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The “Mincer Equation” Thirty Years after *Schooling, Experience, and Earnings**

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Abstract

The paper evaluates the empirical performance of the standard Mincer earnings equation thirty years after the publication of *Schooling, Experience and Earnings*. Since those days, there has been a dramatic expansion in micro data and estimation techniques available to labor economists. How does the Mincer equation stand in light of these advances in empirical labor economics? Is it time to revise our benchmark model? On the basis of the existing literature and some new empirical estimates, I find that the Mincer equation remains an accurate benchmark for estimating wage determination equations provided that it is adjusted by 1) including a quartic function in potential experience instead of just a quadratic, 2) allowing for a quadratic term in years of schooling to capture the growing convexity in the relationship between schooling and wages, and 3) allowing for cohort effects to capture the dramatic growth in returns to schooling among cohorts born after 1950.

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1. Introduction

Thirty years ago, Jacob Mincer published his landmark book *Schooling, Experience, and Earnings* (Mincer, 1974) that had a profound and lasting influence on empirical work in the field of labor economics.¹ On the basis of both theoretical and empirical arguments, Mincer modeled the natural logarithm of earnings as a function of years of education and years of potential labor market experience (age minus year of schooling minus six). In the most widely used version of Mincer's "human capital earnings function", log earnings are modelled as the sum of a linear function of years of education and a quadratic function of years of potential experience:²

$$(1) \quad \log y = \log y_0 + rS + \beta_1 X + \beta_2 X^2,$$

where y is earnings (y_0 is the level of earnings of an individual with no education and no experience), S is years of schooling, and X is years of potential labor market experience. Equation (1) has become the "workhorse" of empirical research on earnings determination. It has been estimated on thousands of data sets for a large number of countries and time periods which clearly makes it one of the most widely used model in empirical economics.

What explains the popularity of the Mincer equation? One part of the answer lies in the fact that equation (1) is based on a formal model of investment in human capital. Though the definite version of the Mincer equation was proposed in *Schooling, Experience and Earnings*, many of the key ideas of the book were already present in Mincer's Ph.D. dissertation (published in Mincer (1958)). In particular, Mincer (1958) pointed out that the "schooling part" of equation (1) ($\log y = \log y_0 + rS$) was an equilibrium condition in a model where identical agents optimally invest in human capital to maximize the present value of their future earnings. In this model, the parameter

¹ See Rosen (1992) and the other chapters in this book for a survey of Jacob Mincer's major contributions to labor economics.

² Though the human capital earnings function is typically associated with the name and the work of Jacob Mincer, other authors also made important contributions to that line of research. In the words of Willis (1986): "...A major development in the literature, initiated by Becker and Chiswick (1966) and carried to full fruition by Mincer (1974), sought to use the theory to restrict the functional form of the earnings function ... This work was carried out with such ingenuity, sophistication, and care by Mincer (1974) that the resulting function is often referred to as "the" human capital earnings function..."

r is the rate of return to an additional year of education and is equal to the discount rate, in equilibrium. This "human capital" interpretation of the model is completed by adding experience which captures post-school investments in human capital.

Another part of the answer is that the Mincer equation provides a parsimonious specification that fits the data remarkably well in most contexts. In this regard, the key contribution of *Schooling, Experience and Earnings* was the introduction of potential experience as a standard regressor in the earnings regression. It was known prior to Mincer's work that earnings grew as a (concave) function of age.³ In his early work, Mincer (1958) also pointed out that the resulting "age-earnings profile" was steeper for more educated workers than for less educated workers. In other words, log earnings are not a strictly separable function of education and age. There is no such thing as a single rate of return to education but rather a different rate of return for each age group.

By contrast, Mincer pointed out in *Schooling, Experience and Earnings* that the experience-earnings profiles were relatively parallel for different education groups. This point can be readily seen in Figure 1 that reproduces Mincer's original charts of earnings as a function of both age and potential experience (using data from the 1960 U.S. Census). Introducing potential experience as opposed to age in the earnings equation is, therefore, a parsimonious way of capturing both the shape of the age-earnings profile and the differential slope of the age-earnings profile across education groups. Another advantage of this additively separable model is that, conditional on years of potential experience, there is a single rate of return to education, r , in the labor market. From this point of view, the Mincer equation provides the foundation on which a large and growing literature that attempts to estimate the causal effect of education on earnings has built on (see Card, 1999, for a review).

It is quite remarkable that, thirty years after *Schooling, Experience and Earnings*, most studies still tend to estimate earnings regression that are very closely related to equation (1). Though a list of other regressors are typically added to the basic Mincer equation, the three key variables in equation (1) still appear in most empirical estimates of earnings regressions. Furthermore, the logarithmic specification for earnings is almost always used in these models. Unless the Mincer earnings equation is really a *law* of earnings determination, it is difficult to

³ See Miller (1960).

believe that, for most data sets, equation (1) is truly the most parsimonious model of earnings determination that would be obtained through careful econometric specification testing. On the one hand, as long as the Mincer earnings regression remains a good approximation for the "true" earnings equation, it is quite valuable to keep estimating the same equation for the sake of comparability across studies. If, on the other hand, the Mincer equation is not, or is no longer, a good approximation, we may be getting a quite inaccurate picture of earnings determination from all these studies that all make the same mistakes.

The goal of this paper is to critically reappraise the standard Mincer earnings equation thirty years after the publication of *Schooling, Experience and Earnings*. Since those days, there has been a phenomenal expansion in the computer power and in the number of micro data sets available for empirical labor economic research. Sophisticated parametric and non-parametric procedures are now available to perform careful specification analyses. How does the Mincer equation stand in light of all these advances in empirical labor economics? Is it time to revise our benchmark model?

This paper is a limited attempt at answering these questions. I review the results of few recent studies that have implications for the choice of an accurate "benchmark" earnings equation *à la* Mincer. I make no attempt to cover the large literature on earnings determination that has been well surveyed elsewhere (see, for example, Polachek and Siebert (1993)). I also supplement the main findings of the existing studies with some new empirical results based on the Current Population Survey (CPS) for the years 1979 to 2001.

The remainder of the paper is divided in five themes. In Section II, I look at whether the natural logarithm is the appropriate transformation for earnings. In the following two sections, I discuss whether education should enter linearly (Section III) and potential experience should enter as a quadratic function (Section IV) in a separable earnings equation. The issue of separability between schooling and experience is examined in Section V, while Section VI looks at whether cohort effects should be included in the earnings equation. I conclude in Section VII.

II. Earnings in logs or not?

As mentioned earlier, the dependent variable in the standard Mincer earnings equation is the log, as opposed to the level, of earnings. While logs are typically used in econometric models for reasons

of convenience or fit, there is a strong theoretical rationale for using log earnings in a human capital earnings regression. As pointed out by Mincer (1958), education should have a *multiplicative* effect on human capital in a simple model where identical individuals maximize the present value of future income which is equalized for all education levels in equilibrium. The reason is that investments in human capital, like other investments, are only undertaken as long as the rate of return (not the absolute return) on the investment exceeds the discount rate. Log-linearity of earnings as a function of years of schooling is in fact a key empirical implication of the human capital model with identical individuals proposed by Mincer (1958).

The existing evidence generally supports the log-earnings specification. For example, Heckman and Polachek (1974) estimated a Box-Cox model and could not reject the log specification. More recently, Fortin and Lemieux (1998) use a more flexible "rank regression" model in which earnings are specified as a relatively unrestricted monotonic transformation of a Mincer-type human capital index (sum of a linear function of education, polynomial function of potential experience, few other regressors and a normally distributed error term). Using large samples from the 1979 and 1991 outgoing rotation group (ORG) supplement of the CPS, they find that the log wage is close to a log-linear function of the human capital index for values of the wage above the minimum wage. Their findings are reproduced for men in Figure 2.⁴ The human capital index appears to have a smaller effect on wages around the minimum wage, which is consistent with minimum wages compressing the wage distribution at the low end of the skill distribution. Figure 2 shows, nevertheless, that the assumption of log-linearity is very accurate for most of the range of the wage distribution.

