nationwide, I examine data on the number of black engineering majors. I begin with broad national counts and then move to more detailed statistics. Current nationally representative ACS 2009–2013 data allow a broad-brush view of the change that occurred because the educational attainment of today's adults reflects the educational opportunities available when each cohort reached college age. Figure 3.1 graphs the share of the U.S. population and of the black population currently holding college degrees, and the share holding college degrees with an engineering major, by birth cohort. Over time, the share of all Americans with engineering degrees fluctuated with labor market conditions but remained close to the nearly 2 percent average, as modeled and described by Freeman (1976b). Over the 1950–2000 interval, increasing shares of successive cohorts of black Americans earned engineering degrees, with fastest growth between the 1970s and 1980s. Even so, across all cohorts, black representation is far below the national average. Among those who reached age twenty-two during the 1950s, only 0.37 percent (1 in 270) trained as engineers. The share

13. Since programs must be operational before they can be evaluated for accreditation, the actual dates of establishment are earlier. Accreditation dates are based on information provided at the website of ABET, Inc., formerly known as the Engineer's Council for Professional Development (ECPD, 1932–1980) and the Accreditation Board for Engineering and Technology (ABET, 1980–2005). (http://www.abet.org/AccredProgramSearch/AccreditationSearch.aspx.)

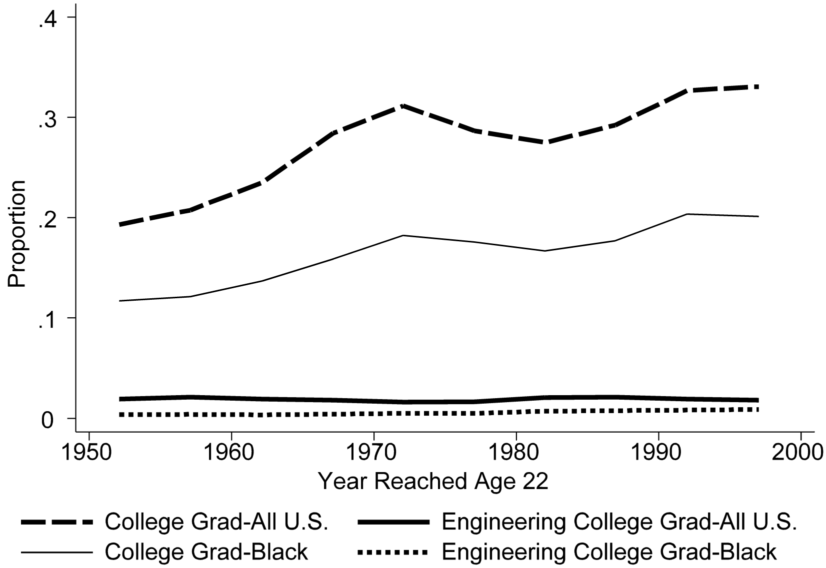

Fig. 3.1 Share of indicated population reporting college degree or college degree with a major in engineering by race and birth cohort (year reached age twenty-two, in five-year intervals)

Sample: American Community Survey 2009–2013, restricted to those born in the United States between 1928 and 1977 (age twenty-two in 1950–1999).

increased over time so that for the cohort that reached age twenty-two in the 1990s it was 0.84 percent, still less than half of the national share but over two times the 1950s ratio—evidence of a diminished racial gap in the propensity to enter engineering. Much of the remaining gap in the 1990s is related to a lower propensity to graduate college. The average propensity to graduate college increased over time, but the relative propensity for the black population remained near 60 percent of U.S. levels throughout the fifty-year span. For the most recent cohort depicted in figure 3.1, 4.15 percent of black college graduates majored in engineering compared to 5.67 percent of U.S. college graduates.[14] This represents three-fourths the national share, up from less than one-third estimated for the earliest cohort depicted. The next question is whether the timing of this shift corresponds to the policy efforts described in the previous section.

To describe changes over time in the number of black engineering grad-

14. To confirm that these estimates based on birth cohort are fairly accurate, I compared the ACS estimates for college graduates who turned twenty-two between the 1950s and the 1970s with comparable estimates for college graduates who actually earned their degrees between the 1950s and the 1970s drawn from the 1993 and 2003 National Surveys of College Graduates. In both cases, I estimate that 2–3 percent of black college graduates majored in engineering during that era, compared to nearly 7 percent of all U.S. graduates.

uates, estimates or complete counts of the annual number of bachelor's degrees in engineering earned by black men and women in the United States were assembled for all academic years between 1959–1960 and 2010–2011. The most detailed statistics on the racial composition of engineering graduates are available only in later years. Beginning in the 1982–1983 academic year, the U.S. Department of Education required each institution of higher education to report the number of graduates in each detailed field of study by race and gender.[15] Before this time, counts were aggregated in different ways. Between academic years 1975–1976 and 1981–1982, the U.S. Department of Education began to count the number of black male and black female graduates in broad categories of academic field in some years, but racial counts at accredited engineering programs were combined with less rigorous engineering technology programs. In these and earlier years, the Engineering Manpower Commission (EMC) collected somewhat more detailed data on the number of engineering graduates from each institution each year, eventually including detailed counts by race and by gender (but not both) beginning with the 1968–1969 academic year (Alden 1970, 1971; EMC 1972, 1977, 1978, 1980, 1981, 1984, 1987, 1988, 1989).[16] For this study, the best available information from all of these sources is combined to paint a complete picture of changes over time.

Before 1968 there are no systematic periodic counts of the number of black engineering graduates, but previous estimates suggest that at least half of all black engineering graduates attended the HBCU6 campuses (Pierre 1972). Due to pervasive segregation at this time, earlier counts of the number of HBCU6 engineering graduates serve as a proxy for the number of black engineering graduates from those schools in earlier years. If correct, the estimate that these account for at least half of all black engineering graduates will allow us to create an upper bound for all other institutions.

Information from different sources is consistent with the "at least half" estimate. The six HBCU6 institutions accounted for 60 percent of all black U.S. engineering graduates in each of the first two years of the EMC survey (Alden 1970, 1971). However, after correcting for a pair of typographical

15. This requirement was implemented shortly after the December 1980 passage of the federal Science and Technology Equal Opportunities Act (part B of Public Law 96-516).

16. Some earlier statistics exist. Wharton (1992) gathered names of black engineers who graduated between 1914 and 1929. He found about 400 (averaging twenty-seven per year), with the largest concentration of these from Howard University (n = 36, or 2.4 per year) and MIT (n = 31, or 2.1 per year). Early government statistics indicate that Howard University graduated thirteen engineers between 1922 and 1926 (2.6 per year), consistent with the counts made by Wharton (1992). Downing (1935) enumerated about 100 black engineering students in 1930, thirty-one at Howard University (where he was soon to become dean of the School of Engineering and Architecture), and the remainder in northern institutions including MIT, Cornell, Rensselaer Polytechnic Institute, Ohio State University, and the Universities of Michigan, Pennsylvania, Pittsburgh, Illinois, Wisconsin, and Armour Institute of Technology. Carey (1977) reports a count of 150 graduating black engineers in 1955.

errors that I discovered, the true statistic is closer to 65 percent.[17] The Project Talent longitudinal survey of students from the high school classes of 1960 and 1961 includes fourteen black students who held bachelor's degrees in engineering when they were resurveyed either five or eleven years after high school. Of the fourteen, all of those who graduated from southern high schools attended one of the HBCU6 institutions, and all students from northern high schools attended northern colleges. Reweighting the Project Talent data to control for the oversampling of certain high schools and students yields the estimate that 65 percent of the black engineers from these cohorts were educated at one of the HBCU6 campuses.[18] Another source of information is the 1993 National Survey of College Graduates (NSCG93), a retrospective survey that asked a representative sample of college graduates where and when they attended high school and college. While the data have been recoded to regional-level indicators to protect confidentiality, it is possible to estimate the proportion of black engineers educated during the 1960s who got degrees from colleges and universities in southern states. Based on a sample of thirty-seven respondents, I estimate that 63 percent of black engineers were educated in the South—most likely in HBCU6 programs. All of these suggest that "at least half" is an underestimate of the contribution of HBCU programs in the 1960s, and that the truth might be closer to two-thirds. Although imprecise, this estimate allows us to construct a proxy for national counts in earlier years, and helps us understand the degree to which growing EMC counts reflect true gains rather than more accurate counts.

The next step in the analysis is to compare growth in the number of black engineering graduates across different types of institutions. Figure 3.2 describes growth within different subsets of U.S. engineering programs using estimates in the earlier years from numbers recorded by the EMC, and later estimates from the U.S. Department of Education National Center for Education Statistics (NCES).[19] Figure 3.2, panel A, depicts trends in the number of black engineering graduates from HBCU campuses, with counts

17. The EMC warns that early year data may exaggerate racial stratification because many non-HBCU6 institutions left the racial counts blank. In fact, in the first year of the survey, more than half of the institutions left this question blank. Unless these blanks were all true zeros, they would lead to an exaggerated picture of the contribution of the HBCU6 institutions. As administrators became accustomed—eventually required—to answer these questions, the counts arguably got better. However, estimates based on other data sources suggest that most of the blanks are true zeros.

18. Although the sample is small, a 70 percent confidence interval has lower bound at 0.51, meaning there is only 15 percent probability that the true value is below half.

