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**ACHIEVEMENT, TEST SCORES
AND
RELATIVE WAGES**

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ACHIEVEMENT, TEST SCORES AND RELATIVE WAGES

During the postwar period the US has experienced large gyrations in the academic achievement of high school graduates and in the return to a college education. The test scores of students completing high school which had been rising continuously since World War I, peaked in 1965-67 and declined 1.25 grade level equivalents by 1979. At that point a recovery began which has returned test scores to the levels achieved in 1966.¹ Trends in the payoff to college have followed a remarkably similar path. The college wage premium was quite low in the years immediately following World War II but once the market had digested the large cohort of GI Bill graduates, the college premium grew substantially during the 1950s and early 60's. For men with 1 to 5 years of post-school work experience the wage premium appears to have peaked at 41 percent in the middle 1960's after which a slow decline set in with a trough occurring in the late 1970s at 28 percent. Since then the college premium for men with 1-5 years of experience has boomed and it has now reached 70 percent.²

This article examines the causal connections between these two phenomena: changes in the academic achievement of high school graduates and changes in the payoff to college. Four specific questions are addressed. The questions and the answers generated by our examination of the data are outlined below:

1. Did the postwar cycles in the payoff to college contribute to the rise, then fall, then rise of academic achievement levels of students completing their high school education?

Apparently, yes. The timing of the peaks and the troughs of these two series is remarkably coincident in the postwar period and students living in communities with high rates of return to college are more likely to take college preparatory courses in high school.

2. Did the test score decline slow the growth of the aggregate supply of well educated workers? Did it contribute to the recent general escalation in the payoff to college?

Yes. If a grade level equivalent metric is used for the calculation, the test

score decline caused almost as large a deceleration in the growth of workforce quality during the 1980s as the slowdown in the growth of mean years of schooling. The deceleration in the growth of both the quantity and quality of schooling is one of the reasons why the college premium rose during the 1980's.

3. What has happened to the academic achievement of college graduates? Did the relative quality of college graduates fall during the 1970s and grow during the 1980s and did this in turn contribute to recent increases in the payoff to college for recent cohorts of college graduates? Yes. **Test scores of college graduates did decline in the early 1970s but not by as much as high school test scores. Consequently, the relative quality of recent college graduates hit bottom in 1975 and has been increasing ever since. Shifts toward more remunerative majors have also improved the relative wage of recent college graduates during the 1980's.**
4. Did the overall shortage of well educated workers during the 1980s cause increases in the wage payoff to academic achievements not signaled by school credentials? **Apparently, no. For workers under the age of 30, the payoff to years of college and to work experience increased substantially during the 1980s but the payoff to higher test scores did not.**

Each of these questions is taken up in turn.

I. The Impact of the Payoff to College on Effort and Achievement in High School

Probably the most important connection between relative wage trends and test score trends is the impact of the payoff to college on the incentive to study in high school. Academic achievement in high school has important effects on the probability of attending college, the quality of college attended and the probability of completing college but, as we will see shortly in section 4 of this paper, achievement in science, mathematical reasoning, reading and vocabulary has almost no effect during the decade following graduation on the wage rates and earnings of those not going to college.³ Consequently, the payoff to the

college degree is a primary determinant of the economic payoff to studying in high school. This suggests that the magnitude of the payoff to college may influence course taking and effort in high school. This issue can be examined in both time series and cross section data. Let us begin by reviewing how test scores of high school students have changed over time.

Test Score Trends: For the post-WWII era, the best data on trends in the general intellectual achievement of students nearing completion of compulsory schooling comes from the Iowa Test of Educational Development (ITED). This data set is extremely valuable because it provides equated data extending back to 1942 and annual data from 1960 to the present. Because about 95 percent of the public and private schools in the state of Iowa regularly participated in the testing program, the analyses of trends in ITED data for Iowa is not plagued by changing selectivity of the population taking the test. This feature of the data makes ITED trends for Iowa a better representation of national trends prior to 1970 than the ACT, the SAT, and the American Council on Education Psychological Exam. Since these other tests were taken at first by a highly selected group of students and only more recently by more representative samples of college bound students so trends in scores on these tests are biased by the decreasing selectivity of those who took the test.

Figure 1 plots the trends of ITED composite scores for Iowa 11th and 12th graders. Through 1965 the trend was up: at first moderately so, and then dramatically after Sputnik.⁴ The gains for 12th graders between 1942 and 1966 are all the more remarkable for they coincide with an increase in the high school graduation rate in Iowa from 65 percent in 1941 to 88 percent in 1968.

In 1966 the educational achievement of high school students stopped rising and began a decline that lasted about 13 years. On the ITED the composite scores of Iowa 9th graders dropped .283 SDs and the scores of seniors dropped .35 SDs or about 1.25 grade level equivalents. Comparable declines occurred throughout the country and for upper elementary and junior high school students as well.⁵

It appears that recent efforts to improve the quality and rigor of the curriculum have had an effect, as test scores are rising again. By 1988 Iowa 12th graders had recouped about three-quarters of their previous decline and ninth graders had surpassed their 1965 record by almost two-fifths of a grade level equivalent. SAT and ACT scores have risen as well though at a slower rate because of increases during the 1980s in the proportion of high school graduates taking these tests.

College Payoff Trends: The wage premium received by those with a college education has also varied a great deal over the course of the last 60 years. The ratio of the weekly earnings of five high level professional occupations to the weekly earnings of manufacturing production workers fell substantially during the depression and World War II from 3.3 in 1929, to 2.88 in 1939 and 2.46 in 1950.⁶ Professional wages then rebounded and the ratio rose to 2.9 in 1964. Decennial census data on the payoff to college for men with limited amounts of post school work experience exhibit a similar pattern. The ratio of the incomes of 25 to 35 year old white males with four or more years of college to the incomes of 20 to 29 year old high school graduates was 1.99 in 1939, 1.45 in 1949, 1.68 in 1959 and 1.76 in 1969 (see figure 1).⁷ Figure 1 also presents Katz and Murphy's estimates of college/high school weekly earnings ratio for workers with less than 5 years of post-school work experience. Their carefully constructed series indicates that the wage premium for college degree holders with under 5 years of work experience fell from 51 percent in 1963-64 to 44 percent in 1979-80 and then rose to 84 percent in 1988.⁸ Marvin Kosters' data on trends in the payoff to college tell the same story. He calculated that the college-high school hourly wage differential for workers of all experience levels fell from 49 percent in 1973 to 40-41 percent in 1979 for both men and women and then grew rapidly in the 1980s, reaching 82 percent for men and 52 percent for women by 1988 (see Chapter 1).

Comparing Trends: The time-series data for the postwar period appear to suggest that changes in the economic payoff to college for young and inexperienced workers ~~appear to~~ influence the academic achievement of students in high school. Both the college payoff and test scores rose during the 1950s and peaked during the 1960s. The two series then decline together and starting in 1979-80 they start up together. When the average 11th and 12th grade ITED test score is regressed on the logarithm of the current college graduate/high school graduate weekly earnings ratio and a trend, one obtains the following results:

$$\text{ITEDAV} = 22.07 + 1.41 * \log(\text{CollegeWage}/\text{HSWage}) - .0114 * \text{YEAR} \quad R^2 = .78 \\ (5.56) \quad (7.92) \qquad \qquad \qquad (3.70) \quad 1969-1987$$

The results suggest that the decline in the payoff to college between 1969 and 1979 lowered test scores by 15 percent of a standard deviation (about half the total decline in academic achievement at the end of high school) and the rise between 1979 and 1987 raised test scores by 29 percent of a standard deviation.

Further support for the hypothesis comes from the fact that categories of students who have higher than average probabilities of attending college--white students, suburban students and college going students--experienced larger than average test score declines between 1966 and 1979.⁹ On the other hand, test scores and the payoff to college moved in opposite directions during the 1930s and 1940s and there are other plausible explanations of the post 1966 test score decline and rebound. There was, for example, in the late 1960s and early 1970s, a series of EEOC and court decisions which forced most companies to drop the use of basic skills tests assessing verbal and mathematical competence as selection devices.¹⁰ This probably lowered the rewards for studying for the non-college bound and this might have in turn influenced their effort in high school. In addition, graduation requirements and teacher expectations appear to have followed the same kind of cycle. Consequently, this examination of aggregate time series data provides only suggestive evidence regarding the link between rates of return to college and academic performance in high school.

Cross Section Evidence: Cross section data provide a second opportunity to examine how the college payoff influences the behavior of high school students. There is spatial variation in the future payoffs to college education so, if most young people intend to remain in the local labor market after school, one would expect geographic differentials in the payoff to effect (a) the number of college prep courses taken in high school, (b) the time spent studying and (c) the probability of attending college. In previous work I have found that a rather crude measure of the college payoff--the average differential between accountant's, teacher's and engineer's wages and operative wages--had significant positive effects on the college attendance rates of ~~young men~~ in the top 75 percent of the ability distribution.¹¹

Table 1 presents linear regression estimates of the effect of college payoff, academic orientation of courses and study time on the subsequent college attendance of 27,046 high school juniors at Project Talent high schools in 1960. Separate models were estimated for students categorized by family income. The control variables included in the regression are listed at the bottom of the table. Academic orientation of courses has substantial positive effects on college attendance and hours of study has modest positive effects. The college payoff variable has significant direct effects on college attendance rates of students from low and moderate income families even when hours spent studying, the academic orientation of courses and aptitude are controlled.¹² Since students probably base judgments about the reward

to college on both local and national data, these results are probably a lower bound estimate of the aggregate effect of a nation wide change in the payoff to college.

Do, however, prospective payoffs to college influence behavior of students while they are in high school? To explore this issue, our measure of the college payoff was included in models predicting the number of college prep courses taken through the junior year of high school and the weekly number of hours spent studying including in-school study periods. The standardized regression coefficients (representing the effect of a 20 percent change in the payoff to college) are presented in Table 2. The findings are that students living in labor markets with a large college payoff take additional academic courses but they do not spend more time studying. The absence of the expected positive effect of payoff on hours studying may be due to the inclusion in the study time variable of in school study periods, for college bound students typically take heavier course loads and consequently schedule fewer study periods.

We view this evidence as suggesting that the decline in the payoff to college for young workers during the late 1960s and 1970s probably contributed to the test score decline. A reliable estimate of the magnitude of this response does not appear feasible at this time, however. We will now turn to the effects of the test score decline on wage profiles. The next section of the paper examines the impact of recent slow downs in the improvement in the quality and the quantity of educated workers on trends in the overall payoff to college?

II. The Effect of the Test Score Decline on the Aggregate Supply and Relative Wage of Well Educated Workers

During the past century a rapidly expanding supply of college graduates has raced a fast growing demand for the skills developed at colleges and universities. When supply grows faster than demand, the payoff to college falls. That is what was happening during the 1970s when the payoff to college for males was declining at a yearly rate of .46 to .93 percent per year (see bottom panel of Table 3). When demand grows more rapidly than supply, the payoff to college rises. That is what happened during the 1980s when the college payoff for males rose at an unprecedented rate of 2.08 to 2.83 percent per year.¹³ What caused this change? Was there a deceleration in the growth of relative supply of college graduates or was there an acceleration in the growth of the relative demand for college graduates?

Elsewhere in this volume Murphy and Welch suggest that the recent trade deficit and the resulting decline of US manufacturing may have contributed significantly to the large real wage declines suffered by high school graduates and the relative gains of college graduates. Bound and Johnson point out, however, that some of the industries which are heavy employers of college graduates--education and government--also experienced declines in their employment share and that the net effect of all shifts in the industrial composition of employment on the relative demand for college graduates was essentially zero. Consequently, if the outward shift in relative demand for college graduates, indeed, accelerated after 1979, its cause must be sought within industries. The two most likely causes of an acceleration of historical up-skilling trends are the micro-computer revolution and the transfer to Mexico and overseas of production activities which do not require a great deal of skill.

The other possible source of a pervasive increase in the payoff to college is the sudden deceleration during the late 1970s of the increase in the relative supply of college graduates and of skilled workers generally. An examination of Figure 2's data on bachelors degrees awarded reveals that there was indeed a significant deceleration in the growth of the college educated work force during the late 1970s and 1980s. Bachelors degrees awarded rose rapidly in the first three decades of the postwar period. However, the peak was reached in 1974 for men and numbers of degrees awarded to men is still nearly 50,000 below that peak. Bachelors degrees awarded to women has grown sluggishly since 1974. The deceleration in

the growth of the college share for all men and women 18 to 65 years old is rather modest--from 3.7 percent per year for 1973 to 1979 to 2.7 percent per year for 1979 to 1987--but it is larger for men and for younger workers, the groups which experienced the largest increases in the payoff to college.¹⁴ Rates of growth of workers with 12 or fewer years of schooling also changed. The ratio of employed college graduates in the labor force to workers with 12 or fewer years of schooling, which rose by 5.27 percent per year between 1972 and 1980, grew at the slower rate of 3.92 percent per year between 1980 and 1988.¹⁵

In fact, however, the aggregate number of degrees granted by American colleges and universities during 1980s was significantly smaller than the growth in the numbers of people reporting 16 or more years of schooling to CPS interviewers so the deceleration in the true growth of college graduate supply appears to be larger still. Adkins has compared estimates of the stock of people who have completed 16 or more years of schooling in Census and CPS data to estimates of the number of college graduates based on cumulating degrees awarded and reconciled the differences for 1959, 1966 and 1970. He concludes that after appropriate adjustments are made, the two data sources yield remarkably similar estimates. When Adkins' reconciliation methodology is applied to the growth of college degrees after 1970 similar results are obtained for the 1970s. During the 1970s colleges awarded 8,523,000 bachelors degrees and the number of individuals born after 1925 claiming 16+ years of schooling increased by 10,675,000. Immigration probably accounts for about 809,000 of this discrepancy and individuals with 16 years of schooling but no degree for the rest.¹⁶

The growth in the number of bachelors degrees awarded decelerated dramatically in the late 1970s and 1980s (see Figure 2). Between 1980 and 1987, colleges awarded 6,543,000 bachelors degrees. In CPS data, however, the numbers claiming to have 16+ years of completed schooling rose by 9,181,000. Immigration can account for no more than 734,000 of this increase and individuals with 16 years of schooling but no degree for another 1,019,000. This leaves a remaining discrepancy of 885,000 that is probably increased misreporting of years of schooling. If so, the annual growth rate of the ratio of college to high school workers between 1980 and 1988 in Table 3 drops from 3.92 percent per year to 3.51 percent per year and the implied deceleration in the growth of relative supply grows to 1.76 percentage points.

The second reason why CPS data on college graduates understates the true deceleration in the supply of well educated workers is the post 1966 decline in the knowledge and skills

of the students graduating from high school. Bishop has shown that this caused a substantial deceleration in the growth of effective supply of well educated workers. His EQ index describing the schooling constant average test scores (measured in population standard deviation units) of workers weighted by their share of compensation grew much more slowly in the late 1970s and 1980s than in the 1950s and 1960s (see Table 3).¹⁷

The growth of mean years of schooling also decelerated during the 1980s. The annual growth rate of mean years of schooling, which was .0964 in the 1960s and .0915 in the 1970s, fell to .0588 in the 1980s (see bottom panel of Table 3). Since a population standard deviation on academic aptitude and broad spectrum achievement tests is approximately 5 grade level equivalents, we can translate the changes in the EQ index into a years of equivalent schooling metric by multiplying by 5. The yearly rates of gain of the EQ index multiplied by 5 are given directly below the rates of gain of mean years of schooling. This way of equating test score gains with years of schooling implies that during the 1960s the gain in average "quality" of workers at given levels of education was about 2/3rds of the gain in schooling quantity. The test score decline resulted in a reduction in the contribution of improvements in "educational quality" to the growth of worker quality during the 1970s and an even larger drop in the 1980s. The next line of the table 3 reports the rates of growth of an index which combines the two effects. Clearly the rate of growth of the quantity and quality of the schooling embodied in the work force declined substantially in the 1980s. The annual rate of gain, which had been .157 years of schooling equivalent in the 1960s and .137 years of schooling equivalents in the 1970s, fell to .084 years of schooling equivalent during the 1980s.

