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ABSTRACT

This paper presents evidence that recent aptitude test score decline is signaling a significant deterioration in the quality of entering cohorts of workers. The impact of general intellectual achievement (GIA) on productivity; trends in the GIA of the adult populations, students, and working adults; accounting for the labor quality growth when credentials signal GIA; and the productivity consequences of test score decline are discussed. The test score decline, which began around 1967, was roughly equal to the learning that takes place in 1.25 years of high school. The resulting wage rate decline was determined to be 7.1%. New estimates of the quality of the work force are developed that take into account improvements in the quality and quantity of education. Although substantial evidence links the decline in productivity with test score decline, the timing may seem inappropriate in linking the two factors causally. Teenagers play only a minor role in the economy; thus, a decline in their test scores cannot account for a simultaneous drop in productivity growth. Nevertheless, declines in test scores for teenagers since the late 1960s may be responsible for the non-appearance of the anticipated rebound in productivity growth forecast for the 1980s. Eight figures, eight data tables, and 81 references are provided. (TJH)

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Abstract

The paper presents evidence that the recent test score decline is signaling a significant deterioration in the quality of entering cohorts of workers. The test score decline which began around 1967 was roughly equal to the learning that takes place in 1.25 years of high school. Analysis of PSID data reveals that, if errors in measurement are accounted for, a 1.25 grade level equivalent decline in adult test score lowers wage rates by 7.1 percent when years of schooling are controlled. In addition, studies of the productivity of workers doing the same job find that a fall in academic achievement lowers productivity significantly more than it lowers one's relative wage rate.

This deterioration in the quality of the output of the educational system is historically unprecedented. Prior to 1967, student test scores had exhibited almost 50 years of uninterrupted improvement. Between 1942 and 1967 scores on tests given to Iowa high school seniors rose .75 grade level equivalents per decade. The men who fought in WWII scored about 3 grade level equivalents (.73 standard deviations) higher than WWI recruits on the Army Alpha test even though they had on average only two additional years of schooling. Furthermore, scores on I.Q. tests given to random samples of children and adults had been rising 3.1 IQ points per decade.

New estimates of the quality of the work force are developed which take into account improvements in the quality as well as the quantity of education. Improvements in the cultural environment and the quality of education contributed .35 percent per year to the growth of labor quality between 1948 and 1973. Their contribution to labor quality growth declined subsequently to .259 percent per year between 1973 and 1980 and .139 percent per year in the 1980s. If the test scores of high school graduates had continued to grow after 1967 at the rate that prevailed in the previous quarter century, labor quality would now be 4.8 percent higher and GNP 3.2 percent or $142 billion higher. The labor quality shortfall is projected to be 9.1 percent in the year 2000 and 11 percent in 2010. Discounted to 1987 at a real discount rate of 6 percent, the forecasted total cost through the year 2010 of the test score decline is estimated to be $5.24 trillion.

Large as these effects are, one cannot blame the slowdown in productivity growth on the test score decline. The timing is wrong. Teenagers play only a minor role in the economy, so a decline in their test scores cannot account for a simultaneous drop in productivity growth. The effects of the test score decline on the economy had to wait until the cohorts affected had become a major share of the work force. Thus it is in the 1980s that the test score decline is having its major impact. The rebound in productivity growth that was forecast for the 1980s has not occurred and the test score decline is in part responsible.

IS THE TEST SCORE DECLINE RESPONSIBLE FOR THE PRODUCTIVITY GROWTH DECLINE?

Multifactor productivity growth in the nonfarm business sector which was 1.66 percent per year between 1948 and 1973 slowed to 0.14 percent per year between 1973 and 1986 (BLS 1987). If pre-1973 trends had continued, the nation would now be 22 percent richer. The research on the causes of the productivity growth slowdown has examined a long list of potential culprits: rising energy prices, government regulations, a shift of output toward services with low rates of technological progress, short term managerial horizons, reductions in R&D, patents and innovations, the changing demographic composition of the work force, and declines in work effort. Quite clearly some of these factors have contributed to the decline, but a large portion of the drop in multifactor productivity growth remains unexplained even after interindustry shifts, demographic shifts, energy prices, the slowdown in R & D investment and increases in government regulations are taken into account (Denison, 1984; Baily, 1986; Baily, 1981). The absence of a rebound in multifactor productivity growth during the 1980's is particularly difficult to explain. Despite falling oil prices, lowered marginal tax rates, scaled-back regulation and the entry of the baby boom generation into their prime working years, multifactor productivity grew a meager .33 percent per year between 1979 and 1986.

There has been some speculation that the decline of SAT scores may be signaling a large drop in the quality of young entrants into the work force and that this may be responsible for a portion of the productivity growth slowdown (Kendrick, 1980). Martin Baily examined this issue in 1981 and rejected it as a major cause of the productivity slowdown. He calculated how large the decline in the quality of entering cohorts of labor would have to be to explain one half of the slowdown in productivity growth between 1968 and 1979. During the last few years of this period, the implied relative quality of entering cohorts would have had to be 40 percent below the pre-1968 levels. "In my view, such a sharp decline is implausible and of a much larger magnitude than anything implied by the SAT scores or related evidence, which suggests that the cohort-quality hypothesis can at most explain a small fraction of the slowdown." (Baily, 1981, p. 13).

This paper reexamines this issue and reaches the same conclusion regarding the 1960s and the 1970s but a different conclusion regarding the

1980s and 1990s. The timing of the decline in test scores and productivity growth are remarkably coincident. But a decline in the academic achievement of teenagers cannot cause a coincident decline in productivity growth, for teenagers receive only slightly more than 2 percent of total wages. Test scores were rising rapidly in the decades preceding 1967, and the lagged effects of these gains caused the academic achievement of the total work force (weighted by wage rates) to grow rapidly in the early 1970s.

The significance of the post-1966 test score decline derives from its large size (1.25 grade level equivalents) and from the fact that it was a decisive break in a 50-year trend of continuous gains in the knowledge and basic skills of those graduating from high school. In Iowa, the preceding 24 years had seen a 1.82 grade level equivalent gain in the performance of high school seniors. Comparable improvements in the quality of high school graduates occurred elsewhere in the country and in earlier decades. The fact that the test scores of students at given stages of schooling had been rising for more than 50 years prior to 1966 makes the decline that much more remarkable and greatly magnifies its long-term effects on productivity growth.

These effects are quite substantial. Wage rates of adults are significantly influenced by general intellectual achievement even when years of schooling are controlled for. Previous studies have understated the magnitude of the relationship because (a) the tests employed were unreliable and models were estimated without correction for measurement error and (b) tests taken decades earlier often prior to the end of schooling were used to examine the effects of academic achievement. Furthermore, the effect of academic achievement on productivity is larger than its effect on wage rates because academic achievement is not efficiently signaled to the labor market and so tends to be under- compensated (Bishop 1987b).

The test score decline started to have important effects on productivity growth during the middle of the 1970s. The contribution of educational quality to labor force quality dropped from a postwar peak of .39 percent per year between 1966 and 1970 to .26 percent per year between 1973 and 1980 and to .14 percent per year between 1980 and 1987. If the rate of gain in the academic achievement of the workers with given amounts of schooling that prevailed between 1948 and 1973 had been maintained, labor quality would instead have grown by .49 percent per year between 1973 and 1980 and by .535

percent per year between 1980 and 1987. Workers would have been 2.2 percent more productive in 1980 and 4.8 percent more productive in 1987. The effected workers will remain in the labor force for 50 years, so the vintage model developed in this paper forecasts even larger reductions in productivity in the coming years. Even with an assumption of big gains in educational quality in the future, the forecast is for a 9.1 percent labor quality shortfall in the year 2000 and a 11 percent shortfall in 2010. The social costs of the test score decline are now 142 billion dollars a year and will nearly double in the coming decade. (This can be compared with the $172 billions spent on the compensation of labor by all public and private schools and colleges in 1986.) Discounted to 1987 at a 6 percent real discount rate, the forecasted total social cost through 2010 of the test score decline is $5.24 trillion or 17 percent greater than the gross national product in 1987.

The paper is organized in seven sections. The first section analyzes PSID data and demonstrates that when the errors in measurement are accounted for the general intellectual ability of an adult has large effects on wage rates. Section two analyzes data from standardization samples for adult IQ tests and other studies and finds a strong upward trend in the IQ of adults during the first 70 years of the twentieth century and indications of a break in this trend for those who entered the labor market after 1970. The third section examines time series data on the achievement of those at specified levels of schooling and finds a similar pattern.

In the fourth section a vintage based accounting framework for general intellectual achievement is developed and used to describe the impact of the test score decline on work force quality. The fifth section of the paper summarizes evidence presented in a companion paper, Bishop (1987b) that the true effect of GIA on productivity is about 50 percent greater than its effect on wage rates. The sixth section of the paper presents estimates of the impact of the test score decline on productivity growth and examines the sensitivity of these results to changes in assumptions. The final section of the paper discusses the implications of these estimates for historical analysis of productivity growth and for educational and labor market policy.

I. The Impact of General Intellectual Achievement on Productivity

General intellectual achievement (GIA) is a constellation of cognitive abilities, competencies and knowledge which contributes to productivity in most jobs. Included in this construct are abilities such as reading, listening, speaking, writing, analyzing, synthesizing, reasoning, doing mathematics, thinking critically and knowing important facts and principles of the sciences, history and art. These abilities are essential for performing many job tasks, the tools for learning new tasks and the foundation upon which much job-specific knowledge is built. Educators refer to it as basic skills and higher-order thinking skills or more simply as academic achievement. The word intellectual is substituted for "academic" in order to bring attention to the fact that much of the learning that generates GIA occurs outside school. In principle, the best measure of GIA is a broad spectrum achievement test such as the Iowa Test of Educational Development (ITED) or the Science Research Associates achievement series (SRA). Curriculum specific achievement tests will be good measures of GIA only if the curriculum for which the test is developed is broad and comprehensive.

GIA is also well proxied by such familiar "aptitude" tests as the AFQT, the SAT, the ACT, the WAIS-R Verbal IQ and the G aptitude of the GATB. Evidence for this assumption is (1) school attendance raises scores on these aptitude tests (Lorge 1945; Husen 1951; Department of Labor 1970) (2) trends of scores on aptitude tests parallel trends for achievement tests and (3) broad spectrum achievement tests correlate almost as highly with verbal and mathematical aptitude tests as alternate forms of the same test correlate with each other.[1] Despite differences in purposes, subject matter and modes of administration, all of these tests apparently measure a similar constellation of abilities. It is fortunate that all of these tests are reasonably good indicators of the same latent variable, for such an assumption facilitates a consistent accounting of GIA's effect on productivity growth.[2]

The starting point for such an accounting must be an estimate of the impact of general intellectual achievement on the productivity of individual workers. The standard way to approach this question is to infer the effect of GIA on productivity from its effect on wage rates. Models must be estimated in which wage rates are predicted by a <u>contemporaneous</u> measure of GIA while controlling for schooling and other important demographic characteristics. It is essential that GIA be measured long after the completion of schooling and as close as possible to the date of the wage rate observation. Studies that have had scores on tests taken many years apart have found that the more recent test is by far the more powerful predictor of earnings. (Husen, 1969; Hause, 1976). The difficulty, however, is that reliable GIA tests are time consuming and costly to administer. Consequently, data sets which measure both adult GIA and earnings for national probability samples are rare. When they are available, the measure of GIA is typically a short form IQ test of rather low reliability. The PSID's measure of GIA, for example, has 13 sentence completion questions (taken from the Lorge-Thorndike intelligence test) and a KR-20 reliability of only .652. The result, of course, is that estimated relationships between GIA and wage rates are attenuated by measurement error.

Consequently, the true impact of GIA and years of schooling on wage rates must be estimated as part of a system of equations that includes a measurement model for both GIA and years of schooling (S). Such a model was estimated for 1971 PSID data on male household heads 25 to 64 years old:

$$\text{(1)}\quad \text{WEARN} = a_o + a_1\text{GIA} + a_2\,\text{S} + a_3\,\text{AGE} + a_4\,\text{NONWHITE} + v_1$$
$$\text{TEST} = \text{GIA} + v_2$$
$$\text{YRED} = \text{S} + v_3$$

where WEARN is the log of weekly earnings. GIA and S are latent variables, V(GIA) is fixed as 1 and V(GIA)/V(TEST) = .652 and V(S)/V(YRED) = .915.[3] The results were:

$$\text{(2)}\quad \text{WEarn} = \underset{(6.85)}{.204}\,\text{GIA} + \underset{(9.16)}{.0584}\,\text{S} + \underset{(3.21)}{.004}\,\text{AGE} - \underset{(.86)}{.04}\,\text{NONWHITE} + a_o \qquad R^2=.255 \quad N=1774$$

Neglecting to correct for errors in measurement causes a substantial bias for without it, a_1 = .119 and a_2 = .0639. Thus, correcting for measurement error nearly doubles the estimated effect of GIA and slightly reduces the direct effect of years of schooling.

If GIA is dropped from the model, the coefficient on S is .09. Thus adding GIA, a major outcome of schooling, to the model lowers the education coefficient by 35 percent. This implies that the gains in GIA that are associated with schooling account for 35 percent of the total effect of schooling on wage rates. The large direct effect of schooling even when

GIA is measured without error suggests that schooling develops or signals other economically productive talents such as discipline, reliability, perseverance and occupationally specific skills. It also suggests that employers may not know the GIA of job applicants and employees and may use schooling as a signal of GIA. This possibility is discussed in section 5.

The paper treats the .204 coefficient as an unbiased estimate of the response of wages to changes in GIA resulting from improvements in the cultural and educational environment. At this point it is important to address a potential objection to this assumption. Those who believe that IQ tests truly measure inherited learning ability might argue that productivity is an outcome of on-the-job learning rather than in-school learning, and that GIA tests measure inherited learning ability rather than outcomes of schooling that help one do a job well. In this view, GIA tests are good measures of inherited learning ability because everyone receives roughly equivalent instruction in the material covered by the test, therefore, differences in knowledge at the end of instruction primarily reflect differences in inherited learning ability. This view, however, does not withstand scrutiny. Many of its key predictions are contradicted by data. (1) If it were true, we would expect childhood IQ tests to predict adult labor market success just as well as adult GIA tests. In fact, when adult GIA tests compete with childhood IQ tests, it is the adult test not the childhood test which has by far the biggest effect on labor market success (Husen, 1969). (2) In addition, we would expect culture reduced non-verbal IQ tests to be just as good predictors of labor market success as a test of reading and writing skills. In fact, a study of Kenyan workers has found that wages were significantly effected by literacy but not by non-verbal IQ (Brossiere, Knight and Sabot, 1985). (3) Furthermore, we would expect education obtained abroad in non-English speaking countries to be just as good a signal of high IQ (and therefore just as good a predictor of wage rates in the U.S. economy) as education obtained in the U.S. or English speaking countries. In fact, a year of schooling obtained in a non-English speaking country has a much smaller effect on wage rates than a year of schooling obtained in the U.S. or some other English-speaking country. (Chiswick, 1978). (4) Finally, we would expect that controlling for genotype IQ (e.g. by comparing identical twins) would reduce the effect of test scores on labor market success to zero. Since siblings are genetically similar, we would expect IQ's effect to diminish when siblings are being compared. In fact, the effect of IQ (measured while in school) on labor market success is actually greater when brothers are compared than in standard cross section regressions (Olneck 1977).

These findings suggest that the associations between IQ test scores and economic success arise because the tests are really achievement tests measuring traits that in fact contribute to productivity. This in turn has important implications for growth accounting. The growth accountant can no longer assume (as Denisor implicitly does) that IQ scores of children are fixed over historical time and therefore something that should be controlled to obtain corrected measures of the contribution of schooling to labor productivity. Rather, IQ probably changes over historical time and needs to be explicitly included in any accounting system for labor quality. Evidence that the IQ and GIA of young children and adults has indeed risen over time is presented below.

II. Trends in the General Intellectual Achievement of the Adult Population

The cultural, economic and educational environment to which children and adults are exposed has improved dramatically in the last century. If we compare, for example, those born between 1897 and 1901 to those born 50 years later, the proportion born on a farm fell from 42.4 percent to 10.6 percent, the proportion growing up in a broken family fell from 17 to 13 percent, the average number of siblings fell from 4.8 to 3.3, and father's average years of schooling rose from 6.9 years to 10.7 years. (Hauser and Featherman, 1976). Time spent in school has increased dramatically. Between 1890 and 1960, the average length of the school term increased 19 percent, average daily attendance rates rose 40 percent and mean years of schooling completed increased more than 50 percent.

These changes appear to have caused major improvements in the average GIA of the population. Even tests which were originally designed to measure inherited learning ability--individually administered IQ tests--exhibit the improvement. Evidence of it can be found in cross section data on the association between age and raw IQ scores and in time series data on the mean IQ of large random samples of the population.

In cross section data the relationship between raw IQ scores and age is curvilinear. The highest scores are typically obtained by people in their twenties. Representative results from the standardization samples of the WAIS and WAIS-R, are presented in Table 1. Looking down the columns one can see that for those over age 25 raw scores for Full Scale IQ appear to decline .027 SDs per year and Verbal IQ scores appear to decline .013 to .014 SDs per year. A cross-section relationship like this is a mixture of aging effects and cohort effects. If the decline after age 25 reflects deterioration of the intellect over time (as most psychologists believed prior to 1955), the cross-section data are consistent with the mean IQ of the population being stable over time. If, however, scores on these tests do not decline as one grows older, the cross section pattern implies that older cohorts had a lower IQ throughout their lifetime. This, in turn, implies that as new better educated cohorts replaced older cohorts the mean IQ of the population advanced.

Longitudinal studies which retest individuals over long intervals of time are one way to distinguish between the aging and cohort explanations of the cross-section pattern. These studies have found that scores decline with age on the timed performance components of IQ tests but that they improve on the more verbal parts of test which are not timed. (Bayley 1955; Bradway, et al. 1958; Schaie and Strather 1968; Schaie and Hertzog 1983).