19. In the 1960s, I use the total number of engineering graduates from HBCU6 campuses to estimate black graduates from these campuses, and double this number to estimate the number of black graduates from all U.S. campuses. It is visually apparent that the estimates match up well in figure 3.2, panel A, but are mismatched in figure 3.2, panel B. Either HBCU6 campuses actually produced more than half in the 1960s, or the earliest EMC counts are too low due to nonreporting campuses.

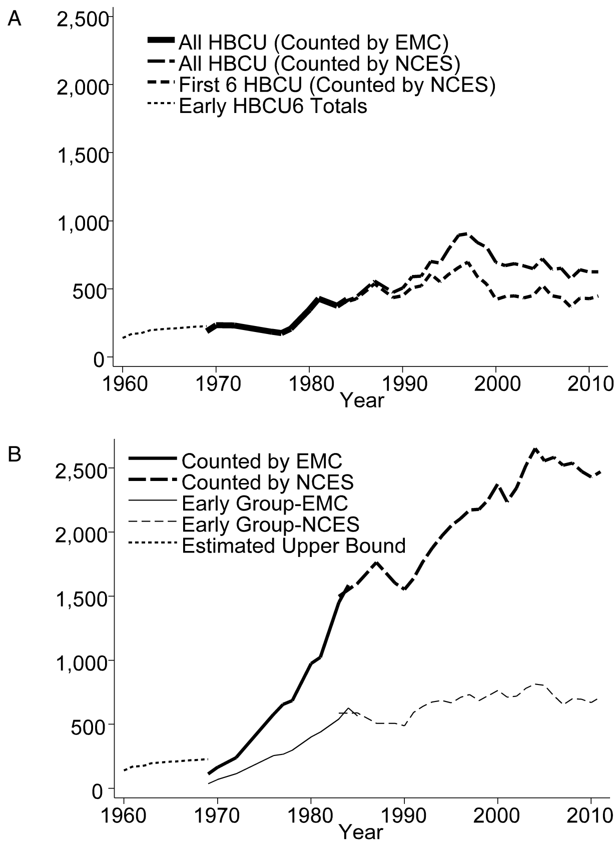

Fig. 3.2 By institution category, number of black engineering graduates from HBCU and other campuses, 1960–2011. ***A*****, HBCU campuses;** ***B*****, Non-HBCU campuses.**

Data source: Administrative records reported by educational institutions to the U.S. Department of Education or the Engineering Manpower Commission.

Note: Additional curve in panel A distinguishes between the original six HBCU engineering programs and new HBCU programs established later. Additional curve in panel B describes trends within a small subset of engineering programs that were early participants in efforts to increase the enrollment of black students.

for the original six institutions indicated separately from the full counts. It shows a sharp jump around 1980, reflecting the fact that between the mid-1970s and mid-1980s, the HBCU6 campuses expanded from an average of about 200 black graduates per year to about 500 graduates per year over a ten-year interval. Additional HBCU growth during the 1990s is primarily due to the opening of new HBCU engineering programs. Figure 3.2, panel B, depicts the corresponding counts for other U.S. campuses, and shows a steep upward trend in the number of black engineering graduates, eventually dwarfing the HBCU counts of figure 3.2, panel A.[20] The trend line labeled "Early Group" indicates subtotals for the thirty-four non-HBCU institutions with publicly stated early intention to change as recorded in the 1974 Blueprint Report (PCEMOE 1974).[21] This vanguard group—representing only 20 percent of U.S. engineering graduates—was responsible for a disproportionate 37 percent of the growth in black engineering graduates between 1969 and 1985.[22] Afterward, however, most of the growth was driven by expansion of black enrollment at additional institutions, as evidenced by the flattening of the "Early Group" line and continued growth of the total. A closer look at the EMC data suggests that the remaining institutions also made some initial changes by the mid-1980s: seventy percent of the 240 non-HBCU engineering schools outside the Early Group recorded at least one black graduate over the two-year interval covering 1983–1984 or 1984–1985, compared to only 30 percent over the first two years of EMC data collection.[23] These patterns suggest that early efforts led to small changes at a wide range of institutions and substantial growth in the number of black engineering graduates at a small number of institutions within a relatively short time frame, and spurred a movement that continued to expand in ensuing decades.

The timing and net effects of expansion were different in different geographic areas. Figure 3.3 combines the counts from all institutions and includes separate trend lines for large subsets of institutions, including those within the group of states containing the HBCU6 institutions, and the set of all institutions within southern states.[24] An additional trend line describes the unique contribution of Georgia Tech, which was averaging more than fifty black engineering graduates per year by the mid-1980s. The small difference between the trend lines for HBCU6 states and all southern states before 1980 indicates the initial dearth of opportunities for black students to major in engineering at southern institutions outside the HBCU6 locations.

The timing of changes in figure 3.3 suggests three distinct periods of expansion. During the early 1970s, expansion of opportunities to study engi-

20. These counts include graduates who began their studies in a dual-degree program on an HBCU campus. Additional research is required to estimate how many of these graduates participated in dual-degree programs. Close examination of NLSY cohorts that reached age twenty-two in 1979–1986 suggests that the number was small. Among black college graduates who spent any time as an engineering major, fewer than 10 percent could have earned dual degrees from an HBCU and another institution.

21. I included all non-HBCU institutions mentioned in the report in this category.

22. If Georgia Tech is excluded, the remaining members of the Early Group accounted for 33 percent of the total growth.

23. All of the engineering schools in the Early Group recorded at least one black graduate in either 1983–1984 or 1984–1985, compared to only 50 percent over the first two years of EMC data collection. Ninety percent of these, and 50 percent of programs outside the Early Group, averaged at least four per year by the mid-1980s.

24. The HBCU6 areas are Louisiana, North Carolina, Tennessee, Texas, Alabama, and the District of Columbia.

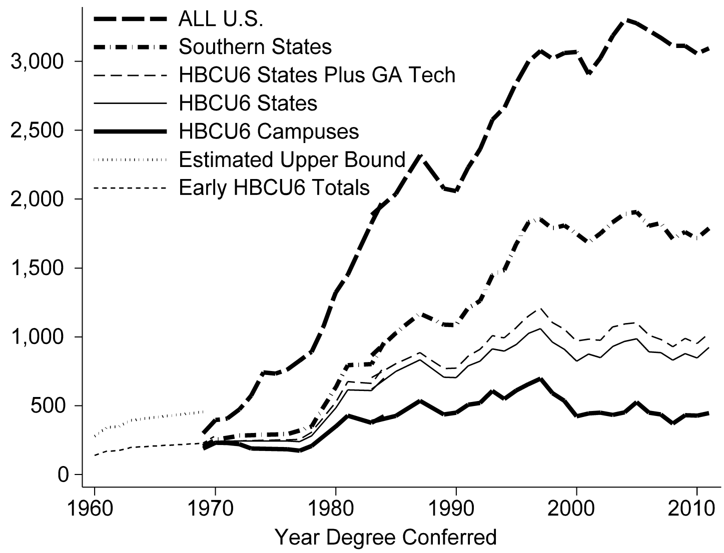

Fig. 3.3 Geographic breakdown of the number of black engineering graduates from U.S. campuses and selected subgroups, 1960–2011

Data source: Administrative records reported by educational institutions to the U.S. Department of Education or the Engineering Manpower Commission.

Note: Separate curves indicate counts for HBCU6 campuses (North Carolina A&T, Southern, Prairie View, Tennessee State, Tuskegee, and Howard), for HBCU6 states (North Carolina, Louisiana, Texas, Tennessee, Alabama, and the District of Columbia), for HBCU6 states plus Georgia Tech, and for all southern states.

neering was largely confined to (a handful of) northern institutions. In the late 1970s and early 1980s, a dramatic expansion occurred at the HBCU6 institutions, with some additional expansion at other institutions in the same six states. After this, the pattern of expansion spread to other southern states and to additional institutions in the north. These statistics indicate substantial change in a short period of time at both HBCU and other campuses, with particularly rapid per-institution impact at the HBCU6 institutions.

To better interpret the trends in numeric counts, figure 3.4 adjusts for simultaneous trends in the number of college graduates, describing how many black graduates (within various subsets of institutions) had engineering majors compared to the share among all U.S. students who graduated college the same year.[25] The topmost line indicates that before the intervention, new graduates of HBCU6 campuses were a bit more likely than the typical new U.S. graduate to hold an engineering degree, with a sharp

25. In figure 3.4, the state-level estimates from 1969–1972 rely on ballpark estimates of the total number of black college graduates in each region generated from information in the NSCG 1993 plus birth-cohort-specific information from the CPS. The short gap between 1973 and 1975 reflects years in which race-specific, institution-level data were not made public.