We conclude, therefore, that measured in efficiency units the growth of the supply of well educated workers slowed more substantially after 1980 than has previously been thought. Employers may have reacted to the declining quality of high school graduates by raising the minimum levels of schooling expected of new hires. Does the deceleration in the growth of relative supply fully account for the rapid rise in the return to college during the 1980s? That depends on the elasticity of substitution between college and non-college labor. If elasticities of substitution are no higher than one, the slowdown in the growth of the relative supply of college graduates can probably fully account for the growth of the college premium. If, however, elasticities of substitution are greater than one, the growth of the college premium

must have been occasioned by an acceleration in the growth of relative demand as well as a deceleration in the growth of relative supply.¹⁸

III. Did Shifts in the Relative Quality of College Graduates Occur during the 1960s, 70s and 80s ?

Bound and Johnson have suggested that shifts in the quality of college graduates relative to high school graduates might be responsible for some of the growth of the wage differential between college and high school graduates for young workers. The relative academic achievement of a cohort of college graduates will increase if college admission and completion becomes more contingent on initial levels of achievement or if colleges become better at promoting learning. It will also grow if college students shift from majors which offer little remuneration to majors which are well remunerated. All three possibilities will be explored. We will begin by examining the evidence of changes in the first of these mechanisms--the association between academic achievement in high school and college attendance.

3.1 Trends in the Impact of Academic Achievement on College Entrance Rates

Taubman and Wales examination of trends in the impact of academic test scores on the probability of college entrance between 1924 and 1960 concluded that ability became an increasingly important determinant of the probability of high school graduates entering college during the period.¹⁹ This trend might have reversed in the 1960s, however, for the 1960s and early 1970s were a period of rapid growth for colleges with open door admissions policies. Growing numbers of low ability students pursuing vocational curricula in 2 year institutions might have reduced the academic achievement differential between those entering college and those completing schooling with a high school degree.

To test this hypothesis the calculations made by Taubman and Wales were replicated in two more recent nationally representative longitudinal studies of high school seniors--National Longitudinal Survey Class of 72, and High School and Beyond (1980 graduates). Rates of college entrance for the year following graduation were calculated for each quartile of the ability distribution. The relationship between college entrance rates and a student's ability ranking was approximated by a series of linear segments and mean ability rankings

were calculated for college entrants and for non-college going high school graduates.²⁰ The results are presented in Table 4. The mean ability ranking of high school graduates not going to college was .47 in 1925, .43 in 1946, .42 in 1950, .40 in 1957, .35-.36 in 1960-61, .38 in 1972 and .364 in 1980. The class rank gap between those attending and those not attending college grew from .06 in 1925 to .20 in 1946 and then .28 in 1960. The gap then fell to .22 in 1972 and then returned to .25 in 1980. These calculations imply that the dependence of college entrance on ability did indeed fall between 1960 and 1972 but then rose again between 1972 and 1980.

Correlations between test scores and college entrance are an alternate way of characterizing the dependence of college entrance on ability. The correlation between test scores (high school grades) and a zero-one dummy for college attendance 18 months following high school graduation was .399 (.315) for 1972 high school graduates and .442 (.384) for 1980 high school graduates.²¹ Clearly the dependence of college entrance on ability was rising during the 1970s. Evidence on changes between 1961 and 1972 can be obtained by comparing the .399 correlation obtained in NLS Class of 72 data to the average correlation (for 5 family income strata) between test scores and college attendance 18 months after graduation in Project Talent data on students who graduated in 1961. The Talent achievement composite's correlation with college attendance was .458 around 1961 indicating a large decline in academic selectivity by 1972 when the comparable figure was .399.²²

Data on the characteristics of college freshman from the American Council on Education's (ACE) Cooperative Research Program provide another look at trends in the degree to which college entrance depends on prior achievement levels. The percentage of freshman who self reported themselves to be in the bottom half of their high school graduating class first rose from 22 percent in 1968-69 to 26.8 percent in 1970-71 and then dropped to 20.2 percent in 1978. At this point the wording of the question changed but the trend appears to have continued after 1978. The percentage of freshman who reported that they were in the bottom 60 percent of the high school graduating class dropped from 38.8 percent in 1979 to 36.0 percent in 1986.²³ When combined with the fact that college entrance rates were rising in the 1980's, these data suggest that the effect of high school achievement on the likelihood of entering college rose during the 1970s and 80s after falling during the 1960s.

For the period after 1980 the final source of data on trends is a 1985 survey of college admissions directors. The 2203 institutions who responded to the survey represented 74

percent of the institutions admitting freshman students into bachelors and/or associates degree programs. The admissions directors were asked retrospective questions about changes in admissions selectivity between 1980 and 1985. Only 2 percent of the institutions reported that they had become less selective during that period. The proportion reporting they had become more selective, on the other hand, was 42 percent at four-year private colleges, 49 percent at four-year public colleges and 30 percent at two-year private colleges and 8 percent at two-year public colleges.²⁴ All of these data sets tell a consistent story of first declining then rising effects of academic achievement on college entrance probabilities.²⁵

3.2 Trends in the Relative Test Scores of College Graduates

The differential in academic achievement between high school graduates and college graduates will also increase if college graduation becomes more conditional on initial achievement levels and/or if colleges become more effective promoters of learning.

A natural way to assess trends in the selectivity and value added of college is to compare the trends on tests taken by recent college graduates to the trends on tests taken at the end of high school. Such comparisons face difficulties, however, because the tests taken by college graduates--the Graduate Record Exam (GRE), the Law School Admissions Test (LSAT), the Graduate Management Admission Test (GMAT) and the Medical School Admissions Test (MCAT)--are not taken by representative samples of college graduates. These tests are primarily taken by students applying for admission to graduate and professional schools. The share of college graduates entering such programs and the selectivity of these programs have changed. In 1966, the first year for which data is available for all four graduate tests, the number of graduate exams taken (uncorrected for multiple test taking) was equal to 42 percent of the BAs awarded in that year (see column 5 of Table 5). By 1971 the ratio had risen to 62.7 percent. Since that date the ratio has fluctuated between 60.6 and 68 percent. An additional problem with the data arises from the fact that many test takers are returning to school many years after completing their BA.

Still another problem arises from the fact that foreign nationals are a large share of GMAT test takers (about 20 percent) and an increasing share of GRE test takers.²⁶ A time series of GRE scores for US citizens was, therefore, used for the period 1972/73 through 1988/89 and earlier data on average scores was spliced onto this. On the GMAT, foreign nationals obtain comparable scores on the quantitative section but substantially lower scores

on the verbal section. I was not able to obtain data on GMAT scores of foreign nationals prior to 1983, so it is not clear how GMAT trends would change if foreign nationals were not included. Because of these problems, comparisons of graduate test scores and high school test scores need to be done cautiously.

The time series constructed from these data is intended to measure trends in the general academic achievement of recent college graduates. Scores of the four different tests were deviated from their value in 1977, divided by their standard deviation and averaged.²⁷ The weights used in constructing the average were 0.253 for the GMAT, 0.182 for the LSAT, 0.077 for the MCAT and 0.488 for an average of GRE verbal and quantitative scores. The weighted average of the four graduate tests is presented in column 1 of Table 5-5. An index of these college graduate test scores (with a value of 1 in 1966) was generated by adding .8845 to this average and the result is plotted in Figure 3.

The academic achievement of graduate test takers apparently declined during the late 1960s. Between 1966 and 1972 there was a 0.20 SD decline on the quantitative Graduate Record Exam (GRE), a 0.28 SD decline on the verbal GRE and a 0.215 SD decline in the Graduate Management Admission Test (GMAT). There were small increases of 0.06 SD on the Medical School Admissions Test (MCAT) and of 0.09 SD on the Law School Admissions Test. The overall average declined by 0.13 SD. The decline of the Graduate Test Average during this period was probably in part a result of substantial increase during this period in the proportion of high school graduates completing college (see column 4 of Table 5-5 and figure 3). In addition, the proportion of BA recipients who took graduate exams rose substantially (see column 5). Consequently the average quality of all college graduates probably declined less than is indicated by the graduate test series.

As with high school graduates, there appears to have been a rebound in the test scores of college graduates planning to continue their schooling. The overall index remained essentially flat between 1972 and 1980 but has since risen 0.23 SD above the 1972 level. Trends have differed substantially across tests. Between 1977 and 1989 there were declines of 0.095 SD on the MCAT but increases of 0.146 SD on the verbal GRE, 0.24 SD on the quantitative GRE, 0.337 SD on the GMAT, and 0.179 SD on the LSAT.

The index of trends in the academic achievement of high school graduates to which the college graduate test score time series is compared is a weighted average of ITED test scores for the high school graduating classes of 4 to 9 years earlier.²⁸ Figure 3 plots high

school test scores on the same graph as the college graduation rate. Clearly there is a strong positive association, suggesting that the test score decline may have helped cause the fall of college graduation rates during the 1970s.

A rough summary statistic describing changes in the gap between college and high school test scores--constructed by adopting test score standard deviations as a common metric and then subtracting the high school index from the college graduate index--can be found in column 3 of table 5-5. Given that caution must be exercised in drawing inferences from this data series, what does a comparison of these two time series tell us about changes in the selectivity and value added of a four year college education during the past twenty-five years? The test scores of high school graduates rose rapidly during the early 1960s. Selectivity of college entrance fell and the proportions of high school graduates completing college rose (from 0.281 in 1966 to 0.327 in 1972). Value added appears to have declined possibly because of the disruptions associated with the Vietnam War period. As a result the improvements in the quality of students graduating from high school did not produce gains on the tests taken by college graduates four years later. In fact the test scores of these college graduates were declining during the late 1960s. The index of the gap between college graduate test scores and high school graduate test scores four years earlier fell by 0.37 standard deviations between 1966 and 1972. The trough of this series occurs three years after Woodstock (indicated by the vertical line on figure 3) and two years after four students demonstrating against the Vietnam War were killed at Kent State University. This figure exaggerates the magnitude of the true decline, however, since some of this measured decline in the relative quality of college graduates is a spurious result of the rise in the number of college graduates seeking admission to graduate school and taking the graduate tests.

At this point, we entered a decade of declining test scores for entering students and stable scores for college graduates. Value added probably underwent a recovery as the disruptions associated with the Vietnam War ended. In addition, the selectivity of college entry and graduation increased. Ratios of bachelors degrees awarded to high school graduates four to nine years earlier fell from 0.345 in 1972 to 0.301 in 1979. Thus the decline in the quality of the students entering college resulted in an increase in attrition, but no decline in standards for graduation.

Then starting about 1979 first graduate and then high school test scores began to rise. By 1984 the index of the gap between college graduate and high school graduate test scores

rose by 0.41 standard deviations from its low in 1972. Since then the gap has remained stable.

To sum up, the test score gap between college graduates and high school graduates has fluctuated violently. It fell by 38 percent of a standard deviation between 1966 and 1972 and has since risen 41 percent of a standard deviation. Test score fluctuations of this magnitude have probably had significant effects on the wage premium received by young college graduates. An estimate of their magnitude may be obtained by multiplying the changes in the test score gap by .1406, Bishop's estimate of the effect of a one high school standard deviation test score differential on the logarithm of the weekly wage. This implies that changes in the test score gap lowered the college wage premium for young college graduates during the 1970s by about 5 percent and then raised it by a similar amount during the 1980s.²⁹ It would appear that growing academic achievement differentials between college and non-college youth have contributed significantly to the growing wage differential between the groups during the last decade.

3.3 Trends in the Distribution of College Majors

The wages received by college graduates depend on what the student studied while in school. The first four columns of Table 5-6 present data from periodic surveys of random samples of recent college graduates on the effects of field of study on salaries received one year after graduating from college.³⁰ The differences across field are sometimes as large as the wage gains accruing to those obtaining higher level degrees. During the 1980s engineers were receiving 64 to 78 percent higher starting salaries than humanities majors and business majors were receiving 29 to 34 percent higher starting salaries than humanities majors.

Data on the earnings of college graduates years after leaving college solidify the finding that majors in humanities, education, biological sciences and social sciences other than economics earn far less than business, physical science and engineering majors. The salaries of business majors tend to catch up with the engineers, but education and liberal arts majors remain far behind those with engineering and business degrees even when the quality of one's college is controlled. The seventh and eight columns of table 5-6 present data on the relationship between college major and yearly earnings of men aged 21 to 70 from the 1967 Survey of Economic Opportunity. With college rank constant, undergraduate business majors earned 32 percent more and engineers 51 percent more than humanities majors and education majors.³¹ The ninth column of table 5-6 presents 1984 data on monthly earnings

by major for men and women combined. Physical science majors earned 93 percent more, engineers earned 114 percent more, and business majors earned 103 percent more than humanities majors.³²

The fifth and sixth columns of the table present estimates of the effects of college major on 1979 hourly earnings of young men and women who had graduated from high school in 1972 while controlling for family background and the student's preferences regarding life goals (for example, the importance of being wealthy and of helping others.³³ Humanities, social science and education majors received the lowest wage rates. Male engineers obtained 34 percent more than male humanities majors; male business majors were paid 13 percent more. Female engineers were paid 27 percent more than female humanities majors, and female business majors were paid 25 percent more. Clearly, the market values some of the skills developed in college much more highly than others.

During the last two decades the life goals of entering college students and the fields of study shifted dramatically. "Develop[ing] a meaningful philosophy of life," which was considered essential or very important by 82 percent of entering freshman in 1967-1969 is now [1987] considered very important by only 39.1 percent of entering freshman. "Be[ing] very well-off financially" which in 1967-1969 was considered essential or very important by only 43 percent of freshman is now considered essential or very important by 75.6 percent of freshman.³⁴

Shifts of this magnitude in the priority attached to making money could be expected to result in students shifting out of fields of study leading to low paid occupations (such as education and the humanities) into fields (such as business and engineering) leading to more remunerative occupations. A second factor that has shifted student demand toward business and technical majors has been changing attitudes regarding occupations appropriate for women. The rapid growth in numbers seeking access to programs in computer science, engineering, and business has been further sustained by continuing strong market demand for students prepared in these fields.

The shifts in college major have been quite substantial. Figures 5-4 and 5-5 present cumulative proportions of the bachelors degrees awarded by college major arranged in a hierarchy that roughly corresponds to the average wage of males or females who received their bachelor's degree in that field. Starting at the bottom of figure 5-4 for males, the fields are education, humanities and social science, natural science, business administration,

engineering and computer science. From the bottom of the figure we see that in 1973 degrees in education, humanities and social science accounted for 50.5 percent of bachelors degrees awarded to men and 83.5 percent of the bachelors degrees awarded to women. By 1986 these percentages had dropped to 35.1 percent and 54.7 percent respectively. Reading from the top, degrees in engineering, computer science and business accounted for 33.2 percent of the bachelors degrees awarded to men in 1973 and for 50.8 percent awarded to men in 1986. For women, degrees in engineering, computer science, and business grew from 3.5 percent to 26.6 percent of degrees awarded.

