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ABSTRACT

This paper presents evidence on the quality of schooling by race and ethnic origin in the United States. Although substantial racial segregation across schools exists, the average pupil-teacher ratio is approximately the same for black and white students. Hispanic students, however, on average have 10 percent more students per teacher. Relative to whites, blacks and Hispanics are less likely to use computers at school and at work. The implications of these differences in school quality for labor market outcomes are examined. We conclude by examining reasons for the increase in the black-white earnings gap since the mid-1970s.

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The history of race and school quality in the U.S. in the last century has not been one of constant, unyielding progress for black students relative to white students.[1] Broadly speaking, between 1890 and 1910 there was a decline in the quality of schools attended by black students relative to those attended by white students, as judged by expenditures per student, average class-size, and the length of the school term. Between 1915 and 1925 there was moderate progress for black students relative to white students, but the progress stalled between 1925 and the Great Depression. From the mid-1930s to the 1950s the racial gap in school quality declined dramatically. Unfortunately, recent trends in racial differences in school quality are not nearly as well documented or well understood as those in the period from 1880 to 1950.

Ironically, the landmark Brown vs. Board of Education of Topeka, Kansas decision in 1954 greatly curtailed the states' dissemination of data on school quality based on race. Although evidence that we present below suggests that school integration did not begin on a wide scale until after 1964, the Brown ruling, which declared segregation in schools unconstitutional, provided the states with a powerful incentive to suppress information that might hasten legal action against them. After 1954, only a few states continued to collect and publish data on the quantity of resources devoted to schools attended primarily by black students and those attended primarily by white students. For a short time, this void was filled by a privately funded organization known as the Southern Education Reporting Service (SERS). But the SERS stopped collecting data in 1966. Moreover, in the 1980s the Department of Education reduced its production of data on school quality by

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[1] See Smith (1984), Margo (1990), and Card and Krueger (1992a). This view was also shared by contemporary observers; see Jones (1917), Bond (1934), and DuBois and Dill (1911).

race. As a consequence, we lack basic information on school quality measures such as the average pupil-teacher ratio by students' race in recent years.

The gap in our knowledge of race and school quality is distressing because evidence suggests that disparities in school quality that historically existed between black and white students are responsible for a portion of the gap in earnings between black and white workers.[2] Furthermore, as several authors have documented, the relative earnings of black workers have declined since the mid-1970s. Our estimates indicate that the "regression-adjusted" gap in the hourly wage rate between black and white workers increased from 6.8 percent to 12.4 percent between 1976 and 1990 (see Figure 7). This expansion in the black-white wage gap comes on the heels of a period (1940-1970) in which the wage gap narrowed substantially.

Smith and Welch and Juhn, Murphy, and Pierce argue that the slowdown of black-white wage convergence may be due to an increase in the price of skills.[3] Their argument is that, on average, minority workers acquired lower skills from having attended inferior schools. The dramatic upturn in the price of human capital in the 1980s would then contribute to the decline in the relative economic position of black workers.[4] Juhn, Murphy, and Pierce provide some indirect evidence for this view by documenting that the earnings of black workers have tracked the earnings of low-wage white workers rather closely in the 1970s and 1980s. This evidence is only indirect,

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[2]See Smith and Welch (1989), Smith (1984), Card and Krueger (1992a), and Nechyba (1990). For a critical analysis of this literature, see Donohue and Heckman (1991).

[3]See Smith and Welch (1989) and Juhn, Murphy, and Pierce (1991).

[4]It should be stressed that it is not important for this argument that the relative quality of education of minorities be declining.

however, and the authors conclude with the plea: "What is needed is further direct evidence on the size of the schooling quality gap" between black and white workers.[5]

In this paper we provide systematic evidence on racial differences in the pupil-teacher ratio, extent of computer use, and other measures of school quality since the Brown vs. Board of Education decision. We concentrate our analysis mainly on tracking resources available to schools as a measure of school quality, instead of students' achievement on standardized tests. We take this approach because public policy has a direct influence on school resources, and because standardized tests scores are typically found to have, at best, a weak relationship with labor market outcomes, such as income. We use several data sets to investigate racial disparities in school quality since the 1950s. In the next section we present a variety of summary measures of the quality of schools attended by the average black student and the average white student. Because the distribution of school resources among members of different racial groups is affected by the degree to which schools are racially segregated, we begin by presenting evidence on the extent of school segregation over the period 1924-1989. We next examine racial trends in a traditional measure of school quality, namely the pupil-teacher ratio. Finally, we focus on the prevalence of computer training in schools, which is a modern indicator of school quality. Most of our analysis focuses on quantifying these characteristics of schools for black and white students, but we also present estimates for Hispanic students.

Perhaps surprisingly, our exploration suggests that, on average, black and white students currently attend schools with roughly equal pupil-teacher ratios. On the other hand, the pupil-teacher ratio is about 10 percent higher for the average Hispanic student than for the average white student. This gap

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[5]See Juhn, Murphy, and Pierce (1991, p.143).

is primarily a result of the high representation of Hispanic students in California, which has large class sizes compared to the rest of the nation.

In the 1980s, schools have undergone a revolution in terms of the importance attached to computers. Computers typically serve a dual function in schools: first, they are used as a teaching tool for traditional subjects such as reading and arithmetic; second, they are used to instruct students on computer literacy and computer programming. We find that black students are much less likely to use computers in school than white students, even after accounting for family income and other factors. Moreover, the gap in computer usage between black and white students has not tended to narrow in the 1980s. If computers facilitate learning, our findings suggest that minority students are disadvantaged by their lower use of computers.

What implications do these differences in school quality have for the wage gap between black and white workers? In Section II we examine evidence on the implications of differences in school quality for the labor market performance of various racial groups. We find that black students who attended racially isolated high schools tend to obtain lower paying jobs, and jobs that are more racially isolated. We also find that students who use computers in school are more likely to obtain jobs that require the use of computers. Also, some evidence is presented suggesting that employees who possess computer skills are more highly paid. These results suggest that the shortage of computer training in schools attended by black students may put black workers at a disadvantage in the labor market.

In Section III we review evidence on trends in the black-white earnings gap since the early 1970s. In light of our analysis of trends in school quality, we doubt that school quality is the main explanation for the decline in the relative economic position of black Americans since the mid-1970s. The reason for this conclusion is that the black-white wage gap has expanded most dramatically for cohorts of workers that were educated in the post-Brown era.

For example, between 1980 and 1990, the black-white wage gap expanded from 20 percent to 37 percent for men born 1950-59, but hardly changed for men born 1930-39. Because the racial gap in school quality and educational attainment was much smaller for the 1950-59 birth cohort than for the 1930-39 birth cohort, it is unlikely that an increase in the return to school quality is responsible for the expansion in the earnings gap. Structural factors, such as the decline in the real minimum wage and decline in unions, which Bound and Freeman emphasize, are alternative explanations for the widening gap.[6]

I. School Quality and Race Since 1954: Fragmentary Evidence

In this section we present historical and recent evidence on the quality of schools attended by black and white students. We measure school quality by the resources available in the schools. Although some researchers have argued that there is only a tenuous relationship between a school's resources, such as the number of students per teacher, and students' scores on standardized tests, much evidence has established a link between school resources and students' subsequent performance in the labor market.[7] In Section II we present some further evidence on the consequences of school quality for labor market outcomes.

A. Extent of Racial Segregation in Schools, 1924-1989

If schools were perfectly integrated, so every school's enrollment was in proportion to the share of each racial group in the population, there would

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[6]See Bound and Freeman (1992).

[7]See Hanushek (1986) for a survey of school resources and test scores. See Card and Krueger (1992b) for evidence on school resources and labor market success.

be little concern over the allocation of resources in schools along racial lines. This is not the case. We have used the Department of Education's survey of schools, known as the Common Core, to examine the extent of racial segregation in public schools.[8] A high degree of segregation exists in public schools. For example, according to our estimates, in school year 1989-90 the average black student attended a school in which 65 percent of the students were nonwhite, while the average white student attended a school in which 17 percent of the students were nonwhite. The average Hispanic student attended a school in which 68 percent of the students were either black or Hispanic.

Figure 1a presents a graph of the cumulative proportion of black students who attend a school with less than the specified proportion of minority students.[9] Figure 1b presents the same information for white students, and Figure 1c presents the same information for Hispanic students. Notice the sharp increase in these cumulative distribution functions around 95 percent for black and Hispanic students. By contrast, there is a sharp increase between 0 and 5 percent for white students. Roughly 30 percent of black students attend schools that have over 95 percent nonwhite enrollment, while over 30 percent of white students attend schools that have less than 5 percent nonwhite students. At all levels, the cumulative distributions are very similar for black and Hispanic students.

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[8]This data set contains information on the racial composition of students in 81,368 schools in 43 states and D.C. Given this large sample size, our estimates are extremely precise and we do not bother to present standard errors.

[9]For the purposes of this paper, black refers to black, non-Hispanic origin, and white refers to white, non-Hispanic origin. We use the term minority to mean all groups other than white non-Hispanic.

The extent of segregation is far greater in public schools in large center cities (i.e., cities with a population of over 400,000). Figures 2a and 2b present graphs of the cumulative percent of white and black students who attend schools with less than the specified percent of nonwhite students, broken down by whether or not the school is in a large center city. Nearly two-thirds (64 percent) of black students in public schools in large cities attend a school in which 90 to 100 percent of the enrolled students are nonwhite, whereas less than 15 percent of black students outside of large center cities attend a school that has 90 to 100 percent nonwhite enrollment.[10] In contrast, only 3 percent of white students in large center cities attend a school with 90 to 100 percent minority enrollment. Furthermore, over 34 percent of black students live in large center cities, compared to 6 percent of white students. We are unaware of comparable data to assess trends in racial segregation in large cities. However, Welch and Light find that the percentage of white students attending selected central city school districts has declined sharply in every region of the country between 1968 and 1980.[11]

The most widely cited historical evidence on the extent of public school desegregation in the United States is based on the work of Gary Orfield, who analyzed school-level data on students' race supplied by the U.S. Department of Education.[12] These data only cover the period 1968-

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[10]The level of segregation is even greater in large cities in the Northeast and Border states. In the Northeast, 70 percent of black students are enrolled in schools that have 90 to 100 percent minority enrollment. The comparable figure for the border states is 77 percent.

[11]See Welch and Light (1987).

[12]See Gary Orfield (1983).

1980.[13] Further, 1968 is considered a key year in terms of mandatory school desegregation because in that year the Supreme Court held in Green vs. County Board of Education of New Kent County that "freedom of choice" was no longer a viable means of desegregating noncompliant school districts.[14] Unfortunately, little is known about the efficacy of school desegregation before 1968, so it is not clear whether Green instigated a change in racial segregation. Here we provide some new evidence on the trend in segregation during this crucial period, as well as update Orfield's original estimates of racial segregation through 1989.

We use the Common Core data for school year 1989-90 to update Orfield's estimates of the percentage of black students enrolled in predominantly minority schools (i.e., over 50 percent minority enrollment) and in schools with 90 to 100 percent minority enrollment.[15] Tables 1a and 1b present Orfield's estimates of the extent of segregation for 1968-80, and our estimate for 1989.[16] It is clear from these tables that the degree of

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[13]Earlier work by Coleman, Kelly and Moore (1975) uses school district level data from 1968-73 to analyze the extent of racial school segregation. These data suffer from missing any within-district segregation.

[14]See Hochschild (1984, p.27).

[15]See Orfield (1983, p.4). Although many other indices of school segregation are possible, we use these measures for historical comparison.

[16]Although we lack data for 7 states, if we re-compute Orfield's estimates for 1980 using just the subset of states included in our data set, none of our conclusions is meaningfully altered. For example, in 1980 the estimate of the percent of black students in 90 to 100 percent minority schools for the South using our subset of states is 24.6 percent, which is close to Orfield's original estimate of 23.0 percent. The estimates for the other regions are even closer.

segregation in the nation as a whole dropped precipitously between 1968 and 1972, and then remained roughly constant over the 1970s. Our extension of these data through the 1989-90 school year reveals that racial isolation for black students increased slightly in the 1980s.

The trends in school desegregation differ across regions of the country. The decline in segregation between 1968 and 1972 was primarily concentrated in the Southern and Border states. In 1968, 77.8 percent of black students in the South attended schools that had over 90 percent minority students; this figure dropped to 24.7 percent just four years later. School segregation appears to have increased in the South since the mid 1970s. Observing the high rate of segregation in Orfield's data for the South in 1968, some scholars have concluded that desegregation did not occur on a wide scale before 1968.

Between 1968 and 1989, there has been a gradual decline in school segregation for black children in the Border, Midwest, and West regions. In the Northeast, however, black students are now substantially more racially isolated than they were in 1968. While school segregation rapidly declined in the South between 1968 and 1972, the Northeast experienced a rise in school segregation. Moreover, in spite of the upward drift in school segregation in the South, the South is now the region of the country with the highest level of racial integration in schools, and the Northeast is now the region of the country where minority students are most racially isolated.

Hispanic Students

The pattern of segregation for Hispanic students is presented in Tables 2a and 2b. In contrast to the experience of black students, there was not a dramatic decline in segregation for Hispanic students between 1968 and 1972. Moreover, in almost every region and every time period for which we have data, Hispanic students have become increasingly more racially isolated, by

both measures.[17] The greatest increase in the number of Hispanic students has occurred in the West and Midwestern regions, and these regions have experienced the greatest increases in segregation. As a consequence, Hispanic students now face roughly the same level of racial isolation in schools as black students. Moreover, to the extent that bilingual education is a great concern for Hispanic students, this trend toward increasing segregation may have great consequences.[18]

New Historical Evidence: National Survey of Black Americans

Attempts to interpret historical trends in school desegregation have been hamstrung by the lack of comparable data before the Green decision in 1968. In particular, the Civil Rights Act of 1964 may have reduced the extent of school segregation by prohibiting federal aid to segregated institutions. The incentive for districts to desegregate was further strengthened by the passage of the Elementary and Secondary Education Act of 1965, which increased the amount of federal spending on public schools to compliant school districts. In short, beginning in 1964 the Federal government provided financial incentives for school districts to desegregate, and the Civil Rights Act enabled the Justice Department to join in suits against non-compliant school districts.[19]

To measure the extent to which the move toward desegregation was already afoot in the South and Border regions prior to 1968, we analyze data

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[17]The extent of segregation is also greater in urban areas for Hispanic students. Considering cities with over 400,000 people, 55 percent of Hispanic students are enrolled in schools with 90 to 100 percent minority enrollment.

[18]See Hochschild (1984, p.45).

[19]See Hochschild (1984, p.27).

from the National Survey of Black Americans (NSBA).[20] In 1980, the NSBA asked black Americans age 18 or older retrospective questions concerning school segregation: whether they attended an "all black" or "mostly black" grammar school, junior high, or high school. The survey also identifies the state the individuals grew up in and their age. We use this information to construct a time series of data on school segregation. Specifically, we infer the calendar year in which each individual would have attended grade school, junior high, or high school, and then pool the data together based on calendar year to derive an estimate of the extent of segregation each year.[21] This procedure is likely to smooth the actual series and make it difficult to determine precisely the year of breaks in the series.[22] On the other hand, we are able to examine the extent of school segregation with comparable data over a broad sweep of history (1924-1971).