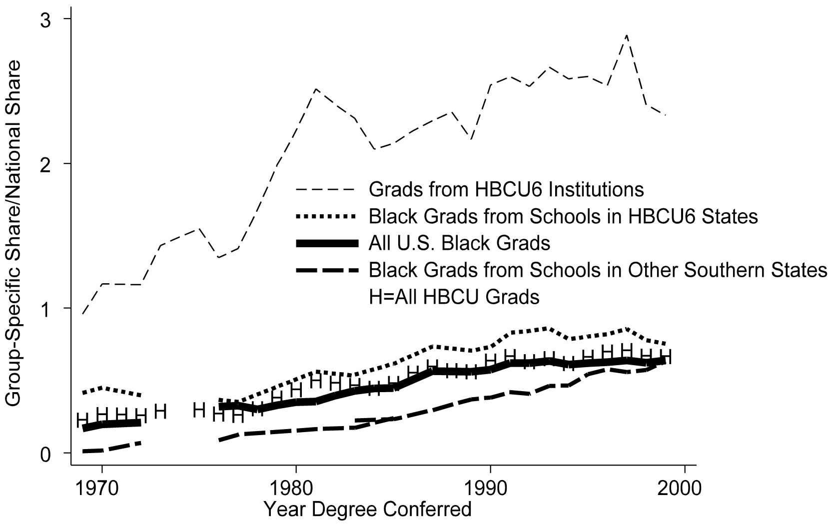

Fig. 3.4 Relative share of new graduates from each indicated group with an engineering major, based on counts of bachelor's degrees conferred in each year

Data source: Administrative records reported by educational institutions to the U.S. Department of Education National Center for Education Statistics or the Engineering Manpower Commission.

Notes: Relative shares are computed for each year as the proportion of graduates within indicated groups who majored in an engineering field divided by the proportion of all U.S. college graduates with an engineering major in the same year. The "HBCU6 States" category includes North Carolina, Louisiana, Texas, Tennessee, Alabama, and the District of Columbia, the locations of the original six black engineering campuses. Detailed counts were not made public between 1973 and 1975.

increase to more than twice as likely after the intervention. Below this, the bold line shows that the national relative share of black college students majoring in engineering followed a fairly smooth upward climb over three decades. The trend line indicated by the symbol "H" shows that as a group, the complete set of historically black colleges followed the U.S. trend most of the time, with the exception of a short-lived relative boost in the early 1980s. This pattern suggests that the main advantage of the HBCU campuses was in the ability of the HBCU6 to adjust quickly, rather than the total eventual amount of adjustment at HBCU relative to the much larger set of non-HBCU engineering campuses. The cost of acquiring engineering accreditation was too high for most HBCUs.

A geographic differential in the rate of expansion is also apparent in figure 3.4. The shorter dashed line shows that the upward trend came relatively sooner within the six southern states containing one of the HBCU6 campuses. The lowest curve underscores the lagged but persistent progress, eventually catching up to the national average, among southern campuses outside the HBCU6 states.

Although, overall, black students born in southern states with no historically black engineering campus lagged in the availability of new opportunities, there are notable exceptions. Since 1974, more than 4,000 black engineering students have graduated from Georgia Tech. More than one-third of those graduates began their studies at an HBCU campus (Chubin, May, and Babco 2005); in the earliest years more than one-half began at one of four Atlanta HBCUs.[26] Thus, even in this case, HBCU campuses played an important role as a conduit to facilitate the expansion of opportunities to study engineering. Institutional and historical features of the educational environment interacted with policy, leading to an uneven pace of expanded educational access across geographic regions.

If students first choose a career path, and then travel to the location where that path can be pursued, the geographic idiosyncrasies of the expansion of opportunities might not matter. But previous research suggests that geographic distance from home and social distance matter to students (Card 1995; Mykerezi, Mills, and Gomes 2003; Mykerezi and Mills 2008). Research using data from the 1980s finds that geographic proximity to a HBCU is a far better predictor of educational attainment among black adults in a community than simple proximity to a college or university (Mykerezi, Mills, and Gomes 2003). For this reason, differences in the timing of change across geographic regions, and between HBCU and other campuses, are likely to have influenced which groups of young people were affected by these changes in different years.

The Project Talent data described above suggested a strong geographic component determining who was likely to attend the southern engineering schools. This geographic pattern can also be seen in the far larger NSCG sample. A sample of 331 African American engineering graduates drawn from the NSCG93 data reveal that the vast majority of those who attended high school in the South remained in the South during college, while most of those from outside the South did not. When all cohorts of engineering graduates are combined, 89 percent of those who graduated high school in southern states attended college in the South (n = 167), and 88 percent of those who graduated high school in northern states attended college in the North (n = 164). Despite the proliferation of engineering recruitment efforts, these patterns did not vary much over time. Among the younger cohorts of this sample who graduated between 1976 and 1988, the corresponding statistics are 90 percent (n = 101) and 87 percent (n = 122).[27] These statistics further strengthen the case that the impacts of policy changes at HBCU6 campuses are likely to be geographically localized.

26. Estimated from data generously provided by Dr. Jane Weyant of Georgia Tech, combined with EMC data. The Atlanta University Center-Georgia Tech dual degree program was established in 1969 with a grant from the Olin Charitable Trust Fund (Blackwell 1987).

27. Among those who earned engineering degrees between 1944 and 1965, 22 percent of southern high school graduates (n = 23) and 96 percent of northern high school graduates (n = 18) attended college in the north.

Analysis of data linking place of birth to educational attainment confirms that those born near one of the HBCU6 institutions experienced particularly rapid increase in the propensity to study engineering. Using 2009–2013 ACS data for the full U.S.-born population, figure 3.5 shows that black students born in different parts of the United States were more likely to complete a bachelor's degree in engineering if they were born later, but that the rate of change within each region was related to the historical legacy of segregation and the geographic distribution of the HBCU6 institutions. Meanwhile, contemporaneous cohorts of black students from southern states with no historically black engineering campus enjoyed some gradual improvement, but experienced a persistent lag in the availability of expanded opportunities, relative to those in the HBCU6 states. On average, black students born outside the South had superior access to educational opportunities in engineering until the 1990s, when students from the HBCU6 states caught up. While figure 3.4 shows regional differences in the provision of education, figure 3.5 shows the consequences for black students born in different places and times.

Geographic differences in rates of change are robust to controls for local-

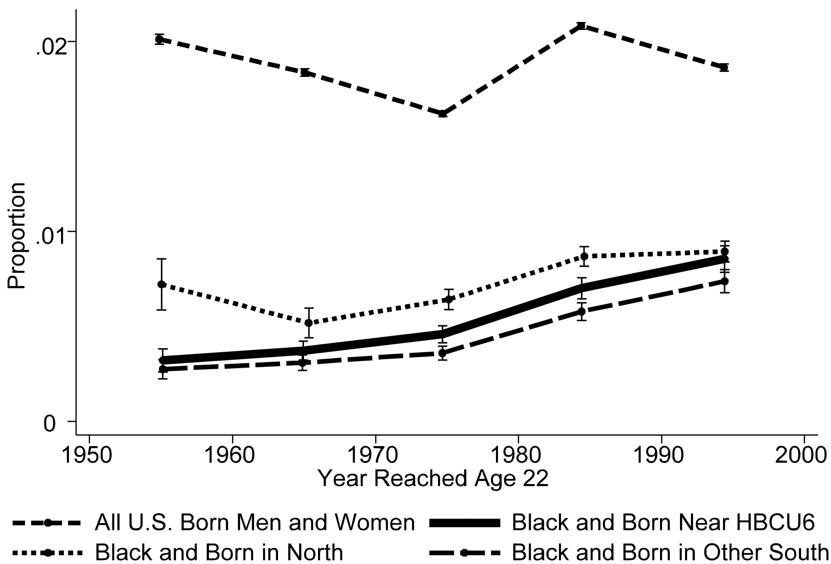

Fig. 3.5 Geographic differences in the propensity of black cohorts to graduate college with an engineering major by birth cohort and location of birth

Sample: American Community Survey 2009–2013, restricted to those born in the United States between 1928 and 1977 (age twenty-two in 1950–1999, divided into five ten-year birth cohorts), lower three curves restricted to those indicating black or African American heritage and birth in the indicated region of the country. The "Near HBCU6" category includes those born in North Carolina, Louisiana, Texas, Tennessee, Alabama, and the District of Columbia.

Note: Error bars represent 90 percent confidence intervals.

ized differences in rates of bachelor's degree attainment and the propensity of local college students to study engineering. Figure 3.6 presents ratios of ratios for each of the three regions: the proportion of black college graduates with an engineering degree divided by the proportion of all college graduates with an engineering degree in the same region and decade. The relative, conditional proportions displayed here accentuate the early and consistent success of the HBCU6 states in expanding opportunities for black college students to become engineers, and also highlights the lagged response of the southern states that initially lacked a historically black engineering college. As a group, these other southern states eventually caught up in the 1990s, possibly influenced by the benchmark set by the HBCU6 states. The more modest sustained relative gains in engineering-degree attainment among black college students from nonsouthern states are also evident here. While the national push to expand opportunities for black college students to become engineers had nationwide impacts, the timing and amount of expansion varied across regions of the country.