It has been argued, however, that practice effects may last the full 7+ year interval between test administrations in these studies,so the improvements in IQ may be illusory. Therefore, other kinds of data are necessary to prove conclusively that the mean IQ of the population has risen over time. What is needed is a large random sample of the adult population which have been given the same or equated IQ tests many years apart. The standardization studies for the WAIS and WAIS-R adult IQ tests provide the necessary stratified random samples of the population, and five studies have been published which equate the two tests. The equating studies determined the correspondence of scores on the earlier and later versions of the test by administering both tests in counterbalanced order (to neutralize practice effects) to a sample of people. These studies found that it was easier to get a high score on the WAIS which had been standardized on the U.S.

population during 1953-54 than on the WAIS-R which was standardized between 1976 and 1980. The implied gain in IQ for the population 16 to 70 years old was 6.37 IQ points (.425 SDs) on full scale IQ and 6.48 IQ points (.432 SDs) on verbal IQ between 1953 and 1978. (Wechsler 1981, Urbina, Golden & Ariel 1982; Smith 1983; Mishra & Brown 1983; Lippold & Claiborn 1983). These equating studies have been used to calculate the relationship between column 1 and 2 and between column 4 and 5 of Table 1. A graph of the Verbal IQ relationship is presented in Figure 1.[4] Yearly rates of gain in IQ for each age group are presented in column 3 and 6 of table 1. The IQ gains for cohorts over the age of 25 were generally around .02 SDs per year.

The equating studies comparing other IQ tests obtain similar results: IQ scores on the older tests are almost invariably higher and the magnitude of the difference is linearly related to the time between standardizations of the tests (Thorndike 1975; Flynn 1984). Flynn finds that the rate of increase in Full Scale IQ is remarkably consistent across age groups and time periods. Analyzing 77 equating studies with a total of 7431 subjects involving 18 different IQ test comparisons, he concludes that between 1932 and 1978 the gains have averaged 3.1 IQ points or .21 standard deviations per decade (Flynn 1987). This estimate of gains over time is close to that derived by going down column 1 or 2 of table 1 assuming that full scale IQ is constant between ages 25 and 60.

Comparisons of white enlisted soldiers serving in World War I and II push the trend data back to the beginning of the century. When a stratified random sample of white WWII recruits took a test very similar to the test that all literate WWI army recruits had taken, they scored .73 standard deviations higher (Yerkes 1921; Tuddenham 1948).[5] Performance on the Alpha apparently improved .29 standard deviations per decade over the 25 year period. Since only the literate 83 percent of white soldiers took the Alpha during WWI, this comparison understates GIA gain for the population as a whole.

IQ and the Test Score Decline

It appears that the historical tendency for each cohort of young adults to do better on GIA tests than predecessor cohorts came to at least a temporary halt during the 1970's and early 1980's. In the 1976-80 WAIS-R standardization sample, there is evidence of a reversal of this historical

Table 1

AGE & COHORT EFFECTS AND IQ

	Full Scale IQ			Verbal IQ		
Age Group	WAIS 1953-54	WAIS-R 1976-80	Growth Rate per yr	WAIS 1953-54	WAIS-R 1976-80	Growth Rate per yr
16-17	.007	.229	.009	-.253	-.028	.009
18-19	.142	.254	.004	-.075	.052	.005
20-24	.277	.759	.019	.065	.507	.018
25-29	.414	.829	.022	.251	.697	.022
30-34	.156			.055		
35-39	.223	.439	.013	.169	.429	.013
40-44	.000			.051		
45-49	-.067	.325	.020	.054	.473	.020
50-54	-.288			-.131		
55-59	-.385	.032	.017	-.169	.302	.019
60-64	-.408			-.182		
65-69	--	-.260	--	--	.163	--
70-74	--	-.498	--	--	.024	--
Yrly Diff by Age 25-35 to 55-64	.027	.027		.013	.014	
Sample Size	1880	1100		1880	1100	

The table reports the mean score for specific age groups relative to grand mean in the 1953-54 WAIS standardization divided by an average of age specific standard deviations. It was derived from table 10 in Wechsler (1955) and table 7 of Wechsler (1981). The WAIS and WAIS-R were normed on representative samples of the U.S. population. The five equivalence studies used to determine the magnitude of the difference between the mean IQ of the two standardization samples (6.37 pts for Full Scale IQ and 6.48 pts for Verbal IQ) are referenced in the text.

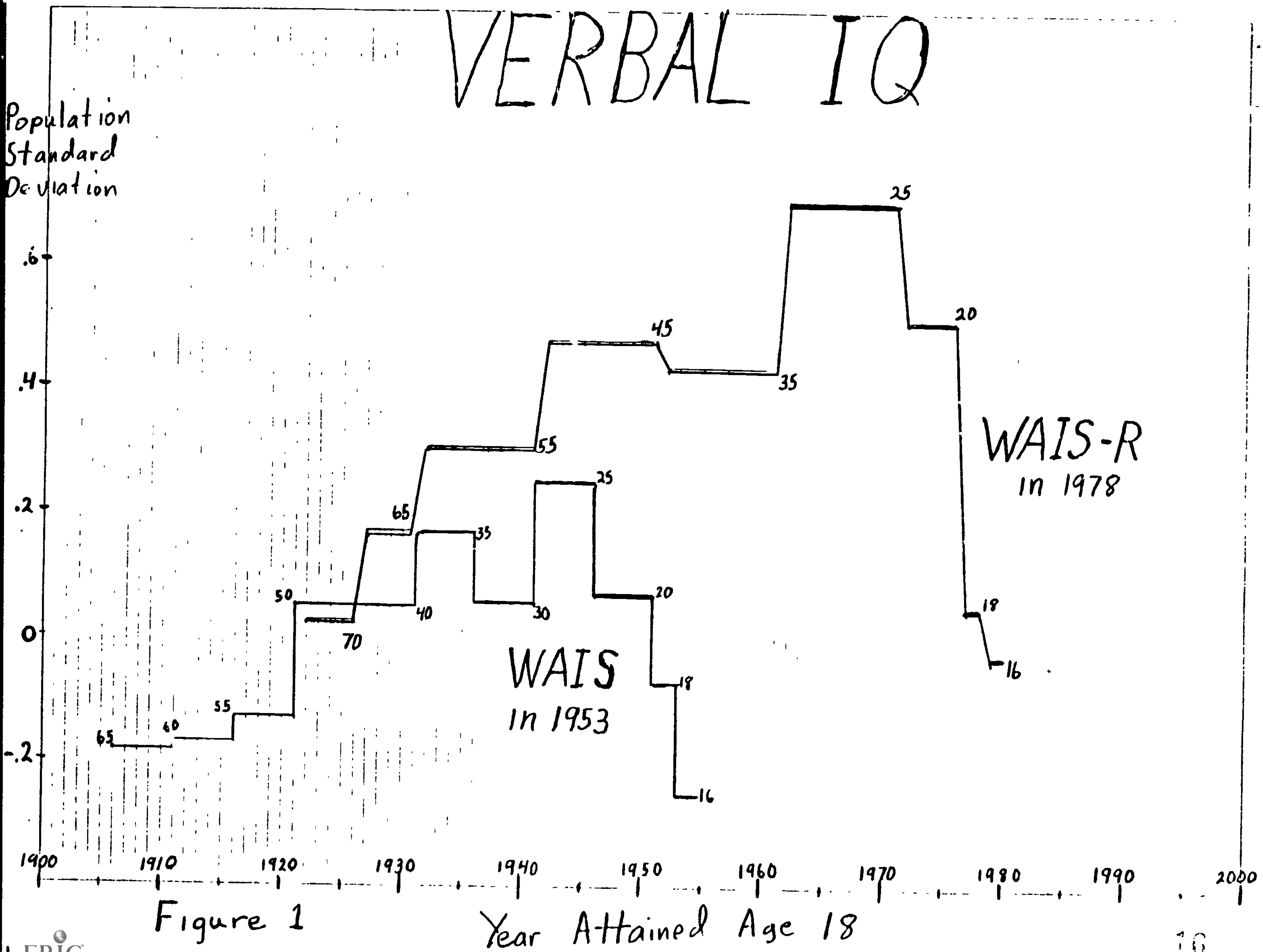

VERBAL IQ
Population Standard Deviation
.6
.4
.2
0
-.2
WAIS-R in 1978
WAIS in 1953
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year Attained Age 18

Figure 1

pattern (see Table 1). The verbal IQ scores of 25 to 34 year olds (those who graduated from high school between 1961 and 1971 when test scores were at or close to their peak level) were .645 SDs higher than the scores of 18 to 19 year olds (those who graduated in 1977 and 1978 when SAT and ACT scores were about .3 SDs below their 1966 level). The 1953-54 standardization samples, in contrast, exhibit a much smaller difference of .228 SDs between 25 to 34 year olds and the 18-19 year olds.[6]

The 1980 restandardization of the Armed Service Vocational Aptitude Battery (ASVAB) on the 18 to 23 year olds of the NLS Youth sample yields still another observation on the long term trend of GIA.[7] While the end point of the comparison is a random sample of all youth, the comparison's starting point, the men who served in the military during WWII, is not. The men who served during WWII were considerably better educated and more able than those who were deferred or rejected. Farmers, the occupational group with the least schooling, received a blanket deferment. When college student deferments were limited to those studying engineering and medicine in 1943, the bulk of male college students outside of these fields either volunteered or was drafted. Overall, only one-fifth of the men 18 to 37 on August 1, 1945 did not serve in the military because of occupational or family deferments. All of the rest were examined and of these 19.3 percent were rejected for physical defects, 5.4 percent for emotional disorders and 4 percent for mental or educational deficiencies. (Ginzberg, et al, 1959) Medical disqualification was more frequent than mental disqualification, but this was in part due to the fact that medical screening preceded mental screening. Medical problems were common for those with limited education, so medical screening tended to screen out those who would have performed poorly on the aptitude test (Eitelberg et al, 1984).

The superior education of those who served in the armed forces is visible in the April 1947 Current Population Survey. The median schooling of veterans not attending school (11.4 years for 20 to 24 year olds and 12 years for 25 to 34 year olds) was 1.8 years greater than the median for non-veterans of comparable age (Bureau of the Census, 1948). The veterans who were attending school had even more schooling. Analysis of OCG-II data reveals that WWII veterans were less likely to have grown up on a farm, less likely to be from a minority background, better educated prior to entry, and more likely to have had a father with considerable education than those who did not serve (Fligstein, 1976). In 1970 veterans in the 45 to 54 year old age bracket had a 10 to 15% higher median income than nonveterans, were 35 percent more likely to be a professional, technical or managerial worker, and were 45 percent less likely to be an inmate of an institution (Bureau of the Census 1978, Table 202). Dummy variables for WWII veterans in earnings functions are invariably positive and significant in large data sets.

The major finding of the restandardization study was that the median AFQT for the nationally representative sample of 1980 youth was slightly (.075 SDs) higher than the median for WWII soldiers (Department of Defense 1982). This finding is quite significant. It means that the gain in GIA preceding 1966 must have been substantially larger than the subsequent decline. When a rough adjustment is made for how selective the army was during WWII, it appears that the 1980 cohort of youth performed about one-third of a standard deviation better on the AFQT than a comparable 1945 cohort of youth would have.[8]

III. Trends in the General Intellectual Achievement of Students at Specified Stages of Schooling

The rise in the general intellectual achievement of the population has been due both to the greater schooling of more recent cohorts and to improvements in the quality of that schooling. Evidence of improvements in the quality of schooling comes from examining time series data on the GIA of students at specified stages in their education.

The Inter-war Period

A search was conducted for studies reporting the results of administering the same test to different cohorts of students at the same school. Only a few such studies were available for the inter-war years. A study of the school children of eastern Tennessee found that over the decade of the 1930s 1st graders gained 11 IQ points and 7th and 8th graders gained 10.8 IQ points (more than two-thirds of a standard deviation). (Wheeler, 1942). A study of two high schools in the midwest found no change in the mean IQ of the students at a small rural high school and a 5 point increase between 1923 and 1942 at a large high school serving a small city and the surrounding county (Finch, 1946). The third set of studies found a 3 point gain in IQ between 1925 and 1935 at Grover Cleveland High School in St. Louis (Shewman 1926; Johnson 1935).

Another method of measuring trends is to collect and analyze local studies reporting mean IQs for an entire class or the entire student body of a high school. If we assume that the random process by which high schools were selected for such studies remained unchanged over time, unbiased estimates of long term trends can be derived from a sample of such studies.

A summary of 29 large sample (over 500 students) studies covering a total of 130,173 students spanning the period 1917 to 1942 is available in Finch (1946). The studies reported measures of central tendency for an IQ test given to all students in a particular grade or to all students in a high school or group of high schools. Almost all the studies used either the Terman or Otis IQ test. When the mean/median IQs reported in these studies are regressed on time and dummies for the test and grade in school, the following results are obtained:

$$(3)\ IQ = \underset{(2.03)}{.169DATE} + \underset{(1.93)}{2.24SENIOR} + \underset{(.21)}{.30FRESH} - \underset{(.80)}{.86OTIS} + \underset{(.71)}{1.23OTHER} \quad R^2=.29 \quad N=29$$

The regression implies that despite major increases in high school attendance that the average IQ of high school students was rising .0113 population SDs per year. Since the standard deviation of an IQ test for high school graduates is 11.12 points this means GIA was rising .0152 HSG SDs per year during the inter-war period. This estimate may well understate the gain for the nation as a whole, because the quality of education was probably improving more rapidly in the South and in rural areas than in the sample of Northern predominantly urban high schools included in the above regression.

<u>The Post War Rise in General Intellectual Achievement</u>

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 (Forsyth 1987). 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 ACE Psychological Exam. These other tests were at first taken by a highly selected group and only more recently by more representative samples of college bound students. Trends in scores on these other tests may be biased by the decreasing selectivity of those who took the test.

Figure 2 plots the trends of 12th grade ITED composite scores and an average of 8th grade scores on the Iowa Test of Basic Skills and 9th grade scores on the ITED (Hieronymus et al 1979). Through 1966 the trend was up: at first moderately so, and then dramatically after Sputnik. The rate of gain for this period, .023 HSGSDs per year, was substantially higher than the .0152 HSGSDs per year during the inter war years. When scores are plotted in standard deviation units, the performance of 12th graders and that of 8th and 9th graders track each other very closely. The gains for 12th graders between 1942 and 1966 are all the more remarkable for they coincide with a increases in the high school graduation rate. The ratio of Iowa public high school graduates to 8th graders four years earlier rose from 65 percent in 1941 to 88 percent in 1968.

Other tests that have been administered for long spans of time to stable test-taking populations also exhibited a positive trend during this period. In Indiana, between 1944 and 1976, 6th graders (adjusted for age effects) gained .576 SDs and 10th graders gained .256 SDs on the Iowa Silent Reading test (Farr and Tone, 1979). Between 1958 and 1966 Minnesota high school juniors gained .39 SDs on the Minnesota Scholastic Aptitude Test (Swanson 1973).

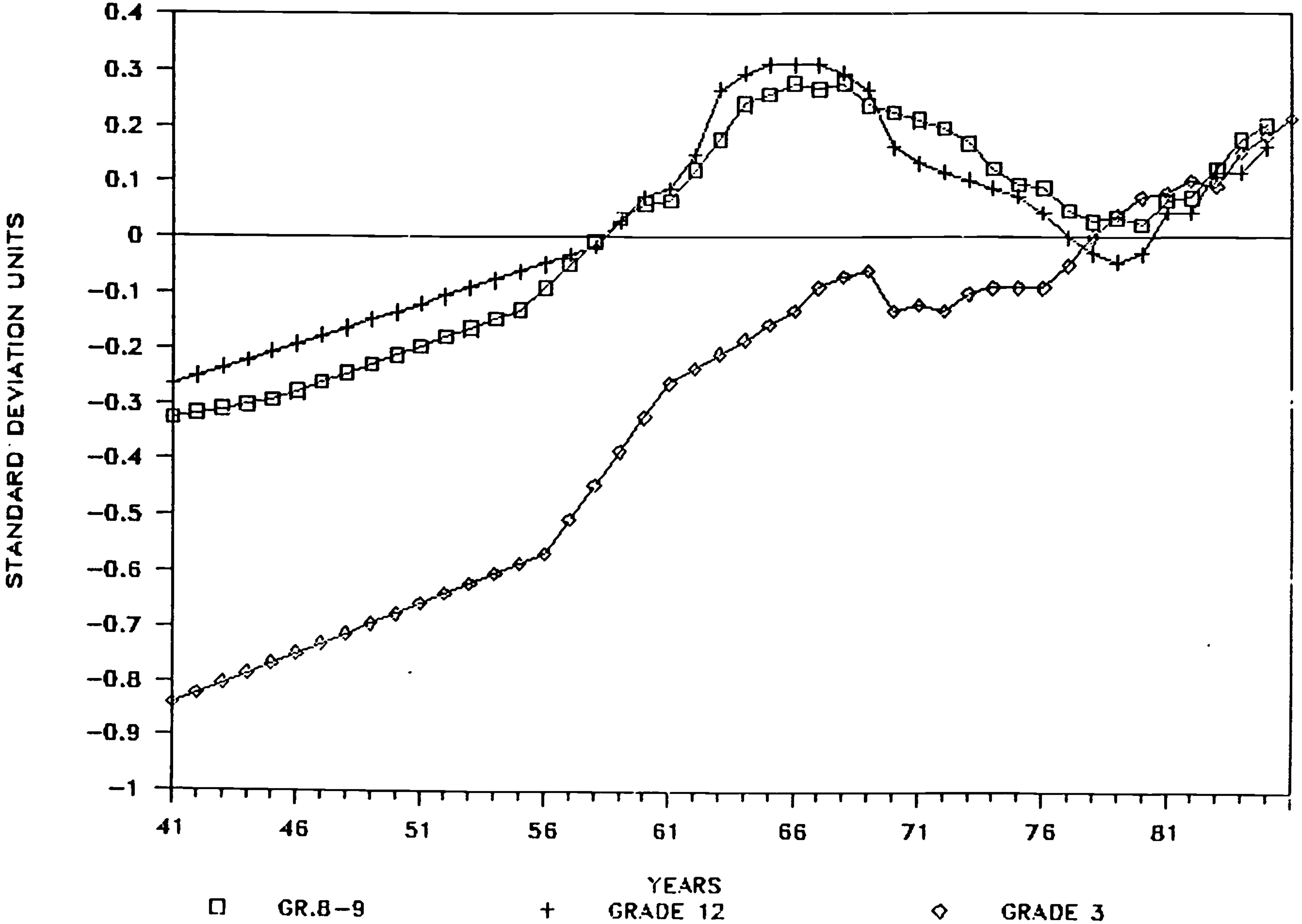
The Test Score Decline and Partial Rebound

Around 1966 the educational achievement of high school students stopped rising and began a decline that lasted for 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. 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 PSAT 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

FIGURE 2

GENERAL INTELECTUAL ACHIEVEMENT

GRADE LEVEL COMPARISONS



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8th graders declined .33 SDs on the Stanford Achievement Test and .32 SDs on the Iowa Test of Basic Skills (Koretz 1986, Waters 1981).