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[20]The data for the National Survey of Black Americans 1979-80, were originally collected by James S. Jackson and Gerald Gurin. We limit the sample to individuals who grew up in the South and Border states.

[21]Specifically, we assume that individuals' response to the grammar school question corresponds to the year in which they turned 9, their response to the junior high question corresponds to the year in which they turned 14, and their response to the high school question corresponds to the year they turned 16.

[22]However, our results are almost numerically equivalent when we limit the sample to the high school and junior high questions, which are a much more narrow time interval. This finding suggests that smoothing may not be a serious problem. We retain the grammar school data in the graphs presented to increase the sample size. The total sample size used to created Figure 4 is 4,152.

The results of this exercise are summarized in Figures 3a and 3b, and the underlying data are reported in Appendix Table 1. For each calendar year, the figure presents an estimate of the proportion of students who attended an all black school (Figure 3a) or a mostly black (Figure 3b) school, and places a one standard error bound around the estimate. In the years in which there is overlap (1968-1971), there is broad agreement between our estimates and Orfield's. It is also clear from these figures that virtually all black students attended completely segregated schools in the Southern and Border states before the Brown decision in 1954. Our estimates document that there was no decline in segregation circa 1954.

But surprisingly, the figures indicate that 1964, not 1968, was a watershed year in the history of school desegregation in the Southern and Border states. In spite of the smoothing due to the use of retrospective data, it is clear that the trend toward school integration began before 1968. These results suggest that, contrary to widespread belief, federal legislation that took effect prior to 1968 was a catalyst for the reduction in school segregation in the South.

B. Pupil-Teacher Ratio

Throughout the first half of the twentieth-century, the typical black student attended a school with far more students per class than the typical white student. There are two principal reasons for this disparity. First, compared to white students, a disproportionately large number of black students lived in the South, and the quality of schools in the South lagged well behind the rest of the nation in the beginning of the century. Second, within the South black students were confined to racially segregated schools that were understaffed and overcrowded relative to schools attended by white students. However, throughout most of the century the pupil-teacher ratios for white and black students have tended toward equality because: (1) the gap in class size

for black and white students within regions has narrowed substantially; (2) the South has caught up to the rest of the nation in terms of school resources; and (3) the share of blacks living in the South has declined.[23]

Figure 4a presents a graph of the relative white-black pupil-teacher ratio in the 17 states with de jure segregated schools and D.C. from 1915 to 1989, and Figure 4b presents a graph of the gap in the pupil-teacher ratio between black schools and white schools.[24] In 1915, the average pupil-teacher ratio in black schools in these state was 60.8, far greater than the average of 37.6 in white schools. In 1953-54, on the eve of the Brown v. Board of Education ruling, the pupil-teacher ratio was 31.6 for black students and 27.6 for white students. Although government records are limited after this period, data from the Southern Educational Reporting Service indicates that in 1966 the average pupil-teacher ratio was 26.1 for black students and 24.0 for white students. Notice that there is no apparent break in the series around 1954; if anything, relative progress for black students was slower in the decade following Brown than in the decade preceding it.[25]

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[23]Note that we shall use the terms class size and pupil-teacher ratio interchangeably.

[24]These figures are based on data from the Biennial Surveys of Education, state education reports, and the authors' calculations using the Common Core data set. The pre-1966 data are described in more detail in Card and Krueger (1991). The term length and average teacher salary show similar trends through 1966. Also see Smith and Welch (1989, Table 17) for related evidence. Henceforth, we refer to D.C. as a state. Comparable data do not exist for nonsouthern states.

[25]Some states even show a decline in relative school quality just after the Brown decision. These observations reinforce Donohue and Heckman's (1991)

Little is known about the pupil-teacher ratio for the average black student and average white student since 1966. Until recently, the Department of Education has not included the number of students enrolled in a school by race in the public-use extract of its basic data set, the Common Core. The 1987-90 Common Core public-use data sets contain the number of students in a school, the race of the students, and the number of teachers in the school, for every public elementary and secondary school in 40 states. We have used these data to tabulate the average pupil-teacher ratio in schools attended by black students and white students. Specifically, we calculate the pupil-teacher ratio for an average member of each race by the following weighted average:

$$PT^r = \Sigma\, PT_i\, N_i^r \,/\, (\Sigma\, N_i^r)$$

where PT^r is the average pupil-teacher ratio for a member of race r, PT_i is the ratio of pupils to teachers in school i, and N_i^r is the number of students in school i who belong to race r.[26] The summation runs over all schools. This procedure is equivalent to assigning to every student in the school the pupil-teacher ratio for his or her school, and then calculating the mean pupil-teacher ratio for members of each race separately.

This approach has some obvious shortcomings. First, by using school level data we miss any possible differences in class size by race within schools. Second, in 1980 11.4 percent of white students and 5.4 percent of black students attended private and parochial schools.[27] The Common Core

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contention that there was not a discrete improvement in school quality for black students around 1954.

[26]This is the same approach used in Coleman et al. (1979).

[27]These figures are based on Welch and Light (1987), Table 3.

files do not have data on the racial composition of students attending private schools, so any difference in class size between public schools and private schools is not reflected in our estimates.[28] Third, 11 states do not report complete data on students' race or on the number of teachers in the Common Core survey. These states must be omitted from our estimates. Nevertheless, we suspect that our weighted averages of pupil-teacher ratios at the school level provide at least a partial picture of the quantity of school resources available to students of different races.

Table 3 reports estimates of the average pupil-teacher ratio for black students, Hispanic students, and white students during school year 1989-90. The table also reports the proportion of students of each race who attend schools that have over 25 students per teacher. In panel A we report estimates for all grade levels and for each region of the country; panels B and C contain the corresponding estimates for grammar schools and high schools, respectively. (Appendix Table 2 reports estimates for each state.) Our estimates are based on a total sample of 69,610 schools.

Perhaps surprisingly, Table 3A indicates that the pupil-teacher ratio is slightly higher for white students (18.3) than for black students (18.1). The long period of a higher pupil-teacher ratio for black students has finally come to an end. On the other hand, the pupil-teacher ratio of the average Hispanic student (20.3) is 11 percent higher than that of the average white student.

Inspection of Table 3 reveals some interesting regional patterns. First, the pupil-teacher ratio is significantly higher in the Western states than in the rest of the country. Because Hispanic students are vastly over-represented in the West, the relatively high pupil-teacher ratio for Hispanic students is mainly due to their regional distribution. Second, black students

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[28]Estimates that we present below for high school students based on the High School and Beyond Survey do include private schools, however.

currently have a higher pupil-teacher ratio than white students in all regions of the country but the South. In the Northeast, for instance, there are an average of .6 more students per teacher in the average school attended by black students than that attended by white students, and the difference is 1.7 students per teacher for high schools.

It is also worth noting that at higher grade levels Hispanic students are at a greater relative disadvantage as far as class size is concerned. The average pupil-teacher ratio for Hispanic high school students exceeds the average for white high school students by 16 percent. Moreover, the high school drop out rate for Hispanic students is 35.8 percent, which greatly exceeds the drop out rate of 12.7 percent for white students and 14.9 percent for black students.[29] Any decline in the drop out rate for Hispanic students is likely to increase the gap in the pupil-teacher ratio between Hispanic students and other students. On the other hand, the relatively high pupil-teacher ratio for Hispanic high school students may contribute to their higher drop out rate.

Within-State

Several scholars, including W.E.B. Dubois and Horace Mann Bond, have noted that across regions of the country expenditures per student in black relative to white schools were inversely related to the fraction of blacks in the population. This pattern was carefully documented with county-level data by Bond and later by Margo.[30] As Bond summarizes:

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[29]These figures are "status" drop out rates, and pertain to 16-24 year olds. The data are based on the Bureau of the Census, Current Population Survey, October 1988, and are reported in Schick and Schick (1991).

[30]See Bond (1934) and Margo (1990).

> Negro schools are financed from the fragments which fall from the budget made up for white children. Where there are many Negro children, the available funds are given principally to the small white minority. Besides depressing expenditures for Negro children, expenditures for white children in these heavily populated Negro counties are far above the median for the entire state.[31]

Bond argued this pattern developed because state funds were allocated on a per student basis, which enabled school superintendents to divert more funds to white schools in areas that were heavily populated by blacks. Since black voters were effectively disenfranchised, they did not have the means to stop this process.

Figure 5 illustrates that the relationship documented by Bond across counties also exists at the state level, using data for the 18 Southern and Border states each decade from 1920-1990.[32] Until 1960, the plots show a strong, persistent negative relationship between the percent of the population in a state that is black and the ratio of the pupil-teacher ratio in white schools to that in black schools. However, the relationship has become weaker with time, and is totally eliminated by school year 1989-90. In fact, there is a weak positive relationship if all states (not just the Southern and Border States) are used. This turnaround is likely a result of increased voting rights for black citizens over the years.

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[31]See Bond (1934, pp. 244-245).

[32]Our data on the fraction of the population that is black is from decadal Censuses of Population, as reported in various issues of Statistical Abstract. The figure for 1990 uses data for 15 states.

School-level Analysis

We have used the Common Core micro data to estimate some descriptive regressions of the relationship between the pupil-teacher ratio, school location, and race. These regressions are summarized in Table 4. The first column reports estimates weighted by the number of black students in the school, the second column weighted by the number of white students in the school, and the third column weighted by the number of Hispanic students in the school. Columns 4-6 present the weighted means of the variables.

The regressions reveal several patterns. First, schools located in the center of large cities tend to have more students per teacher than those located in suburbs. Second, grammar schools tend to have a higher number of students per teacher than junior high schools or high schools. Finally, the regional patterns in the pupil-teacher ratio noted before are even stronger after holding city size and grade level constant.

The bottom part of Table 4 reports the weighted mean pupil-teacher ratio for each racial group. In the second to last row we compute the pupil-teacher ratio for each group using the coefficient estimates based on white students and the means of the independent variables for black or Hispanic students. In the last row of the table we compute the pupil-teacher ratio for each group using the group's own coefficient estimates, but the mean characteristics of white students. Interestingly, the last set of results indicates that if Hispanic students had the same regional distribution and other mean characteristics of white students, their pupil-teacher ratio would be about the same level (18.16) as white students, on average. As mentioned previously, the higher pupil-teacher ratio for Hispanic students is mainly a result of their high representation in Western states.

State-level Analysis

The broader regional trends in school quality in recent years tend to favor black students because black Americans are relatively over-represented

in the South, which now has a lower pupil-teacher ratio than the national average. Furthermore, black Americans are relatively under-represented in the West, which now has a pupil-teacher ratio that is well above the national average. One way of documenting this fact is to calculate the weighted average pupil-teacher ratio for blacks and whites between 1976 and 1986, using the number of black students in a state and the number of white students in a state as weights (see table below). The pupil-teacher ratio used in these calculations is the overall level for the state, which combines black and white students.[33] In 1976, black students were relatively more numerous in states with high pupil-teacher ratios. This would have led to a 6 percent higher pupil-teacher ratio for black students if the within-state distribution of class size was equal. In 1986, however, black and white students were in states with roughly comparable pupil-teacher ratios, on average.

Weighted Pupil-Teacher Ratio, Using State-wide Pupil-Teacher Ratio

	Current Weights		1976 Weights	
Year	White	Black	White	Black
	(1)	(2)	(3)	(4)
1976	21.87	23.18	21.87	23.18
1980	18.88	19.02	18.84	18.99
1984	18.23	18.32	18.18	18.27
1986	17.82	17.97	17.73	17.75

Is the convergence in pupil-teacher ratio (at the state level) between blacks and whites due to migration of black students from states with large class sizes to states with small class sizes, or is it due to a relative improvement in class size in states where black students are over-represented?

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[33]These data are taken from the Digest of Education Statistics.

To answer this question, in columns (3) and (4) we hold the distribution of students across states constant at their 1976 level, and re-compute the weighted averages. The answer is quite clearly that this convergence occurred because average class size declined in states where black students were relatively more numerous.

Wealth and the Pupil-Teacher Ratio: District-level Analysis

Although race does not seem to be a major factor in determining class size, we note that evidence suggests that schools that are located in districts with lower property values tend to have larger pupil-teacher ratios. For example, Figure 6 presents a scatter diagram of the ratio of pupils to teachers in 274 school districts in Massachusetts in 1990 against the log of the equalized property value for the districts in 1988.[34] Notice the wide variation in the pupil-teacher ratio across districts -- the top percentile of school districts has an average of 10 students per teacher, whereas the bottom percentile of districts has an average of 22 students per teacher. The figure also shows a strong inverse relationship between the pupil-teacher ratio and property value. The OLS regression of the pupil-teacher ratio on the log of equalized property value is:

$$\text{Pupils/Teachers} = \underset{(2.56)}{35.17} - \underset{(0.47)}{3.56}\ \ln(\text{Land Value}) \qquad R^2 = .17.$$

The relationship between the pupil-teacher ratio and land value is highly statistically significant (t-ratio=7.57). A 20 percent increase in land value is associated with about .70 fewer students per teacher.

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[34]The property value data are from unpublished tables prepared by the Massachusetts Department of Education.

We have also analyzed the relationship between the median salary of teachers in a school district in Massachusetts and the log of equalized property value. The estimated regression equation is given below:

$$\text{Median Salary} = \underset{(4956.1)}{7227.9} + \underset{(917.1)}{5130.4}\ \ln(\text{Land Value}) \qquad R^2 = .11.$$

There is a highly statistically significant (t-ratio=5.59) relationship between median teacher salary and the property wealth of a school district. For example, a 20 percent increase in property value is associated with over $1,000 higher annual pay for the median teacher.

We prefer not to put a structural interpretation on either of these estimated relationships because the direction of causality is not clear. Higher quality schools may increase the land value of a school district, but it is also plausible that higher income individuals choose to provide their children with higher quality schools. Nevertheless, these results indicate that more school resources are available to children who grow up in wealthier areas. Since black families are more likely than white families to live in low-income areas and in cities, it is noteworthy that the unconditional estimates in Table 3 do not show much of a gap in class size between white and black students.[35]

Perhaps the reason schools attended by minority students have been able to maintain roughly comparable levels of class size as schools attended by

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[35]For example, Blau and Graham (1989) estimate that in the late 1970s, the average black married couple had about one-third as much equity in housing as the average white married couple ($4,222 vs. $13,864). The black-white income ratio for this sample was .75. Based on the relationship for Massachusetts, a property wealth differential of 66 percent would be expected to increase the pupil-teacher ratio by about 2.3 pupils.

white students is by forgoing other resources that are provided to students in wealthier areas. Next we present evidence suggesting that race does have an effect on a more modern measure of school quality, namely the extent of computer use by students.