At the end of the period covered, parity had not been attained in engineer-

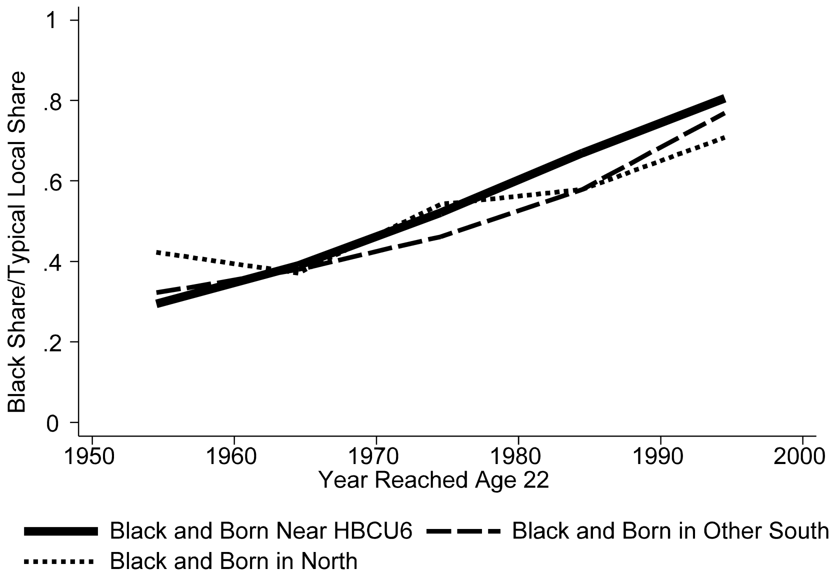

Fig. 3.6 Geographic differences in the relative propensity of black college graduates to major in engineering fields by birth cohort and location of birth

Sample: American Community Survey 2009–2013, restricted to college graduates born in the United States between 1928 and 1977 (age twenty-two in 1950–1999, divided into five ten-year birth cohorts).

Notes: Relative odds computed as the proportion of black college graduates with a degree in an engineering field divided by the proportion of all college graduates in the same region in the same decade with an engineering degree. The "Near HBCU6" category includes those born in North Carolina, Louisiana, Texas, Tennessee, Alabama, and the District of Columbia.

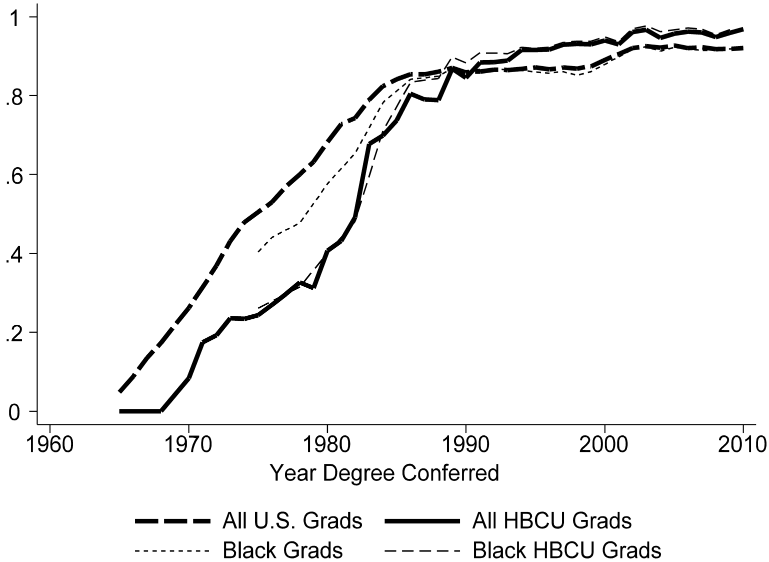

Fig. 3.7 Proportion of new graduates with computer or information science majors available at their institution for indicated subsets of graduates

Data source: Administrative records reported by educational institutions to the U.S. Department of Education.

ing in any of the three regions, even among college graduates. The share of black graduates with engineering degrees increased from about 40 percent of the national average to 70 or 80 percent, with the fastest increase attained near the HBCU6 locations.

3.2.2 Access to Computer Science Education

While nationwide efforts to broaden participation in engineering involved both HBCU and other campuses, a corresponding effort in computer sciences focused on HBCU campuses.[28] Between the 1970s and the early 1990s, as the number of historically black campuses with accredited engineering programs expanded from the original six to eleven, the number of HBCU campuses reporting new computer science graduates increased from a handful to more than sixty.

Computer science did not emerge as a popular and available college major choice until the late 1970s. Figure 3.7 describes the spread of opportunities to study computer science across the country as more U.S. campuses began to offer this major. In 1965, very few students of any race had opportunities to major in computer science. By the mid-1970s only half of all U.S. college

28. A conversation with John Brooks Slaughter (2012), who headed NSF at the time, confirmed that this change was driven by the administrations of the colleges and universities themselves, and was not a "top-down" effort.

students, and 40 percent of black college students, graduated from a campus where a computer science major was offered; among those black students at HBCU campuses, only a quarter had access to a computer science course of study at that time. These racial gaps persisted until the mid-1980s, when very rapid changes at HBCU campuses completely eliminated this differential. In 1980, new HBCU college graduates were only 60 percent as likely as new U.S. graduates to have classmates with a computer science major, by 1990 new HBCU graduates were just as likely as the typical new U.S. graduate to have classmates who were computer science majors. The introduction of computer science programs to additional HBCU campuses entirely accounts for the disappearance of the gap in access to computer science courses.

This increase in access quickly translated into increased attainment of computer science degrees among black college graduates (figure 3.8). In contrast to the situation in engineering (figure 3.4), policies at HBCU campuses during the mid-1980s promulgated the choice of computer and information science majors among black college students relative to all U.S. students and also relative to black college students at other U.S. campuses. This figure

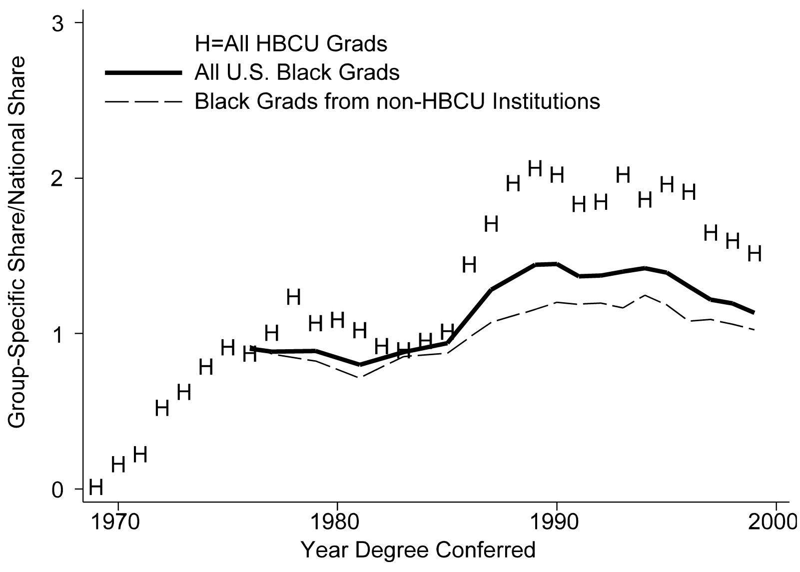

Fig. 3.8 Relative share of new graduates with computer or information science majors based on counts of bachelor's degrees conferred in each year for indicated subsets of institutions or students

Data source: Administrative records reported by educational institutions to the U.S. Department of Education.

Note: Relative shares are computed for each year as the proportion of graduates within indicated groups who majored in a computer or information science field divided by the proportion of all U.S. college graduates with a computer or information science major in the same year.

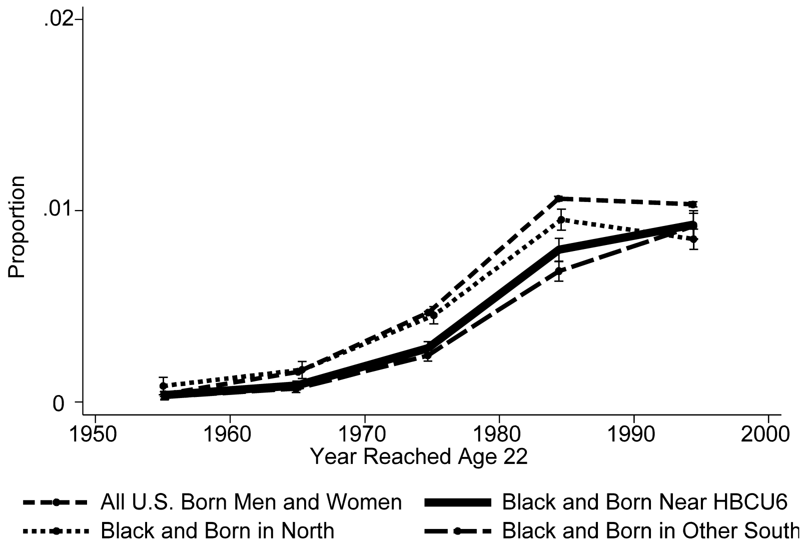

Fig. 3.9 Geographic differences in the propensity of black cohorts to graduate college with a computer science major by birth cohort and location of birth

Sample: American Community Survey 2009–2013, restricted to those born in the United States between 1928 and 1977 (age twenty-two in 1950–1999, divided into five ten-year birth cohorts), lower three curves restricted to those indicating black or African American heritage and birth in the indicated region of the country. The "Near HBCU6" category includes those born in North Carolina, Louisiana, Texas, Tennessee, Alabama, and the District of Columbia.

Note: Error bars represent 90 percent confidence intervals.

shows very rapid growth during the 1970s in the share of HBCU graduates with computer science majors. While there are no corresponding data on black computer science graduates at other campuses until the late 1970s, the information that does exist suggests that early HBCU policies played an important role in preventing a large racial gap in the propensity to study computer science from ever emerging. By the mid-1970s, new HBCU graduates were as likely as all U.S. graduates to hold a computer science degree. By the late 1980s, the same was true of new black graduates from other U.S. institutions, and HBCU graduates were majoring in computer science at a rate twice as high as the national average.