III. Linear education?

Though Mincer (1974) considered several functional forms for the earnings equation, the most commonly used is equation (1). There are several reasons, however, why a simple linear

⁴ Fortin and Lemieux (1998) divide the wage distribution into 200 intervals and estimate an ordered probit model for the probability that wages are in a given interval, conditional on the observables (as captured by education, a quartic in experience, and marital status). Figure 2 is simply a plot of average log wages in each interval as a function of the estimated thresholds in the ordered probit. If the true model was $\log(\text{wage}) = \mathbf{x}\mathbf{b} + e$, where e is normal (Mincer model

specification for years of education may be inaccurate. For example, log earnings will be a concave function of years of schooling in a simple human capital investment model in which individuals have different preferences (discount rates) but all face the same concave production function (the return to a year of schooling declines as years of schooling increase). More generally, Mincer (1997) shows that in a Becker (1975) type model where individuals are heterogeneous in their preferences and earnings opportunities, average log earnings may either be a convex or a concave function of years of schooling.⁵

Another possibility is that in addition to years of schooling per se, educational credentials also have a direct impact on earnings. In the presence of "credential" or "sheepskin" effects, the return to a year of schooling should be higher between 11 and 12 years of education (high school credential effect) and between 15 and 16 years of schooling (college credential effect) than for other years of schooling. One simple way of testing the linearity of years of schooling is to estimate log earnings as an unrestricted (non-parametric) function of years of schooling and see whether this unrestricted function is approximately linear.

Card and Krueger (1992) estimate such an unrestricted earnings function as part of their study of the impact of school quality on earnings.⁶ Their results for three separate birth cohorts of white men (Figure 2, p. 7) show that log earnings appear to be a linear function of years of schooling for most levels of schooling. One exception is between 15 and 16 years of schooling where, consistent with credential effects, the return to schooling is systematically higher than for other schooling levels. Interestingly, however, there are no abnormal returns associated with high school completion. The other exception is at very low years of schooling where returns to schooling are relatively low. This phenomenon is particularly clear for the younger (and most educated) cohort born in 1940-49 for which returns below five years of schooling are essentially zero. Card and Krueger (1992) conclude from their analysis that log earnings are an approximately linear function of years of schooling except for the lowest two percentiles (for a cohort) of the

with normal errors), then the function plotted in Figure 2 should be linear.

⁵ This model was introduced by Becker in his 1967 Woytinski Lecture which is reproduced in Becker (1975).

⁶ Card and Krueger estimate regression models for log weekly earnings using data for white men from the 1980 U.S. Census. The explanatory variables included in their regressions are a set of dummy variables for each single year of schooling plus standard controls for potential experience, marital status, and geographical location.

schooling distribution.

Whether or not log earnings is a linear function remains an open debate. For example, using similar data as Card and Krueger (1992), Heckman et al. (1996) conclude that log earnings are a non-linear function of schooling because of the large increase in earnings between 15 and 16 years of schooling. Perhaps more importantly, however, Mincer (1997) and Deschênes (2001) show that since 1980, log earnings have become an increasingly convex function of year of schooling.

In Figures 3 to 5, I report some new estimates of effect of schooling on male wages for 1979-81, 1989-91, and 1999-2001, respectively. Unlike the aforementioned studies that use weekly earnings from the Census or the CPS, I use hourly wage from the ORG supplements of the CPS as dependent variable in the regression analysis.^{7 8} For each time period, I estimate an OLS regression of log wages on an unrestricted set of year dummies for schooling, experience, and calendar year. The estimated coefficients on the year of schooling dummies, along with the estimated confidence intervals (at the 95 percent confidence levels), are reported in Figures 3-5.

The results for 1979-1981 (Figure 3) are qualitatively similar to those of Card and Krueger (1992) in the sense that they are approximately linear for most values of years of schooling. On the one hand, the estimated schooling wage relationship does not systematically depart from a linear specification. When a (weighted) quadratic regression is fit to these data, the quadratic term in schooling is positive but not statistically significant.⁹ On the other hand, the linear approximation is clearly inaccurate for 15 (overpredicts) or 16 (underpredicts) years of schooling, as in Heckman et

⁷ Samples include all men age 16 to 64 with 0 to 40 years of potential experience and non-allocated wages between \$1 and \$100 (in \$1979). Top-coded observations are adjusted by multiplying wages or earnings by 1.4. I pool three years of data for each period to increase sample sizes to 220,737 observations in 1979-1981, 211,759 observations in 1989-1991, and 153,265 observations in 1999-2001.

⁸ I use log hourly wages as dependent variable since Mincer's human capital earnings function is a model for the determination of the hourly price of labor. Traditionally, the model has often been estimated using annual or weekly earnings because hourly wages were generally not available. Mincer (1974) in fact shows that some key results are sensitive to the choice of the earnings measure. For example, he rejects the hypothesis of parallel earnings profiles and linear education when using annual earnings, but fails to reject these restrictions when annual hours are controlled for.

⁹ The weights used are the inverse of the variance of the estimated coefficients from the micro-level wage regression (coefficients on years of schooling dummies).

al. (1996). More generally, a goodness-of-fit test strongly rejects the linear or quadratic specification mostly (but not solely) because of the significant departures from linearity at 15 and 16 years of schooling.¹⁰

Figure 4 reports the same estimates of the schooling-wage relationship for the 1989-91 period. Consistent with Mincer (1997) and Deschênes (2001), Figure 4 shows that log wages are now clearly a convex function of years of schooling. When a (weighted) quadratic regression is fit to these data, the quadratic term in schooling is positive and statistically significant (t-statistic of 4.9). The magnitude of the estimated quadratic coefficient, 0.0031, is economically substantial. It implies that the return to a single year of education is three percentage points larger at 18 than 8 years of schooling. However, the quadratic specification still underpredicts wages at 15 year of schooling and overpredicts wages at 16 years of schooling. These departures are nonetheless not as visually important as the strong overall convexity in the schooling-wage relationship.

Figure 5 shows that by 1999-2001, returns to schooling are an even more convex function of years of schooling than they were in 1989-1991. The estimated coefficient on the quadratic term is now 0.0044 with a t-statistic of 5.9. Note also that because of the changes in the education question introduced in the 1992 CPS, it is no longer possible to identify workers with either 15 or 17 year of schooling. As a result, there is no longer much of a systematic departure from a linear or quadratic specification around 16 years of schooling. This helps clarify the earlier point that the growing convexity of the schooling-wage relationship, as opposed to local non-linearities around 16 years of schooling, is now the dominant source of non-linearity in these data.

Mincer (1997) argues that this growing convexity is readily explained by an increase in the relative demand for skilled labor in a Becker (1975) type human capital investment model with heterogeneous workers (heterogeneous preferences and earnings capacity). This model yields a hedonic equilibrium where marginal returns to schooling can either be an increasing or a decreasing function of years of schooling. In this model, an abrupt growth in relative demand that is not matched by a corresponding increase in relative supply of schooling increases the marginal return to schooling for more educated workers relative to less-educated workers. This results in a more convex schooling-wage relationship since the marginal return to schooling is just the slope of the

¹⁰ The chi-square test statistic is 355, which largely exceeds the critical value at the 95 percent confidence level (17 degrees of freedom). The statistics is reduced by almost two thirds when

schooling wage relationship reported in Figures 3 to 5.

This suggests that the linear approximation may only be accurate in a stable environment where the growth in relative demand is matched by a corresponding growth in relative supply. By contrast, studies such as Katz and Murphy (1992) suggests that the post-1980 period has been unstable in the sense that relative supply did not increase enough to match the growth in relative demand. This has apparently resulted in both an increase in the returns to education (Katz and Murphy, 1992) and in the convexity of the schooling wage relationship (Mincer, 1997).

IV. Quadratic experience?

Murphy and Welch (1990) examine in detail whether the standard quadratic specification in years of potential experience captures well the empirical experience-earnings profile. Using March CPS data from 1964 to 1987, they conclude that a quadratic function is not flexible enough to capture the main features of the experience-earnings profile. The main problem is that the quadratic function understates earnings growth over the first 10 to 15 years of career. By contrast, they find that a quartic function in years of experience captures very well the main features of the empirical experience-earnings profiles.