C. Computer Utilization

The computer revolution of the 1980s has had a profound impact on the operation and organization of elementary and secondary schools. The number of computers in use by elementary and secondary schools increased by over 17 times between 1981 and 1988. In 1988, 1.52 million micro computers were used for instructional purposes in public school grades K-12 -- one computer for every 26.9 students.[36] Computer labs are common in public and private schools, and many private schools compete for students by advertising their computer resources. In 1989, nearly half of all students reported that they directly use computers in school. Computers are primarily used for two purposes in schools: (1) computer-aided instruction; (2) providing students with computer skills that are of use in the labor market and elsewhere.

To date, there have been only two studies of the extent of students' computer use by race.[37] Both of these studies analyzed data from the earlier 1980s, just before the widespread adoption of computers in schools. To explore racial differences in computer use in schools more recently, we analyze data from the 1984 and 1989 October Current Population Survey (CPS) School Enrollment Supplement microdata files. In these two

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[36]In private schools there was one computer for every 23.5 students. These figures are drawn from Statistical Abstract of the United States, 1990, Tables 238 and 1340.

[37]See McPhail (1985).

supplements, respondents were asked: "Does ... directly use a computer at school?"[38] In addition to being more recent than the data analyzed by the previous researchers, the CPS data files have the advantages of providing large, nationally representative samples, and of providing detailed demographic information on students and their families. We limit our sample to students age 6-18 who are enrolled in grades 1-12.

Table 5 reports our estimates of the proportion of students who use a computer in school by grade level and race in 1984 and 1989. Between 1984 and 1989 there was tremendous growth in the proportion of students using computers in schools. Black students, however, are substantially less likely to use a computer in school than white students. Across all grade levels in 1984, 36 percent of white pupils used computers in school and only 18 percent of black pupils -- black students were half as likely as white students to be trained on computers in school in 1984. Furthermore, computer utilization is no greater among Hispanic students than among black students.

By 1989, the black-white gap in computer use for all grade levels declined slightly, from 18.0 percentage points to 17.1 percentage points. However, the racial gap in computer use at the high school level has declined greatly, while the gap has remained roughly constant at the grammar school level. Thus, white school children are exposed to computers, and are instructed with the aid of computers, at a much earlier stage of their educational career than black or Hispanic children.

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[38]According to the questionnaire, computer use means: "'Direct' or 'hands on use' of computers. These computers may be personal computers, mini computers, or mainframe computers." Excluded are "hand-held calculators or games, electronic video games, or systems which do not use a typewriter-like keyboard."

We have also explored the black-white gap in computer use across regions. Appendix Table 3 presents estimates of the extent of students' computer use by state and race for 1989. Our results indicate that the gulf in computer use between black and white students is greater in the Midwest (20 points) and Northeast (18 points) than in the South (13 points) and West (9 points). On the other hand, computer use by students is least common in schools in the South, where slightly over half of all black Americans live.

How much of the gap in computer use can be accounted for by family characteristics such as income and region of residence? To answer this question we have estimated a set of linear probability models with the 1989 data, including various sets of explanatory variables.[39] These results are summarized in Table 6. In the first column we only include two race/ethnic group dummies; the omitted group is white non-Hispanic students. In the second column we include dummy variables indicating the student's gender and whether the student attends a public school, as well as linear variables measuring the grade and age of the student.[40] In column 3 we include the same explanatory variables plus region of residence, 3 dummy variables for the type of city/town the student lives in (e.g., central city), and 7 dummy variables indicating the size of the city the student lives in. Finally, in

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[39]Logit models yield similar conclusions. We present the linear probability models for simplicity.

[40]Notice that, holding grade constant, older students are less likely to use computers in school. This finding would be expected if students who progress more slowly are less likely to be trained on computers.

column 4 we include the same explanatory variables as in column 3 plus 14 dummy variables for family income class.[41]

Controlling for student characteristics, such as grade and age, does not reduce the magnitude of the racial gap in computer use. Including city size, city type, and region, however, reduces the black-white gap in computer use by about 5 percentage points, and the Hispanic-white gap by 4 points. Computer use at school is strongly related to family income. For example, children from families with over $75,000 in annual income are 50 percent more likely to use computers in school than children from families with under $10,000 in annual income. Accounting for differences in family income reduces the gap in computer use relative to white students to 9.3 points for black students and 7.7 points for Hispanic students. In sum, accounting for all of these variables cuts the racial gap in school-related computer use roughly in half. Nevertheless, the gap is still large and statistically significant.

For students age 15-18, the CPS also contains information on whether the students' families have computers at home. In 1989, 35.8 percent of white students were in families that owned a home computer, whereas only 15.3 percent of black students and 14.3 percent of Hispanic students had such a luxury. Furthermore, 29.7 percent of all white students used computers at home, whereas only 10 percent of black and Hispanic students used computers at home. In results not reported in the table, we find that students who come from families with computers available at home are 6.0 percentage points (t=3.8) more likely to use a computer in school, after controlling for all the

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[41]Family income is reported in 14 intervals: less than $5,000, $5,000-$7,499, $7,500-$9,999, $10,000-$12,499, $12,500-$14,999, $15,000-$19,999, $20,000-$24,999, $25,000-$29,999, $30,000-$34,999, $35,000-$39,999, $40,000-$49,999, $50,000-59,999, $60,000-$74,999, $75,000 or more. We also include a dummy for family income not reported (5.8% of cases).

variables in column 4. Thus, lower access to computers at home may further compound differences in computer use between minority and nonminority children.

A question of policy concern is: Why does the racial gap in computer use exist? There are four plausible explanations that should be investigated. First, schools attended by minority students may lack sufficient resources to obtain computer equipment and maintain adequate levels of other school resources, such as the student-teacher ratio. Second, teachers in schools attended by minority students may not know how to use computers effectively as teaching tools. Third, relatively many minority students may not come to school prepared to use computers. Fourth, computer distributors may have discriminated against inner-city schools in the provision of free computers or in computer prices.

Although we cannot address all of these potential explanations here, we can provide some information on the likely sources of the racial gap in computer use. First, we should stress that even if the average minority child comes to school less prepared to learn complex computer programming because of having a lower socio-economic status, computers are widely used by schools for remedial education. It is more common for schools to employ computers as a learning device for a subject area than as a tool for teaching computer literacy. In this sense, computer use is not like taking a course in an advanced subject. On the other hand, if minority children are less likely to be exposed to computers at home, they may not see computers as a worthwhile tool to use in school.

Computer Use and Other Characteristics of High Schools; 1982

We have used the High School and Beyond Survey to further explore racial differences in computer training and school resources. This data set consists of several files, some containing information on school characteristics

in 1980 and 1982, and others containing longitudinal information on students' experiences and academic achievements. Here, we present evidence based on the Schools File.[42]

The baseline HSBS Schools file contains information on the racial composition of students, number of students, number of teachers, qualifications of teachers, and other characteristics for nearly 1,000 high schools in 1980. In addition, a follow-up survey conducted in 1982 contains information on whether the school offered computer courses. The high schools in the sample include both public and private schools. We use the HSBS to calculate weighted averages of several school characteristics, where the weights are the number of black students and number of white students attending each high school.[43]

Table 7 presents means of a variety of variables by race. In 1982, 60 percent of white students attended a high school that offered a computer class, but only 50 percent of black students attended a high school that offered a computer class. Although the number of computer courses that schools offered per student was low in 1982, white students attended schools that, on average, offered 50 percent more computer courses per enrollee than the average school attended by black students. These results suggest that, at least in part, black students are less likely than white students to use computers in school because their schools are less likely to offer computer classes.

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[42]In Section II we use information based on the student's file to examine the implications of computer training for job placement.

[43]Because the HSBS did not use a random sample design, we weight the data by the product of the sample weights and the number of black or white students attending the school.

The HSBS also enables us to estimate racial differences the pupil-teacher ratio, teacher training, teacher pay, and other school characteristics in 1982. The HSBS estimates indicate that the average black high school student attends a school with about .6 more students per teacher than the average white student. Recall that our tabulations with the 1989-90 Common Core data indicated a .2 higher pupil teacher ratio for the average black student at the high school level.

Although these data pertain to the beginning of the computer revolution in schools, the tabulations based on HSBS data do not provide much evidence that black students are less likely to use computers because their teachers are incapable of using computers. The educational attainment or experience of teachers in schools attended predominantly by black students does not differ tremendously from that of teachers in schools attended predominantly by white students. Of course, crude measures such as the teachers' mean level of education or experience do not indicate whether the teachers themselves are capable of instructing students with the aid of computers. But these results do not suggest that teachers in the schools that black students attend in large numbers are incapable of being trained to effectively use a computer for teaching purposes.

In sum, our findings are poignantly described by Kozol's interview of a junior high school teacher in Camden, N.J.[44] Over 98 percent of students in the school are black or Hispanic, and each term the teacher says she must explain to her students: "We are in the age of the computer.... We cannot afford to give you a computer. If you learn on these typewriters, you will find it easier to move on to computers if you ever have one." Below we explore whether minority workers' chances of obtaining a job that requires

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[44]See Kozol (1991, p.139).

computer skills are diminished by their lower probability of having used computers in school.

D. Test Scores

We briefly note that evidence suggests that minority students' performance on standardized tests, such as the Scholastic Aptitude Test (SAT) and the National Assessment of Educational Progress (NAEP), have improved relative to white students at least since the early 1970s. However, on average, minority students still perform below white students on these exams. For example, in 1975 the average black student taking the SAT scored 354 on the math portion of the exam, compared to 493 for the average white student. By 1988 the average black student's score had risen to 384, while the average white student's score declined to 490.[45] Likewise, at all age groups, the average black student has shown greater improvement on the NAEP than the average white student since 1969.[46]

The implications for labor market success of these trends in test scores are difficult to interpret for two reasons. First, changes in the proportion of students who take these exams are likely to significantly affect the mean scores. This is especially likely to be a problem with the SATs because students self-select to take the exam.[47] But changes in the proportion of students taking the exams may also be a problem for exams in which students are randomly selected to take the exam because school enrollment rates differ

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[45]The verbal scores show a similar pattern. These figures are from Digest of Education Statistics (1989, p.120). Earlier data are not available.

[46]See Jaynes and Williams (1989, pp. 348-352) for a detailed review of time-series trends in test scores for black and white students.

[47]See Dynarski (1987).

among different racial groups, and have changed over time. Second, and perhaps more important, most empirical studies have found little relationship between achievement test scores and measures of labor market success.[48] Standardized test results are not a good indicator of individuals' success in the labor market. For these reasons, we prefer to focus directly on the relationship between schooling inputs and labor market outcomes. Nevertheless, it is worth noting that available evidence on time-series trends in test score performance by racial group does not indicate a deterioration in the quality of minority students' education.

Although there are many aspects of schools that we have not considered, such as teacher quality and possible neighborhood effects, our results provide at least a partial evaluation of the quality of schooling by racial group. Moreover, the broad evidence on test scores are not inconsistent with our findings for traditional measures of school quality, such as class size.

II. Economic and Scholastic Implications of School Quality Differences

Our exploration of school resources suggests that, on average, Hispanic students attend schools that have more pupils per teacher than white students and black students, and that the average pupil-teacher ratio is about the same for white and black students. We also find that white students are far more likely to use computers in the classroom than black or Hispanic students. Finally, our results indicate that racial segregation in schools has been rising gradually for black students in some regions of the country, and has been rising steadily for Hispanic students. In this section we explore the labor market implications of these findings, concentrating mainly on the likely

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[48]For examples, see Griliches and Mason (1972), Blackburn and Neumark (1991), and Conlisk (1971).

implications of racial isolation in schools and lower computer training among minority students.

A. Implications of School Segregation

Although over 100 studies have examined the relationship between students' achievement on standardized tests and the extent of school segregation, only a few studies have examined the effect of school segregation on labor market outcomes.[49] Because school segregation may limit minority students' opportunities to develop contacts that are later used to find jobs, and may affect individuals' attitudes towards different racial groups, the extent of school segregation might influence labor market outcomes such as the probability of working in an integrated work environment. Ideally, to measure the effect of racial isolation in schools on various outcomes, one would like to be able to study an experiment in which students are randomly assigned to attend schools with different proportions of minority students.

Probably the most compelling evidence on the effect of school desegregation on labor market outcomes is from Crain and Strauss's follow-up study of the experience of black elementary students from Hartford, Connecticut, who were randomly given a choice to be bused to an integrated suburban school based on a court-mandated lottery in 1966.[50] Students who participated in this lottery were re-interviewed in 1983. Not every student

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[49]See Braddock, Crain and McPartland (1984) for a survey of the literature on impact of school desegregation on long-term outcomes. The past literature has found that minority students who attend schools with a higher proportion of white students tend to obtain jobs in more integrated firms and to complete more years of schooling.

[50]See Crain and Strauss (1985).

who was given the option to be bused chose to be bused. Crain and Strauss find that students who were given the option to be bused to an integrated school are more likely to work in white-collar and professional jobs in the private sector.

Crain and Strauss also find that the occupational differences between the treatment and control groups are larger for the subset of the treatment group that accepted busing than for the subset that was selected for busing but declined. This result could reflect self-selection in which more ambitious students accept busing, or an effect of having attended an integrated school. Moreover, from this analysis it is not clear whether the effects of attending an integrated school stem from greater contact with white students, or from different resources in the suburban schools. And it is not clear whether the effects of school desegregation found in this study are specific to busing in Hartford, or hold more generally. Nevertheless, analysis of this natural experiment suggests that school segregation may have long-term consequences for labor market outcomes.

We provide some further evidence on the impact of attending an integrated school based on data from the National Survey of Black Americans. In particular, we examine the effect of school segregation on four long-term outcome variables for black students: years of schooling completed; the proportion of students who are black in the college in which the individual attends (for individuals who attended college); hourly earnings; and the proportion of individuals' co-workers who are black. We limit our sample to individuals age 25-65 who have at least 10 years of schooling. The extent of

school segregation is measured by the proportion of students who were black in the high school the individual attended.[51]

OLS and two stage least squares (2SLS) estimates are presented in Table 8. The first 4 columns present the OLS estimates. We include several explanatory variables, including a set of dummy variables indicating the state the individual grew up in, a quartic in age, a dummy indicating gender, and in some models 8 region of residence dummies. The results indicate that a higher proportion of students in a high school who are black is associated with fewer years of schooling, a less integrated work environment and college for those who attend college, and lower wages. Each of these effects is statistically significant at the 10 percent level.

An important issue in interpreting these results is that black students who attended integrated schools may differ along relevant, unobserved dimensions that are spuriously picked up by the proportion of black students in the high school. For example, middle class black families may be more likely to live in suburbs and send their children to integrated schools. If, because of differences in family background, these children would have obtained more schooling regardless of the fraction of black students in their school, our estimates would be biased. To adjust for possible selection bias we have estimated 2SLS models.

The identification strategy in our 2SLS model is based on our earlier finding that school desegregation did not begin in the South until after 1964.

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[51]In the NSBA, individuals were asked whether they attended a school in which students were: all blacks, mostly blacks, about half blacks, mostly whites, or almost all whites. We convert this to a proportion by assuming values of 1, .75, .5, .25, and .1, respectively. We similarly coded the questions on the racial composition of students in their college and of their co-workers.