The result is that, in contrast to the large racial differential in engineering (see figure 3.5), the differential in computer and information sciences is quite small as observed in the ACS 2009–2013 data (see figure 3.9). Black cohorts of all ages are nearly as likely to hold computer science degrees as the U.S. average, in contrast to the large and persistent racial gaps in engineering attainment. Even as a share of the full population reaching age twenty-two in the 1990s regardless of education, African Americans were 74 percent as likely to attain a computer science degree, and 86 percent as likely to attain a degree in a more broadly defined set of computer and information systems majors, compared to being 45 percent as likely to attain a degree in engineering. Figure 3.9 also shows that, compared to engineering, the remaining gap is small in both southern and other states.

As figure 3.8 already made clear, the remaining racial gap in computer science degree attainment is entirely due to differences in the propensity to attain a college degree. Among all college graduates who reached age twenty-two in the 1970s, 1980s, or 1990s, African Americans were *more likely* than others to major in computer science fields. In sum, the localized effort centered at HBCU campuses to expand computer sciences led to strong participation of black college students in computer science from the outset of the field far in excess of their relative participation in engineering. But, did the increase in computer science and engineering majors lead to a net increase in the total number of STEM majors, or did it represent the transfer of students from one STEM field to another? Figure 3.10 shows the relative shares of new black graduates with majors in engineering, computer science, and also in either of these two majors *or* math or other sciences. The slopes indicate similar rates of change for engineering, com-

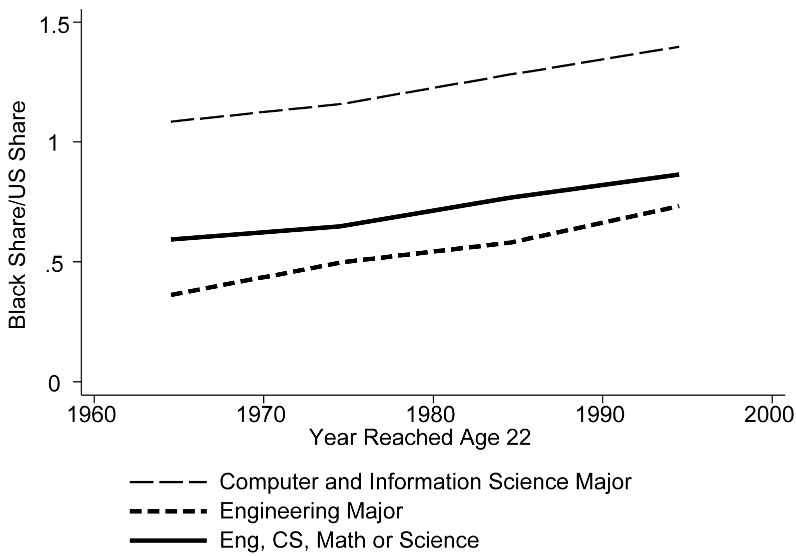

Fig. 3.10 Nationwide trends in the relative odds that a black graduate has a computer science, engineering, math, or other science major compared to the typical likelihood among U.S. college graduates

Sample: American Community Survey 2009–2013, restricted to those born in the United States between 1938 and 1977 (age twenty-two in 1960–1999, divided into four ten-year birth cohorts).

Note: Relative odds computed as the share of black cohort members with indicated major divided by the share of all U.S. cohort members with the same major.

puter science, and the all-STEM category. There was no trend in the "math and other sciences" category alone, which was 74 percent in both the 1960s and 1990s (not depicted).[29] Overall, relative STEM participation grew from 59 percent to 86 percent over this period. The overrepresentation of black students in computer science majors, particularly on HBCU campuses, can be credited with pulling the STEM average closer to parity among college graduates, despite persistent underrepresentation in engineering and other STEM fields.

3.2.3 The Entry of Black Women to Engineering and Computer Science

Gender was an afterthought in national efforts to expand minority involvement in engineering careers. The "Blueprint for Action" barely mentions women at all. Initially, the expansion of opportunities just described largely affected men.[30] However, there was a rapid expansion of opportunities for black women to study engineering during the late 1970s and early 1980s. During the early 1960s the six original HBCU engineering campuses graduated a total of about two women per year between them, rising to four or five by the end of the 1960s. By 1980, more than one hundred women per year were completing degrees at the HBCU6 campuses, and most of these women were black. Within other campuses, there is no way to estimate the number of black women engineering graduates at the institution level in earlier years, though the number was almost certainly small.[31] Due to the absence of data for earlier years, only the share of all engineering graduates who were women (regardless of race), or the share of all engineering graduates who were black (regardless of gender), can be computed consistently at the institution level over a longer interval.

To the extent possible, given data limitations, it is important to understand the extent to which access to engineering education expanded for black women as well as men. Figure 3.11 displays the time trends in the proportion of new engineering graduates who were women among all engineering graduates in the United States, and among HBCU graduates. In each year, the historically black engineering colleges graduated a higher share of women than the typical U.S. engineering college. In 1970 the difference was relatively small, and very few women studied engineering at that time. During the 1970s and 1980s, the share of all U.S. engineering graduates who were

29. There was a transitory dip to 65 percent in between, due to increase in the reference group rather than decrease among black graduates.

30. For a historical perspective on women's entry to engineering, see Bix (1999, 2004, 2013). Biographies of Julia Morgan, whose architecture survived severe California earthquakes due to her early training as a civil engineer, offer some insight into the educational environment during an earlier era.

31. Separate counts for black women engineering graduates were not collected until the 1981–1982 academic year, although some earlier years counted the combined total of black women in either engineering or engineering technology fields, placing an upper bound on the number in engineering.

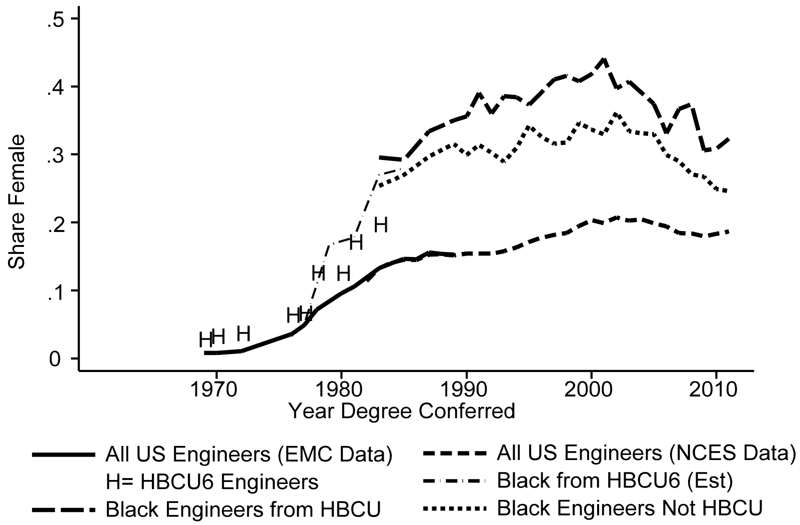

Fig. 3.11 Share female among new engineering graduates, 1969–2011, all U.S. and selected subgroups

Data source: Administrative records reported by educational institutions to the U.S. Department of Education or the Engineering Manpower Commission.

women increased rapidly, flattening out in the late 1980s. However, at the historically black engineering colleges, the share of engineering graduates who were women grew much more rapidly than the national average, and did not flatten out until surpassing the national average by a factor of two. For the later years, estimates of the relatively high share of black engineering graduates who are female are also displayed; by the first time detailed statistics were collected, more than a quarter of black engineering students were women. These indicate high national ratios of women to men among black engineering graduates on average as well as at HBCU campuses.

As the EMC data covering the 1970s do not break down statistics by both race and gender, we cannot determine the full picture for these years. However, an estimate based on all black students in either engineering or engineering technology fields at the HBCU6 campuses shows rapid change. Patchy evidence from the NSCG reveals that, among black engineering graduates who completed bachelor's degrees between 1960 and 1974, only 6 percent of new engineering graduates who attended college in the South (n = 39), and none of those who attended college outside the South (n = 39), were women. By the 1975 to 1979 graduation window, the share female among black engineering graduates had risen to 13 percent (n = 26) in the South, and 3 percent outside the South (n = 27), and by 1980 to 1984 to 27 percent (n = 59) in the South and 33 percent outside the South (n = 57). Going back further, early U.S. Office of Education statistics on the number of women graduating from HBCU6 engineering programs show zero recorded between 1952 and 1956, and an average of two per year (0.33 per campus per year) between 1957 and 1959. Taken together, these statistics indicate that the high ratio of women to men among black engineering graduates observed in the 1980s and later is not the continuation of an older pattern, but likely the result of new policies that dramatically expanded opportunities for black women to study engineering at both HBCU and other campuses.