Since the most rapidly growing fields are also the highest paid, the shifts in subjects studied in college probably account for a portion of the growth in the return to college for the most recent cohorts of college graduates. An index of the effect of the composition of college majors on the payoff to college was obtained by calculating a weighted average of the logged percentage differentials relative to humanities majors reported in column 5 and 6 of Table 5-6 using numbers of degrees awarded in that field as weights. Figure 5-5 presents the index for men and women with exactly sixteen years of schooling and 1 to 5 years of experience. The value of the index is zero if everyone studies the humanities and .22, [$\ln(1.25)$] if all women major in business.

In 1953 the value of the index was 0.088 for males and 0.080 for females. The indexes reained reasonably stable for the following decade but then fell after 1963 reaching a value of 0.071 for both males and females in 1973. At this point the indexes diverged. The shift of women into more remunerative college majors began in earnest in 1973 and the index started a steady climb to 0.100 in 1981 and 0.120 in 1987.

For males the gradual shift towards lower paying college majors did not end until 1976, with an index for that year's degree recipients of 0.066. After 1977 the shift toward more remunerative majors was rapid, and the index for those with 1 to 5 years of experience grew to 0.074 in 1981 and 0.100 in 1987. The decline, then rise of this index are consistent with observed trends in the payoff to college for those with little labor market experience relative to the college payoff for workers of all experience levels.

IV. The Return to Academic Achievement during the 1980s?

The payoffs to visible indicators of skill such as the college degree and to post school work experience have risen substantially during the 1980s. Visible though it may be, however, length of schooling is an imperfect measure of skill. What has happened to the payoff to direct measures of skill such as tests assessing various types of competency? How substantial was the payoff to academic competencies at the beginning of the 1980s? How substantial is it now? The availability of data sets containing direct measures of academic competence for random samples of the population has made possible studies of the impact of academic competencies on wages and earnings for specific points in time. Comparisons over time are difficult because paired surveys of random samples of adults collected a decade or so apart, containing both wage information and test scores for the same test battery, are not to be found. In the absence of such a paired data set, analysis of longitudinal data provides the only feasible way of assessing possible trends in the payoff to academic competency. The youth cohort of National Longitudinal Survey is a data set which may be able to shed some light on this issue.

Data: An analysis of the effects of test scores on wage rates is possible in the NLS Youth because the Armed Services Vocational Aptitude Battery (ASVAB) was administered to the youth cohort of the NLS in 1980. At the time the NLS Youth were between 15 and 23 years of age. The ASVAB is a three-hour battery of tests used by the armed forces for selecting recruits and for assigning them to occupational specialties. The primary purpose of the ASVAB is to predict the success of new recruits in training and their subsequent performance in their occupational specialty. Eighty percent of the jobs held by enlisted personnel in the military have civilian counterparts and the ASVAB is a valid predictor of job performance in the civilian sector.³⁵ During the summer of 1980 all members of the NLS youth sample were asked to take this test and offered a \$50 honorarium as an inducement. The tests were successfully administered to 94 percent of the sample.³⁶

To reduce measurement error and to simplify the specification of interaction variables, the youth's learning achievements were represented by three composite variables: general academic achievement, computational speed, and technical competence. The academic composite was defined by averaging normalized subtest scores for arithmetic reasoning, mathematics knowledge, word knowledge, paragraph comprehension, and general science and then by renormalizing to give the variable a standard deviation of one. Factor analysis of the ASVAB has found that the speeded tests constitute a separate factor. Consequently,

computational speed--the number of correct answers on a three-minute 50 problem arithmetic computation test--was defined as a separate achievement variable. The measure of technical competence was constructed by averaging the mechanical comprehension, auto and shop information, and electronics subtest scores of the ASVAB.

All of these competencies are highly correlated with years of schooling. When these composites are regressed on age, ethnicity, proportion of 1980 spent in school, region, work experience, occupation of parents, and schooling, the coefficients on years of high school range between 0.19 for math and 0.28 for verbal for males and between 0.12 for technical and 0.24 for verbal for females.

Specification: In the basic model the log of the hourly wage rate in the current or most recent job is regressed on test scores, years of schooling, years of college, school attendance, work experience and a variety of other control variables:

$$1) \quad W_t = a_t A + b_t T + c_t R + d_t S_t + e_t C_t + f_t E_t + g_t N_t + h_t Z_t + u_t \quad t = 1979...1986$$

where W_t is the log of the worker's wage in the current or most recent job at the time of the interview in year t .

A is a composite of ASVAB subtest scores measuring competence in reading, vocabulary, mathematical reasoning and science knowledge.

T is the ASVAB technical composite measuring mechanical comprehension and electronics, auto and shop knowledge.

R is a measure of speed in simple arithmetic computation.

S_t is years of schooling completed by the interview date in year t .

C_t is years of college completed by the interview date in year t .

E_t is cumulated weeks of work experience since 1975 divided by 52. Actual experience and its square both enter the models.

N_t is age on the interview date in year t minus 16. Both Age and $(Age-16)^2$ enter the cross section models.

Z_t is a vector of control variables such as school attendance, marital status, parenthood, Hispanic, race, region, past and current military service, residence in an SMSA and current local unemployment rate.

u_t is the disturbance term for year t .

Trends over time in the payoff to various academic competencies will be assessed in two different ways. The first method is to estimate repeated cross sections and then to examine whether the coefficients on test scores are exhibiting a trend. This approach has the advantage of simplicity and transparency. The problem with this approach, however, is that since the effects of academic achievement grow as the individual ages, the estimated effect of test scores on wages will be larger in 1986 than in 1979 even if there are no secular trends in the reward for academic achievement. Consequently, no conclusions regarding secular change in the payoff to academic competency can be drawn from simple comparisons of cross-section regressions estimated in the NLS Youth. The repeated cross-section analysis is, therefore, just a first look at the data, not a test of hypotheses regarding trends in the returns to indicators of skill.

In the second method, data for the full 1981 to 1986 period is used to estimate a single regression equation that explicitly tests for trends in the coefficients on skill variables in the context of a model which allows the payoff to academic competency to also vary with age, student status and advanced education.

Repeated Cross-section Results: Let us turn first to an examination of the repeated cross-section estimates of equation 1 that are reported in Table 5-7. The effects of schooling on wage rates appear to have changed substantially during the 1980s. The impact of high school appears to have been smaller at the end of the sample period than it was around 1980. The effect of college appears to have grown substantially.

The most powerful determinant of the wage rates of young men and women is the cumulated weeks of work experience.³⁷ With age and schooling constant, each additional year of actual work experience raises 1986 wages 6.4 percent for males and 5.7 percent for females. Age has substantially smaller effects. The coefficients on the age and actual work experience variables apparently do not exhibit any trend.

Test scores have important effects on wage rates. As one might anticipate, technical competence has a strong positive effect on the wage rates of young men but not on the wage rates of young women.³⁸ Computational speed is related to higher wage rates for both men and women.³⁹ Academic competence has a modest positive effect on the wage rates of women but a negative effect on the wage rates of men. While the absence of a positive wage response to a male's academic skills (and the small size, 0.7 percent wage increase per grade level equivalent, for females) may appear surprising, it is quite consistent with the findings

of other studies of recent high school graduates using data sets such as High School and Beyond and NLS Class of 1972.⁴⁰ It is also consistent with data on hiring practices. Only 3 percent of new hires with a high school degree at small and medium size firms were administered basic skills tests before hiring in 1987.⁴¹ Employers have been avoiding such tests largely because in 1971 the EEOC started requiring costly validity studies at the firm before a basic skills test could be used for selection.⁴² Research has found that these tests are positively related to job performance in almost all jobs, but the fear of litigation and the costs of doing a special validity study induced all but a few firms to drop testing.⁴³

The effects of test scores on wage rates appear to have grown over time. An increase of one standard deviation in all three test composites, which raised wage rates of males only 4.3 percent in 1980/1981, raised 1985/1986 wage rates 12.5 percent. A similar increase in test scores for females, which raised wage rates only 5.3 percent in 1980/1981, raised wages 10.8 percent in 1985/1986.

The results presented in table 5-7, however, may overstate positive trends in the returns to skill for at least four reasons. First, the apparent trend in the coefficient on test scores may be due to the ageing of the sample. A number of studies have found that the return to overall academic achievement increases with the age of the worker.⁴⁴ This would occur if achievement in academic and technical fields improves access to jobs offering considerable training and enables the worker to benefit more from training. Another probable cause of positive interactions between age and test scores is employer ignorance of the academic achievements measured by test scores and the resulting long delays before workers with strong academic achievement are discovered to be more productive and remunerated accordingly.

Second, the number of the sample participants who were in school diminished as time passed. Students working during the summer or part time during the school year generally have a narrower choice of occupations than young people who have completed their schooling. The high turnover rates and the necessity of scheduling work around school may prevent students from receiving the full wage benefits of their greater schooling and academic competence. If so, the decline in the proportion who are students in the sample would tend to cause the estimated effects of schooling and test scores in table 5-7 to exhibit a spurious positive trend.

Third, the proportion of NLS youth who had completed a few years of college grew substantially between 1979 and 1986. It has often been hypothesized that the return to

academic competency is larger for college graduates than for high school graduates. If so, the average impact of test scores on wages would grow as larger proportions of the sample complete their college education. Whether there is such a positive interaction in models predicting the log of the wage rate is controversial. Analyses of the National Bureau of Economic Research/Thorndike data on men who were in the air force during World War II tend to support the hypothesis but analyses of other data sets have been more equivocal.⁴⁵

Fourth, interactions between work experience and years of schooling are likely. If cumulated actual work experience can substitute for schooling in some jobs, the return to cumulated work experience would be expected to be lower for young workers with greater amounts of schooling. Since schooling and work experience of the NLS Youth were growing between 1979 and 1986, trends in the effects of these variables might have been influenced by such an interaction.

Time Series-Cross Section Results

To test the hypotheses just discussed and obtain an unbiased estimate of the trend in the wage payoff to the skills of young men and women, wage rate models containing the hypothesized interactions were estimated by joint generalized least squares for years 1981 through 1986.⁴⁶ Coefficients on skill variables were not allowed to vary freely from year to year. Instead, the estimation allows the coefficients on test scores, years of schooling and actual work experience (a through f in equation 1) to exhibit a linear trend. In addition, interactions were specified between age and the three ASVAB composites, between student status and both academic achievement and years of schooling, and between years of college and both academic achievement and actual work experience.

The models were estimated using seemingly unrelated regression on a sample of young men and women who were not in the military in 1979 and who reported on a current or recent job in each interview between 1981 and 1986.⁴⁷ Data from 1979 and 1980 were not included because this would have excluded from the analysis many of the youngest members of the NLS youth data base.

Main Effects of Skill Indicators

The results are presented in table 5-8. The specification of the skill variables and interactions is described in the notes to the table. The main effects of the test variables

changed only slightly. The coefficients of main effects on the technical competence and computational speed (b_0 and c_0 in the notes to the table) provide estimates for the year 1983 of the effect of the competency on labor market outcomes of twenty-two-year-old high school graduates. As before, computational speed had a positive effect on the wages of both men and women while technical competence affected only the wages of men. Academic competence had a small positive effect on female wages but a significant negative effect on male wages. While test score effects are highly significant, they are modest in magnitude. An increase of one grade level equivalent in all three test composites raised 1983 wages of twenty-two-year-olds only 1 to 1.5 percent.

The main effects of a year of high school for non-students in 1983 (d_0) were .03 for males and 0.025 for females. The coefficient of main effects on years of college, e_0 , (0.058 for males and 0.034 for females), provides an estimate for 1983 of the amount by which the payoff to a year of college exceeds the payoff to a year of high school for workers with average academic test scores and four years of cumulated work experience.

Both measures of work experience have large effects on wage rates. The existence of diminishing returns to actual and to potential experience was tested by entering square terms into the model. Actual cumulated work experience exhibits significant diminishing returns in the model predicting the wage rates of men but not significantly so in the models predicting the wage rates of women. The effect of actual experience is substantial. With potential work experience constant, the fourth full year of actual work experience raised wage rates of male and female high school graduates 7.3 to 7.4 percent. These results are no doubt in part caused by unobserved heterogeneity, but it is still quite remarkable that one year of actual work experience had a slightly larger effect on wages than a five-grade-level equivalent (that is, a one-population standard deviation) increase in all three test composites. Potential post school work experience exhibited strong diminishing returns. Holding actual work experience constant, the first year of potential post school experience raised the wage of males (females) 4.8 percent (3.45 percent) while the fourth year raised it only 2.3 percent (1.1 percent).

Trends in the Payoff to Skill

The coefficients on the interactions of YEAR with the skill variables (a_1 through f_1) provide estimates of the effect of trends in the estimated wage payoff to various dimensions of skill in a model that allows the effects of skills to vary with age, experience, and student

status. Clearly there is a strong positive trend in the payoff to college. Between 1981 and 1986 the ratio of the wage of college and high school graduates increased 29 percent [$\exp(0.258)$, where $0.258 = (1986-1981)*4*(0.0176-0.0056)$] for males and 14.6 percent for females. The payoff for four years of high school fell during this period 10.4 percent for males and 6.4 percent for females. These results are consistent with the results presented in table 5-7 and the findings reported in other chapters of this volume.

For returns to test scores, however, the results presented in table 5-7 are overturned. When the effect of schooling on wages is allowed to grow with time and interactions of student status and age with test score are included in the model, the F tests on the sum of the test score trend coefficients indicate that there is no tendency for the estimated payoff to test scores to increase over the 1980s. Other specifications do not alter this conclusion as long as test scores are interacted with age and student status as well as with a time trend. For women, the point estimate for the sum of the test score trend coefficients is negative. Since scores on tests taken in 1980 become less reliable indicators of the worker's current academic competency as time passes, this result might have been caused by rising errors in the measurement of true competence as years pass. Consequently the absence of positive coefficients on test score trends is not a decisive refutation of the hypothesis that the return to true competencies rose in the 1980s. Better data are required before the issue can be finally settled.

There is a significant positive trend in the payoff to cumulated actual work experience for men but not for women. Models not reported here also tested for trends in the return to potential work experience; none were found.

Lifecycle Determinants of the Payoff to Skill Indicators

Age: The findings regarding the effect of age on the payoff to the competencies measured by the ASVAB are presented in row 16 to 18 of table 5-8. An F test was conducted on the sum of the coefficients on age interactions with the three test composites. The sum of the coefficients was significantly positive in both regressions ($p = 0.09$ for males and $p = 0.016$ for females from two-tail tests). Ceteris paribus, a differential of one standard deviation in all three test composites raised the wage rates of male high school graduates not in school 4.8 percent at age nineteen, 7.2 percent at age twenty-two and 9.6 percent at age twenty-five. For comparable women, a one-SD increase in all three tests raised wage rates

2.4 percent at age nineteen, 6.3 percent at age twenty-two and 10.2 percent at age twenty-five.