The decline appears to have been caused by something that happened to children after third grade. The IQ of children at entry to school rose .29 SDs between 1964 and 1972. (Flynn 1984). Scores of third graders on the Iowa Test for Basic Skills never declined and in fact rose substantially. (see figure 2). There was a gain of .286 SDs per decade (about .7 grade level equivalents in all) between 1940 and 1966, followed by a period of stagnancy until 1975 when the upward trend of test scores resumed. Since then, third graders have gained .31 SDs or .3 grade level equivalents.

It appears that recent efforts to improve the quality and rigor of the curriculum have had an effect, as test scores are rising again. In ITED data 12th graders have recouped about half of their previous decline and ninth graders have recouped all of a somewhat smaller decline. SAT and ACT scores are rising as well. Rates of gain have been substantial. On the ITED the gain has been .025 SDs per year for 9th and 10th graders. On the ITBS it has been .033 SDs per year for 7th and 8th graders and .027 SDs per year for 3rd and 4th graders. These younger students will not be graduating for four to nine years, so it is very likely that the GIA of high school graduates will continue to improve for some time. Nevertheless, general intellectual achievement of high school graduates remains substantially (.554 SDs or 1.96 grade level equivalents on the ITED) below the level that would have been reached if the trends of the 1940s, 1950s and early 1960s had continued, rather than reversing after 1966.

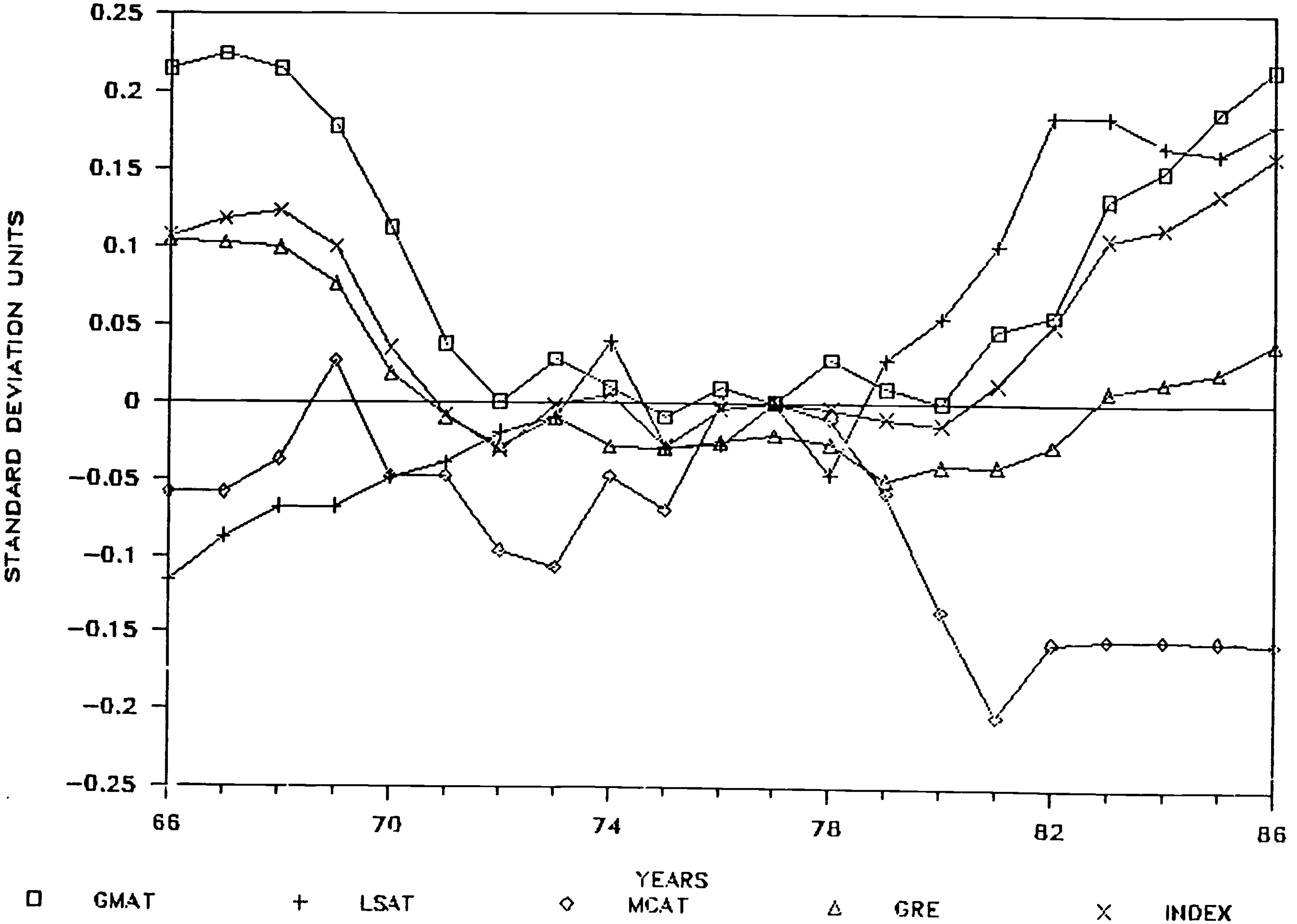
A parallel decline seems to have occurred among those applying for graduate or professional school. (See Figure 3). Between 1966 and 1977 there was a .13 SDs decline on the quantitative Graduate Record Exam (GRE), a .23 SDs decline on the verbal GRE and a .215 SDs decline in the Graduate Management Admission Test (GMAT). There were small increases of .06 SDs on the Medical School Admissions Test (MCAT) and of .09 SDs on the Law School Admissions Test. An overall average of these scores declined by .107 SDs.[a] The decline is no doubt in part due to the substantial increase during this period in the proportion of BA recipients who entered graduate or professional schools.

As with high school graduates, there appears to have been a rebound

FIGURE 3

GRADUATE AND PROFESSIONAL

ADMISSION TEST SCORES



in the test scores of college graduates planning to continue their schooling. The overall index fell an additional .014 SD between 1977 and 1980 but has since risen .173 SD. Trends have differed substantially across tests. Between 1977 and 1986 there were declines of .156 SD on the MCAT and .116 SD on the Verbal GRE but increases of .27 SD on the quantitative GRE, .215 SD on the GMAT, and .179 SD on the LSAT.

IV. Trends in the GIA of Working Adults With Specified Years of Schooling

The data just reviewed on changes in the GIA of students at specified points in their schooling strongly suggests that, during the first 70 years of the twentieth century, the GIA of the adult population was growing more rapidly than gains in years of schooling alone could account for. Further support for this conclusion comes from analysis of the army recruit samples. Cross section regressions of test scores (T) on schooling (S)

Table 2
Change in GIA: WWI to WWII

	r_{TS}	$\bar{S}$	SD_s	B_s	Increase Explained by School.	Observed Increase	Residual Due to Other Factors
WWI Sample	.63	8.0	2.6	.242	.484	.727	.243
WWII Sample	.75	10.0	3.0	.25	.500	.727	.227

were estimated and the effect of years of schooling on test scores (B_s) was found to be almost identical in both data sets. One additional year of schooling is associated with a .24 to .25 SDs higher test score. This means that the two extra years of schooling of the WWII sample explains .48 to .50 SDs of the total .727 SDs test score gain between WWI and WWII leaving a residual improvement of .23 population SDs that must be due to improvements in other environmental factors. The tests were taken 25 years apart, so the yearly rate is .0092 population SDs per year. This result is quite close to the estimate for high school students .0113 POPSDs per year derived independently from Finch's (1946) data.

A Vintage Model

Estimates of the time path of GIA for working adults were calculated by implementing a simple vintage model of labor force GIA. Since the effects of age and years of schooling are already incorporated in growth accounting frameworks. What is needed is an estimate of changes in the quality of workers of specified age and schooling which are purged of the effects of changes in the age and schooling composition of the work force. The index to be derived is intended as an additive correction to the labor quality indexes of Jorgensen, Gollop and Fraumeni (1987), not as a substitute. Estimates of GIA trends were made for three groups: people who obtain 12 or fewer years of schooling, people who obtain one to four years of college education and people who enter graduate school. The crucial assumptions of the model are that the average GIA of worker cohorts with specified years of schooling is determined by its age and vintage. Specifically, the mean GIA of any cohort of adults is related to the test scores this cohort obtained when it was completing schooling by the following equation:[10]

4) GIA(age) = GIA(17) + f(age, schooling)

For the period after 1942, the key building blocks of the calculation are (1) the time path of scores on tests taken by students entering graduate and professional schools between 1966 and 19[illegible]d (2) the time path of Iowa Test of Educational Development scores for hig[illegible]ool seniors running from 1942 to 1985.

Time paths of mean GIA for those with 0 to 16 years of schooling are derived from the time series of 12th grade composite ITED scores for 1942 to 1985. The metric of all calculations is a POP SD, the standard deviation of a test given to a random sample of adults. The standard deviation of random samples of high school seniors on these tests is 74 percent of the standard deviation for random samples of adults (U.S. Department of Labor 1970, Table 20.3). Consequently, all of the ITED trend data discussed in the previous section was multiplied by .74 to translate it into a POP SD metric.

The first step was to construct a time series of the mean GIA for high school graduates who terminate schooling at the high school diploma. There have been major increases in both the proportion of high school graduates entering college and in the selectivity of college entrance, and adjustments had to be made for these changes.

Taubman and Wales' (1972) careful study of how the selectivity of college entry has varied over time provides the data for making this adjustment. They report that in 1934 those who continued their schooling after graduation were on average at the 58th percentile in GIA and those who ended their schooling with the diploma were on average at the 43rd percentile. On the assumption that GIA is normally distributed this 15-point difference on a percentile scale at the middle of the distribution corresponds to a GIA differential at entry to college of .385 HSG SDs or .285 POP SDs.

In 1946 college entrants were on average at the 62nd percentile and those not going on to college were at the 43rd percentile. The estimated GIA differential was .39 POP SDs. By 1960 the mean GIA percentile of college entrants in Project Talent data was 62 and the mean percentile of those not going to college was 36. Assuming normality this corresponds to a GIA differential between the two populations of .54 POP SDs. Using these estimates of GIA differentials, an assumption that selectivity of college entrance was constant after 1961, and 1970 census data on the proportion of each cohort which entered college, separate GIA time series were calculated for those who terminated schooling with the dipioma and those who attended college.[11]

The trends of each of the GIA time series are exhibited in Figure 4 and Appendix Table A1. (The levels of the indices are arbitrary). The increasing selectivity of college entrance caused the GIA of college entrants to increase more rapidly (.0205 POP SDs per year) between 1942 and 1966 than the GIA of high school graduates who did not enter college (.0136 POP SDs per year). It was assumed that changes in the GIA of those with fewer than 12 years of schooling paralleled the index for high school graduates who ended their schooling with the diploma. The GIA index for college entrants is employed as the GIA index for college drop outs and for college graduates not going to graduate or professional school. Up to 1966, it is also used to index the GIA of those with graduate and professional education. After that date an average of GRE, GMAT, LSAT and MCAT scores is used as the GIA index for this group.[12]

Yearly data on the GIA of school leavers is not available prior to 1942, so a simple trend extrapolation was employed. For those with 0 to 12 years of schooling the GIA trend was assumed to be .0092 POP SDs per year. This