The 2SLS estimates are identified by temporal variation in the proportion of students in the high school who are black resulting from post-1964 school desegregation. Since the trend toward school desegregation after 1964 was exogenous to students, this provides a potentially valid instrument. Moreover, the pace of desegregation varied among the states, so we allow for a different post-1964 effect by state. Specifically, we create a dummy variable that equals one if the individual attended high school after 1964, and zero otherwise. This dummy is interacted with dummies indicating the state in which the individual grew up to allow for a different relationship across states. Individuals in the sample grew up in 29 different states, providing 29 excluded instruments.[52]

Unfortunately, the 2SLS estimates are not very precise. Nevertheless, except for the equation for the race of co-workers, the coefficients on the school segregation variable have roughly the same magnitude and sign as in the OLS models. Although issues of nonrandom selection still need to be addressed, these results suggest that school segregation has had a lasting effect on some labor market and educational outcomes. Whether these findings result directly from racial isolation, from lower school resources in predominantly black schools, or from some combination of these factors, should be a subject of further research.

B. Implications of Computer Use

Compared to white students, black and Hispanic students are much less likely to use computers at school. Here we explore whether minority

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[52]Notice that to control for other possible secular trends that may be correlated with the period in which an individual attended high school, we have included a fairly flexible specification for age, and to control for effects of differences in school resources across states, we have included unrestricted dummies for the state where the individual grew up.

workers are less likely to be employed in jobs that require the use of computers, and whether there is any link between computer use in school and on the job. It should be stressed that our analysis is indirect. Ideally we would like to measure the effect of students' computer use in school on their subsequent incomes.

Table 9 reports the percentage of workers in various educational categories who directly used a computer at work in 1984 and 1989. The estimates are tabulated from the October 1984 and 1989 CPS, and pertain to employed men and women age 18-65. According the questionnaire, individuals are considered to use a computer if they have "direct or hands on use of computers" at work. For example, based on the CPS questionnaire, a manager who does not directly use a computer at work would not be considered to use a computer at work, whereas a secretary who uses a computer for word processing would be considered to use a computer at work.

The results indicate that minority workers are less likely to use computers on their jobs. In 1984, for example, 28 percent of white workers used a computer at work, while only 20 percent of black workers and 17 percent of Hispanic workers used a computer at work. The share of workers using a computer at work grew substantially for all groups between 1984 and 1989, but the growth was greater for white workers. Thus, in 1989 42 percent of white workers reported using a computer on the job, while only 29 percent of black workers and 24 percent of Hispanic workers used computers on the job. Moreover, the racial gap in computer use at work is evident across all levels of education.

Some evidence suggests that students who have not been instructed on computers in school are less likely to use them on the job. In particular, we have used the HSBS data to examine the relationship between education-related computer use and work-related computer use. Our sample consists of individuals who have exactly a high school degree and are working in 1984.

Table 10 presents estimates of linear probability models to explain whether a worker uses a computer at work. Workers who have used computers in their educational training are 7.6 percentage points more likely to use a computer at work, other things being equal. Since only 18.4 percent of workers in this sample used a computer at work, having taken a course that involved using a computer in the past greatly increases the odds of obtaining a job that involves working with a computer.

Of course, one could easily argue that individuals who are interested in computers as students are more likely to use them when they enter the work force -- i.e., the relationship in Table 10 is due to an omitted factor. However, computers were relatively new to schools in 1980, when these individuals were in high school. Roughly half of the high schools in our sample did not offer any computer courses at this time. Thus, in many cases the students could not take a computer course even if they wanted to. We also note that ideally one would like to measure the impact of school-related computer training on students' subsequent earnings in the labor market. Although we have not been able to perform such an analysis, the evidence does suggest that school-related computer training is linked to obtaining a job that utilizes computer technology.

In any event, we should emphasize that the vast majority of workers who use computers at work were not trained on computers in school. In 1989, for example, 39 percent of white workers age 45-54 used computers on the job, and 23 percent of black workers in the same age group used computers on the job. These workers were surely not trained on computers in elementary and secondary school. Thus, differential use of computers in school can directly account for only a small portion of the racial gap in computer use at work. Nevertheless, if computer skills are valuable in the labor market, black students may be disadvantaged by their lower use of computers.

We find that black workers were less likely to be employed in occupations that experienced above average growth in computer use between 1984 and 1989. In particular, we calculate the proportion of workers in each of 487 three-digit occupations that used a computer at work in 1984 and 1980. A regression of the change in computer use on the proportion of workers in the occupation who are black yields a coefficient of -.60, with a t-ratio of -8.79.[53] If we also include average education in the industry, the coefficient on the proportion of workers who are black declines to -.25, but remains statistically significant (t-ratio = -3.63). Thus, occupations in which computers have proliferated are occupations in which the share of workers who were black was relatively low, even after adjusting for average education.

Wages and Computer Use at Work

If operating a computer is a skill that is costly or difficult to acquire, one would expect workers who use computers at work to earn a wage premium. What is the premium for being able to use a computer at work? This is a very difficult question to answer because workers who are observed to use computers on the job may possess high levels of other skills that are not observed or held constant. Furthermore, skilled workers who do not use computers at work may still profit from the computer revolution because the likely increase in demand for skilled workers brought about by the computer revolution is likely to have shifted out the demand for their services.

Krueger contains an empirical analysis of the premium workers receive for knowing how to use a computer at work based on CPS and other

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[53]This regression was weighted by the average number of employees in the occupation in 1984 and 1989.

data.[54] Those findings are summarized and extended here. First, we try to measure the direct reward for using a computer at work by simply estimating a set of log wage equations that include a dummy variable that equals one if workers use a computer on the job, and zero otherwise. Our estimates are based on data from the October CPS for 1984 and 1989, and are reported in Table 11. The wage equations indicate that workers who use a computer on the job earn roughly 20 percent higher wages than those who do not directly use a computer on the job, holding experience, education, and other factors constant.

An obvious concern with these results is that the estimated premium for computer use may overstate the extra value workers derive from learning how to use a computer because workers with more ability may be more likely to use a computer at work. One way to address this concern is to add more explanatory variables to absorb the effect of omitted ability. Krueger finds the computer premium falls to roughly 10-15 percent if variables measuring a worker's industry and occupation, high school grade point average, achievement test scores, or parents' education are included in a wage equation.[55] Additionally, he finds that birth cohorts that experienced great growth in computers also experienced faster wage growth, after adjusting for the age-earnings profile. Because the ability of a given cohort is fixed over time, this finding weighs against attributing much importance to omitted variables.

To add to this research, we find that occupations that have experienced above average growth in computers use have experienced above average wage growth. For example, using data for 487 three-digit occupations, we regressed

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[54]See Krueger (1991).

[55]See Krueger (1991).

the change in the mean log wage in an occupation on the change in the proportion of workers in the occupation using a computer at work. The coefficient on the change in computer use is .122 (t-ratio=4.39). If we include the change in the mean education in the occupation, the coefficient on computer use increases to .134 (t-ratio=4.88). A similar result is found across industries. Since the innate ability of workers in an occupation or industry is not likely to change very much over five years, it is likely that the growth in demand for workers who know how to use a computer has increased wages in occupations in which computer use has expanded.

Nevertheless, the computer differential may still reflect workers' unobserved qualities. As a final way to address this issue, we analyze a new data set on twins.[56] Twins provide a natural experiment to hold constant unobserved family effects. Moreover, in principal, identical twins provide a means to difference out unobserved genetic factors. We use a survey of twins collected by Ashenfelter and Krueger in August, 1991.[57] Unfortunately, the survey did not ask individuals whether they use a computer at work; instead, we assign to each individual the proportion of workers' in the individual's three-digit occupation who use a computer at work, based on the October 1989 CPS. This introduces additional measurement error to our estimates, and thus might be expected to bias our estimated computer differential downward. Nevertheless, this approach enables us to net out family and other components

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[56]This technique has been used in the literature assessing the importance of ability bias for estimates of the return to schooling (for example, see Behrman, Hrubec, Taubman, and Wales (1980)).

[57]The survey was conducted at the Twinsburg Twins Festival in Twinsburg, Ohio. The questionnaire that was used was a modified version of the CPS. The survey is described in Ashenfelter and Krueger (1992).

that might be correlated with the probability that workers in a particular occupation use computers.

Our results are presented in Table 12. The first column reports generalized least squares (GLS) estimates of an earnings equation using data for identical and fraternal twins, and the second column presents within-family estimates (i.e., first-differenced estimates) for the same sample.[58] The third and fourth columns present GLS and within-family estimates based on the subset of identical twins. When we look within-families, we find little evidence of attenuation of the premium associated with the propensity to use a computer in an occupation. Although the reader should have reservations about omitted variable bias, taken together these findings suggest that computer skills are highly valued by employers. If, for the sake of argument, we assume that workers who learn how to use a computer can earn 15 percent higher income, we can calculate the impact of the growth in computer use at work on the black-white wage gap. In 1989, white workers were 13.4 percentage points more likely to use computers at work than black workers. Fifteen years ago, when computers were a rarity, it was likely that the percentage gap in the use of computers between black and white workers was trivial. Thus, the direct effect of the lower use of computers by black workers may have led to an expansion of the black-white wage gap of roughly 2 points (= 15% x .134). Since the black-white earnings gap expanded by 5.6 points between 1976 and 1990, lower utilization of computers by black workers may be responsible for as much as one-third of the increase in the gap. Of course, this would be an overestimate if obtaining computer skills does not result in 15 percent higher income.

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[58]GLS was performed to allow for a within family correlation in residuals.

Computer-Aided Instruction and Student Achievement

In addition to preparing students for work, computer training in schools is intended to facilitate learning. Are computers effective teachers? Do students tend to learn more if they have undergone computer-aided instruction? Between 1976 and 1979, Educational Testing Service implemented an experimental evaluation of this question in the Los Angeles Unified School District.[59] The study used a complex randomized block design. In brief, students in grades 2-6 were randomly assigned to different amounts of time for computer-aided instruction, and to different CAI programs. Students who were assigned to no computer-aided instruction were taught with traditional teaching methods. The experiment ran for 3 years. The results supported a conclusion that student achievement on standardized tests increased if students were exposed to computer-aided instruction. Students who were assigned to CAI courses experienced statistically significant increases on math, computation, reading, and language tests compared to the control groups.[60] Because minority students are less likely to use computers in school, they are less likely to receive the academic benefits of computer-aided instruction.

III. Evidence on the Black-White Earnings Gap: 1973-90

We have estimated a series of human capital earnings equations to examine trends in earnings between black and white workers since the early 1970s. Specifically, we regress the log of the hourly wage rate on two race

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[59]See Ragosta, Holland and Jamison, 1982.

[60]A battery of tests were used for the evaluation, including the Iowa Tests of Basic Skills, Comprehensive Tests of Basic Skills, and curriculum specific tests.

dummies, years of education, experience and its square, a dummy variable indicating gender, veteran status, a part-time hours dummy, 8 region dummies, and an SMSA dummy. The regressions were estimated using CPS data from May 1973-1978, and the full-year outgoing rotation group files from 1979-1990.[61]

Figure 7 presents a graph of the black-white log hourly wage differential for workers age 16-65 after adjusting for the factors mentioned previously. The year to year fluctuations are large, even relative to the standard error of the estimates, which range from .003 to .007. Nevertheless, it is clear that there has been an upward trend in the magnitude of the black-white wage gap since the mid-1970s.[62] The black-white hourly wage gap for all workers has nearly doubled between 1976 and 1990, from -6.8 percent to -12.4 percent. Moreover, recent CPS data for 1991 indicate that the black-white earnings gap has continued to rise.[63] The expansion of the black-white wage gap contrasts with the declining wage gap observed between 1940 and 1970 with Census data.[64] Also, the annual March CPS files, which

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[61]The 1975 and 1976 May CPS's do not indicate residence in an SMSA. Consequently, we must exclude this variable in these years. In 1974, the black-white wage gap was .016 greater if the SMSA dummy was omitted, so we adjust the estimated black-white wage gaps for 1975-76 by this amount.

[62]This trend has been documented by other researchers. For example, see Bound and Freeman (1992) and Juhn, Murphy, and Pierce (1991).

[63]See Daily Labor Report, October 28, 1991, p. B-1.

[64]See Smith and Welch (1989).

provide a yearly picture, suggest that the black-white wage gap narrowed precipitously around the time the Civil Rights Act of 1964 took effect.[65]

Why has the black-white wage gap expanded? Bound and Freeman rule out as an explanation a decline in the enforcement of Federal Affirmative Action and equal employment policy because the gap began to expand in the Carter years.[66] Juhn, Murphy, and Pierce and others have argued that the black-white wage gap expanded because the price of skills increased, and because minority workers possess lower levels of skills on average as a result of having historically attended inferior schools.[67] In other words, their argument is that in the 1980s the wages of highly skilled workers have expanded relative to the wages of less skilled workers. If minority workers are disproportionately represented in the lower end of the skill distribution because of lower school quality, then the expansion in the wage gap may reflect an increase in the price of skills.

To explore these issues further, Figure 8 presents separate estimates for men, women, and young workers (age 25-34). The results show that the black-white wage gap increased by roughly the same magnitude for men and women. On the other hand, the gap increased substantially more for young workers than for all workers. This finding suggests that different cohorts of black workers were affected differently by whatever forces have caused the wage gap to expand.

Trends in the black-white earnings gap across cohorts have been studied extensively with Census data, which provide large samples. To extend this analysis, we compare the 1960, 1970, and 1980 Census results to the

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[65]See Freeman (1973).

[66]See Bound and Freeman (1992).

[67]See Juhn, Murphy, and Pierce (1991).

March 1990 and 1991 CPS files.[68] The results are contained in Table 13. The table reports the mean of the log of weekly earnings by race for various birth cohorts, and the change in mean log earnings for each cohort each decade. A few findings should be noted. First, between 1980 and 1990 the black-white wage gap for 21-60 year old men expanded by about 4 log points. This is a sharp contrast with the narrowing of the gap in the preceding decades (e.g., from -.388 to -.293 between 1970 and 1980).

Second, if we follow a given cohort over time, the black-white earnings gap tends to increase as the cohort ages for young cohorts, but tends to decrease as the cohort ages for older cohorts. Also, if we look across birth cohorts in a given year, the black-white wage gap tends to be larger for older cohorts.

Third, between 1980 and 1990 the increase in the black-white earnings gap has not been uniform across birth cohorts. The earnings gap expanded by 17 log points for the 1950-59 birth cohort, but hardly changed for the 1930-39 cohort. Because the school quality of a given cohort does not change over time, the increase in the black-white gap is not due to an erosion of school quality. Moreover, it is unlikely that a change in the return to skills is responsible for the increase in the earnings gap because, as documented in Section I, the school quality gap is smaller for the 1950-59 cohort than for the 1930-39 cohort. The 1930-39 cohort attended elementary and secondary school between 1936 and 1955, when black schools tended to have 10 to 20

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[68]The results for 1960-1980 are taken from Card and Krueger (1992a), Table 1. We pool together the 1990 and 1991 March CPS's to increase the sample size. The earnings variable is annual earnings in the preceding year divided by weeks worked. We used the CPI to convert earnings in 1989 into 1990 dollars. To the extent possible, we have defined the samples and variables to be comparable between the Census and March CPS's.

percent more students per teacher than white schools (see Figure 4); the 1950-59 cohort was educated in the post-Brown era.[69] Thus, a change in the price of skills would be expected to increase the black-white wage gap more for the older cohorts. Furthermore, Figure 8 indicates that the decline in black workers' relative earnings was greatest for young workers, so differential age-earnings profiles are not likely to be responsible for the cohort patterns.