Figures 6 to 8 confirm the findings of Murphy and Welch using more recent CPS data on hourly wage rates. While Murphy and Welch estimate separate experience-wage profiles for four broad education groups, Figures 6 to 8 simply report estimates of the experience earnings profiles from a pooled specification with all education groups included in. I first estimate regressions with a full set of education, experience, and year dummies for each of the three periods (1979-1981, 1989-1991, and 1999-2001). All three figures show the 95 percent level confidence bands around the unrestricted estimates of the experience-wage profiles. I then re-estimate two restricted versions of the model where the set of experience dummies is either replaced by a quadratic or a quartic function of experience.

Consistent with Murphy and Welch (1990), the figures show that the standard quadratic specific is not flexible enough to capture important features of the data. In particular, it systematically understates the growth in wages for the first 10-15 years of experience. As a result,

the test is limited to years of schooling other than 15 and 16.

the quadratic predictions are systematically above the confidence band for workers with 3 or less years of experience, and systematically below the confidence bands for workers with about 4 to 14 years of experience. The quadratic also predicts too much of a decline in wages past 25 years of experience. In fact, the confidence bands show that wages are quite stable between 25 and 40 years of experience. The predicted decline in wages in the last 10-15 years of career is an artifact of the quadratic specification.

By contrast, Figures 6-8 show that the quartic specification rarely falls outside of the confidence bands for the unrestricted model. The only noticeable exception is around 35 years of experience in 1989-91 where there is an unusual (likely spurious) drop in the unrestricted confidence bands.

In summary, recent research and the new evidence presented in this paper show that it is important to "fine-tune" the standard Mincer equation by adding higher order polynomials in potential experience. Otherwise, the standard Mincer equation understates wage growth for younger workers. The quadratic specification also predicts a spurious decline in wages among older workers.

V. Additive separability in education and experience?

As mentioned earlier, one main empirical innovation in Mincer (1974) was the introduction of a concave function of years of potential experience as a parsimonious way of capturing both the (concave) shape of the age-earnings profile and its interaction with schooling. One may wonder, however, whether the empirical relationship identified for data from more than forty years ago (1960 U.S. Census) still holds in more recent data.

Figures 9 to 11 compare the empirical experience-wage profile for male college and high school graduates to the profiles predicted by a Mincer model where these two groups are constrained to have the same (quartic) experience-wage profile. The predicted profiles are obtained by fitting a regression to a pooled sample of men with exactly a high school or college degree for the same three time periods as before: 1979-1981, 1989-1991, and 1999-2001. The regressors used are a quartic function of experience, a dummy for college degree, and year dummies. For the sake of simplicity, I only look at college and high school graduates which are the two largest education

groups in these samples.

At the bottom of each graph, I plot the confidence intervals around the empirical college-high school wage gaps (the difference between the actual college and high school wages in the graph) and compare them to the gap predicted by the Mincer equation. The key empirical prediction of the standard Mincer model with additively separable experience and education effects is that the college-high school gap should be a constant function of experience.

Figure 9 shows that in 1979-1981, the empirical (or actual) experience profiles for college and high school graduates look approximately parallel. Indeed, for most of the values of experience, the constant college-high school wage gap predicted by the model (0.323) is within or close to the confidence bands around the empirical wage gaps. A closer examination of the evidence indicates, however, that the empirical college high school wage gap tends to grow as a function of experience. For example, the empirical wage gap is significantly lower than predicted by the model around 3-9 years of experience, but higher than predicted around 27-35 years of experience. This systematic pattern is confirmed by a linear regression of the empirical college-high school wage gap on experience. The estimated coefficient (0.0018) is significantly different from zero (t-statistic of 3.1). This implies that the wage gap is 7-8 percentage point larger for workers with 40 years of experience than for young workers with no experience.

The results for 1989-1991 (Figure 10) and 1999-2001 (Figure 11) are markedly different from those for the earlier period. In both periods, the college-high school wage gap now tends to *decline* as a function of experience. The estimated coefficients in a simple regression of the wage gap on experience are now -0.0020 (t-statistic of -4.8) and -0.0042 (t-statistic of -5.9) for 1989-1991 and 1999-2001, respectively. The results imply that in 1999-2001, the college-high school wage gap is 15-20 percentage points larger for the youngest workers (0 years of experience) than for the oldest workers (40 years of experience). Figure 11 indeed shows that the empirical experience-wage profiles are no longer parallel in more recent data. The experience-wage profile has clearly become steeper for high school than college graduates over the last two decades.

In summary, the standard Mincer equation in which log earnings is an additively separable (no interaction term) function of schooling and potential experience does not fit the recent data nearly as well as it used to do in the 1960 Census. This finding is confirmed by Card and Lemieux (2001a) and Heckman et al. (2003) who conclude that experience-earning profiles are no longer

parallel in more recent data. I now look at potential explanations for this change in the next section.

VI. Cohort effects?

There has always been an important gap between the theory underlying the human capital earnings function and the data used to estimate it. On the theoretical side, the age-earnings profile pertains to the evolution of the earnings of a given individual (or cohort of individuals) over the life-cycle. By contrast, empirical age-earnings are typically based on a cross-section of individuals at different points in their life-cycle. Mincer was well aware of this problem in his early work (Mincer, 1958), and conjectured that the cross-sectional age-earnings profiles were probably understating life-cycle earnings growth since, in those days, there was substantial secular growth in average earnings.¹¹

Interestingly, many researchers now believe that the cross-sectional age-earnings profile *overstates* life-cycle earnings growth. For example, Beaudry and Green (2000) conclude in their recent study on the earnings of Canadian men that the slope of the cross-sectional age-earnings profile has increased because new cohorts of men are entering the labor market at increasingly low earnings level. This highlights the well known problem of distinguishing between age, cohort, and year effects in earnings growth. Since these three variables are linear combinations of each other, it is difficult to identify separately the effect of these three variables on earnings even when repeated cross sections are available.¹²

Another way of thinking about the problem is to simply ask whether one "needs" cohort effects to "fit" the empirical relationship among schooling, experience and earnings. On the one hand, Mincer (1974) analyzed this issue in detail and correctly concluded that, on the basis of the 1960 Census data, it was not necessary to include cohort effects to fit these data. On the other hand, the standard Mincer equation does not fit very well the more recent data for the 1980s and 1990s. Could the addition of cohort effects help improve the fit of the model?

Card and Lemieux (2001a) investigate this issue in detail while trying to understand the

¹¹ Mincer (1974) examines this issue in more detail and concludes that, apart from understating earnings growth rates by a constant, cross-sectional age-earnings profiles are a good approximation of the life-cycle profiles.

¹² Examples of recent studies attempting to separate cohort from age and year effects are MaCurdy and Mroz (1991) for the United States, Gosling, Machin and Meghir (1999) for the United

sources of change in the college-high wage gap for the United States, Canada, and the United Kingdom over the last three decades. In the case of U.S. men, they use the 1960 Census and a large number of March CPS supplements to study the evolution of the college-high school wage gaps by age groups (5-year age groups) between 1959 and 1996. For the sake of comparability with the other figures presented in the paper, I show the same college-high school wage gaps using hourly wages from the March CPS for the years 1975-76, 1979-81, 1984-86, 1989-91 and 1994-96.¹³

The wage gaps are reported in Figure 12. The figure shows how the age profile of the college-high school wage gap evolved from a positively sloped profile in the mid-1970s, which is consistent with Mincer's model, to an essentially flat profile in the mid-1990s, which is inconsistent with Mincer's model.¹⁴ Figure 12 strongly suggests that the profile became increasingly flatter because cohorts of men born after 1950 experienced increasingly high returns to schooling relative to older workers. Between 1975-75 and 1979-81, the entire profile of the college-high school gap shifted down, with the exception of the youngest age group (age 26-30 in 1980 i.e. born in 1950-54) for whom the gap remained constant. By the mid-1980s the gaps for older workers were back to their levels of the mid-1970s, but the gaps for the *two* youngest age groups were much higher. Moving to 1989-91, the gaps for the *three* youngest age groups were substantially higher than those in the mid-1970s, while those for other workers were not too different. Finally, in the mid-1990s, the gaps for the *four* youngest age groups were well above the levels of the mid-1970s, but the gaps for older workers were still comparable to those 20 years earlier.