FIGURE 4
GENERAL INTELLECTUAL ACHIEVEMENT TEST SCORES

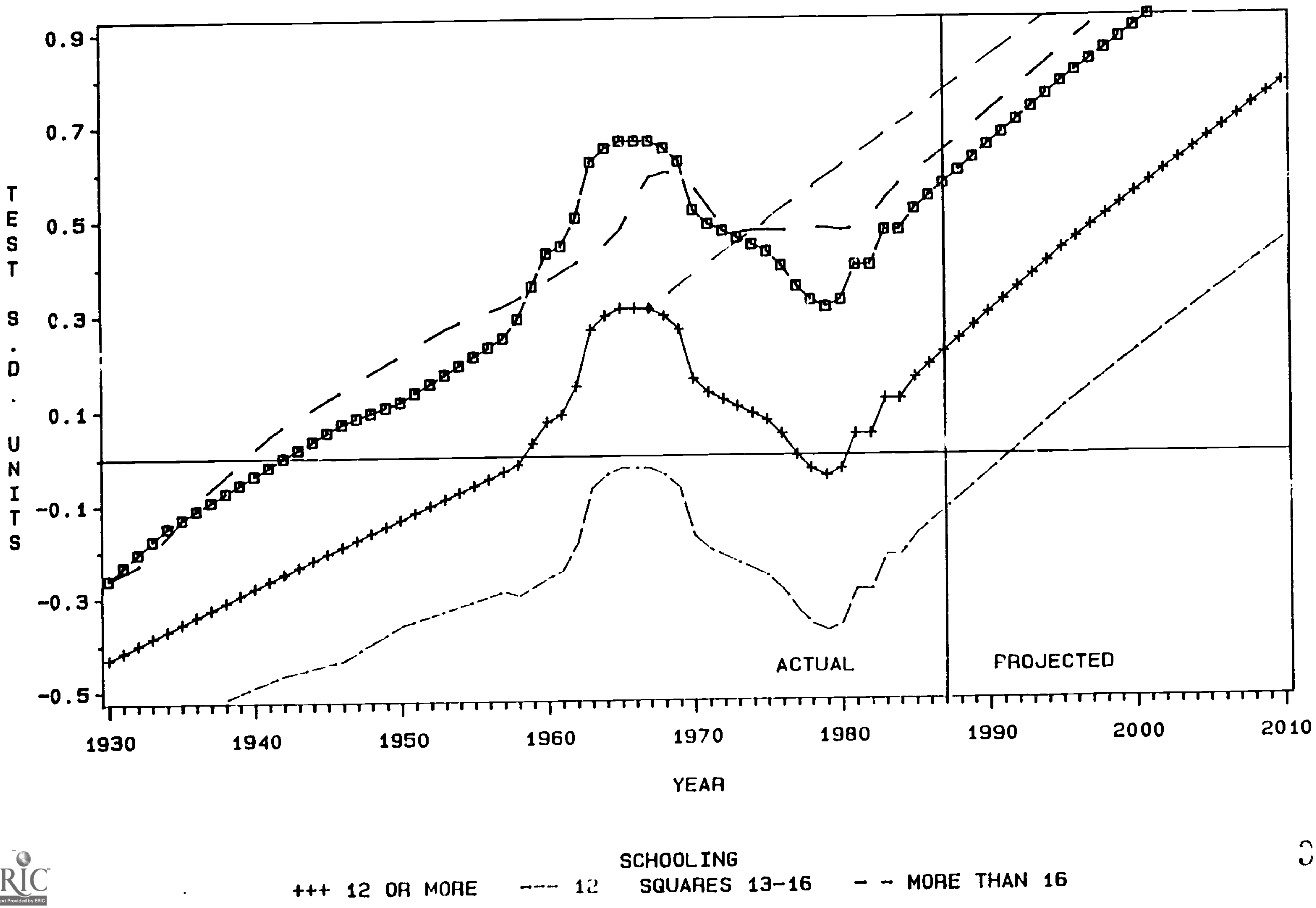
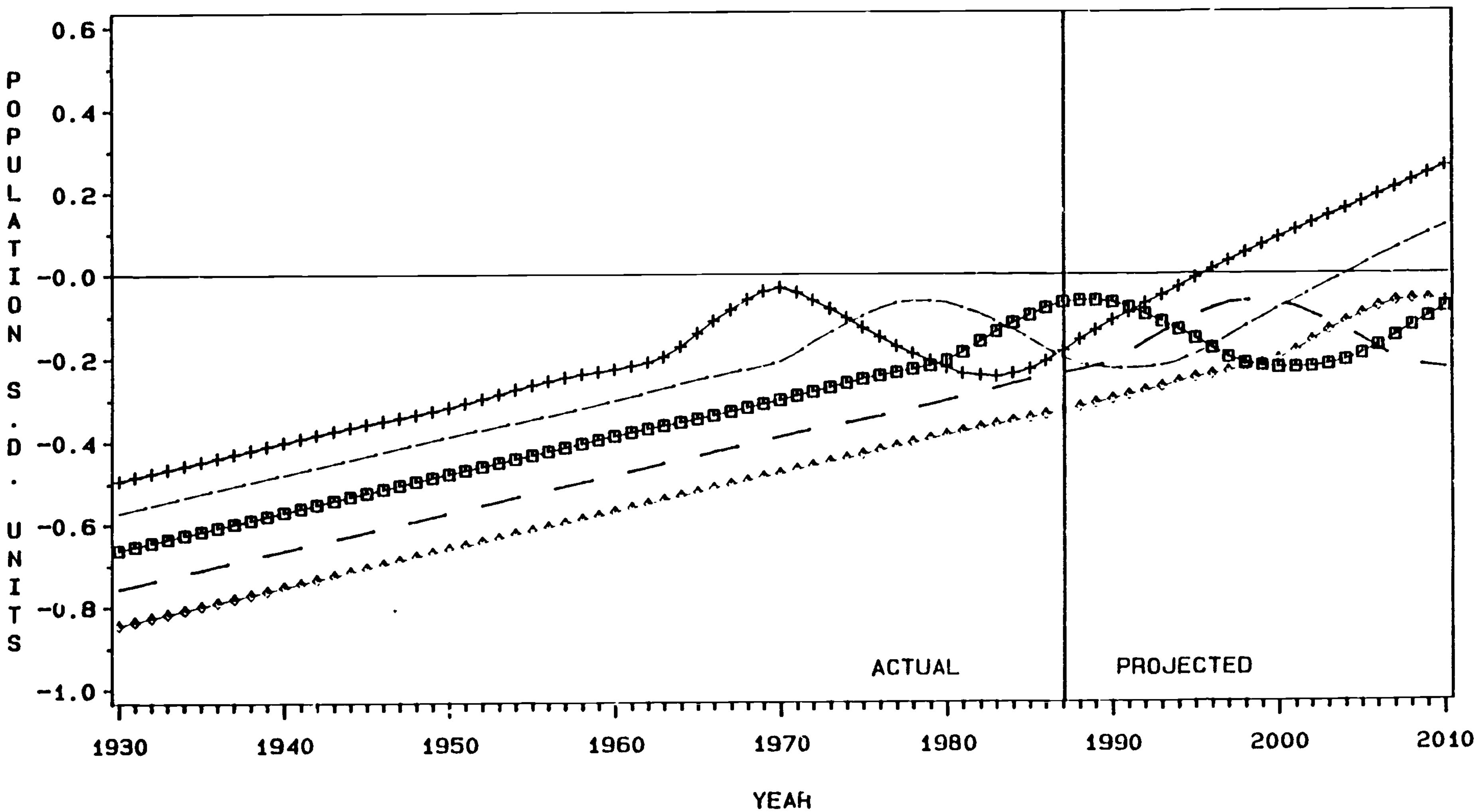
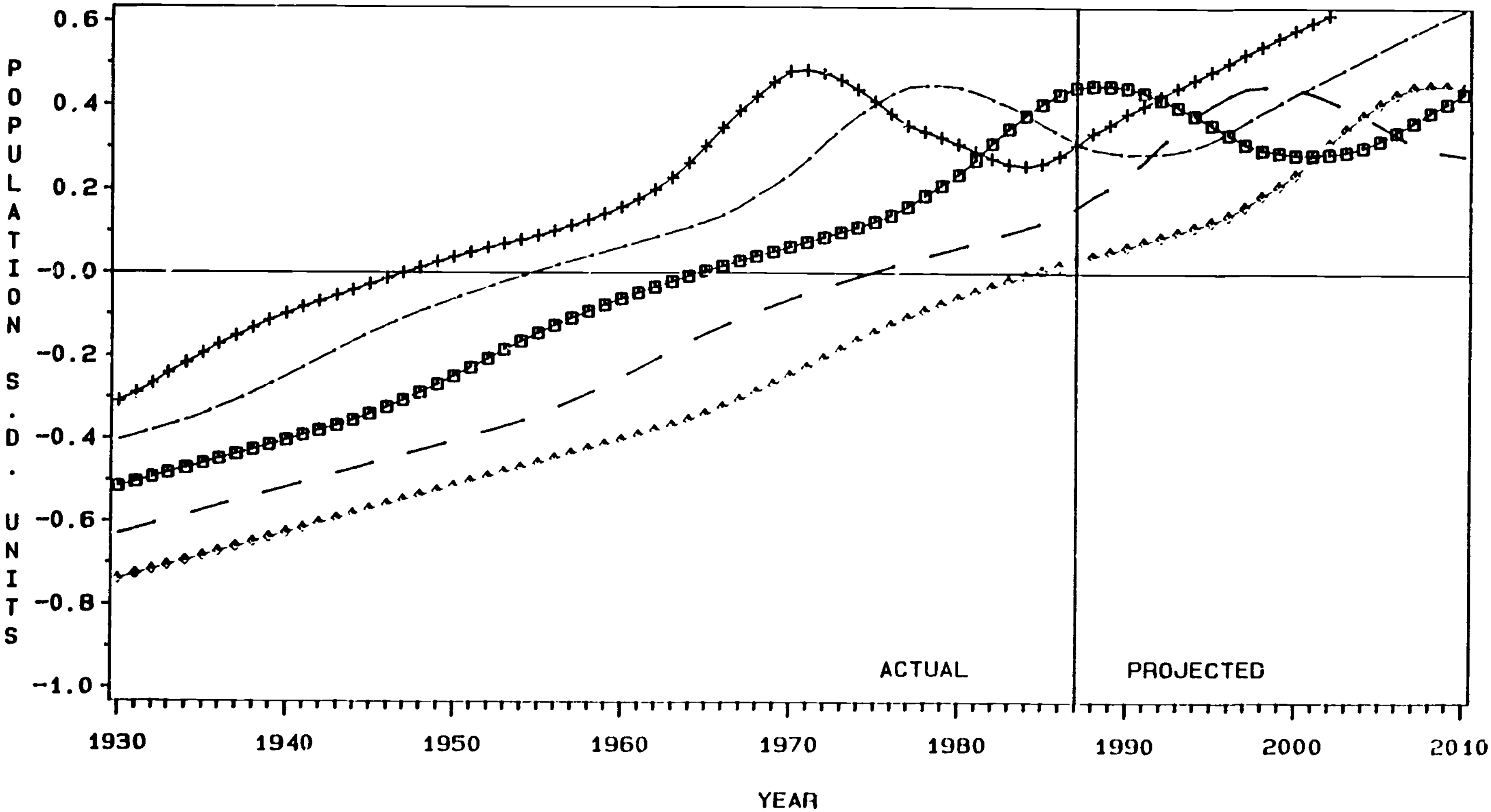


FIGURE 5
GENERAL INTELLECTUAL ACHIEVEMENT TRENDS
FOR THOSE WITH 0-12 YEARS OF SCHOOLING
BY AGE COHORT



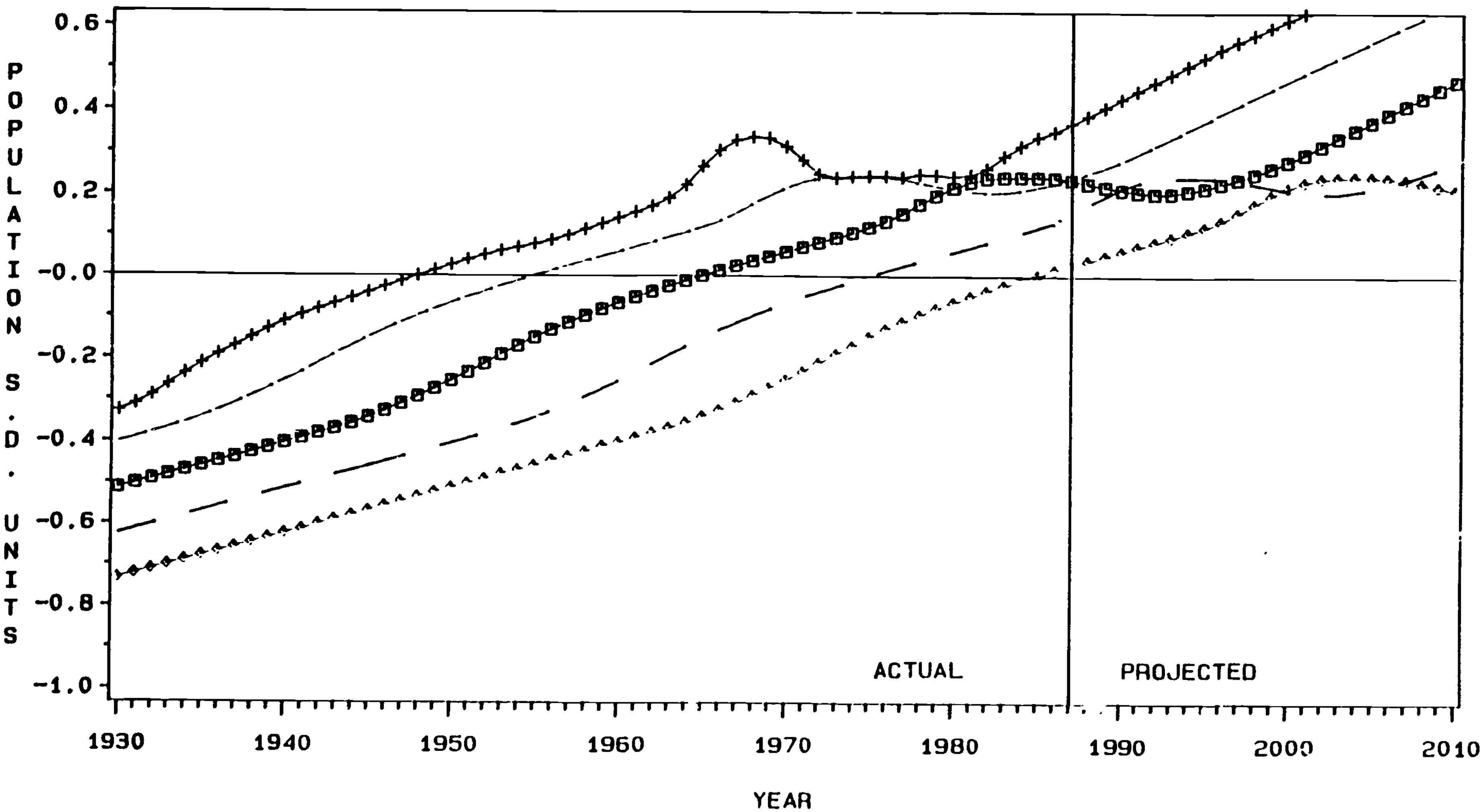
AGES
+++ 18-24 ---- 25-34 SQUARES 35-44 - - 45-54 DIAMONDS 55-64

FIGURE 6
GENERAL INTELLECTUAL ACHIEVEMENT TRENDS FOR THOSE WITH 13-16 YEARS OF SCHOOLING BY AGE COHORT



AGES
+++ 18-24 --- 25-34 SQUARES 35-44 - - 45-54 DIAMONDS 55-64

FIGURE 7
GENERAL INTELLECTUAL ACHIEVEMENT TRENDS FOR THOSE WITH GRADUATE EDUCATION BY AGE COHORT



AGES
+++ 18-24 ---- 25-34 SQUARES 35-44 - - 45-54 DIAMONDS 55-64

was taken from the analysis of Tuddenham's data on army recruits of WWI and WWII presented in Table 2. The GIA trend for those continuing their schooling beyond high school was derived by adjusting the .0113 POP SDs per year trend exhibited in the Finch data for the increasing selectivity of college entrance. Estimates of the selectivity of college entrance are available in Taubman and Wales back as far as 1925. Selectivity was assumed to have been constant prior to 1925. The GIA trend for the 30-year period 1912 to 1942 was found to be .0136 POP SDs per year.

GIA indexes for the "k"th age cohort of adult workers with specified years of schooling (GIA_{hkt}, GIA_{ckt}, and GIA_{gkt}) are weighted averages of the GIA indexes for these individuals when they were 17 years old. The GIA index for 18 to 24 year olds with less than 13 years of schooling (GIA_{h1t}) is defined as:

$$(5) \quad GIA_{h1t} = C_{h1} + \left[\sum_{m=t-1}^{t-7} POP_m GIA_{hb}\right] / \sum_{m=t-1}^{t-7} POP_m$$

C_{hk} is an appropriately weighted average of f(age, schooling) for the k th age cohort. It is equal to the change in GIA that takes place as a cohort matures from an age of 17 (the age for which test scores are available) to the average age of the k th cohort and is assumed to be constant. The weights (POP_m) are the size of the one-year age cohort when it was 17 years old. The GIA indexes for the 25 to 34 year old cohort and the 35 to 44 year old cohort were defined as:

$$(6) \quad GIA_{h2t} = C_{h2} + \left[\sum_{m=t-8}^{t-17} POP_m GIA_{hb}\right] / \sum_{m=t-8}^{t-17} POP_m$$

$$(7) \quad GIA_{h3t} = C_{h3} - C_{h2} + GIA_{h2t-10}$$

Figure 5 graphs the cohort specific GIA indexes for those with 12 or fewer years of schooling (assuming constant C_{hk}'s equal to zero). Figure 6 and 7 are the analogous graphs for those with 13 to 16 years of schooling and for those with graduate or professional education. The data for these graphs are presented in Appendix tables A2, A3, and A4.

The vintage model allows us to forecast the GIA of most of the adult population into the 21st century. The only new assumption needed is the rate of GIA gains for entering cohorts. The gains being made in the lower grades right now are quite large, about .020 POP SDs per year, and this rate of gain has been assumed to prevail until 1995. After 1995 it is assumed to drop to .0173 POP SDs per year, the rate of gain that prevailed between 1942 and 1966. This last assumption may be overly optimistic. These projections are displayed in Figures 5, 6 and 7.

The test score decline ripples through the work force, first affecting the productivity of 18 to 24 year olds. then of 25 to 34 year olds and so on. At the end of the forecast in 2010, the cohort most affected by the decline will be 45 to 54 years old and they will still have 15 years of participation in the labor force ahead of them. The figure also displays the effect of the test score decline on the relative GIA of adjacent age cohorts of workers with the same amount of schooling. Prior to 1973 each generation of new entrants to the work force arrived in their first job better prepared academically than earlier generations with the same amount of schooling. This is no longer the case. This fact is partly responsible for recent declines in the relative wages of youth.

The next step is to calculate indices of educational quality change for workers classified by their years of schooling ($\dot{EQ}_h$, $\dot{EQ}_c$, and $\dot{EQ}_{\alpha}$). These are chain-weighted averages of the yearly changes in GIA for the six age cohorts indexed by k. For example, the formula for educational quality change of those with fewer than 12 years of schooling ($\dot{EQ}_h$) is:

$$(8) \quad \dot{EQ}_{ht} = [\sum_{k=1}^{6} w_{hkt}(GIA_{hkt} - GIA_{hkt-1})] / \sum_{k=1}^{6} w_{hkt}$$

The weights (w_{hkt}) are an average for the leading and lagging year of the share of total labor compensation going to that age-education group.[14] These indexes measure the change in educational quality of workers with particular levels of schooling averaged over all age groups. Figure 8 provides a plot of the $\dot{EQ}$ indexes multiplied by 100 (ie. their metric is percentage points of a POPSD of GIA). The $\dot{EQ}$ indices are also presented in Appendix Table A5. Because of the increased selectivity of college entrance, the quality of college educated workers grew faster than the quality of those with 12 or fewer years of schooling. The aggregate $\dot{EQ}$ index characterizes change in the educational quality of the work force averaged over all age-sex-education groups. It is a chain weighted average of $\dot{EQ}_h$, $\dot{EQ}_c$ and $\dot{EQ}_{\alpha}$ with compensation shares as weights. EQ level indexes were defined by assigning an arbitrary value of zero in 1929 and then cumulating the yearly changes:

$$(9) \quad EQ_t = \sum_{t=29}^{t} \dot{EQ}_t$$

These indexes are designed to be consistent with Jorgenson (1984), Jorgenson et al (1987) and Chinloy's (1980) accounting of the effects of changes in the age, sex and educational composition of the work force on labor quality.[15,16] The total change in work force quality is the sum of the change in a standard labor quality index ($\dot{LQ}$) and the $\dot{EQ}$ index multiplied by the derivative of productivity with respect to test scores scaled in a POPSD metric (b):

(10) $\dot{TLQ}_t = \dot{LQ}_t + b\,\dot{EQ}_t$

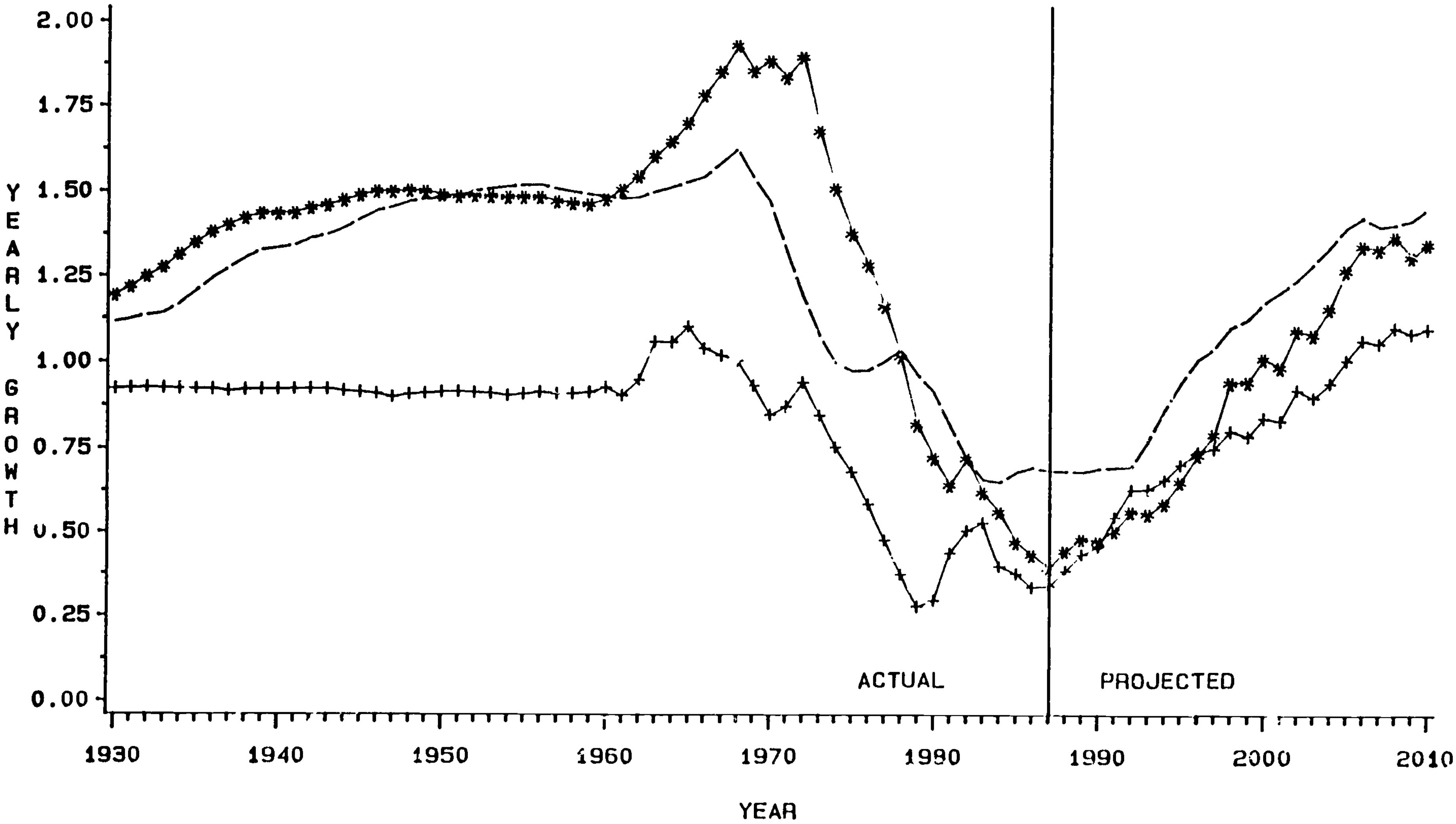
V. Accounting for the Labor Quality Growth When Credentials Signal GIA

Growth accounting assumes that all factors are paid their marginal product. While theory states that wage rates and earnings differentials are good proxies for differentials in marginal revenue product when different firms, jobs and occupations are being compared, signaling and implicit contract theory implies that no such prediction can be made when co-workers with the same job assignment are being compared.