On the other hand, the "active" labor market hypothesis suggests that wage structure changes occur more rapidly for young workers, who are more mobile and therefore more affected by market shocks. But even in this view, it is surprising that the black-white wage gap did not expand at all for the older cohorts of workers if the widening gap is due to an increase in the value of skills. Older workers, who may be relatively insulated from the market, still have been affected by the increase in the return to education. For example, Katz and Revenga find that the high school-college wage differential expanded for men with 25 years of experience in the 1980s.[70]

Finally, we have examined the economic return to education by race over time. In the past, many researchers have used estimates of the payoff to education as an alternative indicator of the quality of schooling for black and white workers.[71] Specifically, we used the CPS full-year outgoing rotation group files for 1979-1990 to estimate separate log-wage regressions by race

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[69]In terms of years of schooling, the gap between blacks and whites is much greater for the 1930-39 cohort than the 1950-59 cohort: on average, whites in the 1930-39 cohort have over 2 more years of schooling than blacks, whereas the gap in years of schooling is under one year for the 1950-59 cohort.

[70]See Katz and Revenga (1989).

[71]See for example Welch (1973).

and gender each year. The regressions controlled for years of education, marital status, experience and its square, part-time status, residence in an SMSA, and region of residence. Figure 9 plots the return to a year of education for men and women by race. The return to education follows roughly the same path over time for black and white women in the 1980s. For men, there is some weak evidence that the return to education increased by more for white workers than for black workers in the 1980s. Nevertheless, the time-series pattern of the estimated returns to education for black and white workers are roughly the same in the 1980s, suggesting that differences in education are not the primary cause of the expansion in the black-white wage gap.

In sum, the cohort patterns in Table 13 and the returns to schooling presented in Figure 9 provide little evidence that a change in the price of skills, or an erosion in the relative quality of schools for black workers, is responsible for the increase of the black-white earnings gap. More promising explanations for the increase in the gap are likely to involve structural factors examined by Bound and Freeman, such as the decline in unionization, the decline in the real minimum wage, and industrial shifts.

IV. Conclusion

This paper has assembled and analyzed a great deal of information regarding the quality of public schooling provided to black and white students since 1954. We draw six main lessons from our analysis.

(1) Wealth, not race, now seems to be the main determinant of the student-teacher ratio. Moreover, in spite of having lower family wealth, on average, black students and white students attend schools with roughly comparable pupil-teacher ratios, nationwide. In the Northeast, however, class sizes are larger for the average black student than for the average white student.

Hispanic students, on the other hand, attend schools with a higher pupil-teacher ratio than black or white students, on average. The larger class size for Hispanic students results mainly from their high representation in the West.

(2) Minority children are much less likely to be exposed to computers in school than white children, even after adjusting for family income. Minority children are also less likely to use computers at home than white children. Children from low-income families are less likely to use computers in school than children from high-income families.

(3) The decline in school segregation for black students in the South began on a wide scale around 1964, about 10 years after the Supreme Court's landmark decision in Brown vs. Board of Education. Significantly, the movement toward integration began about 4 years before the Green decision, which required mandatory desegregation plans. The federal government's refusal to give funds to segregated school districts may have precipitated the movement toward integration.

(4) Racial segregation in schools has been rising steadily for Hispanic students at least since 1968. Racial segregation in schools for black students has crept up in some regions and declined in others. Between 1968 and 1989, the Northeast has gone from being the least racially segregated region in the country to the most racially segregated region for black students, and the South has gone from being the most racially segregated region to the least. Moreover, black and Hispanic students in large, urban areas face extremely high levels of racial isolation.

(5) Although far from conclusive, evidence suggests that students who use computers in the classroom are more likely to obtain jobs that require

computer skills. Moreover, jobs that require the use of computers tend to pay a higher wage than jobs that do not require workers to use a computer. The widening gap in computer use between black and white workers can account for at most one-third, and probably much less, of the increase in the black-white earnings gap between 1976 and 1990.

(6) Between 1980 and 1990, the earnings gap between white and black workers expanded most for the 1950-59 cohort of workers, and least for the 1930-39 cohort. This finding is difficult to explain by either an erosion in school quality, or by an increase in the price of skilled labor.

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Table 1A: Percentage of Black Students in Predominantly Minority Schools

Area	1968	1972	1976	1980	1989
South	80.9	55.3	54.9	57.1	59.5
Border	71.6	67.2	60.1	59.2	58.5
Northeast	66.8	69.9	72.5	79.9	75.4
Midwest	77.3	75.3	70.3	69.5	69.7
West	72.2	68.1	67.4	66.8	68.5
U.S average	76.6	63.6	62.4	62.9	65.1

Table 1B: Percentage of Black Students in 90%-100% Minority Schools

Area	1968	1972	1976	1980	1989
South	77.8	24.7	22.4	23.0	26.0
Border	60.2	54.7	42.5	37.0	33.6
Northeast	42.7	46.9	51.4	48.7	49.9
Midwest	58.0	57.4	51.1	43.6	40.1
West	50.8	42.7	36.3	33.7	27.1
U.S average	64.3	38.7	35.9	33.2	33.8

Sources: Data for 1968-1980 are from Orfield (1983), p. 4, and are based on U.S. Department of Education data; data for 1989 are tabulated from the Public School Universe File, Department of Education. Data are unavailable for: Georgia, Idaho, Maine, Missouri, South Dakota, Virginia, and Wyoming. Predominantly minority means that over half of the students in the school are nonwhite.

Table 2A: Percentage of Hispanic Students in Predominantly Minority Schools

Area	1968	1972	1976	1980	1989
South	69.6	69.9	70.9	76.0	76.1
Border	--	--	--	--	--
Northeast	74.8	74.4	74.9	76.3	75.9
Midwest	31.8	34.4	39.3	46.6	53.1
West	42.4	44.7	52.7	63.5	71.6
U.S. average	54.8	56.6	60.8	68.1	72.0

Table 2B: Percentage of Hispanics Students in 90%-100% Minority Schools

Area	1968	1972	1976	1980	1989
South	33.7	31.4	32.2	37.3	38.5
Border	--	--	--	--	--
Northeast	44.0	44.1	45.8	45.8	43.0
Midwest	6.8	9.5	14.1	19.6	22.1
West	11.7	11.5	13.3	18.5	27.9
U.S average	23.1	23.3	24.8	28.8	32.7

Sources: Data for 1968-1980 are from Orfield (1983), p. 14, and are based on U.S. Department of Education data; data for 1989 are tabulated from the Public School Universe File, Department of Education. Data are unavailable for: Georgia, Idaho, Maine, Missouri, South Dakota, Virginia, and Wyoming. Results are not reported for Border states because the number of hispanic students is small. Predominantly minority means that over half of the students in the school are nonwhite.

Table 3: Pupil-Teacher Ratio for Black, Hispanic, and White Students in 1989

A. All grade levels

	Average P-T Ratio			Percent P-T Ratio > 25		
Area	Black	Hispanic	White	Black	Hispanic	White
South	17.8	17.9	17.9	1.4	2.7	1.8
Border	18.4	17.6	17.7	1.5	1.1	1.0
Northeast	16.4	16.2	15.8	1.1	0.8	1.0
Midwest	18.1	18.5	17.7	2.6	5.6	2.7
West	22.9	23.2	22.3	29.4	32.6	23.4
U.S average	18.1	20.3	18.3	4.2	17.1	6.2

B. Grammar schools only

	Average P-T Ratio			Percent P-T Ratio > 25		
Area	Black	Hispanic	White	Black	Hispanic	White
South	18.3	18.1	18.5	1.8	2.2	2.0
Border	19.6	18.7	18.6	1.7	1.6	1.7
Northeast	17.8	17.5	17.6	1.9	1.0	1.7
Midwest	18.9	18.9	18.9	3.7	5.0	4.3
West	23.9	24.1	23.4	38.1	43.0	23.4
U.S average	19.0	21.1	19.6	5.9	22.6	9.5

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Table 3: Pupil-Teacher Ratio for Black, Hispanic, and White Students in 1989. (Continued)

C. High schools only

	Average P-T Ratio			Percent P-T Ratio > 25		
Area	Black	Hispanic	White	Black	Hispanic	White
South	17.0	17.7	17.0	0.7	3.6	0.9
Border	16.9	16.0	16.8	0.3	0.0	0.2
Northeast	15.6	15.3	13.9	0.0	0.0	0.1
Midwest	16.8	16.9	16.3	0.2	0.4	0.5
West	22.0	22.5	21.2	20.5	23.7	12.7
U.S average	17.2	19.7	17.0	2.2	12.7	2.7

Source: Tabulated from the Common Core Data, Public School Universe File, Department of Education. Data are unavailable for Georgia, Idaho, Maine, Massachusetts, Missouri, Montana, Rhode Island, South Dakota, Virginia, and Wyoming.

Regions are defined as follows:

South: Alabama, Arkansas, Georgia, Florida, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Texas, and Virginia.

Border: Delaware, DC, Kentucky, Maryland, Missouri, Oklahoma, and West Virginia.

Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island and Vermont.

Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

West: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Table 4: Regressions of Pupil-Teacher Ratio on City Characteristics, by Race

Variable	Coefficients (SE)			Means		
	Black	White	Hispanic	Black	White	Hispanic
Intercept	17.101	17.193	15.566	1.000	1.000	1.000
	(.103)	(.086)	(.131)			
Grammar School	1.356	1.704	1.352	0.488	0.475	0.521
	(.034)	(.033)	(.038)			
High School	-0.423	-0.679	0.018	0.267	0.298	0.238
	(.039)	(.035)	(.045)			
Border	0.177	-0.119	-0.591	0.079	0.075	0.009
	(.055)	(.053)	(.168)			
Northeast	-1.866	-2.072	-2.224	0.168	0.175	0.125
	(.043)	(.040)	(.053)			
Midwest	-0.006	-0.161	0.563	0.203	0.301	0.071
	(.040)	(.035)	(.065)			
West	4.751	4.292	5.133	0.094	0.202	0.483
	(.052)	(.039)	(.037)			
Large City	1.109	0.923	2.675	0.341	0.056	0.337
	(.103)	(.095)	(.128)			
Medium City	-0.143	0.298	1.222	0.205	0.154	0.187
	(.104)	(.085)	(.130)			
Fringe of Large City	0.348	0.131	2.684	0.125	0.173	0.190
	(.108)	(.084)	(.130)			
Fringe of Medium City	0.002	0.525	1.882	0.099	0.141	0.076
	(.108)	(.086)	(.137)			
Rural Area	-0.128	-0.175	0.225	0.211	0.45	0.195
	(.104)	(.081)	(.130)			
R-Square	0.262	0.350	0.444			
Pupil-Teacher Ratio				18.16	18.36	20.33
Pupil-Teacher Ratio Using Whites Coeff's and Group's Means				18.26	18.36	20.12
Pupil-Teacher Ratio Using Group's Coeff's and White's Means				18.31	18.36	18.16

Table 5: Percentage of Students who use Computers in School, by Race

	1984	1989
All Grades		
White	36.3%	56.4%
Black	18.3	39.3
Hispanic	19.9	41.9
Grades 1-8		
White	38.5	60.9
Black	16.8	38.4
Hispanic	19.4	42.7
Grades 9-12		
White	31.8	45.5
Black	21.6	41.5
Hispanic	21.3	39.6

Source: Authors tabulations based on the October CPS, 1984 and 1989. Total sample size is 23,295 in 1989 and 25,067 in 1984. White is defined as white, nonhispanic, and black is defined as black, nonhispanic.

Table 6

Determinants of Computer Use in Schools; Linear Probability Models
(Dependent variable Equals 1 if Student Uses Computer in School)

Independent Variable	Model (1)	(2)	(3)	(4)
Intercept	0.564 (0.004)	0.749 (0.030)	0.768 (0.031)	0.663 (0.034)
Black (1=Yes)	-0.171 (0.009)	-0.167 (0.009)	-0.122 (0.010)	-0.093 (0.011)
Hispanic (1=Yes)	-0.144 (0.012)	-0.144 (0.012)	-0.105 (0.012)	-0.077 (0.013)
Female (1=Yes)	---	-0.010 (0.007)	-0.010 (0.006)	-0.009 (0.006)
Public School (1=Yes)	---	-0.010 (0.012)	-0.017 (0.012)	-0.005 (0.012)
Grade	---	0.018 (0.005)	0.018 (0.005)	0.011 (0.005)
Age	---	-0.026 (0.005)	-0.026 (0.005)	-0.020 (0.005)
Northeast (1=Yes)	---	---	0.034 (0.010)	0.038 (0.010)
Midwest (1=Yes)	---	---	0.018 (0.010)	0.024 (0.010)
South (1=Yes)	---	---	-0.053 (0.010)	-0.046 (0.010)
3 Urban Area Type Dummies Included	No	No	Yes	Yes
7 SMSA Size Dummies Included	No	No	Yes	Yes
14 Income Category Dummies Included	No	No	No	Yes
R-Squared	0.018	0.025	0.030	0.036

Notes: Standard errors are shown in parentheses. Sample size is 23,295.

The data set used is the October, 1989 Current Population Survey.

Table 7: Mean High School Characteristics By Race, 1980

(Standard Errors in Parentheses)

Characteristic	Weighted by Number of: Black Students	White Students
Proportion offering Computer Courses	.50 (.02)	.60 (.02)
No. of Computer Courses per 100 Students	.08 (.004)	.12 (.007)
Pupil-Teacher Ratio	19.41 (.14)	18.83 (.18)
Starting Teacher Salary (BA Degree)	$10,645 (41)	$10,485 (42)
Proportion of Teachers With MA/Ph.D.	.52 (.01)	.47 (.01)
Percent of Teachers who ive within 5 miles	33.43 (.84)	43.56 (.91)
Percent of Teachers with 10 or more years exper.	36.89 (.78)	40.36 (.78)
Percent of Teachers who are white	67.21 (.89)	94.63 (.32)
Term Length	180.80 (.18)	180.06 (.17)
Number of Library Books	5,890 (174)	6,159 (162)
School has Student Exchange Program	.38 (.02)	.58 (.02)
School is Under Court Desegregation Order	.47 (.02)	.14 (.01)
School in Urban Area	.49 (.02)	.14 (.01)
Number of Security Guards	2.28 (.10)	.66 (.05)

Notes: The two questions on computers pertain to 1982. The sample consists of 975 high schools, containing 207,301 black students and 771,291 white students. Teacher salaries are in 1980 dollars. Data set: High School and Beyond Survey, Schools File.