Except for these four youngest cohorts, the data in Figure 12 are roughly consistent with the Mincer equation (positively sloped profile). In fact, Card and Lemieux (2001a) show more formally that a simple Mincer model explains well the data from 1959 to 1995 provided that cohort

Kingdom, and Beaudry and Green (2000) for Canada.

¹³ Most of the empirical analysis in Card and Lemieux (2001a) is based on the weekly earnings of full-time workers. Starting with the March 1976 CPS (earnings year 1975), however, it is possible to compute an hourly wage rate by dividing annual earnings by annual hours. Card and Lemieux present a brief analysis of these data (Table 5, p. 731) and find results very similar to the main results based on weekly earnings of full-time workers.

¹⁴ When log earnings are the same concave function of potential experience for high school and college graduates, the college-high school wage gap *must* increase with age. To see this, replace the quadratic function by a generic concave function $f(\cdot)$ in equation (1): $\log y = \log y_0 + rS + f(\text{age}-S-\delta)$. The return to education is given by $\partial \log y / \partial S = r - f'(\text{age}-S-\delta)$. The return to education grows as a function of age since $\partial^2 \log y / \partial S \partial \text{age} = -f''(\text{age}-S-\delta)$, which is positive when $f(\cdot)$ is concave

dummies are introduced for the four youngest cohorts. One promising avenue for understanding why the Mincer equation does not fit the recent data as well is, therefore, to understand what happened to the post-1950 cohorts.

Card and Lemieux (2001a) investigate this issue in detail and conclude that the dramatic increase in the college-high school wage gap for post-1950 cohorts is primarily a consequence of an equally dramatic break in inter-cohort trends in educational achievement. They show that, until 1950, each successive cohort of men was more educated than the preceding cohort. This secular trend abruptly stopped with men born around 1950. As a result, men born in the late 1960s are no more educated than those born 20 years earlier.¹⁵ The relative supply of highly educated workers is, therefore, much lower for post-1950 cohorts than what would have been predicted on the basis of the pre-1950 trend. As long as age groups are imperfect substitutes for each others, this relative decline in the relative supply for post-1950 cohorts should result in a higher college-high school wage gap for these cohorts in a standard supply and demand model of the labor market.¹⁶

The results of Card and Lemieux (2001a) can be viewed as a complement, rather than a substitute, to the basic human capital earnings model of Mincer. Until the mid-1970s, there was a smooth improvement in the level of schooling of each successive cohort of young men entering the labor market. This increase in the relative supply of highly educated labor was more or less enough to offset the increasing relative demand due, for instance, to skill biased technical change. This changed after 1975 with the entry of the post-1950 cohorts who were no more educated, and in some case less educated, than previous cohorts. Relative supply could no longer offset the rising demand for skilled young workers and, as a result, the college-high school wage gap started expanding dramatically for young workers.

In summary, recent evidence suggests that the basic Mincer human capital earnings model remains a parsimonious and accurate model in a stable environment where educational achievement grows smoothly across cohorts. Such an environment prevailed in the data analyzed by Mincer (1974) who correctly concluded that it was not necessary to control for cohort effects in an earnings

($f' < 0$).

¹⁵ See Card and Lemieux (2001b) for a detailed analysis of inter-cohort trends in educational achievement.

¹⁶ Welch (1979) shows that cohort relative supplies have a negative and significant effect on wages, which is consistent with imperfect substitution among age groups in production.

regression. In a less stable environment, however, major shifts in the relative supply of different age-education groups can induce important changes in the structure of wages that have to be taken into account when estimating a standard Mincer equation. This can either be achieved by adding cohort effects to a standard Mincer equation, or by explicitly modeling the relative supply and demand for different groups of workers.

VII. Conclusions

Two broad kinds of conclusions can be drawn from this paper. A first conclusion has to do with "fine-tuning" of the simple Mincer human capital earnings function. Though equation (1) is a good approximation in many cases, it may overstate or understate the effect of experience and schooling on earnings for some groups. In particular, it tends to understate the effect of experience on the earnings of young workers. This problem is readily fixed by adding higher order polynomials (up to a quartic) of potential experience to the basic model. The model also tends to overstate the effect of skills (either experience or schooling) on earnings at the very low end of the skill distributions, because, for example, of compression effects associated with the minimum wage.

A more substantial set of concerns is that the basic Mincer human capital earnings function does not appear to fit the data nearly as well in the 1980s and 1990s as it did in the 1960s and 1970s. The first problem is that wages are an increasingly convex function of years of schooling. The second difficulty is that experience-wage profiles are no longer parallel for different education groups. In particular, the college-high school wage is now much larger for less experienced than more experienced workers. Existing research suggests, however, that these departures from the simple Mincer model are primarily a consequence of the fact that recent increases in the relative supply of educated labor have not kept up with the growth in relative demand. In particular, the educational achievement of men born in the 1950s and 1960s is no larger than for men born at the end of the 1940s.

On balance, the evidence suggests that the Mincer equation remains a useful and accurate benchmark in a stable environment where educational achievement grows smoothly over successive cohorts of workers, as it did in the time period originally studied by Mincer (1974).

Thirty years later, the Mincer equation does not fit the data quite as well as it used to because we are no longer in a stable environment where educational achievement grows smoothly over successive cohorts of workers. In fact, it would have been truly remarkable if the dramatic changes in the wage structure that happened since the late 1970s had had no impact on the quality of the fit of the Mincer equation. It will be interesting to see whether the fit of the Mincer equation improves in the next decade or so, now that the wage structure appears to be stabilizing again (Card and DiNardo, 2002).

In terms of econometric practice, these findings suggest that it is important to verify the robustness of the standard Mincer equation to the inclusion of a quadratic term in years of schooling and cohort effects. These considerations aside, the Mincer human capital earnings function remains a parsimonious and relatively accurate way of modelling the relationship between earnings, schooling and experience. Its status as the "workhorse" of empirical labor economic research on earnings determination is well deserved.

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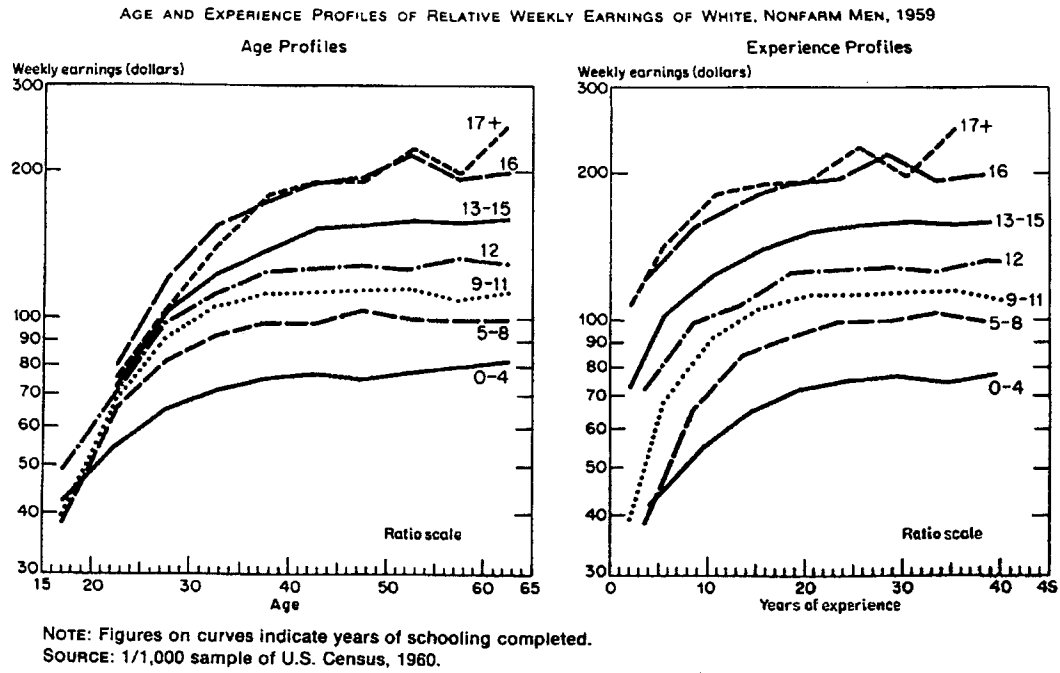
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Figure 1