There are a number of reasons why workers and employers may prefer employment contracts which do not pay individual workers their individual marginal product: the unreliability of the feasible measures of individual productivity (Hashimoto and Yu, 1980), risk aversion on the part of workers (Stiglitz, 1974), productivity differentials that are specific to the firm (Bishop, 1987), the desire to encourage co-workers to cooperate (Lazear 1986) and union preferences for pay structures which limit the power of supervisors. In addition, compensation for differences in job performance may be non-pecuniary -- praise from one's supervisor, more relaxed supervision, or a high rank in the firm's hierarchy (R. Frank, 1984).

At most work places the more productive workers either get no wage advantage or only a nominal advantage (Bishop, 1987a). The most productive are more likely to be promoted and are less likely to quit or be fired, so the labor market does tend to sort the more productive workers into higher wage jobs. However, the sorting process is slow and inefficient because most employers are unable to accurately predict the future productivity of the applicants for their jobs. For workers who have not attended college, they additionally lack information on aptitude test scores or grade point

FIGURE 8
GAINS IN ACADEMIC ACHIEVEMENT
OF THE WORKING POPULATION



YEARS OF SCHOOLING
+++ 0-12 *** 13-16 --- MORE THAN 16

averages that would enable them to make reliable assessments of a job applicant's GIA. Most high schools do not respond to ployer requests for high school transcripts even when the job applicant has signed off on the employer's request. The Equal Employment Opportunity Commission's Guidelines on Employment Testing Procedures have caused many firms to drop tests altogether and other firms to use the test only to screen out the bottom 10 or 20 percent of job applicants rather than to select those with the highest scores (Friedman and Williams 1982; 29C.F>R.S607.5(b)).

If employers do not know GIA when they hire and do not recognize or fully reward their more productive employees, the effect of GIA on productivity cannot be assumed to be equal to its effect on wage rates. Evidence challenging the simple assumption of equality between wage rates and individual productivity and supporting instead signaling and implicit contracts theory is provided in Bishop (1987b). When workers doing the same job in the same setting are compared, there are significant differences in their productivity, and many of these differences are correlated with GIA.

Studies of the variability of output across workers in 69 different jobs are summarized in column 3 of Table 3. For a great many occupations, physical measures of output or gross sales data were the basis of these estimates of the standard deviation of productivity. In factory work, the average coefficient of variation was 20 percent for hourly paid workers and, when this is multiplied by 1985 value-added per full-time worker, the resulting estimates of the SD of output is $7152. The estimates of $4940 for clerical workers and of $6130 for sales clerks were also based on hard data. Surveys of managers and engineers provided the data for the other occupations. In technical, craft, administrative and sales representative (sales outside of retail and services) jobs, the standard deviation of worker productivity is estimated to fall between $9,000 and $17,000.

Some of this productivity variation is caused by differences in work experience. Another portion is caused by differences in GIA. Evidence of this is presented in columns 1 and 2 of Table 3. Many hundreds of studies of the association between job performance and GIA have been conducted by industrial psychologists. Column 1 presents the average raw correlations reported by Ghiselli (1973) in his comprehensive survey of the studies that had been done through 1970. Column 2 reports the results of a variety of

Table 3

GENERAL INTELLECTUAL ACHIEVEMENT AND PRODUCTIVITY ON THE JOB

	Raw Validity of GIA		Coefficient of Variation	Standard Deviation of Output[2] in 1985$	Percent of NonFarm Business in Occupation
	Ghiselli	Recent Estim.[1]			
Professional	--	.43	--	--	7.5
Technical	--	.32	.36	$ 16,210	3.1
Executive	.30	--	--	--	0.5
Administrative	.30	.35	.33	$ 9,501	9.9
Sales (Exc. Retail & Personal Service)	.34	.27	.50	$ 13,660	5.8
Sales Clerk (Retail & Personal Service)	-.06	.14	.38	$ 6,130	6.3
Clerical	.27	.26	.21	$ 4,940	16.8
Foremen	.28	--	--	--	3.4
Plant Operators	--	.18	.54	$ 74,642	.3
Other Craft Occupations	.25	--	.27	$ 12,383	11.6
Semi Skilled and Unskilled Factory	.20	--	.20	$ 6,392	16.5
Transportation Equipment Operatives	.16	--	--	--	5.1
Protective Occupations	.23	.27	--	--	0.0
Other Service	.26	.27	--	--	13.4
					100.0

[1]The raw validity estimates for professional, technical, administrative protective occupations and other service workers are averages of studies reported in the GATB manual. The estimate for clerical workers is from Pearlman, Schmidt and Hunter (1980). The estimate for sales except retail and service is based on Churchill et al's (1985) examination of 44 studies using objective company data with controls for environmental conditions. The estimate for plant operators is an average of results from Dunette et al (1984, Table 5.38) and from Schmidt, Hunter and Caplan, 1983, Table 4.

[2]The estimates of the standard deviation of output are from the review of the 34 studies presented in tables 1, 2 and 3 of Bishop (1987b).

more recent meta-analysis of this issue.[17]

The evidence of substantial variation across workers in productivity and of significant correlations between GIA and job performance implies that standard wage functions such as equation (2) understate the true effect of GIA on productivity. The discrepancy between a worker's productivity and wage rate can be decomposed into 3 elements:

$$(11) \quad P_{ij}-W_{ij} = (P_{ij}-P_j) + (P_j-W_j) - (W_{ij}-W_j)$$

The first term on the right hand side of the equal sign is the worker's "relative productivity", the deviation of the "i"th worker's marginal revenue product net of current required training costs (P_{ij}) from the marginal revenue product net of training costs (P_j) of the average incumbent in the "j"th job at the firm. Bishop (1987b) has estimated the following model predicting $P_{ij}-P_j$:

$$(12) \quad P_{ij}-P_j = \Theta_0 + \Theta_1 GIA_i + \Theta_2 S_i + \Theta X_i + u_{ij}$$

where X_i is a vector of individual characteristics such as sex, race, Hispanic, age, age square, plant experience and it's square, and total occupational experience and it's square. When errors in measurement are accounted for, a one population standard deviation increase in GIA raises a worker's relative productivity by an amount equal to 13.7 percent of the worker's average compensation.

The second term on the right hand side of (11) is the difference between the marginal revenue product of the average incumbent in the job (P_j) and the average wage for the job (W_j). An examination of this term would require direct measures of the marginal revenue product of work groups that are comparable across jobs and across firms. Such data are not available. So, the calculations that follow assume that P_j-W_j summed over a worker's life cycle is not correlated with schooling and GIA.[18]

The third term on the right hand side of (11) is the worker's "within-job relative wage", the deviation of an individual's wage from the mean for that job at the firm. A number of studies have found that within-job relative wage rates respond only modestly to the worker's relative productivity and GIA.(Bishop 1987a, 1987b). None of the estimated elasticities of within-job relative wage rates with respect to relative productivity were greater than .22. Consequently, the within-job productivity effects of GIA that are not associated with higher within-job relative wage rates are assumed to be 20 percent smaller than the relative productivity effects of GIA quoteu above. The estimate of the uncompensated productivity effect of GIA used in the remainder of the paper is, therefore .1096 per POP SD.

The total effect of GIA on productivity (b) is the sum of the wage effect from equation 2 (.204) and the uncompensated effects on relative productivity (.1096). In a logarithmic metric scaled on average levels of compensation, the effect is .3136 per POP SD of GIA. In other words, **if a student's general intellectual ability is raised by one population standard deviation, his/her productivity as an adult will on average be 37 percent (exp .3136) higher even if the improved GIA does not lead additional schooling.**

VI. The Productivity Consequences of the Test Score Decline

Implementation of the GIA accounting system described above produces estimates of the effect on the quality of labor of improvements in the quality of schooling and the cultural environment. It is estimated that between 1948 and 1973 that gains in the GIA of the working population not attributable to increases in schooling improved labor quality by .35 percent per year. Jorgenson, Gollop and Fraumeni (JGF 1987) estimate that increases in years of schooling caused labor quality to grow .725 percent per year during this period.[19] In combination, the gains in the quality and quantity of schooling contributed 1.075 percent per year to the growth of labor quality.[20] Thus, during this 25-year period, labor quality rose 20 percent due to increases in the quantity of schooling and 9.3 percent due to improvements in the quality of schools and the cultural environment.

After 1973, however, improvements in the quantity and quality of schooling began to decelerate. Between 1973 and 1979, the contribution of years of schooling to the growth of labor quality diminished to .612 percent per year. The contribution of schooling-constant GIA gains to the growth of labor quality reached a postwar peak of .377 percent per year between 1966 and 1973 and then fell to .259 percent per year between 1973 and 1980 and further to .139 percent per year between 1980 and 1987. If, instead, the academic achievement of those leaving school had continued to improve after 1966 at the rate that had prevailed between 1942 and 1966 (.0173 percent of a POPSD per year), gains in educational quality would have increased labor quality by .466 percent per year between 1966 and 1973, by .489 percent per year between 1973 and 1980, and by .535 percent per year in the 1980s.

These findings are consistent with Martin Baily's 1981 analysis quoted at the beginning of the paper. The test score decline was not a contributing cause of the post-1965 productivity growth decline and made only a modest contribution to the post-1973 decline. The test score decline induced reduction in labor quality growth between 1973 and 1980 was .23 percent per year. The contribution to the slowdown in GNP growth and labor productivity during this period is .23 percent per year multiplied by the share of labor in total compensation (about .67) or about .154 percent per year. Nordhaus (1980) and Denison (1985) have estimated that between 1 and 1.14 percent of the post-1973 slowdown in total factor productivity growth remains unexplained after the effects of energy prices, demographic shifts, the R&D slowdown, the growing service sector, and health, safety and environmental regulations are accounted for. Thus, the test score decline accounts for 14 to 15 percent of the "unexplained" decline in productivity growth during the 1970s.

The test score decline's major impact on productivity growth has come in the 1980s. During a period in which falling oil prices, lowered marginal tax rates, scaled-back regulations and an aging work force were expected to cause productivity growth to rebound, the test score decline has been an important drag on productivity growth. The rate of growth of labor quality was .396 percent per year lower between 1980 and 1987 than it would have been if test scores had continued to grow at the rate that prevailed between 1942 and 1966. The drag on productivity growth will continue well into the 21st century. The reduction in labor quality growth resulting from the test score decline is projected to be .31 percent per year in the 1990s and .20 percent per year in the first decade of the 21st century.

The cumulative effect of the test score decline on standards of living is quite large. The labor quality shortfall was 2.2 percent in 1980 and 4.8 percent in 1987. The shortfall is projected to be 6.0 percent in 1990, 9.1 percent in 2000 and 11 percent in 2010. The social cost of the test score decline is now $142 billion annually. Sometime in the 1990s the annual social cost of the test score decline will exceed the total factor cost of all public and private education (total compensation of labor in all public and private schools and colleges was $172 billion in 1986). If a 75 percent increase in educational expenditures could have prevented the test score decline, the investment would have paid for itself handsomely. If the forecasted shortfalls in output up to the year 2010 are cumulated assuming a 3 percent rate of growth of GNP and discounted to 1987 at a real interest rate of 6 percent, the total social cost of the test score decline is $5.24 trillion or considerably more than the 1987 gross national product.

The direct effects of the test score decline reduced GNP by 1.5 percent in 1980 and 3.2 percent in 1987 and are forecasted to reduce GNP by 6 percent in 2000 and by 7.3 percent in 2010 (ie. roughly two thirds of the percentage figures quoted for labor quality). When indirect effects of the test score decline are taken into account, the total effect of the GIA decline is likely to be considerably larger than the estimates just quoted. If growth had been higher, the supply of savings and consequently net capital formation would have been higher as well. Additionally, physical capital and GIA appear to be complements (Denny and Fuss 1983), so a decline in GIA reduces investment demand. Thus, the test score decline has reduced both the demand for and supply of capital, and consequently lowered the capital stock that will be available in the future.

GIA also has significant effects on technological progress. The effect of genius on discovery is well known. But important innovations are also often made by blue collar workers and lower level managers who appear to be have only average IQ. Bartel and Lichtenberg (1987) have shown that well-educated workers have a comparative advantage at introducing new technology. Andrew Weiss (1984) reports that one of the major reasons why Japanese electronics plants are more productive than similar plants at Western Electric is the many useful suggestions made by production workers for improving the production process. The suggestions made by employees during just one year had saved $1987 per employee at one firm and $2160 per employee at another. Weiss commented that, "Only an exceptionally intelligent and well motivated labor force is likely to produce such an impressive record of innovation." Ramchandran Jaikumar's (1986) study of US and Japanese flexible manufacturing systems illustrates just how critical work force competence is to successful innovation. The 65 installations he studied in Japan were producing many more different kinds of parts and were much more reliable in operation than the 30 installations he studied in the United States. Average metal cutting time was 20 hours a day in Japan compared to only 8.3 hours a day in the US. He attributed the difference almost entirely to the more effective way the Japanese created and managed intellectual assets. "The critical ingredient here is nothing other than the competence of a small group of people."

Thus, the propensity to innovate and the payoff to innovation depends on the GIA of the work force. This implies in turn that the test score decline has probably reduced the level of R&D, the number of innovations and the profitability of the R&D investments and the innovations that were made. Some of GIA's effects on the profitability of investment in physical capital and R&D turn up in higher wage rates or in higher relative productivity and are therefore included in the accounting of GIA's effects on productivity offered above. Another portion of its effects, however, have probably not been captured by our accounting of GIA's effects. Productivity enhancing suggestions were not taken into account in the measurements of the variability of output across workers and were not a part of the rating questionnaire that provided the data for analysis of the effects of GIA on relative productivity.

VII. Summary and Implications

The paper has presented evidence that the effect of general intellectual achievement on worker productivity is larger than heretofore believed. It is estimated that holding years in school constant, a one POPSD increase in a worker's true GIA raises productivity by approximately 37 percent (exp .3136). This estimate of the effect of GIA is larger than previous estimates for three reasons: wage rates and productivity were related to an adult measure of GIA rather than a childhood measure, errors in the measurement of GIA and schooling were corrected for, and effects of GIA on discrepancies between productivity and wage rates were accounted for. This, in turn, implies that the recent test score decline is signaling a significant deterioration in the quality of young entrants into the work force.

The second major finding of the paper is the historically unprecedented nature of the test score decline that began around 1967. Prior to that year, student test scores had been rising steadily for more than 50 years. New estimates of the quality of the work force were developed incorporating the effects of improvements in the quality as well as the quantity of education. Jorgenson, Gollop and Fraumeni estimate that increases in the quantity of schooling raised labor quality by .725 percent per year between 1948 and 1973. Our estimates imply that improvements in educational quality contributed an additional .35 percent per year to the growth of the quality of labor during this period. The test score decline reduced this contribution to .26 percent per year between 1973 and 1980, and .14 percent per year in the 1980s. If the test scores of high school graduates had continued to grow at the rate that prevailed between 1942 and 1967, labor quality would now be 4.8 percent higher. The social cost in terms of foregone GNP is now 142 billion dollars annually and it is projected to double within 15 years.