Table 8

Effects of Attending a Segregated High School on Educational and Labor Market Outcomes

	OLS				2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Independent Variable	Yrs of Education	Prop. Black in College	Prop. Co-Workers Black	Log Wage	Yrs of Education	Prop. Black in College	Prop. Co-Workers Black	Log Wage
Proportion Black in High School	-0.503 (0.232)	0.274 (0.055)	0.116 (0.049)	-0.115 (0.066)	-0.448 (0.609)	0.343 (0.142)	-0.037 (0.123)	-0.086 (0.145)
Female (1=Yes)	-0.332 (0.121)	0.019 (0.030)	0.013 (0.025)	-0.314 (0.033)	-0.332 (0.121)	0.019 (0.030)	0.013 (0.025)	-0.313 (0.033)
Quartic in Age	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State where grew up dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8 Region of residence dummies	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Sample Size	1102	396	575	696	1102	396	575	696
R-Squared	0.082	0.357	0.157	0.299	0.079	0.332	0.147	0.297
p-value for test of over-identifying restrictions	---	---	---	---	0.973	0.995	0.996	0.980

Note: Standard errors are shown in parentheses. The data set is the National Survey of Black Americans. Sample is limited to individuals age 25 to 65 who have completed at least 10 years of schooling. Columns 2 and 6 only include individuals who have completed at least one year of college. Excluded instruments for columns 5 through 8 are state where grew up dummies interected with a dummy indicating whether the individual attended high school after 1964.

Table 9: Percent of employees who use a computer at work, by race and education, 1984-89

Group	Black	Hispanic	White
		Year: 1984	
All	20.4%	16.8%	28.0%
Less than high school	3.2	1.5	7.5
High school	15.7	16.0	22.7
Some college	29.6	37.4	32.0
College	43.2	37.2	43.6
Post-college	49.3	45.8	45.8
		Year: 1989	
All	28.7%	24.1%	42.1%
Less than high school	3.5	5.7	9.8
High school	21.9	27.2	32.5
Some college	43.0	43.5	49.1
College	51.5	53.8	62.0
Post-college	54.9	72.4	63.6

Source: Tabulated from the October Current Population Survey, 1984 and 1989. Total sample size for 1984 is 25,067, and for 1989 is 23,295.

Table 10

Determinants of Computer Use at Work; Linear Probability Models
(Dependent variable Equals 1 if Computer used at Work)

Independent Variable	Model (1)	(2)
Intercept	0.120	0.035
	(0.009)	(1.545)
Used Computer in School	---	0.076
		(0.012)
Black (1-Yes)	-0.029	-0.014
	(0.013)	(0.015)
Other (1-Yes)	0.021	0.019
	(0.011)	(0.012)
Female (1-Yes)	0.095	0.079
	(0.009)	(0.011)
Senior in 1980 (1-Yes)	0.035	0.040
	(0.009)	(0.017)
Grade Point Average /100	---	0.201
		(0.072)
Achievement Test Score /100	---	0.170
		(0.071)
Age	---	-0.013
		(0.135)
Age-Squared	---	0.000
		(0.003)
8 Region Dummies Included	No	Yes
10 Dummies for Parents' Educ.	No	Yes
R-Squared	0.017	0.042

Notes: Standard errors are shown in parentheses. Column 2 also includes marital status dummy, married*female, union status, 2 dummies for type of high school, urban dummy, and a foreign born dummy. Sample size is 7,016. Data set is the High School and Beyond Survey, 1984 wave.

Table 11: OLS Regression Estimates of the Effect of Computer Use on Wages
Dependent variable: ln (hourly wage)

Independent Variable	October 1984 (1)	(2)	October 1989 (3)	(4)
Intercept	0.669	0.741	0.812	0.913
	(0.025)	(0.024)	(0.025)	(0.025)
Uses computer at work (1=yes)	---	0.213	---	0.221
		(0.009)		(0.008)
Black (1=yes)	-0.086	-0.078	-0.110	-0.089
	(0.013)	(0.013)	(0.013)	(0.013)
Hispanic (1=yes)	-0.052	-0.047	-0.016	-0.009
	(0.017)	(0.017)	(0.017)	(0.016)
Years of education	0.078	0.070	0.089	0.076
	(0.002)	(0.002)	(0.002)	(0.002)
Experience	0.032	0.031	0.032	0.031
	(0.001)	(0.001)	(0.001)	(0.001)
Experience-Squared / 100	-0.053	-0.050	-0.055	-0.050
	(0.002)	(0.002)	(0.003)	(0.002)
Female (1=yes)	-0.165	-0.191	-0.167	-0.198
	(0.013)	(0.013)	(0.012)	(0.012)
Married (1=yes)	0.188	0.177	0.184	0.168
	(0.011)	(0.012)	(0.012)	(0.012)
Married*Female	-0.236	-0.222	-0.197	-0.183
	(0.016)	(0.016)	(0.016)	(0.015)
Union member (1=yes)	0.194	0.208	0.184	0.202
	(0.010)	(0.010)	(0.011)	(0.010)
3 Region Dummies	Yes	Yes	Yes	Yes
R^2	0.384	0.411	0.385	0.417

Notes: Standard errors are shown in parentheses. Sample size is 12,945 for 1984 and 12,988 for 1989. Samples only include black, white, and hispanic workers.

Table 12: Effects of Computer Use in an Occupation on Earnings; Evidence from Twins

Independent Variable	All Twins		Identical Twins	
	GLS (1)	First Difference (2)	GLS (3)	First Difference (4)
Computer use in occupation	0.263 (0.083)	0.300 (0.112)	0.165 (0.099)	0.203 (0.134)
Tenure	0.021 (0.003)	0.027 (0.005)	0.024 (0.004)	0.029 (0.006)
Covered by Union	0.110 (0.056)	0.057 (0.072)	0.127 (0.071)	0.075 (0.090)
Married	0.044 (0.050)	0.054 (0.064)	0.095 (0.063)	0.145 (0.082)
Sample size	406	203	398	149
R-Squared	0.25	0.24	0.33	0.27

Notes: Standard errors are shown in parentheses. Columns 1 and 3 also include education, age and age-squared, nonwhite dummy, gender dummy, and an intercept. Columns 2 and 4 also include education and an intercept. Computer use in occupation is the proportion of workers in the individual's three-digit occupation who use a computer at work.

Table 13

Mean Log Wages and Wage Differentials By Cohort in 1960, 1970, 1980, and 1990

Cohort:	1950 Whites	1950 Blacks	1970 Whites	1970 Blacks	1980 Whites	1980 Blacks	1990 Whites	1990 Blacks	Log Wage Differential Black - White 1960	1970	1980	1990
1900-1909												
Mean Log Wage	4.611	4.083							-0.332			
Std Error	(0.003)	(0.008)							(0.003)			
1910-1919												
Mean Log Wage	4.560	4.132	5.123	4.613					-0.328	-0.310		
Std Error	(0.002)	(0.007)	(0.002)	(0.006)					(0.007)	(0.006)		
1920-1929												
Mean Log Wage	4.667	4.170	5.200	4.726	5.821	5.346			-0.496	-0.483	-0.373	
Std Error	(0.002)	(0.008)	(0.001)	(0.005)	(0.002)	(0.004)			(0.006)	(0.005)	(0.003)	
1930-1939												
Mean Log Wage	4.311	3.831	5.163	4.747	5.939	5.613	6.368	6.022	-0.379	-0.416	-0.344	-0.346
Std Error	(0.002)	(0.006)	(0.001)	(0.004)	(0.002)	(0.004)	(0.006)	(0.027)	(0.007)	(0.005)	(0.004)	(0.020)
1940-1949												
Mean Log Wage			4.710	4.341	5.836	5.576	6.424	6.075		-0.218	-0.282	-0.349
Std Error			(0.001)	(0.004)	(0.002)	(0.003)	(0.006)	(0.019)		(0.005)	(0.003)	(0.020)
1950-1959												
Mean Log Wage					5.416	5.213	6.283	5.913			-0.203	-0.370
Std Error					(0.001)	(0.003)	(0.003)	(0.016)			(0.003)	(0.017)
1960-1969												
Mean Log Wage							5.864	5.636				-0.228
Std Error							(0.003)	(0.015)				(0.016)
All Ages 21-59												
Mean Log Wage	4.384	4.083	5.041	4.652	5.732	5.439	6.101	5.881	-0.460	-0.388	-0.293	-0.330
Std Error	(0.001)	(0.003)	(0.001)	(0.002)	(0.001)	(0.002)	(0.003)	(0.008)	(0.003)	(0.003)	(0.002)	(0.009)
Mean Wage	111.2	89.5	183.3	122.8	288.1	276.4	602.7	431.3				
Ratio of Arithmetic Means of Blacks/Whites		0.824		0.671		0.749		0.716				

Notes: Based on tabulations of weekly earnings of men born in the 48 mainland states in Public-Use Extracts of the 1960, 1970, and 1980 Censuses, and based on the March CPS for 1990-91.

Appendix Table 1
School Segregation in the South and Border States, 1924-71
Proportion of Black Students who Attended All Black or Majority Black Schools

Year	Sample Size	All Black	Majority Black
1924	70	0.953	1.000
1925	48	0.960	0.960
1926	66	1.000	1.000
1927	57	0.971	0.971
1928	46	0.897	0.931
1929	65	0.921	0.947
1930	39	0.955	0.955
1931	73	0.958	0.979
1932	40	0.880	0.920
1933	54	0.971	0.971
1934	52	0.974	1.000
1935	56	0.925	0.950
1936	67	0.922	0.961
1937	60	0.976	1.000
1938	62	0.947	0.974
1939	61	0.974	1.000
1940	62	0.930	0.977
1941	70	0.926	1.000
1942	75	0.903	0.952
1943	74	0.915	0.983
1944	66	0.944	0.963
1945	57	0.957	1.000
1946	54	1.000	1.000
1947	65	0.926	0.981
1948	68	0.981	1.000
1949	68	0.881	0.932
1950	71	0.930	1.000
1951	58	0.887	0.962
1952	75	0.903	0.952
1953	55	0.938	0.979
1954	74	0.883	0.950
1955	72	0.928	0.986
1956	76	0.910	0.955
1957	74	0.955	0.985
1958	79	0.880	0.960
1959	80	0.849	0.945
1960	81	0.924	0.962
1961	83	0.866	0.927
1962	90	0.869	0.976
1963	86	0.864	0.938
1964	102	0.796	0.888
1965	86	0.753	0.840
1966	97	0.656	0.823
1967	78	0.618	0.737
1968	79	0.500	0.711
1969	95	0.484	0.615
1970	88	0.329	0.588
1971	85	0.150	0.463

Appendix Table 2
Pupil-Teacher Ratios by State in 1989 from the Common Core of Data Surveys, Public School Universe File

Number of Schools	State	Average Pupil-Teacher Ratio		
		Blacks	Hispanics	Whites
1287	AL	19.0894	19.2522	19.7255
1095	AR	15.8520	16.3082	16.0131
953	AZ	20.1055	20.1686	20.7494
7293	CA	23.8511	24.3286	23.9680
1301	CO	17.6717	17.8696	18.7698
966	CT	15.0755	15.4574	14.7765
182	DC	18.0986	16.9703	18.5524
164	DE	17.9164	17.3726	17.7218
2217	FL	17.8716	18.7650	18.1882
1606	IA	17.1897	16.7259	16.1367
4134	IL	18.7467	19.4142	18.2635
1855	IN	18.3088	19.1723	18.6283
1455	KS	17.8955	16.9984	16.1701
1359	KY	17.7413	18.3033	18.1012
1460	LA	17.3846	17.5099	17.3882
1178	MD	18.7940	17.6544	18.3017
3266	MI	17.1696	15.9421	15.6980
1487	MN	18.4731	17.9207	18.3243
873	MS	19.1361	19.0542	19.1297
1935	NC	16.9398	17.8275	17.2231
627	ND	22.3619	19.9759	19.1452
1475	NE	17.4660	16.5916	15.7266
443	NH	17.5397	18.2992	16.9796
2237	NJ	15.1145	15.1307	15.1251
654	NM	19.0342	18.7171	19.2739
323	NV	21.5741	21.2390	21.6187
3936	NY	16.6486	16.6518	15.0767
3683	OH	18.1587	18.9292	19.6431
1831	OK	18.3513	17.6333	17.4738
1188	OR	18.9808	19.3807	19.3816
3165	PA	17.1393	16.8294	16.7979
1045	SC	17.2737	18.1471	18.0679
1499	TN	19.9792	20.0756	20.0556
5780	TX	17.0565	17.7840	16.9726
708	UT	23.4357	23.4461	24.7833
335	VT	18.3373	17.3376	18.0864
1632	WA	20.2846	20.4039	21.2567
2008	WI	17.5071	17.4744	16.6285
975	WV	15.9024	16.8722	16.4946
69,610	US Average	18.1295	20.3037	18.3459

Appendix Table 3

Estimates of Students' Computer Use by State and Race

State	Sample Size for All Races	Percent of Students Using Computers at School by Race		
		All Races	Black	White
Alabama	274	38.7	36.4	39.1
Alaska	340	65.9	--	66.5
Arizona	257	54.5	--	58.1
Arkansas	322	44.7	26.0	48.3
California	1487	44.1	40.4	49.4
Colorado	276	65.6	--	65.9
Connecticut	210	51.9	--	54.8
D.C.	138	48.6	46.1	61.9
Delaware	234	41.9	32.8	45.3
Florida	1018	52.0	46.9	55.4
Georgia	340	51.5	46.3	54.9
Hawaii	95	57.9	--	58.1
Idaho	389	44.7	--	46.4
Illinois	1024	52.8	31.0	62.0
Indiana	327	49.9	--	51.6
Iowa	320	62.2	--	62.7
Kansas	317	66.3	--	67.0
Kentucky	292	61.0	--	61.5
Louisiana	301	35.0	30.4	37.2
Maine	257	68.1	--	68.0
Maryland	212	47.2	42.5	50.4
Massachusetts	790	58.5	43.2	60.6
Michigan	983	51.2	39.6	53.1
Minnesota	285	71.6	--	72.4
Mississippi	375	30.9	24.5	35.9
Missouri	241	56.0	--	54.5
Montana	342	57.3	--	56.4
North Carolina	949	54.4	43.4	57.9
North Dakota	326	62.3	--	62.5
Nebraska	327	62.4	--	61.6
Nevada	249	57.0	--	57.5
New Hampshire	203	58.1	--	57.8
New Mexico	335	55.2	--	63.0
New Jersey	778	53.7	33.6	59.9
New York	1362	52.7	46.0	57.7
Ohio	1161	50.2	36.7	52.1
Oklahoma	288	52.8	--	54.6
Oregon	249	53.0	--	53.6
Pennsylvania	925	56.9	40.0	59.0
Rhode Island	208	49.0	--	49.5
South Dakota	397	36.9	--	36.4
South Carolina	396	41.8	37.4	44.7