This finding of a positive interaction between age and test scores is consistent with previous studies.⁴⁸ For males, the competency interacting most positively with age is computational speed. Also noteworthy, age has a larger positive effect on the payoff to test scores than cumulated work experience. Tests for interactions between actual work experience and test scores typically obtain small insignificant positive coefficients when age times test score interactions are in the model. Since the impact of test scores on wages grows even when the individual is not working, it would appear that differential investment in or payoffs to on-the-job training are not the only cause of the interaction between age and test scores. This result is supported by the findings in both NLS and High School and Beyond data that high test scores are not associated with the receipt of greater amounts of on-the-job training when schooling is held constant.⁴⁹ These results suggest that signals of academic competency may not at first be available to employers of high school graduates. Over time, however, the greater competence of the individuals with high test scores is revealed to the market partly by signals generated on the job (for example, promotions) and also by signals generated by further schooling (for example, college reputation and grades) and by unemployment (for example, reasons for turnover and for non-employment) and wage rates increasingly reflect this knowledge.⁵⁰ More research is needed on this issue.

Student Status As hypothesized, the jobs occupied by students do not reward years of schooling as well as the jobs occupied by nonstudents. Being a student reduces the yearly payoff to schooling 3.3 percent for males and 1.6 percent for females. While the coefficients are not statistically significant, the payoff to academic competencies for students appears to be more negative than that for nonstudents.

College-Test-Score Interactions High academic test scores do appear to have the hypothesized significant positive effects on the wage payoff to attending college. The payoff to four years of college in 1983 was a 26.6 percent (42 percent) increase in wages for women (men) at the 43rd percentile in the academic test score distribution, a 34 percent (49 percent) increase for women (men) at the 80th percentile in the test score distribution and a 42.5 percent (57 percent) increase for women (men) at the 96.7th percentile in the test score distribution. College quality and major, however, were not controlled in these models.

Including these two variables in the model probably would substantially reduce the positive interaction between test scores and years of college.

Education and Experience Interactions As hypothesized, the interaction between college and work experience is negative and significant. Each year of college lowers the male (female) payoff to fifty-two weeks of cumulated work experience 1.39 percent (0.72 percent). Apparently these alternative mechanisms for developing skill are substitutes.

V. SUMMARY AND IMPLICATIONS

Four kinds of interaction between the fluctuations in academic achievement of those completing their schooling and fluctuations in the payoff to a college education have been examined. In three cases evidence of interaction appears:

1. The decline then rise in the payoff to college appears to have contributed to the decline in academic achievement in high school between 1966 and 1980 and the subsequent rise in that achievement. A reliable estimate of how much of the test score decline was due to declines in the payoff to college does not, however, appear to be feasible.
2. The test score decline contributed to the deceleration of the growth of the supply of well educated workers and is thus one of the causes of the general increase in the payoff to skill during the past decade.
3. The quality of college graduates relative to high school graduates from the same birth cohort has changed substantially over the past forty years for three reasons. The selectivity of college admissions rose through 1961, declined between 1961 and 1972, and rose again after 1972. Secondly, the gap between the test scores of college graduates and high school graduates appears to have declined in the late 1960s and to have risen continuously since 1972. Finally, the proportions of students pursuing the more remunerative technical and business majors have been changing--first declining during the 1960s and then rising during the last fifteen years. These three forces have tended to raise the productivity and wages of the latest cohorts of college graduates substantially above that of high school graduates with similar levels of experience.

The one exception to the general finding of interactions is the apparent lack of evidence that the general shortage of skilled and well educated workers has bid up the return to achievements measured by test scores. The analysis of NLS youth data implies that school credentials produce large payoffs immediately after leaving school and that these payoffs have grown substantially during the 1980s. The rewards for learning the material being taught in school, if they are not well signaled by a credential, are small at first but grow as the individual ages. But the rewards for such learning do not appear to have risen in the 1980s. Apparently, the shift in the relative demand for skill has bid up wages only where skills are well signaled to the labor market. Society's tendency to reward credentials rather than learning appears to have remained strong during the period of skill shortage.

The threat of litigation brought under the 1971 Griggs interpretation of Title 7 of the Civil Rights Act of 1965 deterred many employers from using tests measuring competence in reading and mathematics and grades in high school to help select new employees. This is one of the important reasons why youth do not on average receive significantly higher wage rates when they learn more English, science and mathematics in high school. Recent court decisions have made it easier to defend using such tests as part of a selection process, but only a few of the larger employers have reintroduced basic skills tests into their selection procedures for clerical and factory jobs. If current interpretations of Title 7 remain in force, the number of employers assessing competence in reading and mathematics prior to hiring is likely to slowly increase and the payoff to basic skills is likely to increase as well, all be it slowly. If, however, the language contained in the Civil Rights bill vetoed by President Bush becomes law, the legal impediments to the use of high school grades and scores on basic skills tests in employer hiring decisions will probably grow and the payoff to basic skills competencies uncorrelated with years of schooling will probably not increase.

REFERENCES

- Adelman, Clifford. The Standardized Test Scores of College Graduates, 1964-1982, prepared for The Study Group on the Condition of Excellence in American Higher Education, National Institute of Education, 1983.
- Adkins, Douglas L. The Great American Degree Machine. The Carnegie Foundation for the Advancement of Teaching, 1975.
- Alsalam, Nabeel, The Condition of Education 1990: Postsecondary Education. Washington, D.C., National Center for Education Statistics, US Department of Education, 1990.
- Astin, Alexander W.; Green, Kenneth C.; Korn, William S.; and Schalit, Marilynn. "The American Freshman: National Norms For Fall 1986." Cooperative institutional Research Program. December 1986.
- Astin, Alexander W.; Green, Kenneth C.; Korn, William S. "The American Freshman: Twenty Year Trends." Cooperative Institutional Research Program, January 1987.
- Bishop, John H. "Information Externalities and the Social Return to Schooling," Center for Advanced Human Resources Research Discussion Paper 1987-04, Cornell University.
- Bishop, John H. "The Productivity Consequences of What is Learned in High School," Journal of Curriculum Studies, Jan. 1990, Vol. 22, 101-126.
- Bishop, John. "The Effect of Public Policies on the Demand for Higher Education." Journal of Human Resources, Vol. XII, No. 3, Summer 1977.
- Bishop, John H. "Did the Test Score Decline Cause the Productivity Growth Decline?" American Economic Review, March 1989a, pp. 178-197.
- Bishop, John H. "Vocational Education for At-Risk Youth: How to Make it More Effective." Center for Advanced Human Resource Research Discussion Paper # 88-12, Cornell Univ. 1988a.
- Bishop, John; Blakemore, Arthur; Low, Stuart. "High School Graduates in the Labor Market: A Comparison of the Class of 1972 and 1980." Columbus, Ohio: National Center for Research in Vocational Education, 1985.
- Bishop, John H. and Kang, Suk. "Vocational and Academic Education: Complements or Substitutes," Economics of Education Review, 1990.
- Blackburn, McKinley; Bloom, David and Freeman, Richard. "The Declining Economic Position of Less Skilled American Men," A Future of Lousy Jobs?, Gary Burtless editor, Washington, DC: The Brookings Institution, 1990.

- Bound, John and Johnson, George. "Wages in the United States during the 1980's and Beyond." presented at Wages in the 1980's, November 3 1989, a conference sponsored by the American Enterprise Institute, Washington, DC.
- Bound, John and Johnson, George. "Changes in the Structure of Wages During the 1980's: An Evaluation of Alternative Explanations." National Bureau of Economic Research, Inc. Working Paper 2983, May, 1989.
- Breland, Hunter M.; Wilder, Gita and Robertson, Nancy J. Demographics, Standards, and Equity: Challenges in College Admissions. A report sponsored by: American Association of Collegiate Registrars and Admissions Officers, The American College Testing Program, The College Board, Educational Testing Service and National Association of College Admissions Counselors, November, 1986.
- Bureau of Labor Statistics, Handbook of Labor Statistics, Table 65, 1983.
- Daymont, Thomas N.; Andrisani, Paul J. "Job Preferences, College Major, and the Gender Gap in Earnings." The Journal of Human Resources, Summer 1984, pp. 408-428.
- Dean, Edwin; Kunze, Kent and Rosenblum, Larry S. "Productivity Change and the Measurement of Heterogeneous Labor Inputs." Bureau of Labor Statistics, U.S. Department of Labor, March 1989.
- Educational Testing Service. College-Bound Seniors. Eleven Years of National Data from the College Board's Admissions Testing Program. The College Board, 1984.
- Farr, Roger and Leo Fey, "Reading Trend Data in the United States: A Mandate for Caveats and Caution," The Rise and Fall of National Test Scores, ed. by Gilbert Austin and Herbert Garber, (New York, New York: Academic Press, 1982), pp. 83-142.
- Forsyth, Robert A. (personnel communication) "Achievement Trends for the Iowa Tests of Educational Development in Iowa: 1942-1985," Iowa City:Iowa Testing Programs, 1987.
- Friedman, Toby and Williams, E. Belvin. "Current Use of Tests for Employment." Ability Testing: Uses, Consequences, and Controversies, Part II: Documentation Section, edited by Alexandria K. Wigdor and Wendell R. Gardner. Washington, DC: National Academy Press, 1982, pg. 999-169.
- Gardner, John A. Transition from High School to Postsecondary Education: Analytical Studies. National Center for Research in Vocational, Ohio State University Research Foundation, Columbus, Ohio, February, 1987.
- Hause, J. C. "Ability and Schooling as Determinants of Lifetime Earnings, or If You're So Smart, Why Aren't You Rich." In Education, Income, and Human Behavior, edited by F. T. Juster. New York: McGraw-Hill, 1975.

ENDNOTES

1. Iowa Test of Educational Development composite scores of 11th grade students in Iowa declined from 18.9 in 1965 to 16.8 in 1977 and then rose to 19.2 in 1989. Composite scores for 12th graders fell from 20.8 in 1966 to 18.4 in 1979 and then rose to 20.2 in 1989. During the 1970s and 1980s, 12th grade scores on the ITED composite averaged about 5.5 points higher than 9th grade scores, implying that a grade level equivalent was roughly equal to 1.835 points. Consequently, in terms of grade level equivalents the decline was 1.31 for seniors and 1.14 for juniors. Data on ITED trends was provided by Robert Forsyth of the Iowa Testing Program.
2. Kevin Murphy and Finis Welch, "Wage Premiums for College Graduates: Recent Growth and Possible Explanations." Educational Researcher, May 1989, pp. 17-26.
3. John H. Bishop, "The Productivity Consequences of What is Learned in High School," The Journal of Curriculum Studies, 1990, Vol. 22, No. 2, pp.101-126. The effect of math, reading and vocabulary test scores on the wage rates and earnings of high school graduates for both 1972 and 1980 in a model that contained controls for grade point average and the number of credit hours of academic and vocational courses. In both these years, none of the variables representing academic performance--the three test scores, GPA and the number of academic courses--had a significant (at the ten percent level) effect on the wage rate of the first post high school job. Only one variable (the vocabulary test for female members of the class of 1972) had a significant effect on the wage 18 months after graduation. John Bishop, Arthur Blakemore and Stuart Low, "High School Graduates in the Labor Market: A Comparison of the Class of 1972 and 1980." Columbus, Ohio: National Center for Research in Vocational Education, 1985.
4. Data on ITED trends was kindly provided by Robert A. Forsyth (personnel communication) "Achievement Trends for the Iowa Tests of Educational Development in Iowa: 1942-1985," Iowa City:Iowa Testing Programs, 1987. ITBS data was obtained from A. N. Hieronymus, E. F. Lindquist and H. D. Hoover. Iowa Test of Basic Skills: Manual for School Administrators, Chicago: The Riverside Publishing Company, 1979. Other tests that have been administered for long spans of time to stable test-taking populations also exhibit a positive trend during this period. Roger Farr and Leo Fey, "Reading Trend Data in the United States: A Mandate for Caveats and Caution," The Rise and Fall of National Test Scores, ed. by Gilbert Austin and Herbert Garber, (New York, New York: Academic Press, 1982), pp. 83-142. Between 1958 and 1966 Minnesota high school juniors gained .39 SDs on the Minnesota Scholastic Aptitude Test. see Edward O. Swanson, "Fashions in Test Scores, or What Goes Up Must Come Down?" Student Counseling Bureau Review, University of Minnesota, September 1973, Vol. 25, No. 1. The periodic national standardizations of the ITED also exhibit an increase during the 1960s.
5. From peak to trough the decline for seniors was .38 SDs on the SAT and .32 SDs on the ACT. For 11th graders it was .28 SDs in the Illinois decade study, .24 SDs on the Preliminary Scholastic Aptitude Test and .22 SDs on the California Achievement

Test. The scores of 9th and 10th graders declined .42 SDs on the Metropolitan Achievement Tests. The scores of 5th through 8th graders declined .33 SDs on the Stanford Achievement Test and .32 SDs on the ITBS. Koretz, Daniel, et. al. Trends in Educational Achievement. Washington: Congressional Budget Office, 1986 and Brian K. Waters, The Test Score Decline: A Review and Annotated Bibliography, Technical Memorandum 81-2, Directorate for Accession Policy, Office of the Secretary of Defense, April, 1981.

6. Bureau of the Census, Historical Statistics of the United States, 1975. For 1929 through 1953, the index for high level professionals is a geometric average of yearly mean incomes of engineers, college teachers, dentists, physicians and lawyers divided by 52 (D913-D916, D920). Data on the net income of lawyers was not available after 1954, so the geometric average of college teacher salary, engineer salary, and median incomes for physicians and dentists was calculated and spliced onto the series (D913, D918-D920). The data on weekly earnings of all manufacturing workers is taken from D804 of the same document.
7. Dieter Marenbach, "Rates of Return to Education in the United States from 1939 to 1959." Stanford University Doctoral Dissertation, University Microfilms, 1973, p.89-90.
8. Lawrence Katz and Kevin Murphy, "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," National Bureau of Economic Research, April 1990. pp. 1-61.
9. Daniel Koretz et. al. Trends in Educational Achievement.
10. Toby Friedman and Belvin E. Williams, "Current Use of Tests for Employment." Ability Testing: Uses, Consequences, and Controversies, Part II: Documentation Section, edited by Alexandria K. Wigdor and Wendell R. Gardner. Washington, DC: National Academy Press, 1982, pg. 999-169.
11. John H. Bishop, "The Effect of Public Policies on the Demand for Higher Education." Journal of Human Resources, Vol. XII, No. 3, Summer 1977.
12. The payoff variable for this analysis was the earnings differential between professional workers and operatives measured in 1959 dollars deflated for the local cost of living. The local labor market is either the SMSA of residence or the non-SMSA portion of the state. In 1959 male high school graduates 25 to 64 years old earned an average of \$6132. The payoff variable had a mean of \$2957 and a standard deviation of \$570.
13. Since the college wage premium was rising at all experience levels, there must have been a rise in the price paid for skill during the 1980s. Changes in the relative quality of college and high school graduates in the cohorts entering the labor market directly effect the relative wages of the youngest workers, but not the relative wages of workers who have been in the labor market at both points in time.