One important implication of the forecasts is that even if current efforts to improve elementary and secondary education are sucessful, the test score decline will continue to be a drag on productivity and productivity growth well into the 21st century. Even with rapid improvements in the quality of elementary and secondary education, the labor quality shortfall grows to 9.1 percent in 2000 and 11 percent in 2010. The only way to prevent these forcasts from being realized is to change the relationship between GIA at age 17 and GIA as an adult. One approach would be to try to attract massive numbers of adults back into school. Other possible strategies would involve expanding educational offerings on television and inducing employers to take greater responsibility for the general education of long term employees.

The policy implications of these findings are probably already obvious to the reader. The education enterprise has historically been one of the primary engines of American economic growth. When that enterprise goes off track as it did in the 1970s, the economic costs are very great and last for generations. Consequently, the potential benefits of remedying the educational problems that caused the test score decline are also very great. In math and science American high school students lag far behind their counterparts in Europe and Japan and the magnitude of the gap appears to be growing (McKnight et al 1987; Jacobson et al 1987). The test score decline was larger for whites than for minorities, larger in the affluent suburbs than in the central cities, and larger at the top end of the test score distribution than at the bottom end (Koretz 1986). Thus, the educational quality problem is not limited to the schools serving minority and immigrant children and is only exacerbated not caused by the rising numbers of minority and immigrant children in the schools. There is no indication that private schools escaped the decline. The only place in the educational system where no decline is visible is in the first few years of elementary school. Children arrived in first grade better prepared than earlier generations, they maintained that advantage through third grade, but by the time they graduated from high school in 1980 they had learned about 1.25 grade level equivalents less than those who graduated in 1967.

The test score decline and the productivity growth decline occurred roughly simultaneously. The changing attitudes toward hard work and authority that are sometimes blamed for the productivity growth decline may have also contributed to the lowering of educational standards. In this sense, the ultimate cause of the test score decline may lie outside the educational system. International competition forced business to reexamine the way it manages and motivates workers and the productivity of manufacturing sector has rebounded. Competitive pressures cannot, however, be expected to solve the educational quality problem. It is a systemic problem that is not likely to be remedied without major changes in the recruitment, training and compensation of teachers, in the organization of schools and in how learning is measured and rewarded (Bishop 1987c).

Footnotes

1. For example, alternative form reliabilities average .75 for 7 SRA subtests and .87 for the G aptitude of the GATB. The G aptitude of the GATB has an average correlation of .7 with the 7 SRA subtests, .75 with the WAIS verbal IQ, .78 with the ITED composite and .81 with the ACT composite (Hunter, Crosson & Friedman 1985; Department of Labor 1970). There are good reasons for high correlations between past achievement and scores on aptitude tests designed to predict future achievement. Past achievement aids learning because the tools (e.g. reading and mathematics) and concepts taught early in the curriculum are often essential for learning the material that comes later. Furthermore, aptitude tests are validated on later achievement levels, not on rates of change of achievement. Consequently, the items that tend to be included look a lot like the items that appear on achievement tests. The tests that do not fit this generalization, such as the WAIS-R's digit span, typically have lower validity than other subtests or are measures of something altogether different like short-term memory and psychomotor ability.

2. Both intellectual achievement and economic performance are specific to particular cultural contexts. Consequently GIA is conceptually distinct from abstract problem-solving ability and the other "culture reduced" measures of IQ that are measured by tests like Ravens Progressive Matrices and the WAIS-R's Performance IQ. Verbal and Performance IQ are distinct traits since their correlation, .74, is considerably lower than the reliabilities of the individual scales, .97 and .93 respectively (Wechsler, 1981).

3. The reliabilities for PSID years of schooling and the IQ test are reported in Jencks et al. (1980). The model was estimated in LISREL using a correlation matrix kindly provided by Peter Mueser.

4. Estimates of how IQ changed as a cohort aged can be obtained by comparing young adults in the WAIS standardization to the people 25 years older in the WAIS-R standardization. This comparison suggests that for Verbal IQ the 20-29 year olds in 1953/54 gained 4.7 points (.315 SDs) in 25 years and the 30-39 year olds gained 2.85 points (.19 SDs). For Full Scale IQ, which contains the nonverbal performance tests all of which are timed, small declines occurred: -0.2 IQ points (-.013 SDs) for the 20-29 year olds and -2.3 IQ points (-.16 SDs) for the 30-39 year olds.

5. The Wells Alpha scores were translated into Army Alpha scores using a table of percentile equivalents developed by Lorge (1936). Means were then calculated and compared to the mean of the WWI army recruits using the SD of the WWI sample for a metric. The resulting estimate of the gain between WWI and WWII is smaller than that reported by Tuddenbaum. This estimate of the GIA gain for army recruits may well underestimate the GIA gain for all youth. The WWI army sample appears to have been more selected. Veterans of WWII accounted for 77 percent of all males 20-29 in 1947, while only 38.5 percent of the men 20-29 in 1920 were veterans of WWI. The sample used by Tuddenham was selected on the basis of AGCT scores to yield a distribution like that of inductees entering during 1943. During much

of 1943 there were no limitations on r cruitment of illiterates. (Department of the Army, 1965) Illiterate recruits included in the representative sample of WWII recruits took the Wells Alpha along with everyone else. During WWI 25 percent of all recruits and 17 percent of white recruits either could not read or write or had fewer than four or six (depending on the army processing center) years of schooling and took the Beta exam instead of the Alpha. They were, therefore, not part of the WWI sample.

6. Only the 1978 WAIS-R standardization sample is recent enough to have been significantly affected by the test score decline. Only one of the 73 studies reviewed by Flynn compares IQ tests, the WISC-R and the WAIS-R, that were standardized during the period of decline. The point estimate from this comparison implies a very slight decline in Verbal IQ (.2 pts) while Performance IQ was rising modestly (1.5 pts). The sample of 16 year olds used to calculate equivalence between the two tests was quite small (only 80) and the interval between standardizations very short (6 years), so this comparison is not a reliable indicator of national trends.

7. Tests like the AFQT, ASVAB, ITED, SAT, and ACT are periodically revised with the new versions being equated to the old. Comparability of standardized scores is not always successfully maintained, however. A major error was made when Forms 5/6/7 of ASVAB were equated with earlier tests in 1976 and it was not corrected until 1981. Other smaller errors may have gone undetected. These problems imply that caution must be exercised in inferring long term trends from time series data on any single test. Solid conclusions can be drawn only when it is possible to average results of many tests or when multiple equating studies are done independently.

8. The estimate of the effect of selectivity was made by assuming (1) that all those rejected for ability or educational reasons and 50 percent of those rejected for emotional, moral or medical reasons were in the bottom 25% of the ability distribution, and (2) that the rest of the those rejected and all deferments were selected randomly with respect to ability. The formula is: $Z_{army} = .1685\ (Zscore(bottom\ 25\%))/.8315 = .254$

9. Data on trends for these Tests was obtained from Adelman (1983) and by correspondence with the organizations which administer these exams. The average was designed to characterize the GIA of those with 17+ years of schooling who take jobs in the private business economy. Scores of the 4 different tests were deviated from their value in 1977, divided by their standard deviation and averaged. The weights for the three professional school tests were the total numbers of test takers between 1976 and 1986. 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 resulting weights were .40 for the GMAT, .22 for the LSAT, .10 for the MCAT and .29 for an index of GRE subtest scores. The calculation of the GRE index will now be described. 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. 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.

10. The vintage model does not assume that GIA, once one leaves school, is constant. Maturation and experiences after school may produce age- related rises or declines in GIA, and years of completed school may interact with age in generating these changes. The crucial assumption is that the parameters of these relationships have not changed over historical time. This, in turn, implies that a rise in the tested achievement of high school graduates between 1930 and 1940 results in an equivalent differential between the GIA of 58 year olds in 1970 and the GIA of 58 year olds in 1980.

11. Trends in the mean GIA of HS graduates not attending college were calculated from the mean (GIA_t) for all HS graduates by $GIA_{ht} = GIA_t - \lambda(GIA_{ct} - GIA_{ht})$ where λ is the share of an age cohort's high school graduates completing at least one year of college (from 1970 Census data), and ($GIA_{ct} - GIA_{ht}$) is the differential calculated from Taubman and Wales (1972) and GIA_t is a normalized ITED composite score extended back from 1942 at the .0113 SDs per year rate derived from the analysis of the Finch data. GIA trends for college entrants are obtained from
$GIA_{ct} = GIA_t + (1-\lambda)(GIA_{ct} - GIA_{ht})$.

12. The GRE, LSAT, GMAT and MCAT tests are primarily taken by students applying for admission to graduate and professional schools. Many of those taking these tests are returning to school many years after completing their BA. There have been major changes in the proportions of college graduates continuing their schooling and in the selectivity of the graduate and professional school admissions processes. Consequently, scores on these tests are poor indicators of the GIA of college graduates who do not go to graduate or professional school. They are, however, reasonably good indicators of the GIA at entry into graduate school of those who obtain 1 or more years of graduate or professional education.

13. The college graduate and college drop out indexes for 18 to 24 year olds take into account the fact that the college graduates in this category are almost all age 21 or over and that the college drop outs are mostly over the age of 19.

14. Compensation share for each age by education group was calculated for 1939, 1949, 1959 and 1969 from the Census for that year and Miller (1960). Where 1939 data were not available (as for women), the necessary earnings ratios are derived from the 1949 Census. For 1975 through 1984, the weights are obtained from the table titled Education and Money Earnings in the P60 series of the Current Population Reports. For 1973 and 1974,

special total money income tables were obtained from the Census and estimates of unearned income were subtracted. For 1930, the number employed for each age group was obtained from Series A 119-134 and D 29-41 of Historical Statistics of the United States (1975). The educational background of each age group was obtained by backward extrapolation from the 1940 census, and the wage rates and employment rates for age/education groups were assumed to be the same as in 1940. For the periods between censuses and for 1971 and 1972, an average of weights at the beginning and end of the time interval are employed. For the 1948 to 1973 period, control totals for compensation paid to those with 12 or fewer years of schooling by sex and 13+ years of schooling by sex were taken from Table 3.8 of Jorgenson (1984). Consequently, only the age breakdowns within educational category remained constant over the intervals between the 1949, 1959 and 1969 censuses. The weights employed in making forecasts were the 1984 weights adjusted for projected changes in the size of the age/education cohorts.

15. Denison's index of work force quality is not defined in a manner consistent with the EQ index. Unlike Jorgenson and Chinloy, who assume that the full effect of schooling on wages in census tabulations reflects a real productivity gain, Denison adjusts for the higher IQ and SES of those who get additional education by reducing census tabulation wage differentials by 40 percent. This downward adjustment is not desireable, however, because parental SES and childhood IQ have been rising and have contributed to improvements in the quality of the labor force. A further source of inconsistency with the EQ index is the inclusion of longer school years and fewer absences in his education quantity series. In the accounting system employed in this paper the EQ index picks up all effects that do not operate through years of schooling. If a rapid expansion of high schools were to lower the average achievement of high school graduates, EQ would decline. Longer school years and lower absenteeism would be expected to raise EQ.

16. The standard LQ index being referred to is an average of percentage rates of growth of hours worked by groups of workers classified by age, sex and schooling weighted by shares of compensation. Despite the fact that the weights respond to changes in relative wage rates, changes in quality along dimensions that are not explicitly included in the accounting system do not produce corresponding changes in LQ. For example, if the quality of a particular category of worker falls and this results in an equal percentage decline in the wage of the group, the LQ index will actually be increased if the group at issue grows more slowly than the average for all workers. Jorgenson, Gollop, and Fraumeni also present LQ indexes in which workers have been cross classified by occupation, industry and class of worker as well as by age, sex and schooling. Incorporating these additional quality dimensions adds only 0.12 percent per year to the growth of LQ between 1948 and 1973 and nothing to LQ growth between 1973 and 1979. Some of the LQ change that JGF attribute to changes in these three quality dimensions might in fact be due to changes in EQ. Since educational quality precedes the choice of occupation, industry and employer both in time and causally, an accounting framework that incorporates test score changes is in my view preferable. Baily (1976)

argues against incorporating o upation, industry and class of worker in LQ. He points out that transferring a worker from an industry with a low average wage to one with a higher average wage does not (when labor markets are competitive) raise that worker's marginal productivity if the capital stocks of the two industries do not change.

17. The job incumbents have been through two different selection processes--hiring and retention--so these raw validity numbers are not estimates of population validities. Population validities will generally be higher.

18. Theory suggests a number of factors which could cause P_j-W_j to be non-zero: adjustment costs, monopsony power, agency problems, and specific human capital. If the firm were in disequilibrium due to a cyclical downturn, the size of the quasi-rents would vary across jobs and their magnitude would probably be correlated with worker's schooling or GIA. Specific human capital investments and monitoring costs are also both likely to be greater in the types of jobs that workers with high levels of schooling and GIA obtain. In all three cases, the time paths of productivity and wages that result have offsetting periods of over- and under-compensation. Consequently, from a long-run life-cycle perspective, these quasi-rents should net out to zero. Monopsony power and bargaining over the division of the firm's quasi-rents, on the other hand, might generate non-zero lifetime P_j-W_j's. Bishop (1978) examined the effect of queuing for union jobs on the social return to schooling and found that the lowered probability of taking union jobs that results from going to college raises the social return to college above the private return. The effect of queuing for union jobs on the social return to GIA was not investigated. An exploration of this and related issues is beyond the scope of this paper. It is an area that could benefit from more research.

19. Estimates of the contribution of schooling to labor quality are obtained by dividing the translog indexes of labor input that take account of age, sex and schooling by a translog index that accounts for age and sex only. Changes in the age-sex composition of the work force lowered labor quality by 0.16 percent per year between 1948 and 1973 and by 0.58 percent per year between 1973 and 1979. (Jorgenson et al 1987 Table 8 4)

20. Bishop (1987b) reports that between 66 and 80 percent of the cross section association between years of schooling and productivity is due to the gains in GIA that are associated with greater schooling. If the source of growth in labor quality were decomposed into a portion due to gains in GIA and a residual other effects of schooling not associated with GIA (eg good work habits, occupationally specific skills), GIA gains alone would account for a 0.83 to 0.93 percent per year gain in labor quality and the other outcomes of schooling would account for further gains of 0.145 to 0.245 percent per year in labor quality.

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Table A1
General Intellectual Achievement Indices

	Indices				Compensation Share		
	12th Grade (GIA_{ht})	12 or Fewer (GIA_{ht})	College (GIA_{ct})	Graduate (GIA_{gt})	12 or Fewer	College	Graduate
920	-.4298	-.5482	-.3757	-.4531	.		
921	-.4187	-.5390	-.3644	-.4420	.		
922	-.4075	-.5298	-.3531	-.4309	.		
923	-.3964	-.5206	-.3418	-.4198	.		
924	-.3853	-.5114	-.3305	-.4087	.		
925	-.3742	-.5022	-.3192	-.3975	.		
926	-.3631	-.4930	-.2928	-.3864	.	.	.
927	-.3520	-.4838	-.2664	-.3753	.	.	.
928	-.3409	-.4746	-.2400	-.3642	.	.	.
929	-.3297	-.4654	-.2136	-.3531	.8251	.1253	.0495
930	-.3186	-.4562	-.1929	-.3420	.8196	.1288	.0516
931	-.3075	-.4470	-.1722	-.3309	.8141	.1323	0537
932	-.2964	-.4378	-.1515	-.3197	.8141	.1323	.0537
933	-.2853	-.4286	-.1309	-.2986	.8141	.1323	.0537
934	-.2742	-.4194	-.1102	-.2723	.8141	.1323	.0537
935	-.2631	-.4102	-.0964	-.2461	.8141	.1323	.0537
936	-.2519	-.4010	-.0826	-.2199	.8141	.1323	.0537
937	-.2408	-.3918	-.0687	-.1975	.8141	.1323	.0537
938	-.2297	-.3826	-.0549	-.1770	.8141	.1323	.0537
939	-.2186	-.3734	-.0411	-.1565	.8141	.1323	.0537
940	-.2075	-.3642	-.0273	-.1360	.8033	.1398	.0569
941	-.1964	-.3550	-.0135	-.1155	.7924	.1474	.0601
942	-.1852	-.3458	0.0003	-.0996	.7924	.1474	.0601
943	-.1745	-.3401	0.0136	-.0860	.7924	.1474	.0601
944	-.1638	-.3344	0.0268	-.0724	.7924	.1474	.0601
945	-.1530	-.3288	0.0401	-.0587	.7924	.1474	.0601
946	-.1423	-.3231	0.0533	-.0451	.7924	.1474	.0601
947	-.1315	-.3095	0.0617	-.0315	.7924	.1474	.0601
948	-.1208	-.2959	0.0700	-.0179	.7901	.1493	.0609
949	-.1101	-.2823	0.0783	-.0042	.7837	.1539	.0626
950	-.0993	-.2686	0.0867	0.0092	.7755	.1597	.0651
951	-.0886	-.2612	0.1006	0.0224	.7721	.1618	.0653
952	-.0778	-.2537	0.1145	0.0357	.7684	.1642	.0674
953	-.0671	-.2462	0.1283	0.0489	.7608	.1695	.0697
954	-.0564	-.2387	0.1422	0.0589	.7535	.1747	.0719
955	-.0456	-.2312	0.1561	0.0672	.7474	.1790	.0736
956	-.0349	-.2237	0.1700	0.0756	.7448	.1808	.0743
957	-.0238	-.2159	0.1843	0.0839	.7404	.1840	.0756
958	-.0128	-.2236	0.2136	0.0959	.7310	.1909	.0784
959	0.0204	-.2092	0.2650	0.1098	.7234	.1961	.0805
960	0.0536	-.1948	0.3165	0.1237	.7118	.2017	.0860
961	0.0647	-.1837	0.3275	0.1376	.6963	.2106	.0927
962	0.1090	-.1395	0.3718	0.1515	.6859	.2181	.0959
963	0.1962	-.0523	0.4590	0.1654	.6838	.2196	.0966
964	0.2179	-.0305	0.4808	0.1795	.6844	.2193	.0965
965	0.2288	-.0196	0.4917	0.2038	.6821	.2207	.0970