- Continued -

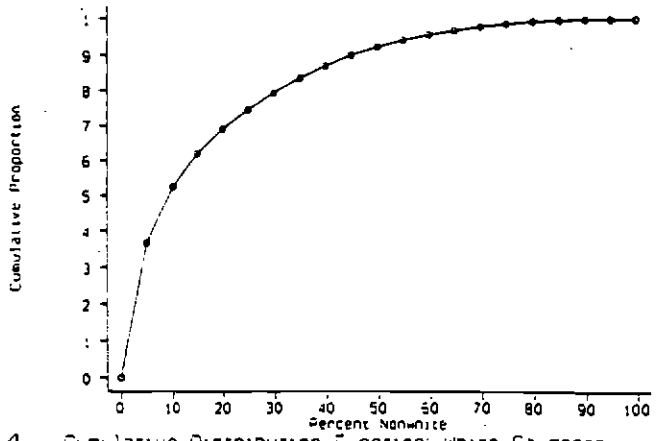
Appendix Table 3 -- Continued

State	Sample Size for All Races	Percent of Students Using Computers at School by Race		
		All Races	Black	White
Tennessee	311	45.9	30.8	54.6
Texas	1245	53.8	24.7	54.0
Utah	439	45.7	--	47.9
Virginia	357	64.3	39.6	64.3
Vermont	185	52.2	--	53.0
West Virginia	309	53.1	--	53.4
Washington	245	75.5	--	75.9
Wisconsin	328	66.8	--	66.9
Wyoming	277	75.5	--	75.9
US Average	23295	52.7	39.3	56.4

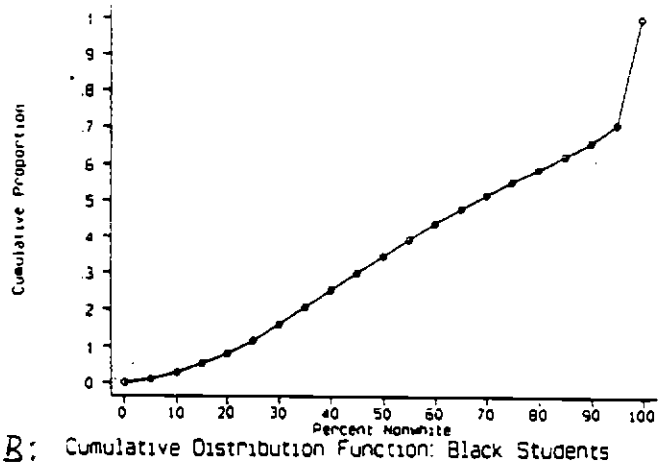
Source: Authors' calculations based on the Current Population Survey, October 1989

Notes: We do not report estimates for states for which there are fewer than 40 observations in the sample. The sample includes students enrolled in public and private schools.