14. Lawrence Katz and Anna Revenga, "Changes in the Structure of Wages: The U.S. Versus Japan." National Bureau of Economic Research, Inc. Working Paper No. 3021, July 1989.
15. The source of data on the educational attainment of the labor force was the 1983 Handbook of Labor Statistics, Table 65 and unpublished BLS data for 1988. Before 1972 the tabulations were for workers over the age of 18. After that date, tabulations were for workers over the age of 16. Consequently, rates of change of educational attainment for the 1970s are for the 8 year period from 1972 to 1980 for which data is consistent over time.
16. Adkins assumes that 11.1 percent of people reporting 16 or more years of schooling have completed 16 years of schooling but lack either a bachelors or first professional degree. Douglas L. Adkins, The Great American Degree Machine. The Carnegie Foundation for the Advancement of Teaching, 1975. p. 65. Data on the share of immigrants with a college degree were kindly provided by George Borjas.
17. John H. Bishop, "Did the Test Score Decline Cause the Productivity Growth Decline." American Economic Review, March 1989, pp. 178-197.
18. For the formal development of a model in which changes in rates of growth of wage differentials are equal to changes in relative supply growth times the inverse of the elasticity of substitution plus shifts in relative demand see McKinley Blackburn, David Bloom and Richard Freeman, "The Declining Economic Position of Less Skilled American Men," A Future of Lousy Jobs?, Gary Burtless editor, Washington, DC: The Brookings Institution, 1990, p.41. Their empirical work suggests that the elasticity of substitution between college graduates and high school graduates 25 to 64 years of age is approximately 4.
19. Paul Taubman and Terence Wales, "Mental Ability and Higher Educational Attainment in the 20th Century." National Bureau of Economic Research Occasional Paper 118, 1972.
20. John A. Gardner, Transition from High School to Postsecondary Education: Analytical Studies. National Center for Research in Vocational, Ohio State University Research Foundation, Columbus, Ohio, February, 1987. This paper provides data on Fall 1981 college entrance rates by ability quartile. The shape of the continuous relationship was derived from the quartile data as follows: the linear line segment characterizing the relationship between the 25th and 75th percentile was assumed to pass through the mean college entrance rates for the second and third quartiles. This produces estimates of entrance rates of .762 for the 75th percentile and .35 for the 25th percentile. The line segment characterizing the relationship in the top quartile was assumed to pass through the mean (.816) for the quartile and connect with the .762 at the 75th percentile. the relationship in the bottom quartile was derived in a similar manner. Once the shape of the relationship was defined the mean ranking of those entering college and those not entering college was calculated.

21. Gregory Jackson, "Did College Choice Change During the Seventies?" Economics of Education Review, Vol. 7, No. 1, pp. 15-27, 1988.
22. Since the tests used to construct the Project Talent achievement composite were different from the tests used in NLS 72, the difference between the correlations for 1961 and 1972 might be due to differences in the test or differences in the representativeness of sample. If the Talent aptitude composite had been used instead of the achievement composite for calculating the 1961 correlation, the correlation would have been .41 and a much smaller reduction in selectivity between 1961 and 1972 would have been implied. In my view, however, comparison with the achievement composite is more appropriate because the mathematics, reading and vocabulary tests available in NLS 72 and HSB appear to be at the achievement end of the aptitude-achievement continuum.
23. For 23 years the ACE has sponsored yearly surveys of the freshman classes of between 500 and 600 two and four year colleges and universities. In 1985 invitations to participate went to all 2741 institutions of higher education listed in the Department of Education's Education Directory with freshman classes of at least 50. The low institutional participation rate and the changing character of participating institutions threatens the validity of the trend data generated by this survey. To minimize this problem, ACE stratifies colleges by size, control and selectivity and the attained sample is then reweighted to construct a profile of all freshman at American colleges and universities. Data is also available on the grade point average of entering freshman. Trends in GPAs, however, are affected by grade inflation so they tell us little about how the effect of academic performance in high school on college entrance is changing over time. In 1966 30.5 percent of college freshman reported they had a high school GPA of C+ or below. This percentage fell to 26.8 percent in 1970-71 and has continued to fall reaching 20.2 percent in 1986. Alexander Astin, Kenneth Green, William S. Korn, and Marilynn Schalit, "The American Freshman: National Norms For Fall 1986." Cooperative Institutional Research Program, The Higher Education Research Institute, University of California, Los Angeles, December 1986 and Alexander Astin, Kenneth C. Green, William S. Korn, "The American Freshman: Twenty Year Trends." Cooperative Institutional Research Program, The Higher Education Research Institute, University of California, Los Angeles, January 1987.
24. Hunter Breland, Gita Wilder and Nancy J. Robertson, Demographics, Standards, and Equity: Challenges in College Admissions. A report sponsored by: American Association of Collegiate Registrars and Admissions Officers, The American College Testing Program, The College Board, Educational Testing Service and National Association of College Admissions Counselors, November, 1986.
25. Data on trends in high school GPA's and class rank are also available for SAT test takers in Educational Testing Service. College-Bound Seniors. Eleven Years of National Data from the College Board's Admissions Testing Program. The College Board, 1984. Unfortunately, the SAT data are not reliable indicator of trends in the relative quality of all college bound students because the proportion of college bound students taking the SAT has risen. The number of entering freshman can be estimated by multiplying Hauser's estimates of the proportion of high school graduates entering

colleges derived from the October interview of the Current Population Survey by the number of high school graduates. Robert Hauser, "College Entry Among Black High School Graduates: Family Income Does Not Explain the Decline." Center for Demography and Ecology, Working Paper 87-19. Then the ratio of SAT test takers to entering freshman was estimated by dividing the number of respondents to the SAT's Student Descriptive Questionnaire by the estimated number of freshman. This ratio was 56 percent in 1973, 54.5 percent in 1976-78, 61.2 percent in 1981 and 61.6 percent in 1985. The percentage of SAT test takers reporting themselves to be in the bottom 60 percent of their high school graduating class was 26 percent in 1973, 24 percent in 1976, 28 percent in 1978, 30 percent in 1982 and 32 percent in 1985. These patterns are clearly at odds with the data from HSB, NLS Class of 1972 and the ACE Cooperative Research Program. The growing proportion of high school graduates entering college and the growing share of them taking the SAT creates an appearance of deteriorating selectivity in SAT data during the late 1970s and the 1980s that is probably spurious.

26. Clifford Adelman, The Standardized Test Scores of College Graduates, 1964-1982, prepared for The Study Group on the Condition of Excellence in American Higher Education, National Institute of Education, 1983.
27. Data on trends for these tests was obtained by correspondence with the organizations which administer these exams and from Clifford Adelman, The Standardized Test Scores of College Graduates, 1964-1982. The weights for the three professional school tests were the total numbers of test takers between 1976 and 1986. There are breaks in the comparability of the LSAT and MCAT. The one year gaps in these series were filled in by assuming no change in mean scores during the interval. Because so many of the GRE test takers do not work in the business sector, the GRE index was given a weight equal to one half the number of test takers. The GRE index was constructed as follows. Since many of those taking GRE tests are headed for jobs in government and the non-profit sector, and GRE subject matter scores used in the index were the fields that typically lead to a job in private business: i.e. math, biology, physical sciences, engineering, psychology and economics. Based on the numbers taking the exams between 1976-1986 the weights were .27 for biology, .09 for chemistry, .06 for physics, .06 for geology, .06 for math, .14 for engineering, .06 for economics, and .27 for psychology. It was assumed that only one-half of those in economics and psychology enter private business. This GRE achievement score index was then averaged with the verbal and quantitative GRE "aptitude" test scores.
28. The time series of SAT and ACT test scores is not used because there have been changes in the share of high school seniors who take these two tests during the period. Separate time series of ITED composite scores for high school juniors and seniors in the state of Iowa were deviated from the value in 1977 and divided by the 1977 standard deviation of the test for each group. Since the ITED is given in the fall of the year, the mean for high school graduates in year t was an average of senior scores for t-1 and junior scores for t-2. In order to calculate an index of the quality of the cohort of high school graduates who reach college graduation age in year t, a weighted average was calculated with t-4 receiving a weight of one-half and each of the five previous years (t-5 to t-9) receiving a weight of one-tenth.

29. John H. Bishop, "Did the Test Score Decline Cause the Productivity Growth Decline." p. 181. Test score standard deviations for populations of high school seniors on which the Iowa tests are normed are about .74 of the standard deviations for random samples of adults. The coefficient was obtained by multiplying .74 by .190. Bishop's estimate of the effect of academic achievement on weekly wages is for adult males. The wage rate effects of test scores are smaller for young workers, so using a coefficient from a study of adult earnings may exaggerate the estimated effect of changes in the relative quality of college graduates on young workers. On the other hand, there is evidence that across individuals, the productivity effects of academic achievement are larger than the wage effects. (John H. Bishop "Productivity Consequences..." 1990 and "Information Externalities and the Social Return to Schooling," Center for Advanced Human Resources Research Discussion Paper 1987-04, Cornell University). If this is the case, differences in academic achievement across recognizable groups might generate group or cohort reputations that in turn cause large mean wage differentials between groups. This would mean that our method underestimates the effect of changes in the test score gap on the college premium for young workers.
30. National Center for Education Statistics, Digest of Education Statistics: 1989, Table 331, p.375.
31. U. S. Bureau of the Census, Characteristics of Men with College Degrees: 1967, Current Population Reports, Population Characteristics, Series P20, No. 201, p. 23.
32. U.S. Bureau of the Census, Current Population Reports, Series P-70, No. 11, What's It Worth? Educational Background and Economic Status: Spring 1984, U.S. Government Printing Office, Washington, D.C., 1987. The very large differentials between college majors found in these data reflect both differences in wage rates and in hours worked per month. If gender were controlled, the differentials would be smaller.
33. Thomas N. Daymont and Paul Andrisani, "Job Preferences, College Major, and the Gender Gap in Earnings." The Journal of Human Resources, Summer 1984, pp. 408-428.
34. Astin et al, "The American Freshman: 1986." and Astin et al, "The American Freshman: Twenty Year Trends." 1987.
35. The ASVAB Manual reports: "Extensive research demonstrates that the ASVAB composites used in military selection and classification predict performance in training for a variety of military occupations. For example, validity coefficients for electrical & mechanical equipment repair specialties range from .36 to .74; those for communication specialties range from .36 to .52; those for data processing specialties range from .39 to ,77; and those for clerical and supply specialties range from .53 to .73. These coefficients have been corrected for restriction of range." U.S. Military Entrance Processing Command. Counselor's Manual for the Armed Services Vocational Aptitude Battery, Form 14. July, 1984, p. 18) The test is highly correlated with the cognitive subtests of the General Aptitude Test Battery, a personnel selection test

battery used by the US Employment Service, the validity of which has been established by studies of over 500 occupations. A validity generalization study funded by the armed forces concluded "that ASVAB is a highly valid predictor of performance in civilian occupations." Hunter, John E.; Crossen, James J. and Friedman, David H. "The Validity of the Armed Services Vocational Aptitude Battery (ASVAB) For Civilian and Military Job Performance," Department of Defense, Washington D.C. August, 1985. p. ix).

36. The 1980 version of the ASVAB (Form 8A) was administered by staff of the National Opinion Research Corporation according to strict guidelines conforming to standard ASVAB procedures. Testing was generally conducted in groups of 5 to 10 persons. The Department of Defense had Dr. R. D. Bock an authority on educational and psychological testing evaluate the quality of the resulting ASVAB data. He concluded: "Data from responses of [the NLS Youth Sample] to the ASVAB are free from major defects such as high levels of guessing or carelessness, inappropriate levels of difficulty, cultural test-question bias, and inconsistencies in test administration procedures." (quoted in US Military Entrance Processing Command, 1984, p. 19) A fuller description of the test battery can also be found in this document.
37. Models containing the actual cumulated work experience outperform models using both the more conventional potential work experience and its square and age and age squared. The corrected R squares of the wage models average .2426 for males and .2129 for females when age and actual experience appear in the model in a linear form. When the experience variables are potential experience and its square, the corrected R squares average .2257 for males and .1837 for females.
38. This result is consistent with previous research on the impact of trade and technical vocational course work on the wage rates and earnings of young men. Technical skills appear to payoff only when used. John Bishop, "Vocational Education for At-Risk Youth: How to Make it More Effective." Center for Advanced Human Resource Research Discussion Paper # 88-12, Cornell Univ. 1988a. The returns to technical skills are likely to be gender specific. Very few young women have jobs for which knowledge of electronics, mechanical principles, auto mechanics and shop tools are essential. This is the reason why one should not expect technical knowledge to have a positive effect on the wage rates of women.
39. Computational speed has a significantly larger impact on wage rates of males than the academic composite in all eight of the cross-sections. This is somewhat of a puzzle, however, for computational speed is something that calculators do better than people and is not viewed by most educators as an appropriate goal for a high school mathematics curriculum (National Council of Teachers of Mathematics, An Agenda for Action: Recommendations for School Mathematics of the 1980s, (Washington DC: National Council of Teachers of Mathematics, 1980)).
40. Paul Taubman and Terence Wales, "Education as an Investment and a Screening Device." In Education, Income and Human Behavior, edited by F.T. Juster. New York: McGraw-Hill, 1975. Robert Willis and Sherwin Rosen, "Education and Self-Selection." Journal of Political Economy, 87, October 1979, pg. S7-S36. Robert

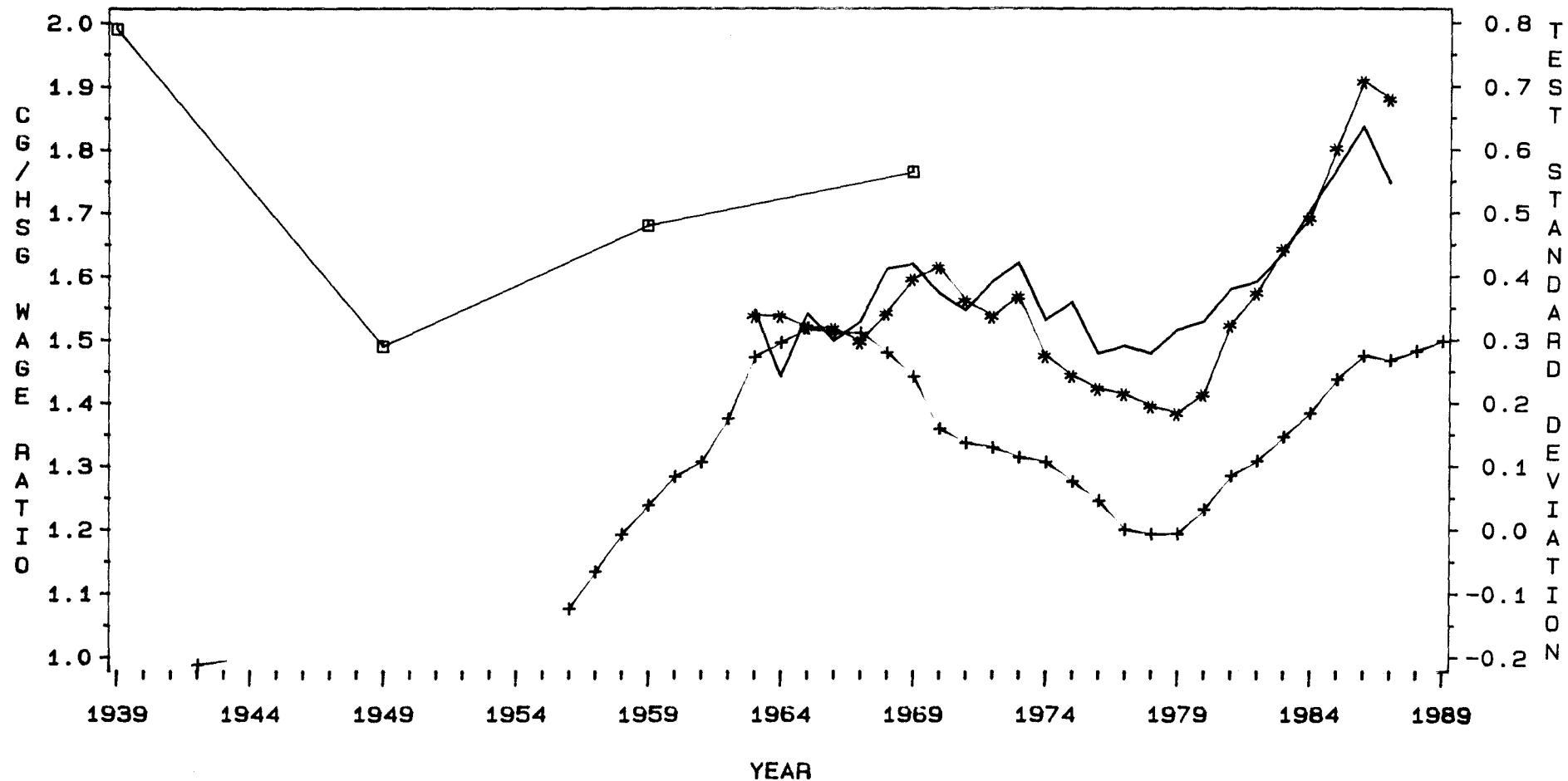
Hauser and Thomas Daymont, "Schooling, Ability, and Earnings: Cross-Sectional Evidence 8-14 years after High School Graduation." Sociology of Education, July 1977, 50, 182-206. Suk Kang and John Bishop, "Effects of Curriculum on Labor Market Success Immediately after High School." Journal of Industrial Teacher Education, Vol 23, No. 4, 15-29, 1986.