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Year	Indices: 12th Grade (GIA_{ht})	12 or Fewer (GIA[illegible])	College (GIA_{ct})	Graduate (GIA_{gt})	Compensation Share: 12 or Fewer	College	Graduate
1966	0.2288	-.0196	0.4917	0.2479	.6789	.2230	.0980
1967	0.2288	-.0196	0.4917	0.2849	.6689	.2302	.1011
1968	0.2179	-.0305	0.4808	0.2926	.6594	.2368	.1039
1969	0.1962	-.0523	0.4590	0.2909	.6535	.2409	.1057
1970	0.1199	-.1286	0.3827	0.2704	.6446	.2479	.1077
1971	0.0981	-.1504	0.3609	0.2380	.6319	.2576	.1106
1972	0.0872	-.1613	0.3500	0.2056	.6218	.2647	.1135
1973	0.0763	-.1722	0.3391	0.1965	.6136	.2730	.1133
1974	0.0654	-.1831	0.3282	0.2000	.5902	.2918	.1180
1975	0.0545	-.1940	0.3173	0.2008	.5630	.3090	.1280
1976	0.0327	-.2158	0.2955	0.2002	.5510	.3147	.1343
1977	0.0000	-.2485	0.2628	0.1989	.5428	.3198	.1375
1978	-.0218	-.2703	0.2410	0.2049	.5332	.3262	.1406
1979	-.0327	-.2812	0.2301	0.2034	.5246	.3330	.1424
1980	-.0218	-.2703	0.2410	0.1999	.5163	.3392	.1445
1981	0.0327	-.2158	0.2955	0.2038	.5024	.3446	.1531
1982	0.0327	-.2158	0.2955	0.2187	.4836	.3529	.1635
1983	0.0872	-.1613	0.3500	0.2482	.4707	.3621	.1672
1984	0.0872	-.1613	0.3500	0.2732	.4620	.3714	.1666
1985	0.1199	-.1286	0.3827	0.2939	.4570	.3769	.1661
1986	0.1399	-.1086	0.4027	0.3071	.4570	.3769	.1661
1987	0.1599	-.0886	0.4227	0.3251	.4570	.3769	.1661
1988	0.1799	-.0686	0.4427	0.3445	.4570	.3769	.1661
1989	0.1999	-.0486	0.4627	0.3645	.4570	.3769	.1661
1990	0.2199	-.0286	0.4827	0.3845	.4570	.3769	.1661
1991	0.2399	-.0086	0.5027	0.4045	.4570	.3769	.1661
1992	0.2599	0.0115	0.5227	0.4245	.4570	.3769	.1661
1993	0.2799	0.0315	0.5428	0.4445	.4570	.3769	.1661
1994	0.2999	0.0515	0.5628	0.4645	.4570	.3769	.1651
1995	0.3199	0.0715	0.5828	0.4845	.4570	.3769	.1661
1996	0.3372	0.0887	0.6000	0.5036	.4570	.3769	.1661
1997	0.3545	0.1060	0.6173	0.5218	.4570	.3769	.1661
1998	0.3717	0.1233	0.6346	0.5391	.4570	.3769	.1661
1999	0.3890	0.1405	0.6518	0.5563	.4570	.3769	.1661
2000	0.4063	0.1578	0.6691	0.5736	.4570	.3769	.1661
2001	0.4235	0.1751	0.6864	0.5909	.4570	.3769	.1661
2002	0.4408	0.1923	0.7[illegible]5	0.6081	.4570	.3769	.1561
2003	0.4581	0.2096	0.7209	0.6254	.4570	.3769	.1661
2004	0.4753	0.2259	0.7382	0.6427	.4570	.3769	.1661
2005	0.4926	0.2441	0.7554	0.6599	.4570	.3769	.1661
2006	0.5099	0.2614	0.7727	0.6772	.4570	.3769	.1661
2007	0.5271	0.2787	0.7900	0.6945	.4570	.3769	.1661
2008	0.5444	0.2959	0.8072	0.7117	.4570	.3769	.1661
2009	0.5616	0.3132	0.8245	0.7290	.4570	.3769	.1661
2010	0.5789	0.3305	0.8417	0.7463	.4570	.3769	.1661

Table A2
General Intellectual Ability Index for
Adults with 12 or Fewer Years of Schooling
By Age

Year	18-24 (GIA_{n1t})	25-34 (GIA_{n2t})	35-44 (GIA_{n3t})	45-54 (GIA_{n4t})	55-64 (GIA_{n5t})	65 (GIA_{n6t})
1920	-.5850	-.6619	-.7541	-.8454	-.9375	
1921	-.5757	-.6528	-.7449	-.8363	-.9283	.
1922	-.5664	-.6438	-.7356	-.8272	-.9190	.
1923	-.5570	-.6347	-.7264	-.8182	-.9097	.
1924	-.5476	-.6257	-.7171	-.8091	-.9004	.
1925	-.5382	-.6167	-.7078	-.8000	-.8912	.
1926	-.5289	-.6076	-.6986	-.7909	-.8819	.
1927	-.5197	-.5985	-.6894	-.7817	-.8727	.
1928	-.5105	-.5894	-.6802	-.7725	-.8636	-.9652
1929	-.5014	-.5801	-.6710	-.7633	-.8636	-.9560
1930	-.4923	-.5707	-.6619	-.7541	-.8545	-.9468
1931	-.4832	-.5613	-.6528	-.7449	-.8454	-.9375
1932	-.4741	-.5518	-.6438	-.7356	-.8363	-.9283
1933	-.4651	-.5423	-.6347	-.7264	-.8272	-.9190
1934	-.4560	-.5329	-.6257	-.7171	-.8182	-.9097
1935	-.4469	-.5235	-.6167	-.7078	-.8091	-.9004
1936	-.4377	-.5142	-.6076	-.6986	-.8000	-.8912
1937	-.4285	-.5052	-.5985	-.6894	-.7909	-.8819
1938	-.4192	-.4961	-.5894	-.6894	-.7817	-.8727
1939	-.4099	-.4871	-.5801	-.6802	-.7725	-.8636
1940	-.4006	-.4782	-.5707	-.6710	-.7633	-.8545
1941	-.3914	-.4692	-.5613	-.6619	-.7541	-.8454
1942	-.3823	-.4602	-.5518	-.6528	-.7449	-.8363
1943	-.3733	-.4511	-.5423	-.6438	-.7356	-.8272
1944	-.3648	-.4420	-.5329	-.6347	-.7264	-.8182
1945	-.3567	-.4328	-.5235	-.6257	-.7171	-.8091
1946	-.3491	-.4235	-.5142	-.6167	-.7078	-.8000
1947	-.3420	-.4142	-.5052	-.6076	-.6986	-.7909
1948	-.3342	-.4049	-.4961	-.5985	-.6894	-.7817
1949	-.3258	-.3958	-.4871	-.5894	-.6802	-.7725
1950	-.3169	-.3867	-.4782	-.5801	-.6710	-.7633
1951	-.3070	-.3780	-.4692	-.5707	-.6619	-.7541
1952	-.2966	-.3697	-.4602	-.5613	-.6528	-.7449
1953	-.2856	-.3619	-.4511	-.5518	-.6438	-.7356
1954	-.2744	-.3543	-.4420	-.5423	-.6347	-.7264
1955	-.2640	-.3463	-.4328	-.5329	-.6257	-.7171
1956	-.2544	-.3378	-.4235	-.5235	-.6167	-.7078
1957	-.2458	-.3289	-.4142	-.5142	-.6076	-.6986
1958	-.2381	-.3196	-.4049	-.5052	-.5985	-.6894
1959	-.2329	-.3105	-.3958	-.4961	-.5894	-.6802
1960	-.2263	-.3012	-.3867	-.4871	-.5801	-.6710
1961	-.2183	-.2916	-.3780	-.4782	-.5707	-.6619
1962	-.2103	-.2818	-.3697	-.4692	-.5613	-.6528
1963	-.1968	-.2716	-.3619	-.4602	-.5518	-.6438
1964	-.1720	-.2612	-.3543	-.4511	-.5423	-.6347
1965	-.1405	-.2514	-.3463	-.4420	-.5329	-.6257
				-.4328	-.5235	-.6167

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Table A2

ar	18-24 (GIA_{h1t})	25-34 (GIA_{h2t})	35-44 (GIA_{h3t})	45-54 (GIA_{h4t})	55-64 (GIA_{h5t})	65 (GIA_{h6t})	+ $IA_{c6t})$
6	-.1108	-.2438	-.3378	-.4235	-.5142	-.6076	.
7	-.0846	-.2361	-.3289	-.4142	-.5052	-.5985	.
8	-.0603	-.2279	-.3196	-.4049	-.4961	-.5894	.
9	-.0411	-.2200	-.3105	-.3958	-.4871	-.5801	.
0	-.0316	-.2079	-.3012	-.3867	-.4782	-.5707	.
1	-.0439	-.1876	-.2916	-.3780	-.4692	-.5613	
2	-.0620	-.1616	-.2818	-.3697	-.4602	-.5518	
3	-.0827	-.1382	-.2716	-.3619	-.4511	-.5423	8878
4	-.1045	-.1174	-.2612	-.3543	-.4420	-.5329	8766
5	-.1272	-.0987	-.2514	-.3463	-.4328	-.5235	8653
6	-.1498	-.0815	-.2438	-.3378	-.4235	-.5142	8539
7	-.1727	-.0681	-.2361	-.3289	-.4142	-.5052	8425
8	-.1899	-.0639	-.2279	-.3196	-.4049	-.4961	8311
9	-.2071	-.0640	-.2200	-.3105	-.3958	-.4871	8197
0	-.2243	-.0687	-.2079	-.3012	-.3867	-.4782	8083
1	-.2382	-.0809	-.1876	-.2916	-.3780	-.4692	7969
2	-.2426	-.0968	-.1616	-.2818	-.3697	-.4602	7856
3	-.2457	-.1143	-.1382	-.2716	-.3619	-.4511	7743
4	-.2388	-.1337	-.1174	-.2612	-.3543	-.4420	7631
5	-.2272	-.1560	-.0987	-.2514	-.3463	-.4328	7519
6	-.2080	-.1794	-.0815	-.2438	-.3378	-.4235	7407
7	-.1832	-.2018	-.0681	-.2361	-.3289	-.4142	7296
8	-.1560	-.2159	-.0639	-.2279	-.3196	-.4049	7184
9	-.1339	-.2221	-.0640	-.2200	-.3105	-.3958	7073
0	-.1098	-.2273	-.0687	-.2079	-.3012	-.3867	6961
1	-.0914	-.2265	-.0809	-.1876	-.2916	-.3780	6850
2	-.0703	-.2249	-.0968	-.1616	-.2818	-.3697	6737
3	-.0508	-.2194	-.1143	-.1382	-.2716	-.3619	6625
4	-.0310	-.2094	-.1337	-.1174	-.2612	-.3543	6512
5	-.0101	-.1937	-.1560	-.0987	-.2514	-.3463	6399
6	0.0112	-.1733	-.1794	-.0815	-.2438	-.3378	6286
7	0.0317	-.1502	-.2018	-.0681	-.2361	-.3289	6172
8	0.0518	-.1257	-.2159	-.0639	-.2279	-.3196	6059
9	0.0709	-.1050	-.2221	-.0640	-.2200	-.3105	5945
0	0.0895	-.0818	-.2273	-.0687	-.2079	-.3012	5831
1	0.1074	-.0628	-.2265	-.0809	-.1876	-.2916	5718
2	0.1248	-.0414	-.2249	-.0968	-.1616	-.2818	5604
3	0.1416	-.0213	-.2194	-.1143	-.1382	-.2716	5491
4	0.1585	-.0008	-.2094	-.1337	-.1174	-.2612	5378
5	0.1757	0.0205	-.1937	-.1560	-.0987	-.2514	5265
6	0.1929	0.0416	-.1733	-.1794	-.0815	-.2438	5154
7	0.2101	0.0615	-.1502	-.2018	-.0681	-.2361	5042
8	0.2272	0.0806	-.1257	-.2159	-.0639	-.2279	4931
9	0.2442	0.0989	-.1050	-.2221	-.0640	-.2200	4820
0	0.2612	0.1169	-.0818	-.2273	-.0687	-.2079	4709
							4598

Table A3
General Intellectual Ability of Adults With 1-4 Years of College
By Age

Year	18-24 (GIA_{c1t})	25-34 (GIA_{c2t})	35-44 (GIA_{c3t})	45-54 (GIA_{c4t})	55-64 (GIA_{c5t})	65+ (GIA_{c6t})
1920	-.43_2	-.5154	-.6286	-.7407	-.8539	•
1921	-.4209	-.5042	-.6172	-.7296	-.8425	•
1922	-.4096	-.4931	-.6059	-.7184	-.8311	•
1923	-.3983	-.4820	-.5945	-.7073	-.8197	•
1924	-.3870	-.4709	-.5831	-.6961	-.8083	•
1925	-.3757	-.4598	-.5718	-.6850	-.7969	•
1926	-.3644	-.4486	-.5604	-.6737	-.7856	•
1927	-.3526	-.4375	-.5491	-.6625	-.7743	-.8878
1928	-.3401	-.4262	-.5378	-.6512	-.7631	-.8766
1929	-.3258	-.4148	-.5265	-.6399	-.7519	-.8653
1930	-.3091	-.4033	-.5154	-.6286	-.7407	-.8539
1931	-.2895	-.3917	-.5042	-.6172	-.7296	-.8425
1932	-.2670	-.3801	-.4931	-.6059	-.7184	-.8311
1933	-.2418	-.3684	-.4820	-.5945	-.7073	-.8197
1934	-.2174	-.3552	-.4709	-.5831	-.6961	-.8083
1935	-.1942	-.3404	-.4598	-.5718	-.6850	-.7969
1936	-.1724	-.3242	-.4486	-.5604	-.6737	-.7856
1937	-.1523	-.3067	-.4375	-.5491	-.6625	-.7743
1938	-.1330	-.2884	-.4262	-.5378	-.6512	-.7631
1939	-.1148	-.2694	-.4148	-.5265	-.6399	-.7519
1940	-.0980	-.2495	-.4033	-.5154	-.6286	-.7407
1941	-.0826	-.2289	-.3917	-.5042	-.6172	-.7296
1942	-.0687	-.2074	-.3801	-.4931	-.6059	-.7184
1943	-.0549	-.1855	-.3684	-.4820	-.5945	-.7073
1944	-.0411	-.1648	-.3552	-.4709	-.5831	-.6961
1945	-.0274	-.1451	-.3404	-.4598	-.5718	-.6850
1946	-.0137	-.1265	-.3242	-.4486	-.5604	-.6737
1947	-.0001	-.1091	-.3067	-.4375	-.5491	-.6625
1948	0.0133	-.0925	-.2884	-.4262	-.5378	-.6512
1949	0.0263	-.0767	-.2694	-.4148	-.5265	-.6399
1950	0.0386	-.0617	-.2495	-.4033	-.5154	-.6286
1951	0.0500	-.0476	-.2289	-.3917	-.5042	-.6172
1952	0.0607	-.0342	-.2074	-.3801	-.4931	-.6059
1953	0.0706	-.0210	-.1855	-.3684	-.4820	-.5945
1954	0.0801	-.0079	-.1648	-.3552	-.4709	-.5831
1955	0.0904	0.0048	-.1451	-.3404	-.4598	-.5718
1956	0.1018	0.0171	-.1265	-.3242	-.4486	-.5604
1957	0.1145	0.0289	-.1091	-.3067	-.4375	-.5491
1958	0.1284	0.0402	-.0925	-.2884	-.4262	-.5378
1959	0.1427	0.0516	-.0767	-.2694	-.4148	-.5265
1960	0.1586	0.0632	-.0617	-.2495	-.4033	-.5154
1961	0.1774	0.0748	-.0476	-.2289	-.3917	-.5042
1962	0.2001	0.0866	-.0342	-.2074	-.3801	-.4931
1963	0.2284	0.0988	-.02·0	-.1855	-.3684	-.4820
1964	0.2625	0.1109	-.0079	-.1648	-.3552	-.4703
1965	0.3025	0.1238	0.0048	-.1451	-.3404	-.4598