Source: Jacob Mincer, *Schooling, Experience, and Earnings*

**Figure 2: Transformation Model for Log Wages:
Men in the 1979 and 1991 CPS**

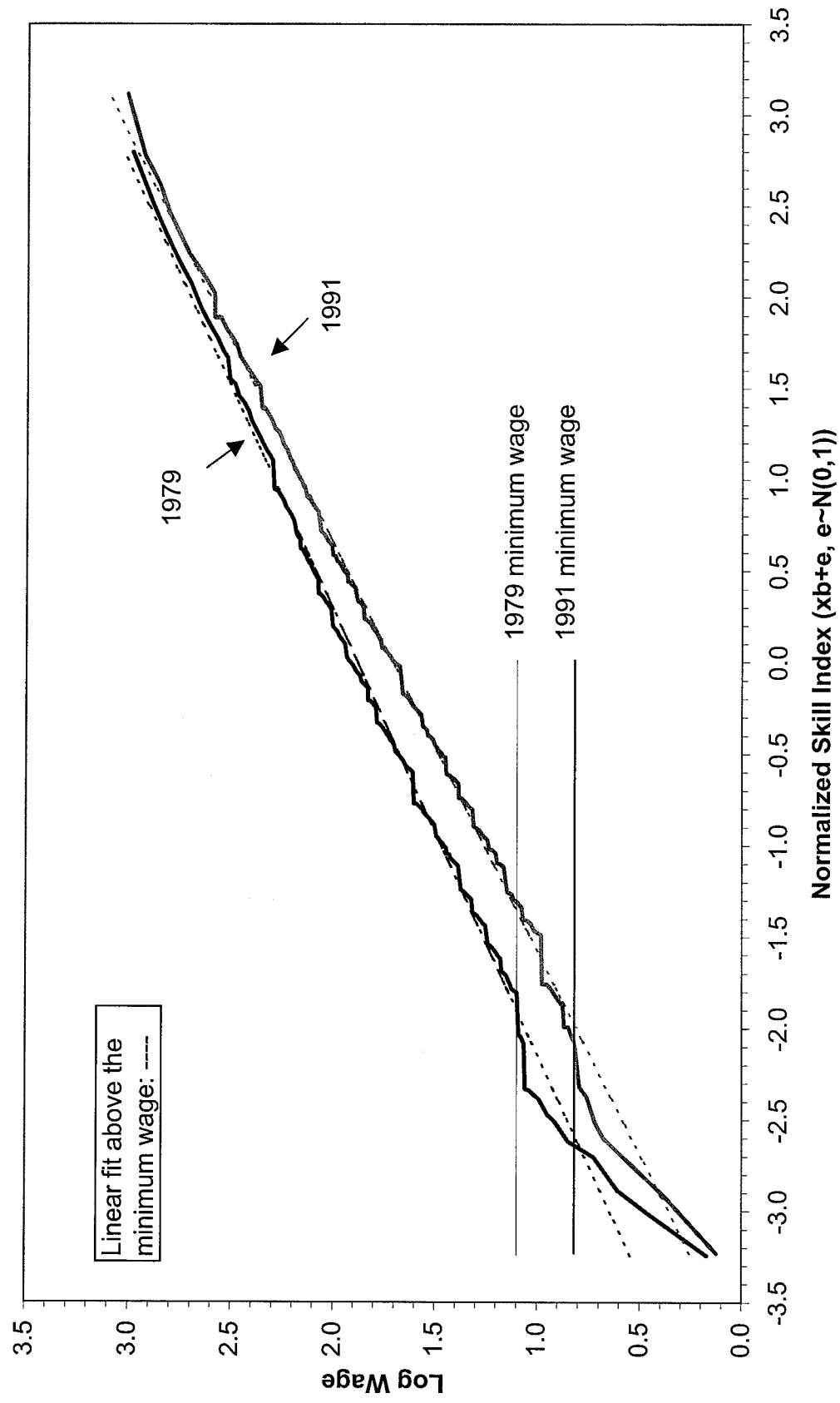


Figure 3: Return to Single Year of Schooling, 1979-81 CPS
(dotted lines are 95 % confidence intervals)

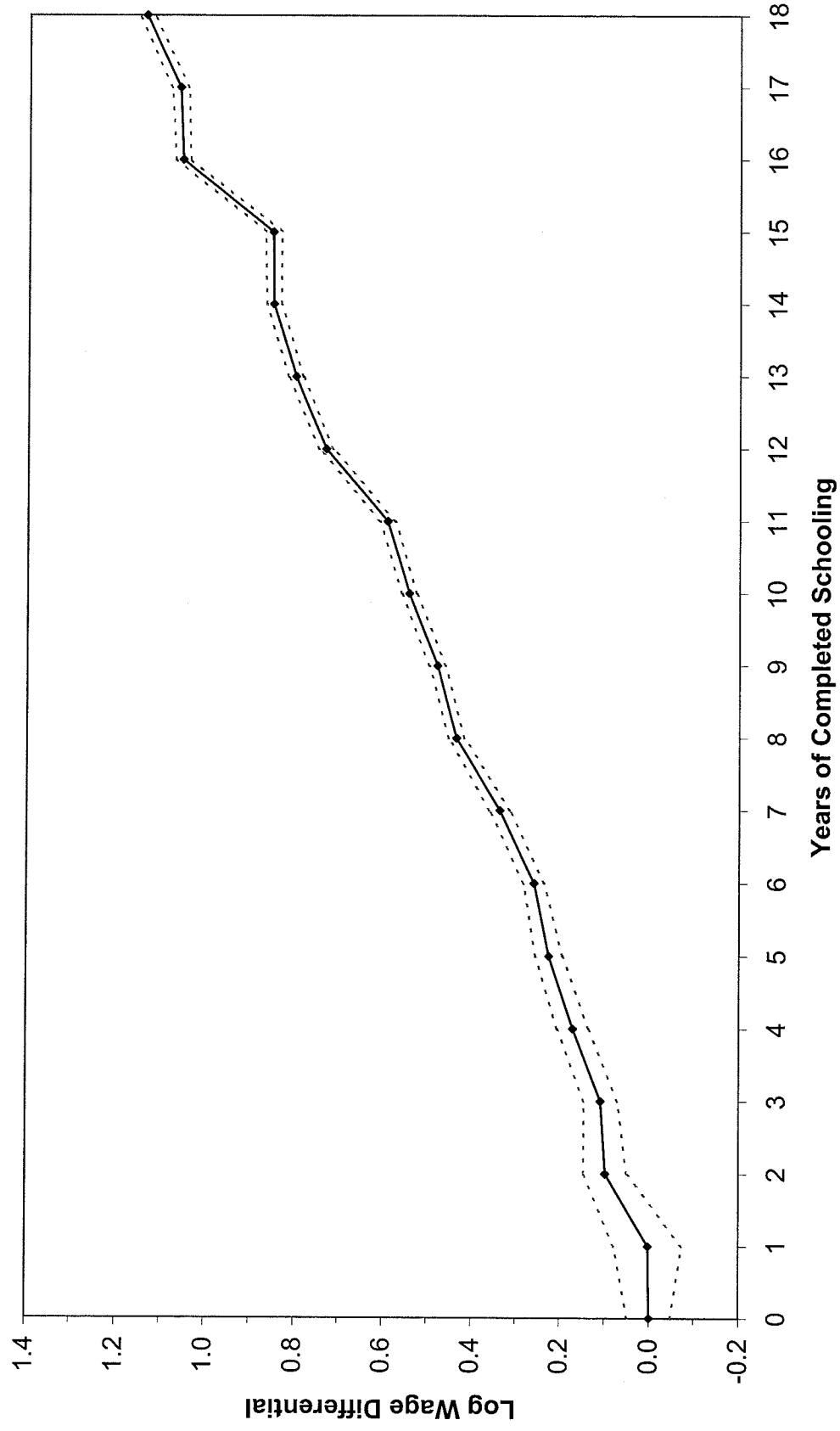


Figure 4: Return to Single Year of Schooling, 1989-91 CPS
(dotted lines are 95 % confidence intervals)