41. This estimate is based on a survey of a stratified random sample of 2000 members of the National Federation of Independent Business conducted in 1987.
42. Friedman and Williams, "Current Uses of Tests for Employment." Because they appear to be more job-related, mechanical aptitude tests like the three ASVAB technical tests have been much more likely to survive court challenge than tests assessing competence in English and mathematics. This is probably a major reason why technical subtests have large positive effects on wages of men even while basic skills tests have negative effects.
43. John Bishop, "The Productivity Consequences of what is Learned in High School" and John Bishop, "Information Externalities" and John A. Hartigan and Alexandra Wigdor, Fairness in Employment Testing, Washington, D.C.: National Academy Press, 1989, p. 169.
44. Paul Taubman and Terence Wales, "Education as an Investment and a Screening Device." Robert Willis and Sherwin Rosen, "Education and Self-Selection." p. S7-S36. Robert Hauser and Thomas Daymont, "Schooling, Ability, and Earnings," p. 182-206.
45. Paul Taubman and Terence Wales, "Education as an Investment and a Screening Device." Robert Willis and Sherwin Rosen, "Education and Self-Selection." p. S7-S36. John C. Hause, "Ability and Schooling as Determinants of Lifetime Earnings, or If You're So Smart, Why Aren't You Rich." In Education, Income, and Human Behavior, edited by F. T. Juster. New York: McGraw-Hill, 1975.
46. In a data set which merges six separate cross sections for a nine year birth cohort, age and DATE are not highly collinear so separate main and interaction effects may be estimated for each variable. While biases caused by the correlation between DATE and age, student status and years of college can be purged from the estimates there is, unfortunately, no way of breaking the perfect confound between DATE and the time elapsed since the ASVAB test was taken. If the true model is a relationship between current academic competence and wages, the ASVAB test scores obtained in 1980 become an increasingly imperfect measure of true competence as time elapses. This will tend to give the interaction between test score and DATE a negative coefficient. If despite this bias, the coefficient on the interaction is significantly positive, we have strong evidence for growing payoffs to true competency during the 1980s. If, however, the coefficient is zero or negative, the result is inconclusive.
47. Data for 1979 and 1980 were not included because requiring individuals to have a job for the entire 1979 to 1986 period would have greatly reduced the size of the sample.

48. Paul Taubman and Terence Wales, "Education as an Investment and a Screening Device." Robert Willis and Sherwin Rosen, "Education and Self-Selection." p. S7-S36. Robert Hauser and Thomas Daymont, "Schooling, Ability, and Earnings," p. 182-206.
49. Donald O. Parsons, "Wage Determination in the Post-Schooling Period: The Market for On-the-Job Training." Pathways to the Future, Vol 7, Center for Human Resources Research, Ohio State University and John Bishop and Suk Kang, "A Bonding/Sorting Model of Employer Finance of General Training" Center for Advanced Human Resources Working Paper 89-
50. This is an implication of a formal model developed by Henry Farber and Robert Gibbons, "Learning and Wage Determination" unpublished manuscript, National Bureau of Economic Research, November 1990.

Figure 1

THE PAYOFF TO COLLEGE AND ACADEMIC ACHIEVEMENT OF HIGH SCHOOL STUDENTS



SQUARE-RATIO COLLEGE GRAD TO HIGH SCHOOL GRAD YEARLY INCOME-MEN WITH 1 TO 10 YRS EXPERIENCE
 *** RATIO COLLEGE GRAD TO HIGH SCHOOL GRAD WEEKLY EARNINGS-MEN WITH 1 TO 5 YRS EXPERIENCE
 --- RATIO COLLEGE GRAD TO HIGH SCHOOL GRAD WEEKLY EARNINGS-WOMEN WITH 1 TO 5 YRS EXPERIENCE
 +++ ACAD ACHIEVEMENT OF 11TH & 12TH GRADERS IN STANDARD DEVIATION UNITS-1977 VALUE EQUALS 0

Figure 2

Bachelor's Degrees Awarded

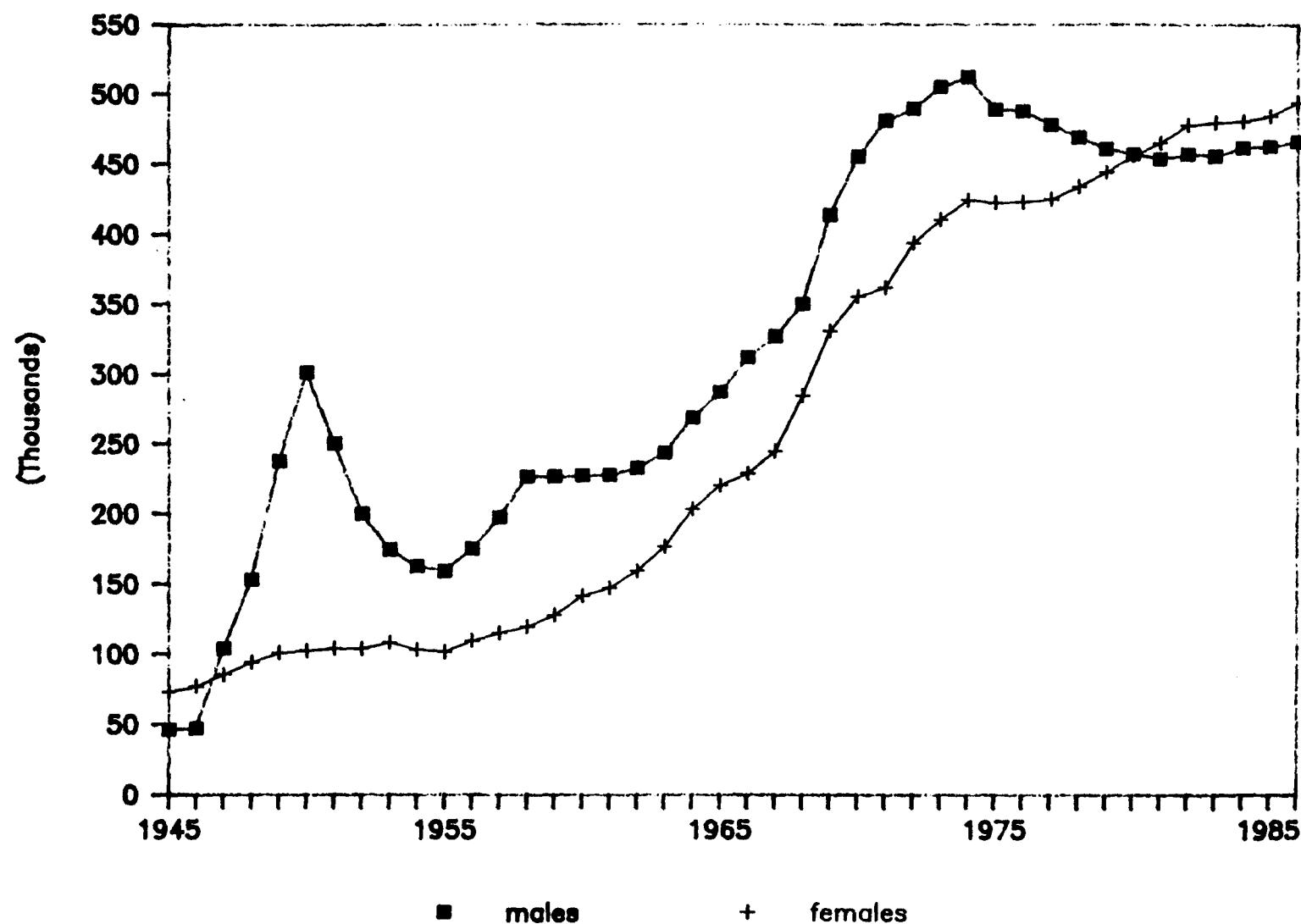
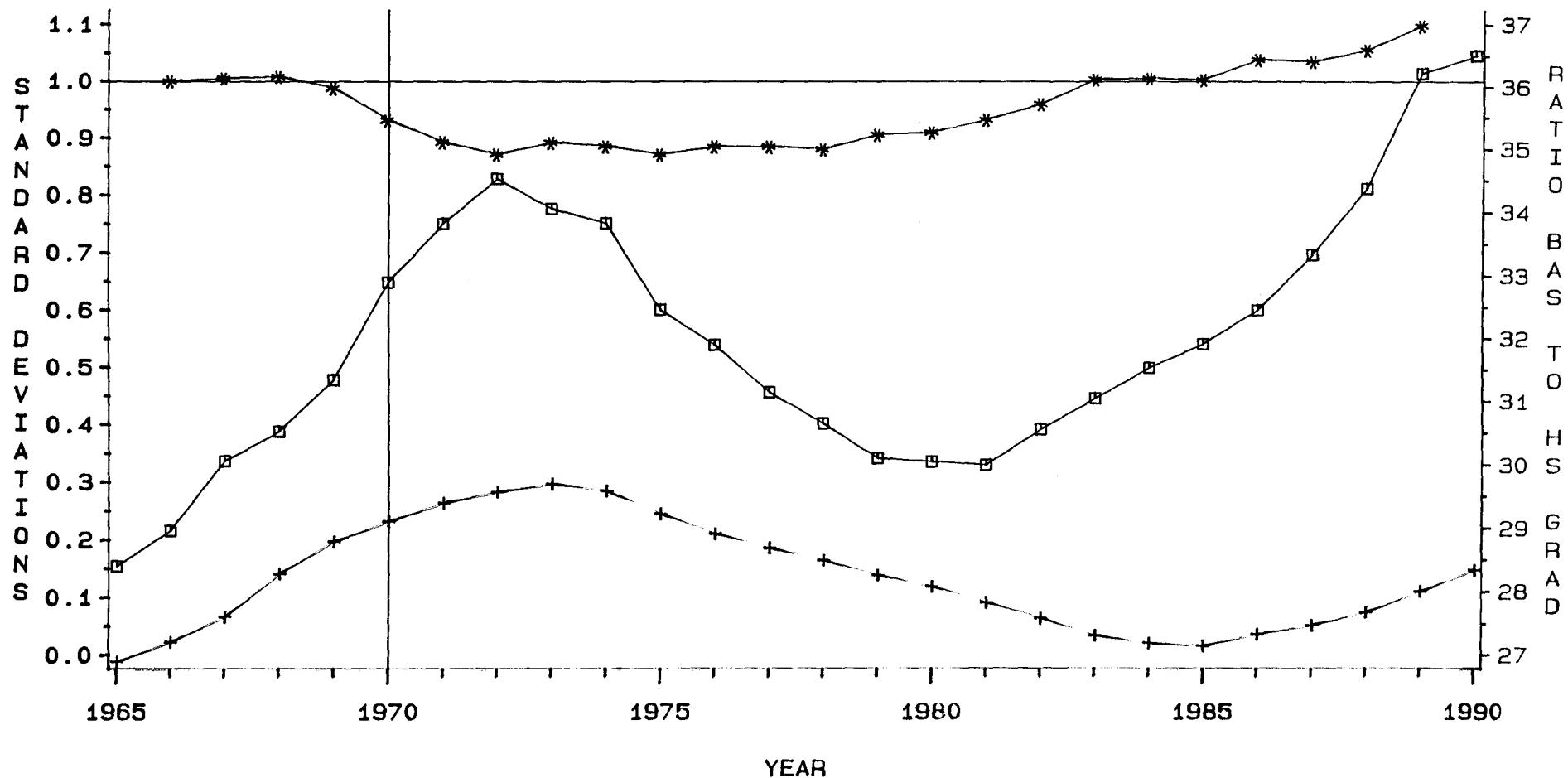


Figure 3
**ACADEMIC ACHIEVEMENT OF HIGH SCHOOL GRADS VERSUS
 PROPORTION GRADUATING FROM COLLEGE AND
 COLLEGE GRADUATE TEST SCORES**