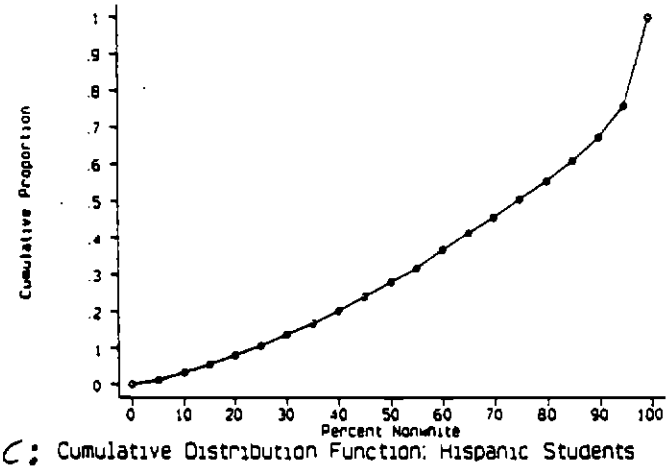
Figure 1



A: Cumulative Distribution Function: White Students

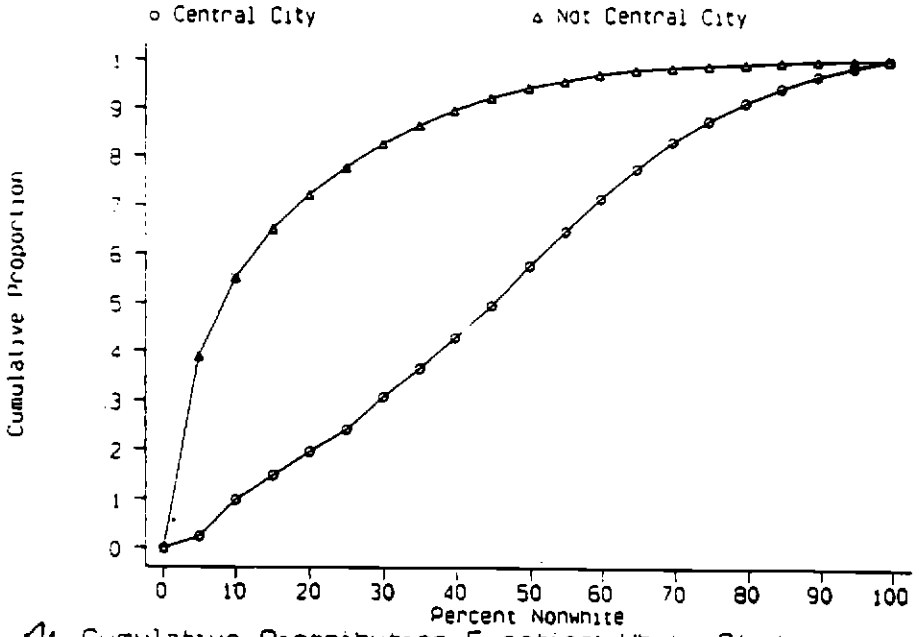


B: Cumulative Distribution Function: Black Students

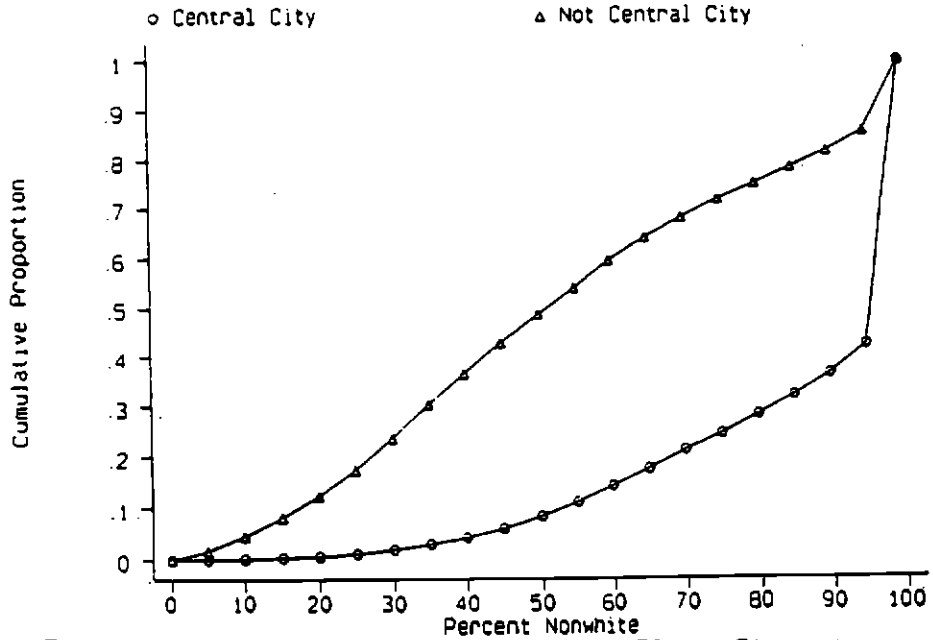


C: Cumulative Distribution Function: Hispanic Students

Figure 2



A: Cumulative Distribution Function: White Students



B: Cumulative Distribution Function: Black Students

Figure 3

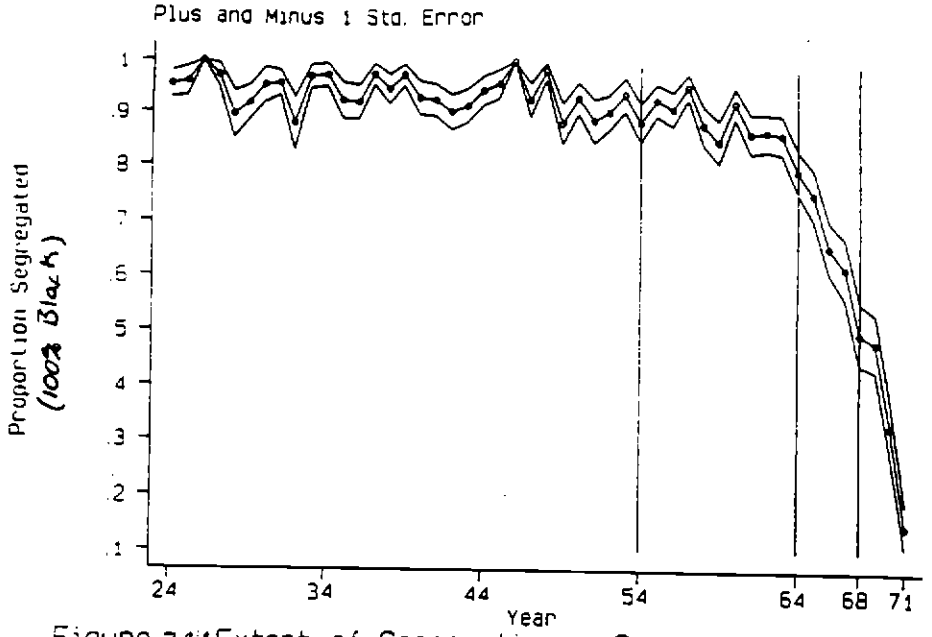


Figure 3A: Extent of Segregation - South and Border

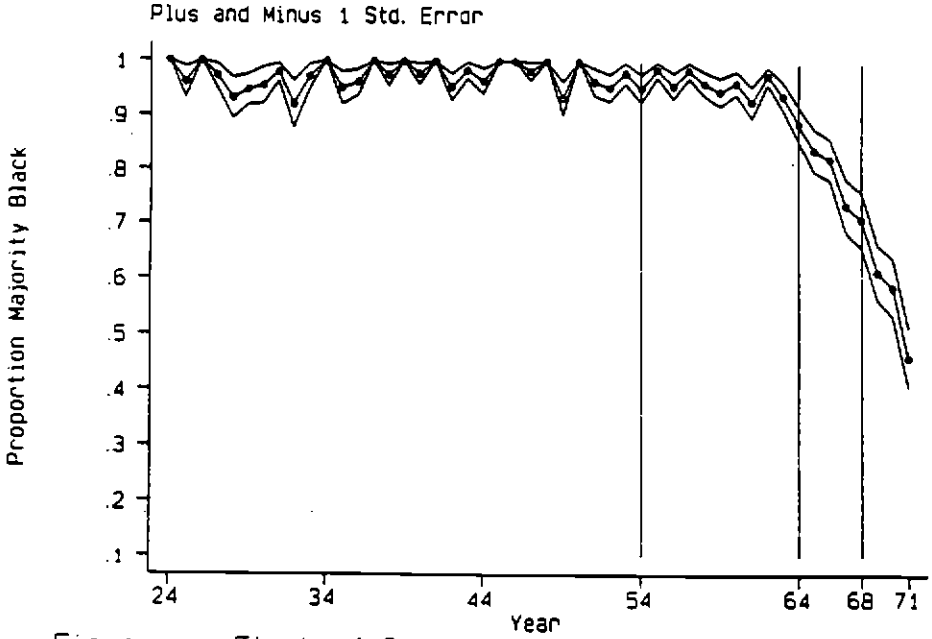


Figure 3B: Extent of Segregation - South and Border

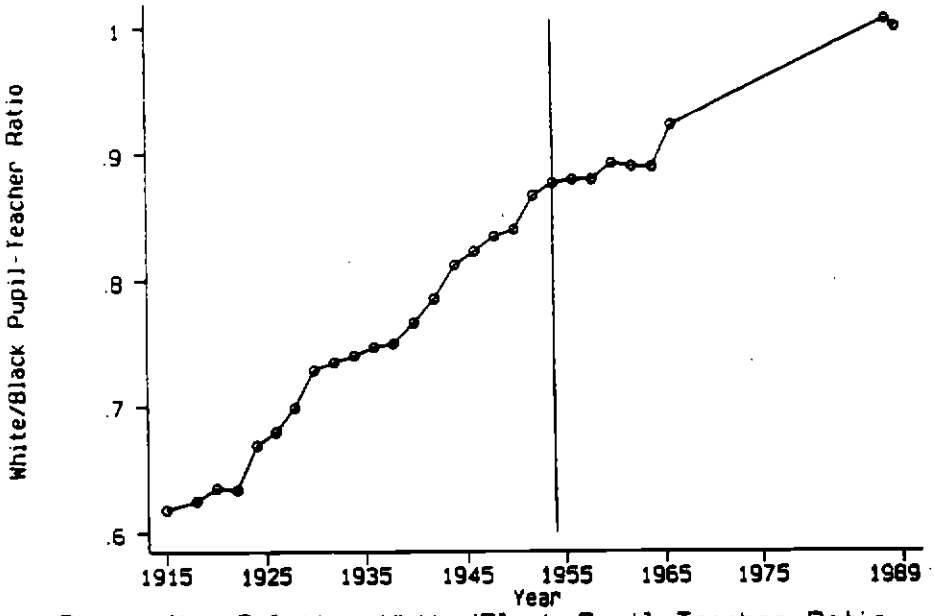


Figure 4A: Relative White/Black Pupil-Teacher Ratio

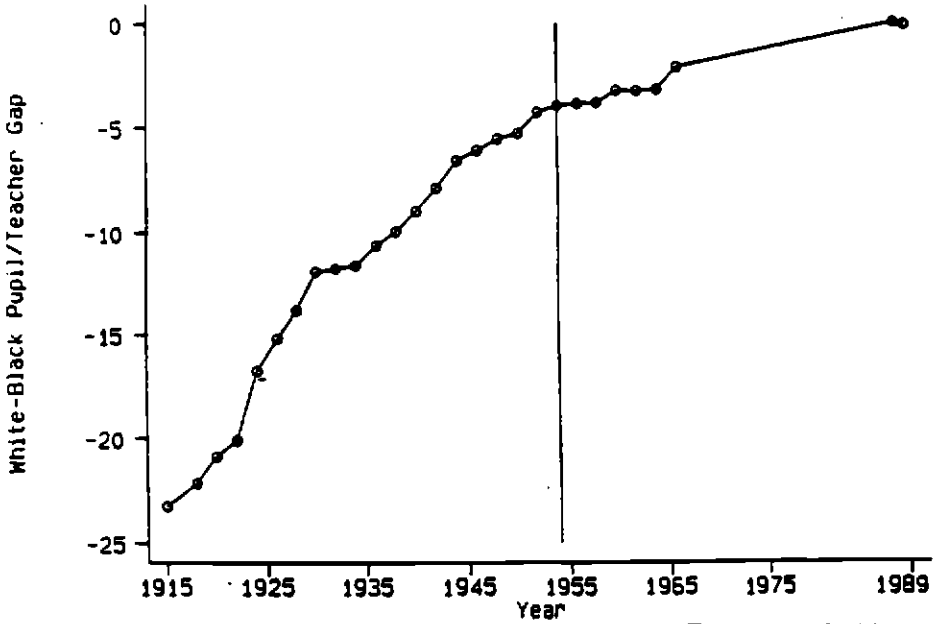


Figure 4B: White - Black Gap in Pupil-Teacher Ratio

Figure 5

Relative School Quality vs. Percent of Population that is Black

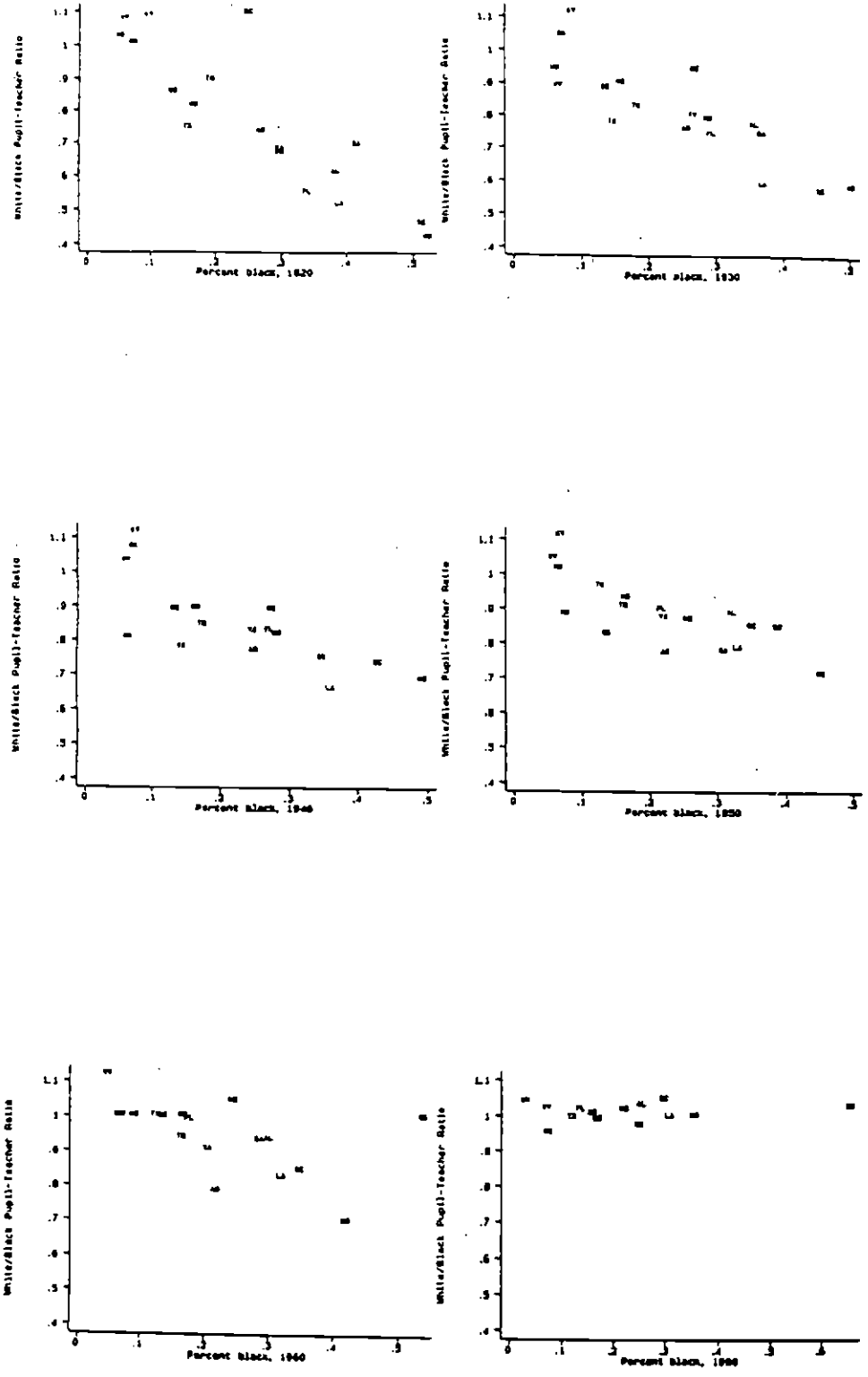


Figure 6: Pupil-Teacher Ratio vs. Land Value; Massachusetts

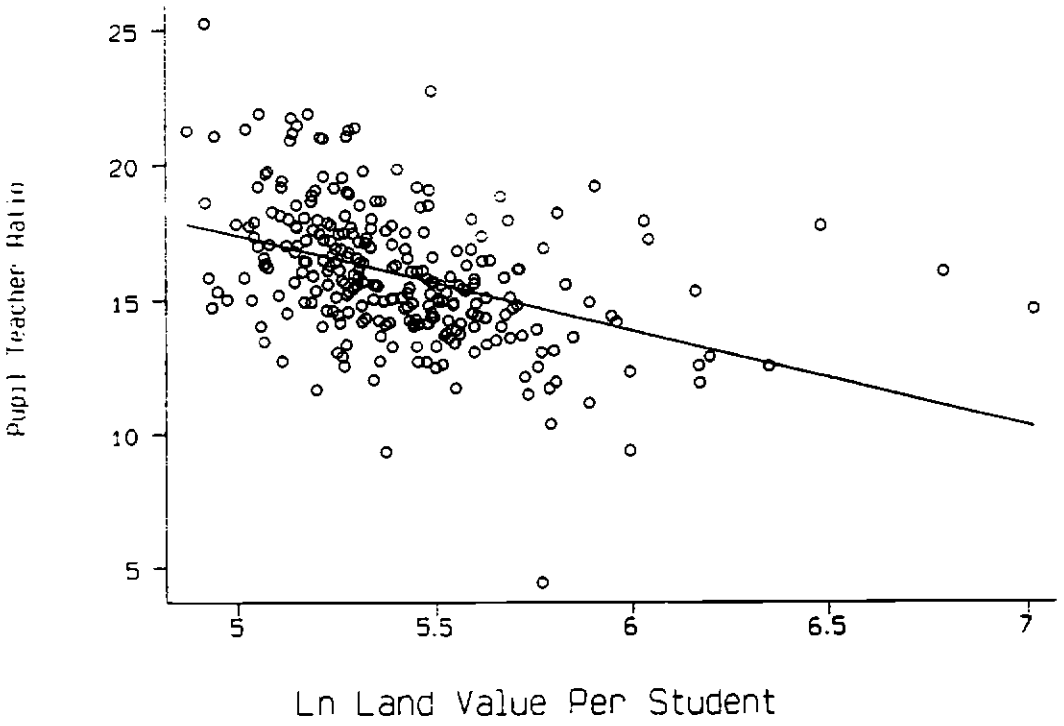


Figure 7

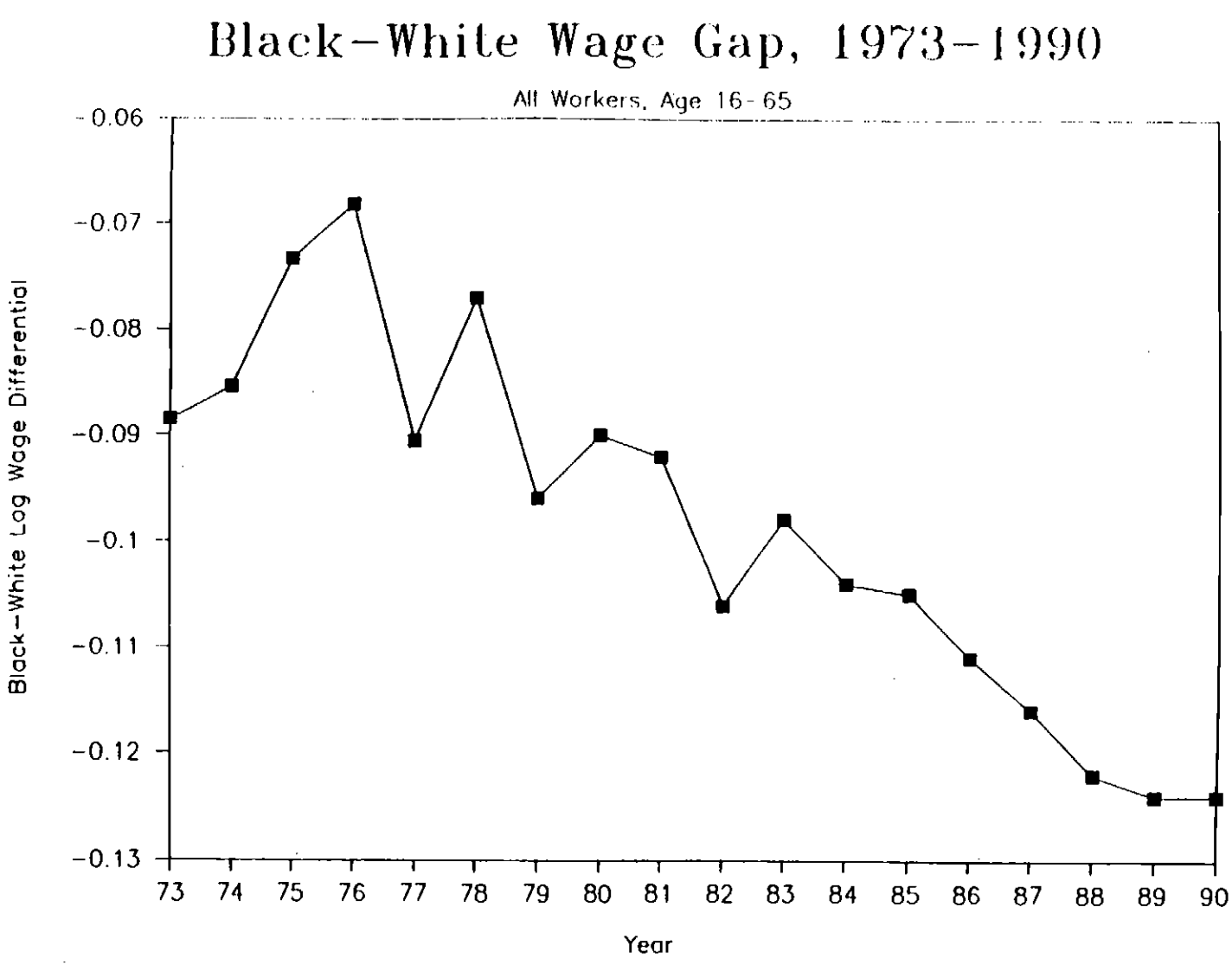

Black–White Wage Gap, 1973–1990
All Workers, Age 16-65
Black–White Log Wage Differential
-0.06
-0.07
-0.08
-0.09
-0.1
-0.11
-0.12
-0.13
73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
Year

Figure 8

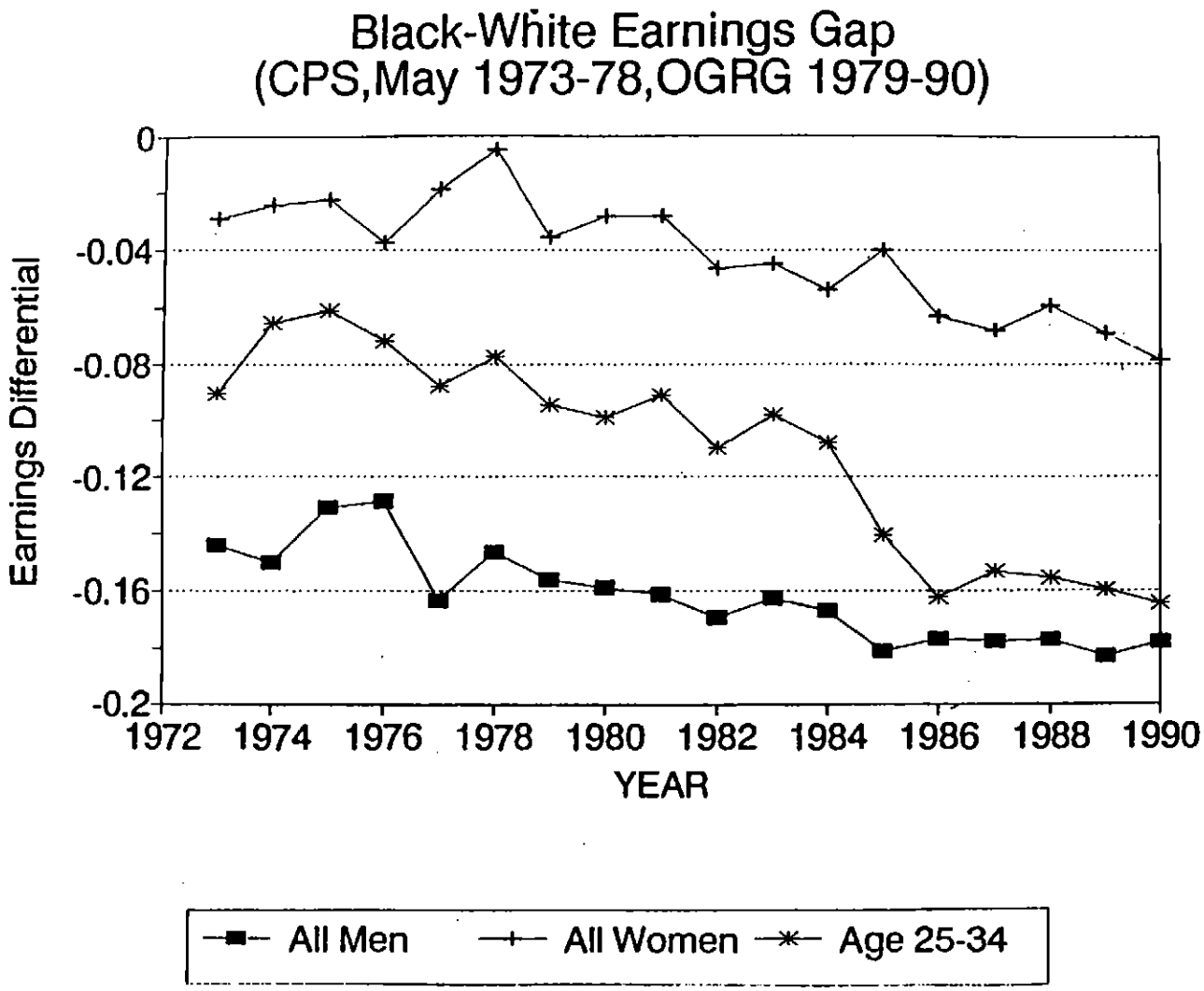

Black-White Earnings Gap
(CPS,May 1973-78,OGRG 1979-90)
Earnings Differential
0
-0.04
-0.08
-0.12
-0.16
-0.2
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
YEAR
All Men
All Women
Age 25-34

Figure 9

RETURNS TO EDUCATION, BY RACE AND SEX
(CPS OGRG Files, 1979-90)