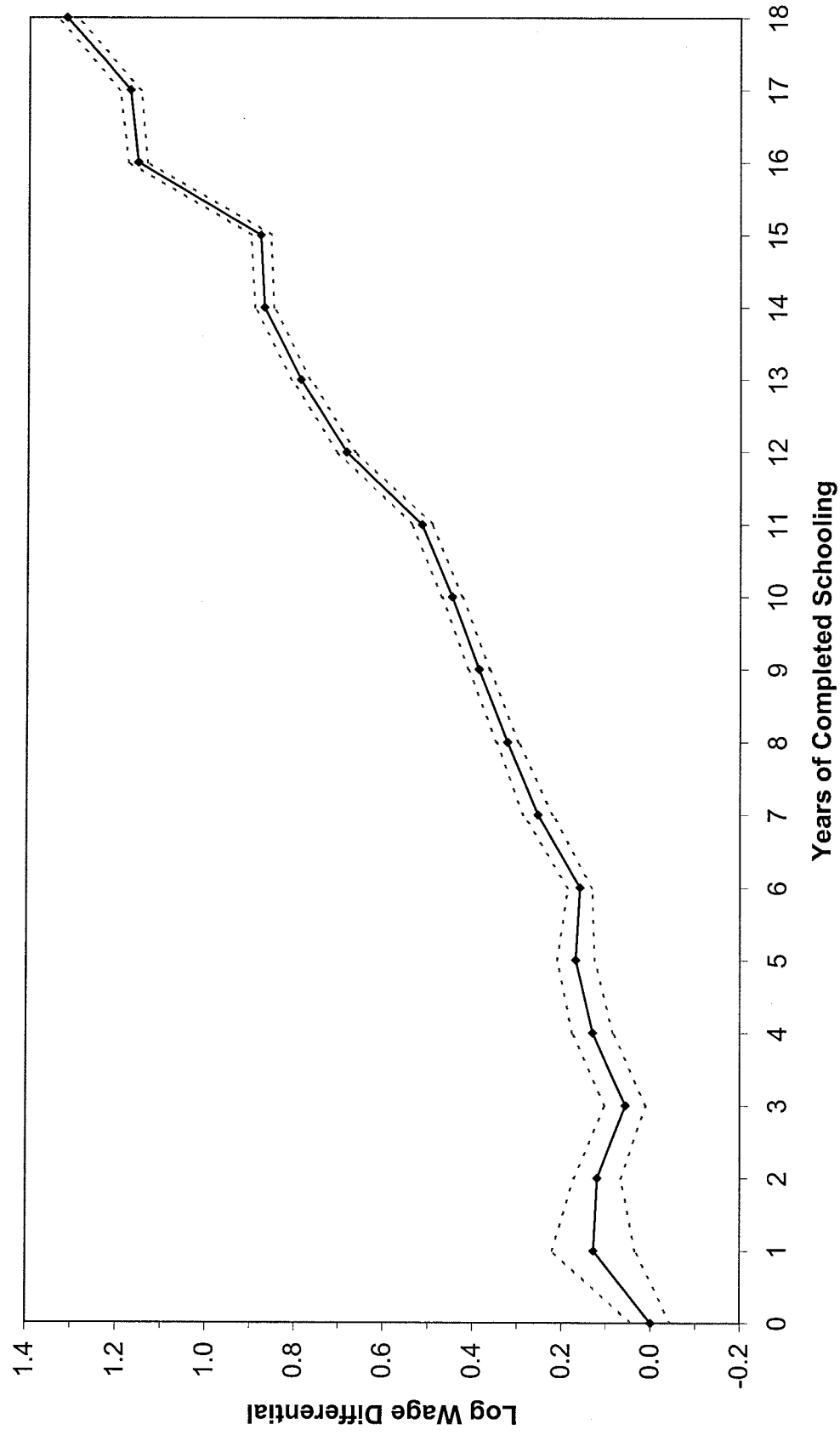


Figure 5: Return to Single Year of Schooling, 1999-2001 CPS
(dotted lines are 95 % confidence intervals)