+++ ITED SCORES OF HS GRADS 4-9 YRS EARLIER

*** SCORES ON GRAD. AND PROF. SCHOOL ADMISSION

SQUARE--RATIO OF COLLEGE GRADS TO HIGH SCHOOL GRADS 4-9 YRS EARLIER

Figure 4
Proportion of Degrees Awarded (by subject)
Bachelor's Awarded to Males

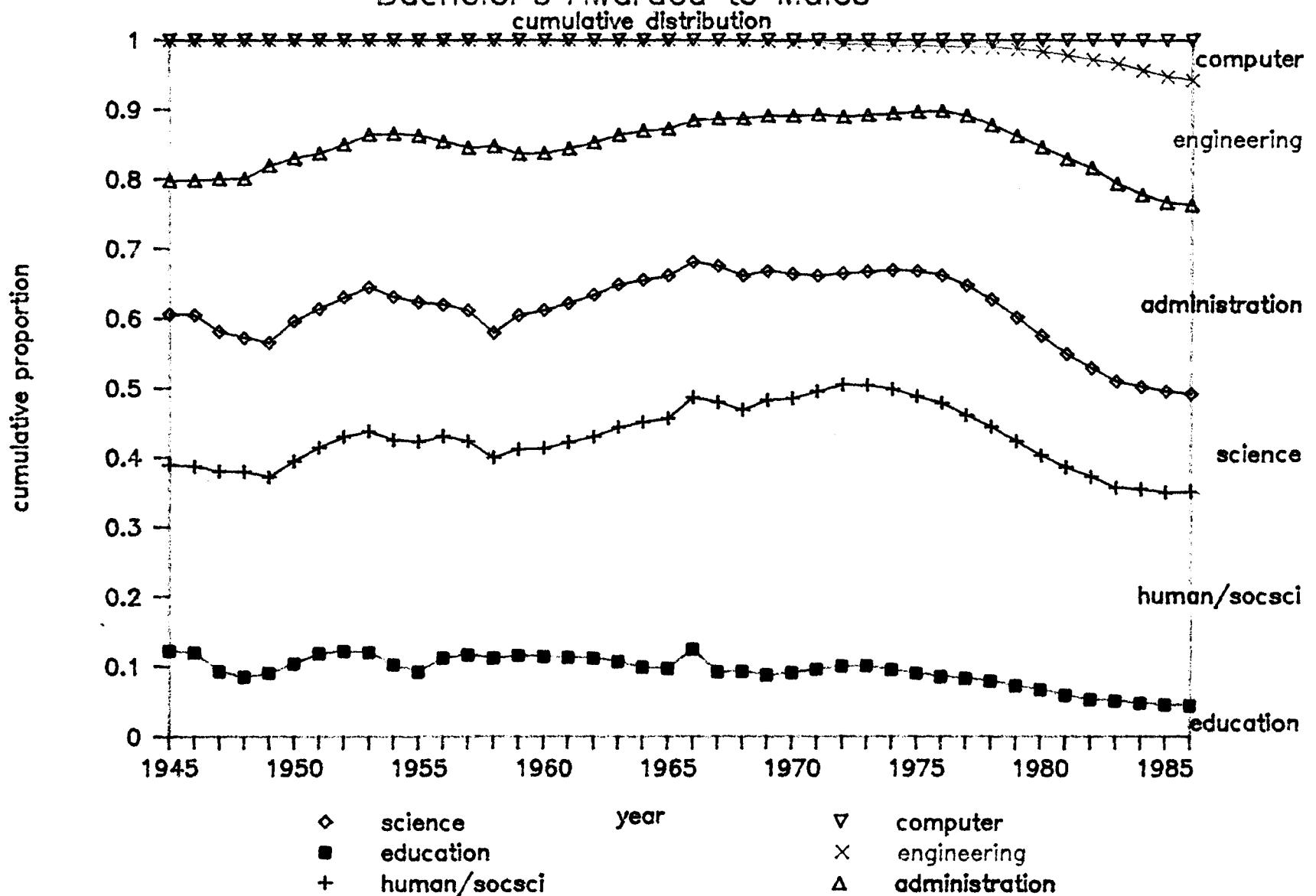


Figure 5
Proportion of Degrees Awarded (by subject)

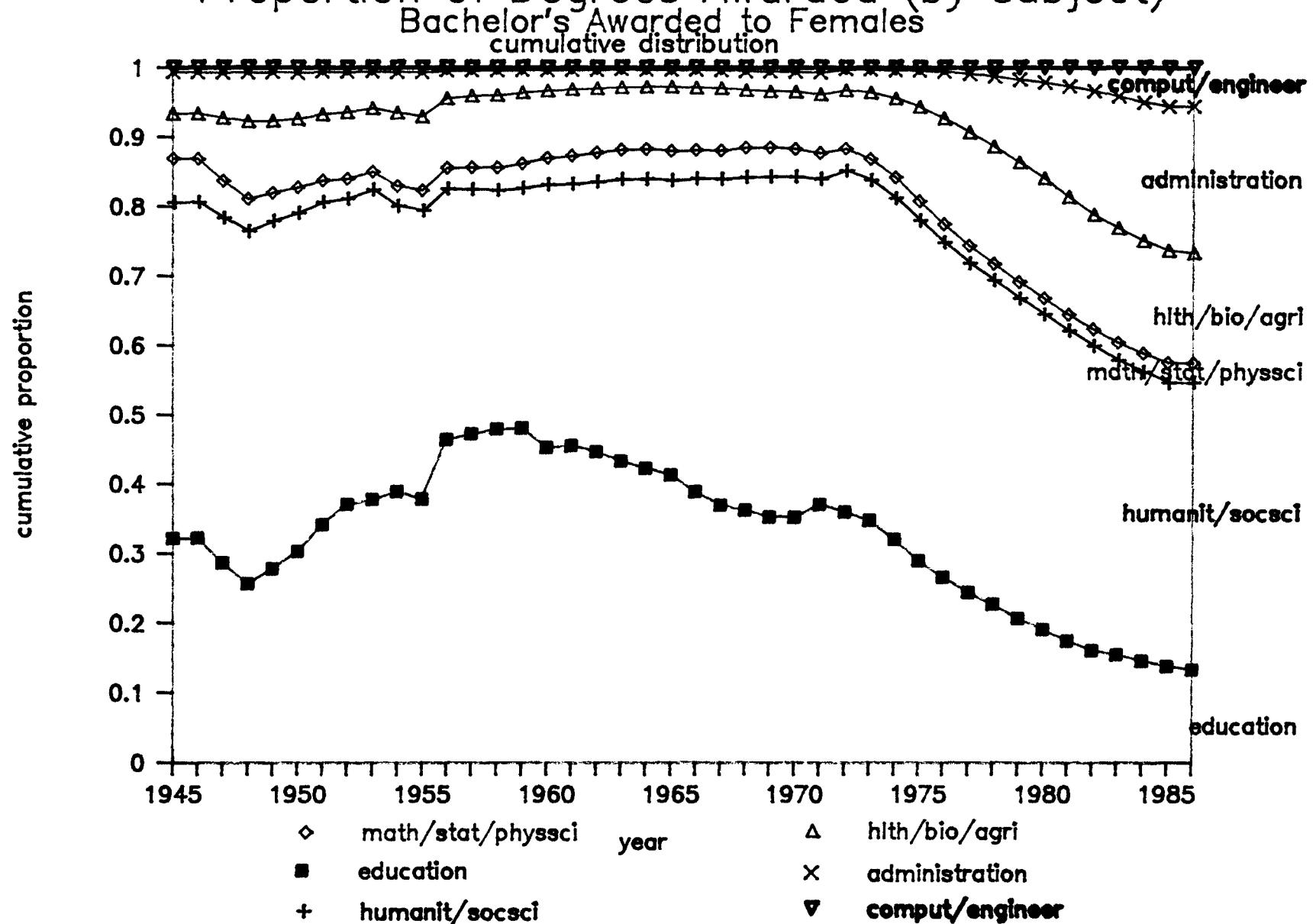


Figure 6

Relative Quality of College Graduates

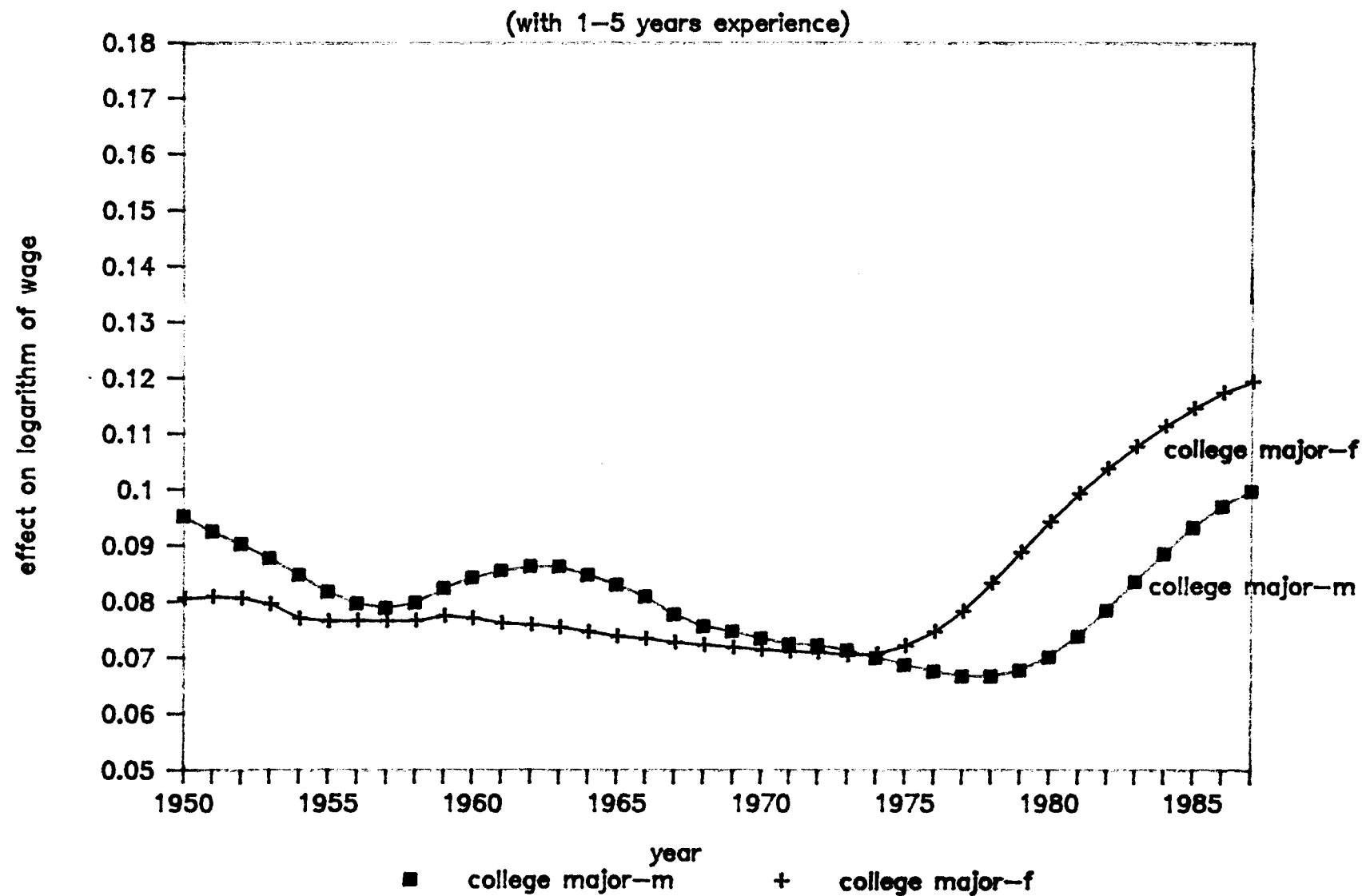


Table 1
Determinants of College Entrance

<u>Independent Variables</u>	<u>Poverty</u>	<u>Income</u>	<u>Lower Middle Income</u>	<u>Middle Income</u>	<u>Upper Middle Income</u>	<u>High</u>
College Payoff (SD = \$570)	.080*** (2.86)		.054*** (3.44)	.036*** (2.89)	-.033* (1.83)	-.018 (1.14)
Academic Orientation	.163*** (7.58)		.201*** (16.16)	.256*** (24.33)	.227*** (14.54)	.227*** (15.87)
Hours of Study (SD = 5.5 hrs)	.092*** (4.59)		.043*** (3.96)	.116*** (12.64)	.057*** (4.16)	-.022 (.12)
R2	.224		.273	.307	.288	.272
Number of Observations	2320		6538	8766	4309	5113

Standardized regression coefficients with t statistics in parenthesis under the coefficient. THe coefficient on the payoff variable represents the effect of a \$570 increase in the difference between professionals and operatives at a time (1959) when mean earnings of male high school graduates 25 to 64 years old was \$6132. The coefficient on the study hours per week variable represents the effect of a 5.5 hour increase in reported study time. Mean hours of reported study time including study halls was about 9 hours.

Source: Weighted least squares prediction of college attendance in fall 1961 using longitudinal data on 27,046 male high school juniors in the Project Talent data base. Students were categorized by family income and separate models were estimated for each group. An extensive set of controls was included in the models: socio-economic status, number of siblings, the number of changes of school, academic aptitude, the tuition at public universities and colleges in the state, the cost (including travel costs) of attending the lowest cost 2 year and 4 year colleges, distance to the lowest cost college, the selectivity of local colleges, the opportunity cost of the student's time (the operative wage rate), and a dummy for being from an intact family and the cheapest local postsecondary institution is a 2 year vocational college. Data was collected by phone from a five percent sample of the non-respondents to Project Talent's mail questionnaires. Because non-respondents to the mail questionnaire were systematically different from those who responded, the people who were part of the non-respondent sample were assigned weights of 20 in the weighted regression.

Table 2

**The Effect of College Payoff on
The Academic Orientation of High School Courses
and Hours of Study Time**

	Poverty	Beta Coefficient on Payoff Variable by Income Group				High Income
		Lower Middle Income	Middle Income	Upper Middle Income		
Regression Predicting Academic Orientation	.103*** (4.01)	.025* (1.81)	.011 (.98)	.065*** (4.26)		.072*** (5.19)
Regression Predicting Study Time	-.060*** (2.14)	-.002 (.10)	-.057*** (4.33)	-.081*** (4.54)		.004 (.25)
Number of Observations	2320	6538	8766	4309		5113

Standardized regression coefficients representing the effect of a \$570 (in 1959 dollars) increase in the earnings differential between professionals and operatives. The payoff variable had a mean of \$2957 and a standard deviation of \$570. Male high school graduates 25 to 64 years old earned an average of \$6132 in 1959. (T statistics are in parenthesis under the coefficient).

Source: Weighted least squares models predicting the academic orientation of course taken and time spent in study halls and studying at home using data on 27,046 male high school juniors in the Project Talent data base. Students were categorized by family income and separate models were estimated for each group. An extensive set of controls was included in the models: socio-economic status, parents education, academic aptitude, religious activity, the tuition at public universities and colleges in the state, the cost (including travel costs) of attending the lowest cost 2 year and 4 year colleges, distance to the lowest cost college, the selectivity of local colleges, the opportunity cost of the student's time (the operative wage rate and the SMSA unemployment rate), and characteristics of the local high school--size, teacher salary, teacher experience, homogeneous grouping, hours of homework assigned and dummies for race, being the eldest child, being from an intact family and sports ability,. Data was collected by phone from a five percent sample of the non-respondents to Project Talent's mail questionnaires. Because non-respondents to the mail questionnaire were systematically different from those who responded, the people who were part of the non-respondent sample were assigned weights of 20 in the weighted regression.

Table 3
The Slowdown in the Growth,
the Quantity and Quality of the Education
of the Employed Work Force

Employed Workforce by Yrs of Schooling ('000s)	<u>1959</u>	<u>1970</u>	<u>1980</u>	<u>1988</u>
16+	6,381	10,185	19,192	26,814
13-15	6,123	10,501	18,875	24,080
12	20,213	30,792	42,285	47,760
9-11	13,037	13,659	16,345	14,535
<u>0-8</u>	<u>20,082</u>	<u>13,817</u>	<u>8,752</u>	<u>6,534</u>
Total	65,842	78,955	105,499	119,725
16+/LE 12 Yrs of School	.1185	.1746	.2848	.3896
Mean Years of School	10.52	11.58	12.46	12.93
EQ Index (1929=0)	.3064	.4267	.5210	.5619

Yearly Rates of Gain

<u>College/HS Wage Ratio</u>	<u>1959-70</u>	<u>1972-80</u>	<u>1980-88</u>
Men: Murphy & Welch	----	-.0046	.0219 ^c
Dean et al.	-.0046	-.0077	.0208 ^b
Kosters	----	-.0093 ^a	.0282 ^d
Women: Dean et al.	.0011	.0030	.0153 ^b
Kosters		-.0122 ^a	.0091 ^d
<u>College/HS Employment Ratio</u>			
CPS-over age 16	.0353	.0488	.0392
CPS-adj. ED overreport	.0353	.0488	.0351
<u>Mean Years of Schooling</u>	.0964	.0915	.0588
EQ Index x 5	.0602	.0472	.0256
Mean Years of School Equiv.	.1566	.1387	.0844

^a Yearly growth 1973-79

^c Yearly growth 1980-85

^b Yearly growth 1980-86

^d Yearly growth 1979-88

Sources: Data on educational attainment of the labor force over the age of 16 is from the Handbook of Labor Statistics, Table 65, unpublished BLS data. The EQ index is from John Bishop, "Is the Test Score Decline Responsible for the Productivity Growth Decline?" The data on rates of change in relative wage ratios is from the articles by Murphy and Welch and by Kosters in this volume and from Edwin Dean, Kent Kunze and Larry S. Rosenblum, "Productivity Change and Measurement of Heterogeneous Labor Inputs," BLS,3/89.