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Year	18-24 (GIA_{c1t})	25-34 (GIA_{c2t})	35-44 (GIA_{c3t})	45-54 (GIA_{c4t})	55-64 (GIA_{c5t})	65+ (GIA_{c6t})
1966	0.3463	0.1391	0.0171	-.1265	-.3242	-.4486
1967	0.3864	0.1596	0.0289	-.1091	-.3067	-.4375
1968	0.4205	0.1860	0.0402	-.0925	-.2884	-.4262
1969	0.4547	0.2097	0.0516	-.0767	-.2694	-.4148
1970	0.4803	0.2364	0.0632	-.0617	-.2495	-.4033
1971	0.4830	0.2700	0.0748	-.0476	-.2289	-.3917
1972	0.4766	0.3096	0.0866	-.0342	-.2074	-.3801
1973	0.4604	0.3447	0.0988	-.0210	-.1855	-.3684
1974	0.4381	0.3759	0.1109	-.0079	-.1648	-.3552
1975	0.4101	0.4036	0.1238	0.0048	-.1451	-.3404
1976	0.3807	0.4268	0.1391	0.0171	-.1265	-.3242
1977	0.3522	0.4432	0.1596	0.0289	-.1091	-.3067
1978	0.3376	0.4473	0.1860	0.0402	-.0925	-.2884
1979	0.3240	0.4473	0.2097	0.0516	-.0767	-.2694
1980	0.3082	0.4426	0.2364	0.0632	-.0617	-.2495
1981	0.2909	0.4304	0.2700	0.0748	-.0476	-.2289
1982	0.2747	0.4145	0.3096	0.0866	-.0342	-.2074
1983	0.2608	0.3970	0.3447	0.0988	-.0210	-.1855
1984	0.2564	0.3776	0.3759	0.1109	-.0079	-.1648
1985	0.2627	0.3553	0.4036	0.1238	0.0048	-.1451
1986	0.2809	0.3319	0.4268	0.1391	0.0171	-.1265
1987	0.3058	0.3095	0.4432	0.1596	0.0289	-.1091
1988	0.3348	0.2954	0.4473	0.1860	0.0402	-.0925
1989	0.3554	0.2892	0.4473	0.2097	0.0516	-.0767
1990	0.3817	0.2840	0.4426	0.2364	0.0632	-.0617
1991	0.3998	0.2847	0.4304	0.2700	0.0748	-.0476
1992	0.4227	0.2864	0.4145	0.3096	0.0866	-.0342
1993	0.4427	0.2919	0.3970	0.3447	0.0988	-.0210
1994	0.4627	0.3018	0.3776	0.3759	0.1109	-.0079
1995	0.4827	0.3176	0.3553	0.4036	0.1238	0.0048
1996	0.5027	0.3380	0.3319	0.4268	0.1391	0.0171
1997	0.5227	0.3611	0.3095	0.4432	0.1596	0.0289
1998	0.5425	0.3855	0.2954	0.4473	0.1860	0.0402
1999	0.5619	0.4062	0.2892	0.4473	0.2097	0.0516
2000	0.5809	0.4295	0.2840	0.4426	0.2364	0.0632
2001	0.5994	0.4485	0.2847	0.4304	0.2700	0.0748
2002	0.6173	0.4699	0.2864	0.4145	0.3096	0.0866
2003	0.6346	0.4899	0.2919	0.3970	0.3447	0.0988
2004	0.6518	0.5105	0.3018	0.3776	0.3759	0.1109
2005	0.6691	0.5317	0.3176	0.3553	0.4036	0.1238
2006	0.6864	0.5529	0.3380	0.3319	0.4268	0.1391
2007	0.7036	0.5728	0.3611	0.3095	0.4432	0.1596
2008	0.7209	0.5919	0.3855	0.2954	0.4473	0.1860
2009	0.7382	0.6102	0.4062	0.2892	0.4473	0.2097
2010	0.7554	0.6282	0.4295	0.2840	0.4426	0.2364

Table A4
General Intellectual Ability of Adults with Graduate Education
By Age

Year	18-24 (GIA_{g1t})	25-34 (GIA_{g2t})	35-44 (GIA_{g3t})	45-54 (GIA_{g4t})	55-64 (GIA_{g5t})	65+ (GIA_{g6t})
1920	-.4383	-.5127	-.6241	-.7344	-.8457	.
1921	-.4272	-.5017	-.[illegible]129	-.7234	-.8345	.
1922	-.4161	-.4908	-.6017	-.7124	-.8233	.
1923	-.4050	-.4798	-.5906	-.7015	-.8120	.
1924	-.3938	-.4689	-.5794	-.6905	-.8008	.
1925	-.3827	-.4580	-.5682	-.6795	-.7897	.
1926	-.3716	-.4471	-.5570	-.6685	-.7785	.
1927	-.3605	-.4361	-.5459	-.6574	-.7674	-.8791
1928	-.3494	-.4250	-.5347	-.6463	-.7564	-.8680
1929	-.3383	-.4138	-.5237	-.6352	-.7454	-.8559
1930	-.3272	-.4025	-.5127	-.6241	-.7344	-.8457
1931	-.3110	-.3911	-.5017	-.6129	-.7234	-.8345
1932	-.2898	-.3796	-.4908	-.6017	-.7124	-.8233
1933	-.2636	-.3682	-.4798	-.5906	-.7015	-.8120
1934	-.2374	-.3557	-.4689	-.5794	-.6905	-.8008
1935	-.2131	-.3416	-.4580	-.5682	-.6795	-.7897
1936	-.1907	-.3261	-.4471	-.5570	-.6685	-.7785
1937	-.1702	-.3093	-.4361	-.5459	-.6574	-.7674
1938	-.1497	-.2915	-.4250	-.5347	-.6463	-.7564
1939	-.1292	-.2729	-.4138	-.5237	-.6352	-.7454
1940	-.1110	-.2536	-.4025	-.5127	-.6241	-.7344
1941	-.0951	-.2334	-.3911	-.5017	-.6129	-.7234
1942	-.0815	-.2123	-.3796	-.4908	-.6017	-.7124
1943	-.0678	-.1908	-.3682	-.4798	-.5906	-.7015
1944	-.0542	-.1698	-.3557	-.4689	-.5794	6905
1945	-.0406	-.1499	-.3416	-.4580	-.5682	[illegible]
1946	-.0269	-.1310	-.3261	-.4471	-.5570	-.[illegible]
1947	-.0133	-.1134	-.3093	-.4361	-.5459	-.6574
1948	0.0002	-. 967	-.2915	-.4250	-.5347	-.6463
1949	0.01[illegible]6	-.0809	-.2729	-.4138	-.5237	-.6352
1950	0.0268	-.0659	-.2536	-.4025	-.5127	-.6241
1951	0.0401	-.0517	-.2334	-.3911	-.5017	-.6129
1952	0.0517	-.038[illegible]	-.2123	-.3796	-.4908	-.6017
1953	0.0617	-.0251	-.1908	-.3682	-.4798	-.5906
1954	0.0700	-.0121	-.1698	-.3557	-.4689	-.5794
1955	0.0783	0.0006	-.1499	-.3416	-.4580	-.5682
1956	0.0885	0.0131	-.1310	-.3261	-.4471	-.5570
1957	0.1006	0.0250	-.1134	-.3093	-.4361	-.5459
1958	0.1145	0.0364	-.0967	-.2915	-.4250	-.5347
1959	0.1284	0.0477	-.0809	-.2729	-.4138	-.5237
1960	0.1422	0.0594	-.0659	-.2536	-.4025	-.5127
1961	0.1561	0.0710	-.0517	-.2334	-.3911	-.5017
1962	0.1701	0.0828	-.0382	-.2123	-.3796	-.4908
1963	0.1893	0.0949	-.0251	-.1908	-.3682	-.4798
1964	0.2210	0.1070	-.0121	-.1698	-.3557	-.4689
1965	0.2650	0.[illegible]197	0.0006	-.1499	-.3416	-.4580

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Year	18-24 (GIA_{g1t})	25-34 (GIA_{g2t})	35-44 (GIA_{g3t})	45-54 (GIA_{g4t})	55-64 (GIA_{g5t})	65+ (GIA_{g6t})
1966	0.3030	0.1343	0.0131	-.1310	-.3261	-.4471
1967	0.3266	0.1531	0.0250	-.1134	-.3093	-.4361
1968	0.3343	0.1760	0.0364	-.0967	-.2915	-.4250
1969	0.3325	0.1964	0.0477	-.0809	-.2729	-.4138
1970	0.3121	0.2147	0.0594	-.0659	-.2536	-.4025
1971	0.2797	0.2285	0.0710	-.0517	-.2334	-.3911
1972	0.2473	0.2371	0.0828	-.0382	-.2123	-.3796
1973	0.2382	0.2400	0.0949	-.0251	-.1908	-.3682
1974	0.2417	0.2405	0.1070	-.0121	-.1698	-.3557
1975	0.2425	0.2404	0.1197	0.0006	-.1499	-.3416
1976	0.2419	0.2387	0.1343	0.0131	-.1310	-.3261
1977	0.2406	0.2336	0.1531	0.0250	-.1134	3093
1978	2465	0.2253	0.1760	0.0364	-.0967	-.2915
1979	0.2451	0.2176	0.1964	0.0477	-.0809	-.2729
1980	0.2416	0.2104	0.2147	0.0594	-.0659	-.2536
1981	0.2455	0.2049	0.2285	0.0710	-.0517	-.2334
1982	0.2604	0.2014	0.2371	0.0828	-.0382	-.2123
1983	0.2899	0.2029	0.2400	0.0949	-.0251	-.1908
1984	0.3148	0.2082	0.2405	0.1070	-.0121	-.1698
1985	0.3356	0.2158	0.2404	0.1197	0.0006	-.1499
1986	0.3488	0.2253	0.2387	0.1343	0.0131	-.1310
1987	0.3668	0.2362	0.2336	0.1531	0.0250	-.1134
1988	0.3862	0.2490	0.2253	0.1760	0.0364	-.0967
1989	0.4062	0.2629	0.2176	0.1964	0.0477	-.0809
1990	0.4262	0.2786	0.2104	0.2147	0.0594	-.0659
1991	0.4462	0.2961	0.2049	0.2285	0.0710	-.0517
1992	0.4662	0.3151	0.2014	0.2371	0.0828	-.0382
1993	0.4862	0.3346	0.2029	0.2400	0.0949	-.0251
1994	0.5062	0.3538	0.2082	0.2405	0.1070	-.0121
1995	0.5262	0.3729	0.2158	0.2404	0.1197	0.0006
1996	0.5453	0.3922	0.2253	0.2387	0.1343	0.0131
1997	0.5635	0.4116	0.2362	0.2336	0.1531	0.0250
1998	0.5808	0.4313	0.2490	0.2253	0.1760	0.0364
1999	0.5980	0.4508	0.2629	0.2176	0.1964	0.0477
2000	0.6153	0.4702	0.2786	0.2104	0.2147	0.0594
2001	0.6326	0.4890	0.2961	0.2049	0.2285	0.0710
2002	0.6498	0.5078	0.3151	0.2014	0.2371	0.0828
2003	0.6671	0.5262	0.3346	0.2029	0.2400	0.0949
2004	0.6844	0.5450	0.3538	0.2082	0.2405	0.1070
2005	0.7016	0.5645	0.3729	0.2158	0.2404	0.1197
2006	0.7189	0.5838	0.3922	0.2253	0.2387	0.1343
2007	0.7361	0.6021	0.4116	0.2362	0.2336	0.1531
2008	0.7534	0.6198	0.4313	0.2490	0.2253	0.1760
2009	0.7707	0.6371	0.4508	0.2629	0.2176	0.1964
2010	0.7879	0.6543	0.4702	0.2786	0.2104	0.2147

Table A5
Educational Quality Indexes
by Level of Completed Education

Year	Growth Rate Indices				Level Indices			
	12 or Fewer (EQ_{nt})	College Educated (EQ_{ct})	Graduate Educated (EQ_{gt})	Aggregate (EQ_t)	12 or Fewer ($EQ_{n}t$)	College (EQ_{ct})	Graduate Education (EQ_{gt})	Aggregate (EQ_t)
1929	.00921	.01168	.01112	.00961	.0000	.0000	.0000	.0000
1930	.00922	.01193	.01113	.00966	.0092	.0119	.0111	.0097
1931	.00923	.01218	.01122	.00972	.0184	.0241	.0224	.0194
1932	.00924	.01249	.01132	.00978	.0277	.0366	.0337	.0292
1933	.00924	.01277	.01139	.00981	.0369	.0494	.0451	.0390
1934	.00922	.01315	.01166	.00987	.0461	.0625	.0567	.0488
1935	.00921	.01351	.01204	.00992	.0554	.0760	.0688	.0588
1936	.00920	.01382	.01242	.00998	.0646	.0898	.0812	.0687
1937	.00916	.01402	.01271	.00998	.0737	.1039	.0939	.0787
1938	.00919	.01422	.01303	.01005	.0829	.1181	.1069	.0888
1939	.00920	.01436	.01325	.01009	.0921	.1324	.1202	.0989
1940	.00920	.01434	.01332	.01014	.1013	.1468	.1335	.1090
1941	.00920	.01436	.01339	.01021	.1105	.1611	.1469	.1192
1942	.00921	.01451	.01360	.01025	.1197	.1757	.1605	.1295
1943	.00920	.01458	.01371	.01026	.1289	.1902	.1742	.1397
1944	.00916	.01473	.01391	.01025	.1381	.2050	.1881	.1500
1945	.00911	.01487	.01417	.01026	.1472	.2198	2023	.1602
1946	.00907	.01498	.01441	.01025	.1563	.2348	.2167	.1705
1947	.00898	.01498	.01452	.01019	.1652	.2498	.2312	.1807
1948	.00906	.01502	.01468	.01028	.1743	.2648	.2459	.1903
1949	.00910	.01498	.01476	.01035	.1834	.2798	.2606	.2013
1950	.00913	.01489	.01477	.01040	.1925	.2947	.2754	.2117
1951	.00914	.01485	.01485	.01043	.2017	.3095	.2903	.2221
1952	.00911	.01487	.01499	.01044	.2108	.3244	.3053	.2326
1953	.00909	.01485	.01506	.01047	.2199	.3392	.3203	.2430
1954	.00903	.01482	.01511	.01047	.2289	.3541	.3354	.2535
1955	.00908	.01483	.01516	.01054	.2380	.3689	.3506	.2640
1956	.00913	.01482	.01516	.01059	.2471	.3837	.3657	.2746
1957	.00908	.01470	.01504	.01055	.2562	.3984	.3808	.2852
1958	.00908	.01465	.01496	.01059	.2653	.4131	.3957	.2958
1959	.00912	.01452	.01488	.01065	.2744	.4277	.4106	.3064
1960	.00926	.01476	.01483	.01083	.2837	.4425	.4254	.3173
1961	.00903	.01504	.01476	.01081	.2927	.4575	.4402	.3281
1962	.00948	.01544	.01481	.01127	.3022	.4729	.4550	.3393
1963	.01058	.01603	.01497	.01218	.3127	.4890	.4700	.3515
1964	.01057	.01646	.01511	.01228	.3233	.5054	.4851	.3638
1965	.01102	.01700	.01526	.01273	.3343	.5224	.5004	.3765

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Year	Growth Rate Indices: 12 or Fewer (EQ_{ht})	College Educated (EQ_{ct})	Graduate Educated (EQ_{gt})	Aggregate (EQ_t)	Level Indices: 12 or Fewer (EQ_{ht})	College (EQ_{ct})	Graduate Education (EQ_{gt})	Aggregate (EQ_t)
1966	.01039	.01731	.01541	.01252	.3447	.5403	.5158	.3891
1967	.01019	.01852	.01583	.01265	.3549	.5588	.5316	.4017
1968	.01004	.01928	.01622	.01284	.3650	.5781	.5478	.4146
1969	.00932	.01854	.01538	.01215	.3743	.5966	.5632	.4267
1970	.00847	.01884	.01468	.01168	.3827	.6154	.5779	.4384
1971	.00871	.01834	.01331	.01167	.3915	.6338	.5912	.4501
1972	.00941	.01894	.01194	.01219	.4009	.6527	.6031	.4623
1973	.00845	.01675	.01077	.01096	.4093	.6695	.6139	.4732
1974	.00754	.01507	.00997	.01000	.4169	.6845	.6239	.4832
1975	.00631	.01376	.00974	.00931	.4237	.6983	.6336	.4925
1976	.00585	.01285	.00977	.00855	.4295	.7111	.6434	.5011
1977	.00477	.01163	.01002	.00766	.4343	.7228	.6534	.5087
1978	.00373	.01017	.01036	.00673	.4380	.7329	.6638	.5155
1979	.00278	.00820	.00964	.00553	.4408	.7411	.6734	.5210
1980	.00296	.00722	.00911	.00527	.4438	.7484	.6825	.5263
1981	.00436	.00642	.00815	.00564	.4481	.7548	.6907	.5319
1982	.00505	.00721	.00719	.00615	.4532	.7620	.6978	.5380
1983	.00528	.00620	.00656	.00582	.4585	.7682	.7044	.5439
1984	.00397	.00502	.00648	.00499	.4624	.7738	.7109	.5489
1985	.00375	.00470	.00679	.00460	.4662	.7785	.7177	.5535
1986	.00335	.00432	.00693	.00430	.4635	.7828	.7246	.5578
1987	.00338	.00393	.00682	.00415	.4729	.7867	.7314	.5613
1988	.00383	.00444	.00681	.00455	.4767	.7912	.7382	.5665
1989	.00432	.00479	.00679	.00490	.4810	.7960	.7450	.5714
1990	.00457	.00473	.00690	.00501	.4856	.8007	.7519	.5764
1991	.00546	.00506	.00694	.00555	.4911	.8058	.7588	.5819
1992	.00628	.00564	.00695	.00615	.4974	.8114	.7658	.5881
1993	.00630	.00557	.00772	.00626	.5037	.8170	.7735	.5942
1994	.00657	.00588	.00861	.00665	.5102	.8229	.7821	.6010
1995	.00703	.00653	.00938	.00723	.5172	.8294	.7915	.6082
1996	.00739	.00731	.01007	.00780	.5246	.8367	.8016	.6160
1997	.00750	.00791	.01040	.00813	.5321	.8446	.8120	.6241
1998	.00801	.00942	.01098	.00902	.5401	.8540	.8230	.6332
1999	.00785	.00944	.01123	.00900	.5480	.8635	.8342	.6422
2000	.00839	.01012	.01170	.00958	.5564	.8736	.8459	.6518
2001	.00831	.00988	.01203	.00951	.5647	.8835	.8579	.6613
2002	.00921	.01092	.01239	.01037	.5739	.8944	.8703	.671[illegible]
2003	.00898	.01080	.01286	.01030	.5829	.9052	.8832	.6819
2004	.00941	.01157	.01336	.01086	.5923	.9168	.8965	.6928
2005	.01007	.01270	.01393	.01169	.6024	.9295	.9105	.7045
2006	.01064	.01342	.01423	.01227	.6130	.9429	.9247	.7167
2007	.01056	.01332	.01397	.01215	.6236	.9562	.9387	.7289
2008	.01100	.01368	.01403	.01250	.6346	.9699	.9527	.7414
2009	.01084	.01310	.01416	.01223	.6454	.9830	.9669	.7536
2010	.01097	.01348	.01452	.01249	.6564	.9965	.9814	.7661