As in engineering, the representation of women among computer and information science graduates is higher among black graduates, and among HBCU graduates, than in the full population. Unlike engineering, data broken down by race and gender are available beginning with the 1975–1976 academic year, and the strong relative participation of black women, especially at HBCU campuses, seems to have begun many years before large numbers of black women were pulled into engineering. Over the most recent decade, the share of computer and information science degrees going to women of all races has trended downward. Nonetheless, in each of the past four decades black women have been a strong presence among computer and information science graduates. The contrast between figure 3.11, showing the transition toward increasing entry of black women to engineering, and figure 3.12, showing the strong participation of women educated at historically black colleges from near the inception of the computer science

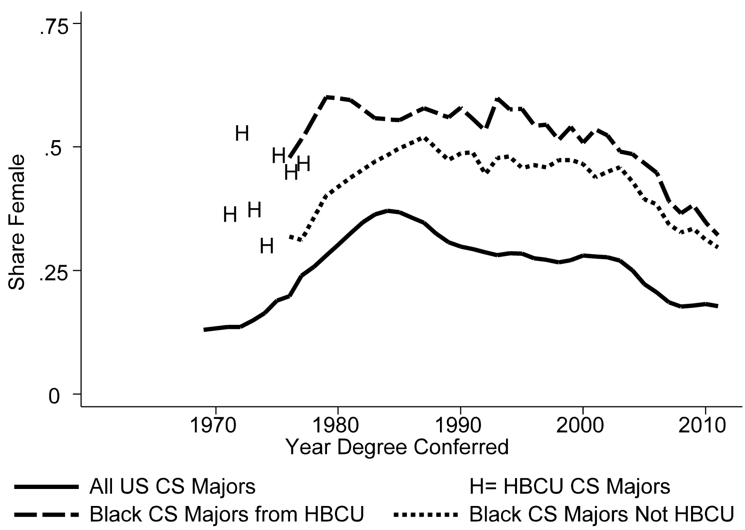

Fig. 3.12 Share female among new computer and information science graduates, U.S. and selected subgroups

Data source: Administrative records reported by educational institutions to the U.S. Department of Education.

field, is striking. In both cases, inclusion of women in engineering and computer science majors is clearly an important factor in the changes that occurred at HBCU campuses during this period.

3.3 Labor Market Outcomes

Recall that the initial motivation for policies to bring black students into engineering and computer science majors was to prepare them for careers not only in these technical fields, but also as future industrial leaders. As Royster's (2003) study of early career experiences among equally well-trained graduates of a public vocational high school shows, the link from expanded educational opportunity to career cannot be taken for granted, even in the post-civil-rights era. The evidence presented in the following section shows that, on average, black workers who graduated college with majors in engineering and computer sciences during the 1970s, 1980s, or 1990s are working in well-paid technical or managerial occupations in today's labor market.

A long literature documents correlations between high school math scores, entry into engineering or computer science college majors, and adult earnings (Fiorito and Dauffenbach 1982; Blakemore and Low 1984; Paglin and Rufolo 1990; Benbow and Arjmand 1990; Murnane, Willet, and Levy 1995; Grogger and Eide 1995; Brown and Corcoran 1997; Weinberger 1998, 1999, 2001; Turner and Bowen 1999; Xie and Shauman 2003; Weinberger and Joy 2007). This body of literature shows clearly that although the relationships vary by race and gender, within all groups of students those with higher math scores as adolescents are more likely to earn a college degree or to select mathematical college majors, and tend to earn more as adults.

Table 3.1 demonstrates a strong relationship between college major and current employment in engineering or computer science occupations using 2009–2013 ACS data on employed college graduates holding a bachelor's degree or higher. It shows that a large share of those with engineering and computer science majors are employed in engineering and computer science occupations, while those with other majors are less likely to work in engineering and computer science occupations. If we allow that individuals promoted to management still use their engineering or computer science education, the majority of those with engineering and computer science majors appear to be in occupations fitting their education. This pattern holds for men and women, and for those likely to have been educated in the 1970s, 1980s, and 1990s, and for black graduates as well. There are, however, systematic differences between black graduates and U.S. averages in the table, with black engineering or computer science graduates having moderately smaller likelihoods of being employed in engineering, computer science, or management careers. Because these jobs are so highly correlated with college major, there are surely more black engineers and computer

Table 3.1 **Percentage of indicated groups of employed college graduates reporting engineering or computer and information science occupation in 2009–2013**

	(1) Men age 22 in 1970–1979, observed 2009–2013	(2) Men age 22 in 1980–1989, observed 2009–2013	(3) Men age 22 in 1990–1999, observed 2009–2013	(4) Women age 22 in 1970–1979, observed 2009–2013	(5) Women age 22 in 1980–1989, observed 2009–2013	(6) Women age 22 in 1990–1999, observed 2009–2013
Engineering majors in eng. or CS occupations	44	47	49	32	37	39
Computer majors in eng. or CS occupations	53	55	60	38	39	39
Math & statistics majors in eng. or CS occupations	26	31	27	16	19	15
Biological & physical sciences majors in eng. or CS occupations	9	10	9	4	4	3
Other majors in eng. or CS occupations	5	6	7	2	2	2
Engineering majors in eng. or CS or managerial occupations	67	71	70	51	59	59
Computer majors in eng. or CS or managerial occupations	67	70	72	51	54	52
Black engineering majors in eng. or CS occupations	44	40	43	32	29	32
Black computer majors in eng. or CS occupations	40	45	51	32	30	39
Black math & statistics majors in eng. or CS occupations	21	27	16	13	20	14
Black biological & physical sciences majors in eng. or CS occupations	6	8	7	3	3	3
Other black majors in eng. or CS occupations	4	5	5	2	2	2
Black engineering majors in eng. or CS or managerial occupations	61	60	62	50	55	53
Black computer majors in eng. or CS or managerial occupations	51	57	60	43	45	50

professionals today than there would have been in the absence of policies to expand educational opportunities in these fields.

What about earnings premiums for black graduates in these fields? It seems likely that the same policies that increased the number of black students entering these majors might have led to changes in the associated earnings, growing over time if factors such as the quality of instruction, precollege preparation, or professional networks of successive graduating classes improved over time, or declining over time if the number of new black engineering graduates grew more quickly than the number of less discriminatory employers. While other between-cohort changes besides those pertaining to engineering or computer science education almost certainly affected the relative earnings of black workers in different age groups, I focus solely on the relation of earnings to college majors.[32]

Table 3.2 presents earnings regressions for the entire current U.S. workforce that estimate log earnings differentials for engineering, computer science, and other science or mathematics majors compared to the omitted group of high school graduates. These regressions do not include measures of occupation, so the estimated earnings boost associated with college major includes the effects of major on the set of attainable occupations, as depicted in table 3.1, and differences in earnings within occupations as well as between them. Column (1) combines men and women of all three birth cohorts, columns (2)–(4) describe the oldest, middle, and youngest cohorts of men, and columns (5)–(7) describe the three cohorts of women. The regressions show consistently high earnings for engineering, computer science, and other science majors, both relative to high school graduates born in the same state and year, and relative to other college graduates. Across all three age groups, both men and women with nonscience bachelor's degrees earn 0.5–0.6 log points more, on average, than the typical high school graduate the same age and from the same birth state. Among men who majored in engineering, there is an additional 0.2–0.3 log points earnings premium, for a total premium near 0.8 log points relative to high school graduates (columns [2]–[4]).

32. Chay, Guryan, and Mazumder (2009, 2014) present evidence that improved access to healthcare during infancy and early childhood was associated with improved health and rising test scores—especially at the upper tail of the math score distribution—among black students in the south. This shift primarily affected the latest cohort in our analysis, those who turned twenty-two during the 1990s or later. Other policy changes during this era, including school desegregation orders, improved K–12 education in southern states, and government programs to improve health, nutrition, and access to preschool education have been linked to positive impacts on health, educational attainment, and earnings among later cohorts (Card and Krueger 1992, 1996; Chay and Greenstone 2000; Garces, Thomas, and Currie 2002; Currie and Moretti 2008; Johnson 2010, 2011; Almond, Hoynes, and Schanzenbach 2011; Hoynes, Schanzenbach, and Almond 2016). The later cohorts also enjoyed increased access to courses in Algebra II during high school (Weinberger 2014). Despite these positive changes for cohorts who would reach adulthood in the 1980s and later, labor market opportunities for young black workers completing school improved only from the mid-1960s through the late 1970s, and then declined, particularly among college graduates (Bound and Freeman 1992).