Table 4
 Average Ability Ranking of College Entrants and
 High School Graduates Not Entering College

		College Average	Non College Average	Entrance Selectivity Differential
O'Brien	1925	53	47	6
Benson	1929	56	45	11
Barker	1934	58	43	15
Phearmon	1946	63	43	20
Berdie	1950	61	42	19
Little	1957	62	40	22
Talent	1960	63	35	28
Berke & Hood	1961	62	36	26
<hr/>				
NLS Class of 72	1972	60	38.9	22
High School and Beyond	1980	61.2	36.4	24.7

Sources: For the period prior to 1961--Paul Taubman and Terence Wales, "Mental Ability and Higher Educational Attainment in the 20th Century." National Bureau of Economic Research Occasional Paper 118, 1972.

For 1972 and 1980--John Gardner, Transition from High School to Postsecondary Education: Analytical Studies. National Center for Research in Vocational, Ohio State University Research Foundation, Columbus, Ohio, February, 1987, Table 3-7.

Table 5
College Graduate Test Score Trends

Graduate Test Average ^a	ITED HS Grad Average 4-9 Years Earlier ^b	Difference between College Grad. & HS Grad	Ratio of BA's Awarded to HS Grads 4-9 Years Earlier ^c	Ratio of Grad. Test Takers to BA's
1960			.261	
1962			.274	
1964	-.049		.281	
1966	.116	.023	.290	.422
1967	.121	.067	.301	.461
1968	.124	.141	.305	.498
1969	.103	.197	.313	.486
1970	.046	.232	.329	.564
1971	.008	.265	.338	.627
1972	-.014	.283	.345	.618
1973	.007	.283	.341	.606
1974	.001	.285	.338	.631
1975	-.014	.245	.325	.666
1976	.000	.211	.319	.654
1977	.000	.186	.311	.666
1978	-.005	.164	.307	.674
1979	.021	.139	.301	.677
1980	.025	.119	.301	.682
1981	.047	.091	.300	.680
1982	.075	.064	.306	.652
1983	.119	.034	.311	.664
1984	.121	.021	.315	.633
1985	.118	.016	.319	.637
1986	.154	.037	.325	.636
1987	.150	.052	.333	.666
1988	.171	.074	.344	.684
1989	.213	.110	.362	.696

^a An index of scores on the tests that students applying for graduate and professional schools take. All tests were deviated from their mean in 1977 and divided by their standard deviation before being averaged.

^b An index of 11th and 12th grade ITED test scores (deviated from their value in 1977 and divided by the standard deviation for that grade) for the cohort of students who graduated from high school four to nine years previously. The weights are .5 for t-4 and .1 for t-5, t-6, t-7, t-8 and t-9.

^c Ratio of bachelors degrees awarded in year t to the number of high school diplomas awarded 4 to 9 years previously. Weights were .5 for t-4 and .1 for t-5, t-6, t-7, t-8 and t-9.

Sources: Data on 12th grade ITED and graduate GRE, GMAT, LSAT & MCAT test scores and the number of graduate test takers was obtained from Clifford Adelman, "The Standardized Test Scores of College Graduates," 1983, Table A), Nabeel Alsalam, editor, The Condition of Education 1990: Postsecondary Education, Indicator 2:12) and by correspondence with the testing organizations. Data on numbers of BA's and high school diplomas is from Digest of Educational Statistics 1989, Table 89 and 200.

Table 6
Wage Relatives by College Major
(Relative to Humanities Major)

	Earnings of Full Time Wkrs 1 Year after BA Both sexes*				Hourly Earnings of 25 Year Olds in 1979 ^b		Median Earnings Males age 21-70 BAs in 1966 ^c		Average Monthly Earnings in 1984 ^d
	1976	1981	1985	1987	Male	Female	Medium Rank	All College Colleges	
Bachelors in Low Wage Major									
Humanities	0	0	0	0	0	0	0	0	0
Social Sciences	16%	11%	13%	25%	2%	5%	15%	14%	--
Social Sci. exc. Economics	ns	ns	ns	ns	ns	ns	ns	ns	28%
Education	9%	-9%	-1%	-2%	-4%	5%	2%	-9%	-6%
Psychology	--	-1%	4%	7%	ns	ns	ns	ns	ns
Biological Sciences	12%	15%	8%	1%	0	28%	4%	-11%	12%
Agriculture	ns	ns	ns	ns	ns	ns	ns	ns	45%
Health	48%	37%	49%	40%	ns	ns	--	--	12%
Bachelors in High Wage Major									
Phy. Sci.-Math-Comp. Sci.	21%	29%	25%	39%	--	--	31%	28%	--
Physical Science	ns	ns	ns	ns	15%	35%	ns	ns	93%
Mathematics	ns	ns	ns	ns	ns	ns	ns	ns	68%
Computer Science	ns	ns	ns	ns	19%	13%	--	--	ns
Engineering	110%	78%	72%	64%	34%	27%	51%	52%	114%
Business	76%	29%	34%	30%	13%	25%	32%	28%	103%
Economics	ns	ns	ns	ns	ns	ns	ns	ns	111%

* Percentage differential between the earnings one year after receiving a bachelors degree of full-time workers who pursued the designated major over that received by humanities majors. Data is based on a probability sample of recent graduates. *Digest of Education Statistics: 1989*, Table 331, p.375.

^b Percentage differential implied by regressions predicting hourly wage rate of college graduates who have been out about 3 years controlling for degree and preferences using 1835 observations from Class of 1972 data. Daymont and Andrisani, "Job Preferences, College Major and the Gender Gap in Earnings," *Journal of Human Resources*, 1984, 408-428.

^c Percentage differential for median yearly earnings of male BA holders with designated major (and MBAs and Masters in Engineering) relative to median earnings of humanities majors. Current Population Reports, P-20, No. 201.

^d Percentage differential for mean monthly earnings of BA holders with designated major relative to earnings of humanities and liberal arts majors. Current Population Reports, P-70, No. 11, p. 13.

Table 7
Effect of Skill Indicators

	Acad Test	Tech Test	Compute Speed	Yrs of Educ	Yrs of College	Actual Exp	Actual Exp Sq.	Age	Age Sq.	R2	Number of Observations
Male											
1986	-.028*	.078***	.068***	.016**	.027***	.064***	-.0009	.007 (.23)	-.0005 (.31)	.264	4160
1985	-.012 (.77)	.073*** (5.63)	.071*** (7.19)	.011* (1.74)	.025*** (2.82)	.068*** (5.21)	-.0017 (1.27)	.028 (1.05)	-.0018 (1.12)	.271	4100
1984	-.023 (1.43)	.065*** (4.83)	.073*** (7.17)	.012* (1.84)	.013 (1.42)	.064*** (4.45)	-.0001 (.04)	.011 (.45)	-.0005 (.32)	.238	4099
1983	-.040** (2.50)	.066*** (5.03)	.067*** (6.72)	.025*** (3.84)	.004 (.46)	.064*** (4.15)	-.0017 (.81)	.011 (.47)	.0003 (.20)	.249	3994
1982	-.036** (2.30)	.052*** (3.96)	.046*** (4.63)	.026*** (3.85)	.002 (.24)	.075*** (4.42)	-.0046* (1.74)	.0006 (.03)	.0015 (.85)	.224	4100
1981	-.035** (2.28)	.033** (2.56)	.051*** (5.14)	.036*** (5.30)	-.017 (1.58)	.100*** (5.20)	-.0113*** (3.26)	-.053 (2.72)	.0076** (3.85)	.241	3617
1980	-.047*** (3.06)	.048*** (3.70)	.035*** (3.54)	.034*** (4.88)	-.012 (.94)	.052** (2.40)	-.0059 (1.25)	-.018 (1.06)	.0048** (2.26)	.229	3392
1979	-.025 (1.34)	.034** (2.16)	.036*** (3.00)	.034*** (4.18)	-.042** (2.36)	.000 (.03)	.009 (1.09)	.026* (1.68)	.0015 (.64)	.247	2205
Female											
1986	.072*** (4.22)	.003 (0.87)	.040*** (3.87)	.001 (.18)	.054*** (5.48)	.057*** (4.70)	.0014 (1.15)	.032 (1.04)	-.0025 (1.53)	.272	4072
1985	.076*** (4.58)	-.016 (.92)	.040*** (3.97)	-.003 (.36)	.049*** (4.92)	.082*** (6.43)	-.0016 (1.18)	.031 (1.11)	-.0019 (1.16)	.254	3960
1984	.048*** (2.83)	.005 (.27)	.045*** (4.33)	-.012 (1.53)	.063*** (6.18)	.098*** (6.98)	-.0037 (2.17)	.026 (1.03)	-.0015 (.86)	.233	3985
1983	.039** (2.42)	-.014 (.80)	.052*** (5.30)	-.006 (.76)	.056*** (5.59)	.083*** (5.49)	-.0021 (1.01)	.015 (.68)	-.0010 (.59)	.209	3894
1982	.005 (.33)	.014 (.85)	.048*** (5.07)	.002 (.31)	.037*** (3.80)	.092*** (5.76)	-.0039 (1.52)	-.004 (.19)	.0007 (.43)	.187	3894
1981	.019 (1.23)	.013 (.78)	.032*** (3.39)	-.002 (.32)	.050*** (4.75)	.085*** (4.49)	-.0026 (.73)	.024 (1.27)	-.0022 (1.17)	.195	3400
1980	.034** (1.96)	-.024 (1.32)	.032 (3.03)	.014 (1.53)	.006 (.47)	.085*** (3.64)	-.0038 (.72)	.060*** (3.14)	-.0060*** (2.67)	.150	3124
1979	-.012 (.58)	.012 (.54)	.041*** (3.14)	.034*** (3.14)	-.035** (1.97)	.045 (1.26)	.00000 (.00)	.129*** (6.97)	-.014*** (5.36)	.235	2061

* significant at the 10 percent level on a two tail test

** significant at the 5 percent level on a two tail test

*** significant at the 1 percent level on a two tail test

Source: Least squares estimation of equation 1 predicting the log of the hourly wage rate on one's current or most recent job separately for each year. The sample included individuals in the NLS Youth data set who were not in the military in 1979 and who answered questions about wages in the yearly interviews from 1981 and 1986. The coefficient on the variables included in this table were constrained to be the same in all years while the coefficients on control variables were not. Controls not shown in the table included school attendance (4 variables), minority status, past and current military service, marital status, having one or more children, four Census regions, rural residence, residence outside an SMSA and the local unemployment rate.

Table 8
Effects of Skills on Wage Rates
1981-1986

	Males		Females	
	Coefficient	T Statistic	Coefficient	T Statistic
Academic Test (a ₀)	-.038**	(2.49)	.020	(1.36)
Technical Test (b ₀)	.053***	(4.36)	.004	(.24)
Computational Test (c ₀)	.057***	(6.06)	.039***	(4.43)
Years of Schooling (d ₀)	.030***	(4.74)	.025***	(3.19)
Years of College (e ₀)	.058***	(3.84)	.034**	(2.37)
Actual Experience (f ₀)	.1076***	(7.64)	.0822***	(5.54)
Actual Experience Sq. (f ₁)	-.0048***	(2.99)	-.0013	(.74)
Potential Experience (g ₀)	.048***	(5.45)	.0345***	(3.69)
Potential Experience Sq. (g ₁)	-.0036***	(5.25)	-.0033***	(4.23)
Interaction of Date with				
Academic Test (a ₁)	.0030	(.39)	.0011	(.14)
Technical Test (b ₁)	.0034	(.59)	-.0036	(.42)
Computational Test (c ₁)	-.0067	(1.31)	-.0027	(.55)
Years of Schooling (d ₁)	-.0055***	(2.74)	-.0033	(1.11)
Years of College (e ₁)	+.0184***	(5.20)	.0101**	(2.50)
Actual Experience (f ₁)	.0053*	(1.80)	.0020	(.66)
Interactions of Age with				
Academic Test (a ₂)	-.0043	(.76)	.0041	(.64)
Technical Test (b ₂)	.0027	(.54)	.0032	(.82)
Computational Test (c ₂)	.0097**	(2.29)	.0058	(.87)
Interactions of Actual Exp. with				
Years of College (e ₄)	-.0139***	(5.11)	-.0072***	(2.71)
Academic Test (e ₅)	.0050	(.99)	.0045	(.72)
Interact Acad. Test & College (d ₅)	.0124**	(2.22)	.0148***	(2.70)
Interaction of Student Status with				
Years of Schooling (d ₃)	-.0327***	(3.80)	-.0163**	(1.99)
Academic Test (a ₃)	.0262	(1.47)	-.0173	(.94)
R ² (Pooled 1981-86 Data)	.1295		.1218	
Number of Observations per year	2155		1920	
F test on Sum of Trend X Test Interactions	.004		.57	
F test on Sum of Age X Test Interactions	2.85*		5.78**	
F test on Sum of Trend X Schooling Interactions	19.91***		6.24**	

Source: Joint generalized least squares estimation of equation 1 predicting the log of the hourly wage rate on one's current or most recent job. The sample included individuals who were not in the military in 1979 and who answered questions about wages in the yearly interviews from 1981 and 1986. The coefficient of the variables included in this table were constrained to be the same in all year while the coefficients on control variables were not. Controls not shown in the table included school attendance (4 variables), minority status, currently in the military, marital status, having one or more children, four Census regions, rural residence, residence outside an SMSA and the local unemployment rate. Potential experience, P, was substituted for age in these models. Potential experience is defined as MAX{ 0, Age - MAX[16, (years of schooling + 6)]}. The model estimated was:

$$W_t = aA + bT + cR + dS_t + eC_t + fE_t + gP_t + hZ_t + u_t \quad \text{jointly for } t = 1981 \dots 1986$$

where:

$$a = a_0 + a_1(\text{Year}-1983) + a_2(\text{Age}_t-22) + a_3(\text{Student}_t)$$

$$b = b_0 + b_1(\text{Year}-1983) + b_2(\text{Age}_t-22)$$

$$c = c_0 + c_1(\text{Year}-1983) + c_2(\text{Age}_t-22)$$

$$d = d_0 + d_1(\text{Year}-1983) + d_3(\text{Student}_t) + d_5A$$

$$e = e_0 + e_1(\text{Year}-1983) + e_4(E_t-4) + e_5A$$

$$f = f_0 + f_1(\text{Year}-1983) + f_4E_t$$

$$g = g_0 + g_4P_t$$

Student_t = share of calendar year t in school