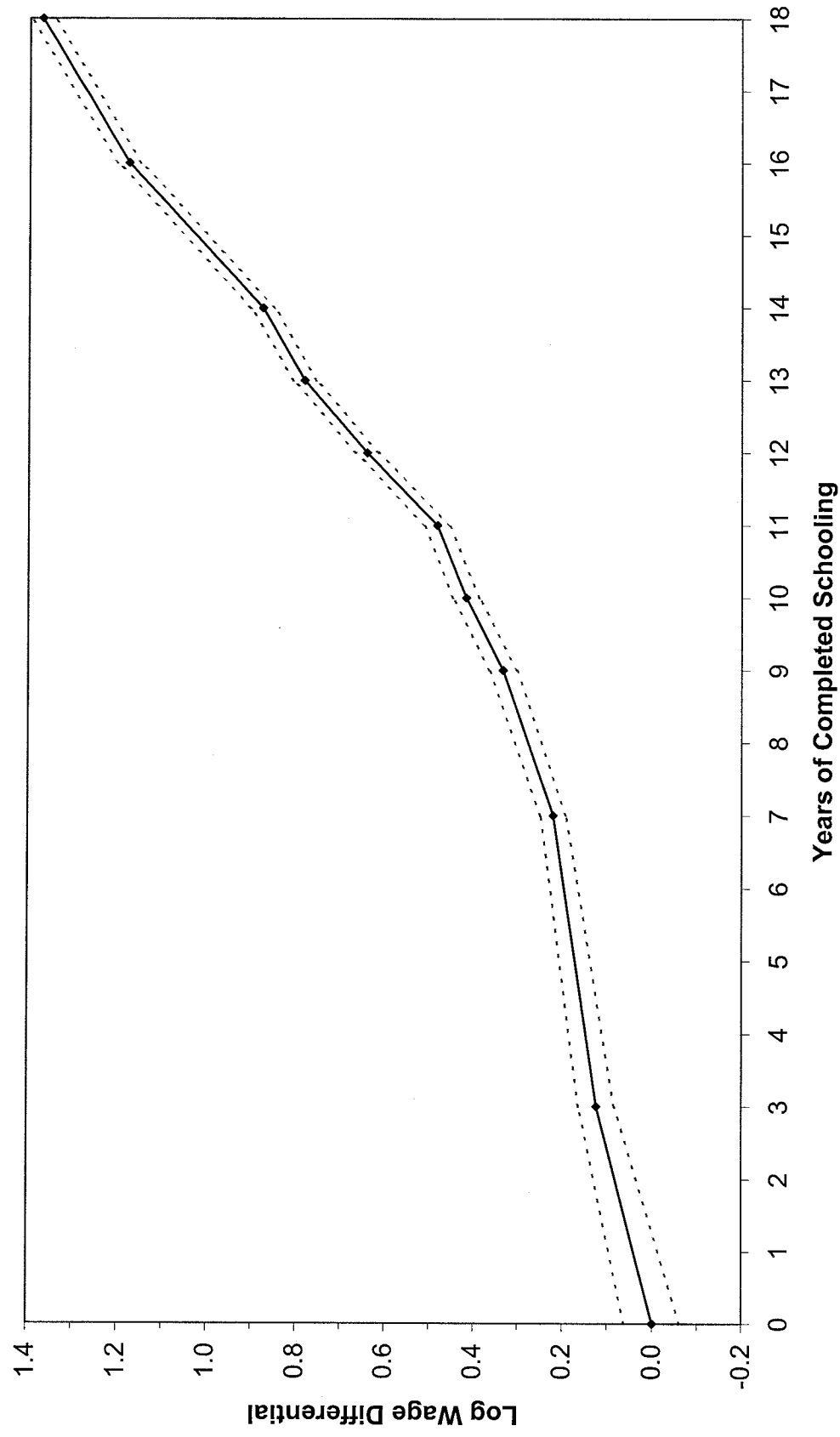


Figure 6: Experience profiles for men, 1979-81 CPS

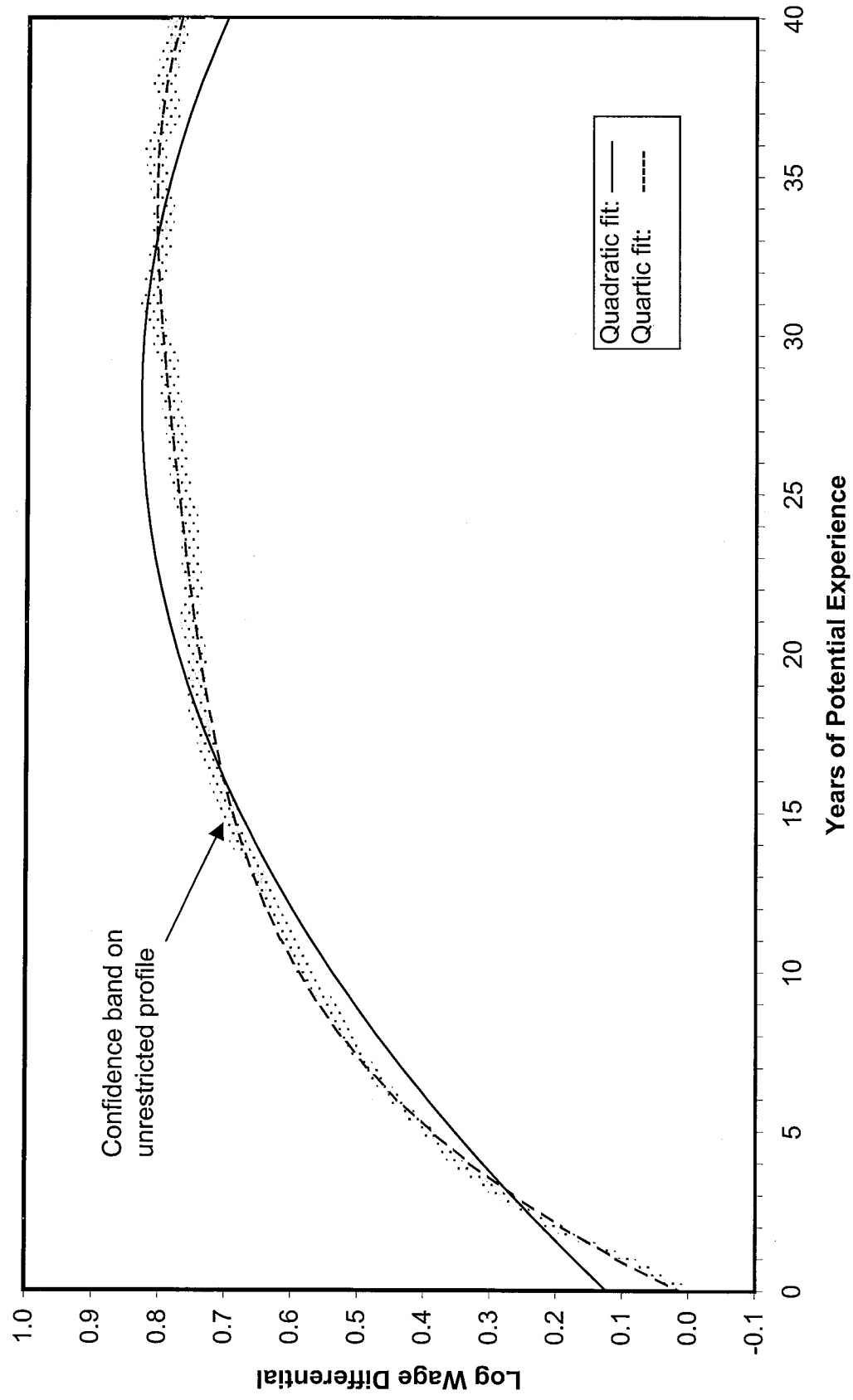


Figure 7: Experience profiles for men, 1989-91 CPS

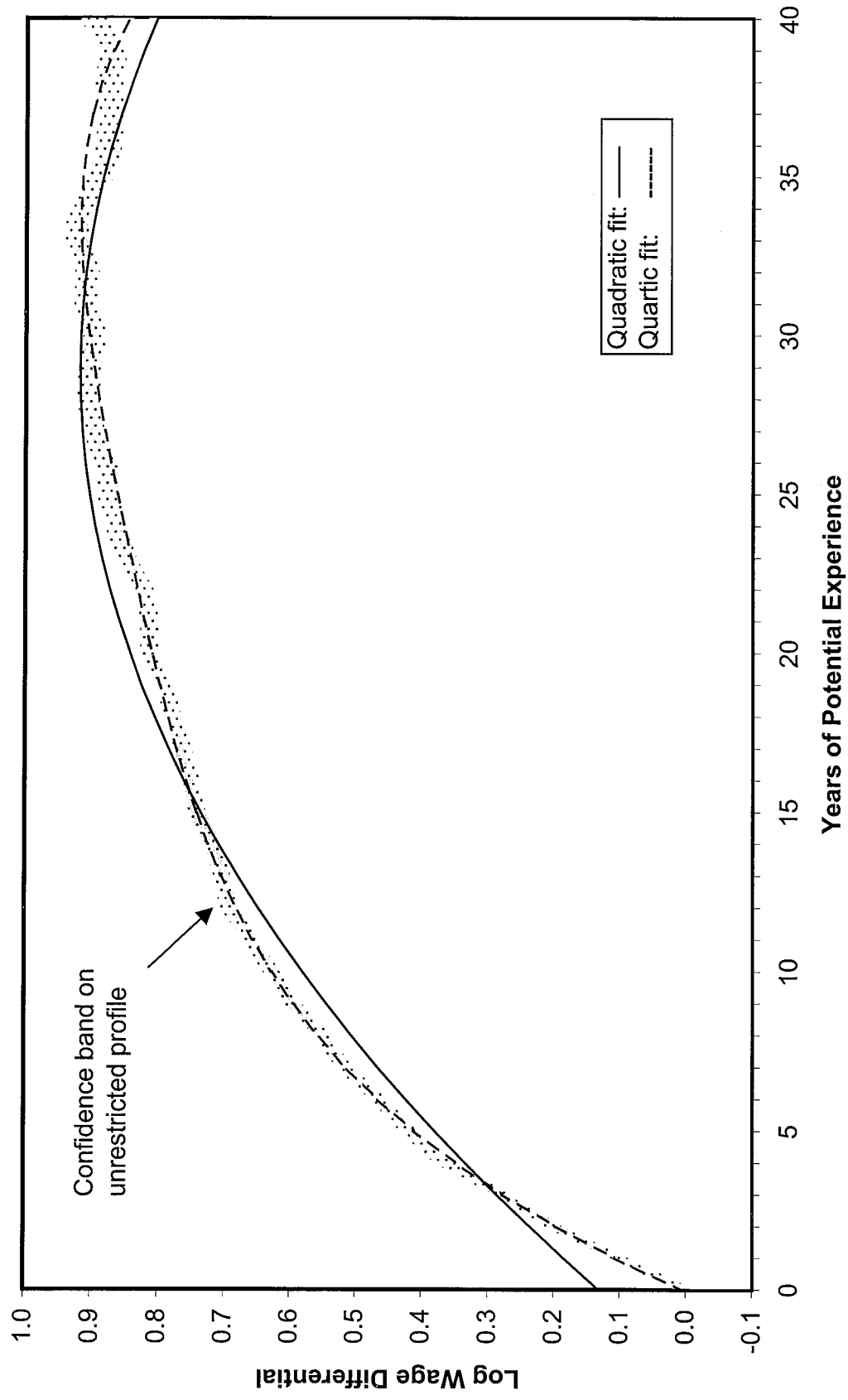


Figure 8: Experience profiles for men, 1999-2001 CPS