Table 3.2 Log annual earnings premiums to indicated educational attainment categories, all U.S. full-time, full-year workers, by birth cohort and sex

	(1) All U.S. age 22 in 1970–1999, observed 2009–2013	(2) Men age 22 in 1970–1979, observed 2009–2013	(3) Men age 22 in 1980–1989, observed 2009–2013	(4) Men age 22 in 1990–1999, observed 2009–2013	(5) Women age 22 in 1970–1979, observed 2009–2013	(6) Women age 22 in 1980–1989, observed 2009–2013	(7) Women age 22 in 1990–1999, observed 2009–2013
Categories of college graduate:							
Engineering major	0.821	0.785	0.818	0.775	0.898	1.001	0.993
	(0.003)***	(0.006)***	(0.005)***	(0.005)***	(0.026)***	(0.014)***	(0.013)***
Computer major	0.714	0.613	0.710	0.683	0.735	0.823	0.779
	(0.004)***	(0.011)***	(0.007)***	(0.007)***	(0.024)***	(0.011)***	(0.015)***
Other science or math	0.741	0.724	0.746	0.686	0.736	0.793	0.777
	(0.003)***	(0.007)***	(0.007)***	(0.007)***	(0.009)***	(0.009)***	(0.008)***
Other major	0.550	0.500	0.566	0.543	0.521	0.580	0.579
	(0.001)***	(0.004)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***	(0.003)***
Higher degree	0.235	0.260	0.243	0.234	0.244	0.220	0.214
	(0.002)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***	(0.004)***
Some college	0.207	0.188	0.206	0.200	0.229	0.226	0.202
	(0.001)***	(0.003)***	(0.002)***	(0.003)***	(0.003)***	(0.002)***	(0.003)***
Less than HS	−0.215	−0.191	−0.218	−0.197	−0.239	−0.250	−0.229
	(0.002)***	(0.005)***	(0.005)***	(0.006)***	(0.006)***	(0.006)***	(0.007)***
Female	−0.325						
	(0.001)***						
Black male	−0.223	−0.232	−0.247	−0.215			
	(0.002)***	(0.004)***	(0.004)***	(0.004)***			
Black female	−0.100				−0.081	−0.095	−0.091
	(0.002)***				(0.004)***	(0.003)***	(0.003)***
Observations	2,708,875	448,416	574,087	474,051	378,723	472,681	360,917
R^2	0.29	0.23	0.26	0.25	0.24	0.26	0.28

Notes: Dependent variable: natural log of annual income, inflation-adjusted to 2010 dollars; sample: U.S.-born full-time, full-year workers from the 2009–2013 American Community Survey, with annual income observed and greater than $2,000; additional controls: fixed effects for year-specific birth cohort × state of birth (or D.C.), for a total of 510 categories per regression.

All estimates reported are national averages relative to the typical high school graduate from the same birth cohort and same birth state, with the exception of "higher degree," which is an average additional premium relative to the typical college graduate with the same undergraduate college major.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Among women who majored in engineering, the additional premium above the earnings of nonscience college graduates is even higher, closer to 0.4 log points above the earnings of women the same age and same state of birth with nonscience college majors, for a total premium more than double the earnings of high school graduates (columns [5]–[7]). The earnings of computer science and other science majors (including physical sciences, biological sciences, mathematics, and statistics) are not quite as high as those of engineering majors, but tend to be substantially higher than the earnings of nonscience college majors.

Table 3.2 also includes estimates of gender and racial wage differentials. The regression of column (1) indicates that when all three cohorts are combined, women earn 0.3 log points less than men on average. Black women face an additional 0.1 log point disadvantage, for a total disadvantage of 0.4 log points. Black men face a somewhat smaller but still substantial 0.2 log point disadvantage. These differentials are large, and are similar across cohorts, fluctuating with no apparent trend. However, these average differentials cannot tell us how each new cohort of black engineers and computer scientists fared, relative to other black college graduates or black high school graduates born in the same state and year.

Tables 3.3 and 3.4 show regressions that are comparable to those in table 3.2, with the samples restricted to black men and women, and showing separate specifications for those born in southern versus other U.S. states. This division is motivated by the concentration of HBCU campuses in the southern states, and the faster pace of change in the number of black engineering and computer science graduates in southern states during this time. Table 3.3 gives estimated earnings differentials for men, while table 3.4 gives the differentials for women. In both tables column (1) relates to the oldest group in the ACS sample—those educated in the 1970s; column (2) relates to the group educated in the 1980s, while column (3) relates to the youngest group—those educated in the 1990s.

The estimates in column (1) of tables 3.3 and 3.4 are for black men and women likely to have been educated in the North during the 1970s. In these groups, the earnings premiums to engineering or computer science degrees are low compared to the U.S. averages shown in table 3.2. We lack data to assess whether these groups received lower-quality education or simply faced higher barriers to obtaining early career employment commensurate with their education. Insights from previous research include the observation that black graduates of HBCU campuses earned more than graduates of other institutions among those educated in the 1970s (Constantine 1995), but are not as well compensated among those educated more recently (Fryer and Greenstone 2010). One hypothesis is that other institutions became better at educating black students over time (Fryer and Greenstone 2010). Another possible explanation is that employers inclined to hire black graduates searched primarily at HBCU campuses during the 1970s but no

Table 3.3 **Log annual earnings premiums to indicated educational attainment categories, black male full-time, full-year workers, by birth cohort and birth region**

	Born in northern states			Born in southern states		
	(1) Black men age 22 in 1970–1979, observed 2009–2013	(2) Black men age 22 in 1980–1989, observed 2009–2013	(3) Black men age 22 in 1990–1999, observed 2009–2013	(4) Black men age 22 in 1970–1979, observed 2009–2013	(5) Black men age 22 in 1980–1989, observed 2009–2013	(6) Black men age 22 in 1990–1999, observed 2009–2013
Categories of college graduate:						
Engineering major	0.601	0.880	0.820	0.847	0.747	0.827
	(0.096)***	(0.040)***	(0.033)***	(0.048)***	(0.043)***	(0.038)***
Computer major	0.496	0.701	0.644	0.694	0.778	0.706
	(0.087)***	(0.048)***	(0.039)***	(0.053)***	(0.036)***	(0.034)***
Other science or math	0.672	0.727	0.801	0.698	0.787	0.661
	(0.057)***	(0.064)***	(0.057)***	(0.049)***	(0.050)***	(0.045)***
Other major	0.462	0.499	0.491	0.459	0.512	0.480
	(0.027)***	(0.018)***	(0.016)***	(0.017)***	(0.016)***	(0.014)***
Higher degree	0.327	0.243	0.277	0.247	0.223	0.232
	(0.032)***	(0.025)***	(0.023)***	(0.024)***	(0.023)***	(0.021)***
Some college	0.213	0.201	0.202	0.197	0.233	0.217
	(0.018)***	(0.013)***	(0.013)***	(0.011)***	(0.010)***	(0.010)***
Less than HS	−0.172	−0.242	−0.232	−0.167	−0.221	−0.197
	(0.032)***	(0.026)***	(0.026)***	(0.015)***	(0.016)***	(0.019)***
Observations	9,635	17,692	17,432	22,215	28,223	22,299
R^2	0.21	0.20	0.22	0.18	0.19	0.21

Notes: Dependent variable: natural log of annual income, inflation-adjusted to 2010 dollars; sample: U.S.-born full-time, full-year workers from the 2009–2013 American Community Survey, with annual income observed and greater than $2,000, restricted to men who identified themselves as black or African American; additional controls: fixed effects for year-specific birth cohort × state of birth (or D.C.). All estimates reported are averages relative to the typical black male school high graduate from the same birth cohort and same birth state, with the exception of "higher degree," which is an average additional premium relative to the typical black male college graduate with the same undergraduate college major.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 3.4 **Log annual earnings premiums to indicated educational attainment categories, black female full-time, full-year workers, by birth cohort and birth region**

	Born in northern states			Born in southern states		
	(1) Black women age 22 in 1970–1979, observed 2009–2013	(2) Black women age 22 in 1980–1989, observed 2009–2013	(3) Black women age 22 in 1990–1999, observed 2009–2013	(4) Black women age 22 in 1970–1979, observed 2009–2013	(5) Black women age 22 in 1980–1989, observed 2009–2013	(6) Black women age 22 in 1990–1999, observed 2009–2013
Categories of college graduate:						
Engineering major	0.570	0.932	0.860	1.195	1.041	0.955
	(0.188)***	(0.061)***	(0.044)***	(0.083)***	(0.069)***	(0.049)***
Computer major	0.433	0.706	0.635	0.640	0.766	0.812
	(0.191)**	(0.037)***	(0.046)***	(0.064)***	(0.038)***	(0.039)***
Other science or math	0.639	0.775	0.777	0.875	0.765	0.769
	(0.057)***	(0.049)***	(0.048)***	(0.050)***	(0.050)***	(0.034)***
Other major	0.513	0.531	0.469	0.545	0.589	0.546
	(0.020)***	(0.014)***	(0.014)***	(0.013)***	(0.011)***	(0.011)***
Higher degree	0.239	0.241	0.242	0.234	0.219	0.201
	(0.023)***	(0.017)***	(0.014)***	(0.016)***	(0.015)***	(0.013)***
Some college	0.182	0.204	0.162	0.238	0.253	0.195
	(0.015)***	(0.012)***	(0.013)***	(0.009)***	(0.008)***	(0.010)***
Less than HS	−0.217	−0.216	−0.188	−0.200	−0.235	−0.229
	(0.033)***	(0.025)***	(0.028)***	(0.015)***	(0.015)***	(0.020)***
Observations	12,420	21,539	21,405	28,477	35,894	28,379
R^2	0.24	0.23	0.24	0.25	0.26	0.28

Notes: Dependent variable: natural log of annual income, inflation-adjusted to 2010 dollars; sample: U.S.-born full-time, full-year workers from the 2009–2013 American Community Survey, with annual income observed and greater than $2,000, restricted to women who identified themselves as black or African American; additional controls: fixed effects for year-specific birth cohort × state of birth (or D.C.). All estimates reported are averages relative to the typical black female high school graduate from the same birth cohort and same birth state, with the exception of "higher degree," which is an average additional premium relative to the typical black female college graduate with the same undergraduate college major.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

longer do so. Consistent with this possibility, Freeman (1976a) reported a dramatic increase in the number of recruiters sent to the thirty black campuses in his study, from an average of four per school in 1960 to more than 300 in 1970. Contemporaneous advice to corporate recruiters recommended that it is better to go directly to HBCU campuses, rather than risk stirring up tensions by recruiting minority students at a recently integrated campus (Lusterman 1979). If the recruiters with the most inclination to hire black graduates tended to avoid northern campuses, the group of graduates educated in the North during the 1970s might have had less favorable early work experience.

In contrast, the coefficients in columns (2)–(6) of table 3.3 show earnings premiums to engineering, computer information science, and other science majors that are comparable in magnitude to the corresponding premiums for all US persons in table 3.2. In most cases, relative to high school graduates, earnings premiums for engineering range from 0.75 to 1.0, compared to 0.78 to 1.0 for all U.S. men and women, and premiums to computer science and other sciences range from 0.6 to 0.9, compared to 0.6 to 0.8 for all U.S. men and women.[33] These estimates are quite close despite the somewhat lower match rate to engineering and computer science occupations. There is no evidence that the labor market value of an engineering or computer science degree declined as larger shares of newer cohorts of the black population entered these fields. It is noteworthy that the engineering and computer science coefficients in columns (4) and (5) of both tables 3.3 and 3.4 (southern cohorts entering the labor market in the 1970s vs. the 1980s) are relatively stable. These estimates span the largest increase in numbers of black college graduates with majors in engineering or computer science, and involve cohorts that predate any changes in the national distribution of math test scores among high school seniors.[34]

Overall, the data suggest that despite rapid changes in educational opportunities throughout the 1970s, 1980s, and 1990s, the current labor market places a high average value on black graduates who earned degrees in engineering or computer science fields during that time, relative to those who chose other educational paths.[35]

33. The estimated engineering premium to the oldest group of nineteen southern women is higher than the estimates for later cohorts, but is not statistically different from the estimate for the adjacent cohort.

34. See the NCES (1994) publication "NAEP Trends in Academic Progress" for evidence on the timing of these trends. Goodman (2017) documents increases in high school mathematics course taking that most likely affected cohorts graduating college in the 1990s and later.

35. Previous research found that, among younger college graduates, the earnings premium to engineering and computer science majors is larger for black than for white students, partially mitigating the overall racial gap in earnings (Freeman 1976a; Weinberger and Joy 2007). This does not appear to be the case in this older sample.

3.4 Conclusion

Nationwide, the racial differential in the propensity to become an engineer has narrowed continuously since the 1970s but with different rates and timing across states. Six historically black engineering programs played an important early role in facilitating change. The research in this chapter shows that when the nation decided to invest in expanded opportunities for black students to become engineers, the six HBCU engineering campuses responded more quickly than most other campuses. A few years later, a broader coalition of HBCU campuses dramatically expanded opportunities to study computer and information sciences near the inception of the field, effectively preventing a large gap in the national number of black computer science graduates from ever becoming the status quo. As a unique component of the U.S. educational infrastructure, HBCU campuses continue to play an important role in our economy, providing a conduit to broaden participation in engineering, computer science, and other technical careers. The graduates of these and other campuses fill valued roles in our current engineering and computer science workforce, and tend to earn substantially more than college graduates with other majors.

It is sometimes difficult to discern whether a targeted minority engineering program actually increases participation or simply reshuffles capable students from one program to another. My analysis suggests that expansion of engineering programs at six HBCU campuses led to localized impacts on the entry of black students to engineering careers. The timing of responses to this "natural experiment" indicates that the geographic distribution of educational opportunities can influence important outcomes. The larger lesson of this inquiry is that educational policies can influence the future career paths of students and the supply of our educated workforce.

Data Appendix

American Community Survey (ACS)

All regressions, figures 3.1, 3.5–3.7, 3.9, and 3.10, and statistics for birth cohorts described by the year of reaching age twenty-two are based on data from the 2009–2013 American Community Survey, collected by the U.S. Bureau of Labor Statistics and provided as part of the IPUMS Project (Ruggles et al. 2010). The sample is restricted to individuals at least thirty-one years old because this group is likely to have completed their education. Because the focus is on the U.S. educational system, individuals born in other countries are not included in the sample. Individual college graduates are coded as holding a degree with an engineering or computer science major based on either the first or second bachelor's degree major indicated. A narrow computer science category is limited to the exact "computer science" designation. A broad computer science category including all majors under the subheading "computer and information systems" plus the interdisciplinary major "math and computer science" was used throughout the chapter, and the engineering designation was similarly inclusive. "Black" is defined as indicating black or African American heritage. The "college graduate" category includes all bachelor's degree graduates, including those who also hold higher degrees.

In the earnings regressions, college major categories are mutually exclusive; the engineering category includes everyone with first or second major listed as engineering; computer science includes those with first or second major listed in a computer or information systems field, but no engineering major listed; and other science or math includes those with first or second major in physical sciences, biological sciences, mathematics or statistics, but no engineering or computer major listed. All remaining college graduates, and all graduates with college major "allocated" by the BLS, are coded to the "other major" category in the earnings regressions. In the figures, allocated majors are treated at face value.

All estimates are weighted by the person-specific weight.

U.S. Department of Education National Center for Education Statistics (NCES)

Institution-level counts of the number of bachelor's degrees conferred by each institution, by gender and academic field of study, were collected by the U.S. Department of Education under the HEGIS program in earlier years, and IPEDS beginning in 1982–1983. These data are currently maintained by the National Center for Education Statistics (NCES). These counts represent a (nearly) complete census of all bachelor's degrees conferred in the United States each year. Statistics broken down by race were collected in 1975–1976, then every other year between 1976–1977 and 1988–1989, and every year since that time. The disadvantage of this data source is that, in the earlier years, the counts by race combine engineers with bachelor's degree graduates who majored in engineering technologies. Therefore, an additional source is used to fill in more detailed information about black engineering graduates before 1983.

For the decade before any racial counts were systematically collected, the total number of engineering degrees conferred by HBCU campuses is used as an estimate of the number of black graduates from those campuses. This number also serves as an upper-bound estimate of the number of black engineering graduates from all remaining U.S. campuses, based on estimates presented in the chapter and elsewhere that HBCU campuses produced at least half of all black engineering graduates at the time.

Information about institutional characteristics was also collected. Where possible, these were aggregated to create a set of time-invariant indicators.

In the original surveys, the level of aggregation across components of a given institution was not uniform over time. To facilitate within-institution (or within-state) comparisons over time, time-consistent institution groupings were constructed. A particular institution grouping might include all campuses of a larger system (if that system ever reported statistics for all campuses combined), or might include two institutions that merged together at some point in time, or a pair of institutions that later split into smaller units for reporting statistics. Graphs depicting time trends within a group of institutions, or within a set of states, include a constant, completely comparable set of institution groupings in each year's estimate.

Care was also taken to maintain comparable definitions of "engineering majors" and "computer science majors" over time. Engineering does not include engineering technology degrees, but is otherwise inclusive of different fields of engineering. In cases where a subfield was categorized as engineering technology in some years and engineering in other years, the most time-consistent assignment was chosen.

Engineering Manpower Commission (EMC)

Beginning in the late 1960s, the Engineering Manpower Commission (EMC) collected similar institution-level counts of the number of bachelor's-level engineering graduates, with more detailed information about field of degrees in engineering or engineering technologies. These surveys include earlier counts by race than the NCES data, but the racial counts are not disaggregated by sex. The advantage of this data source in the early years is that black engineers are counted separately from black bachelor's degree graduates with majors in engineering technologies.

These data were not available in electronic form. They were collected from published volumes and matched to the NCES institution groupings by institution name (Tolliver and Armsby 1959; Tolliver, Armsby, and United States 1961, 1963; Engineering Manpower Commission 1972, 1975, 1977, 1978, 1980, 1981, 1984, 1987, 1988, 1989).

NSF National Surveys of College Graduates (NSCG)

Statistics conditioned on the actual year of college graduation are constructed from the 1993 and 2003 NSF National Surveys of College Graduates. These are representative samples of college graduates drawn from 1990 and 2000 census respondents. The 1993 and 2003 surveys of individuals who indicated in the preceding census that they were college graduates collected retrospective information about all college degrees, including field of degree and graduation dates. For my analysis, this sample is restricted to individuals born in the United States.

Project Talent

This survey of 5 percent of all 1960 U.S. high school students did not even ask students their race during the base year survey. However, the subset of original participants who were resurveyed either five or eleven years after high school graduation were asked about race and educational attainments. This sample contains fourteen black engineering graduates, first observed as high school juniors or seniors in 1960.

Current Population Surveys (CPS)

Statistics on the number of new black engineering graduates have been collected since the late 1960s, but counts of the number of new black college graduates do not begin until nearly a decade later. Estimates of the number of bachelor's degrees earned by black students in earlier years are computed based on a combination of data from different sources, including the total number of degrees conferred each year (from NCES) and estimates of the share of college graduates in the corresponding birth cohort who are black (separate estimates made from CPS data and from NSCG data are averaged).

National Science Foundation (NSF)

Additional statistics on the number of men and women graduating with degrees in engineering or computer science in the early years were drawn from National Science Foundation publications in the Surveys of Science Resources Series (National Science Foundation 1977, 1982a, 1982b, 1984; Hill 1992).

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