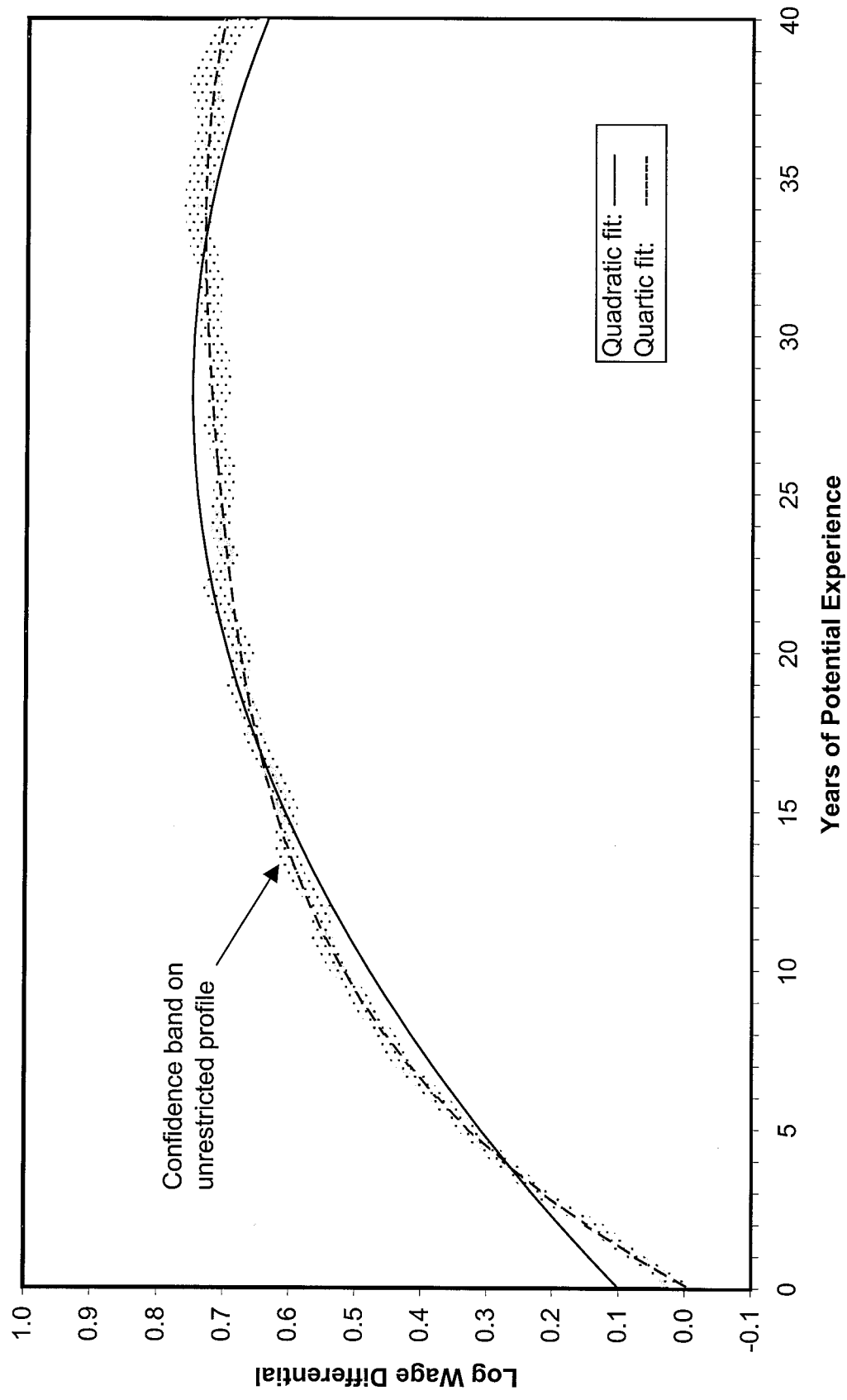


Figure 9: Experience profiles and Wage Gap for College and High School Graduates, 1979-1981 CPS

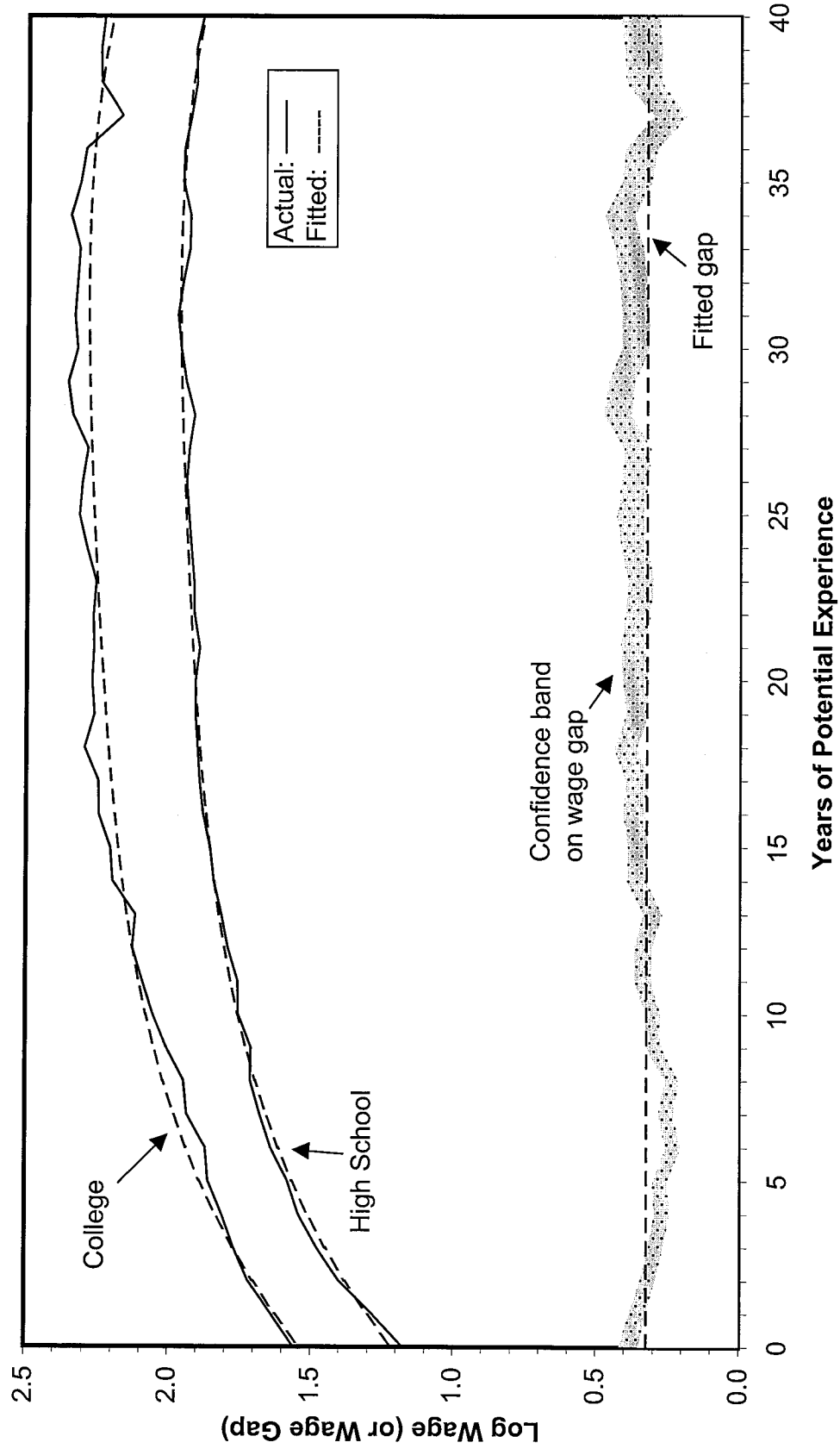


Figure 10: Experience profiles and Wage Gap for College and High School Graduates, 1989-1991 CPS

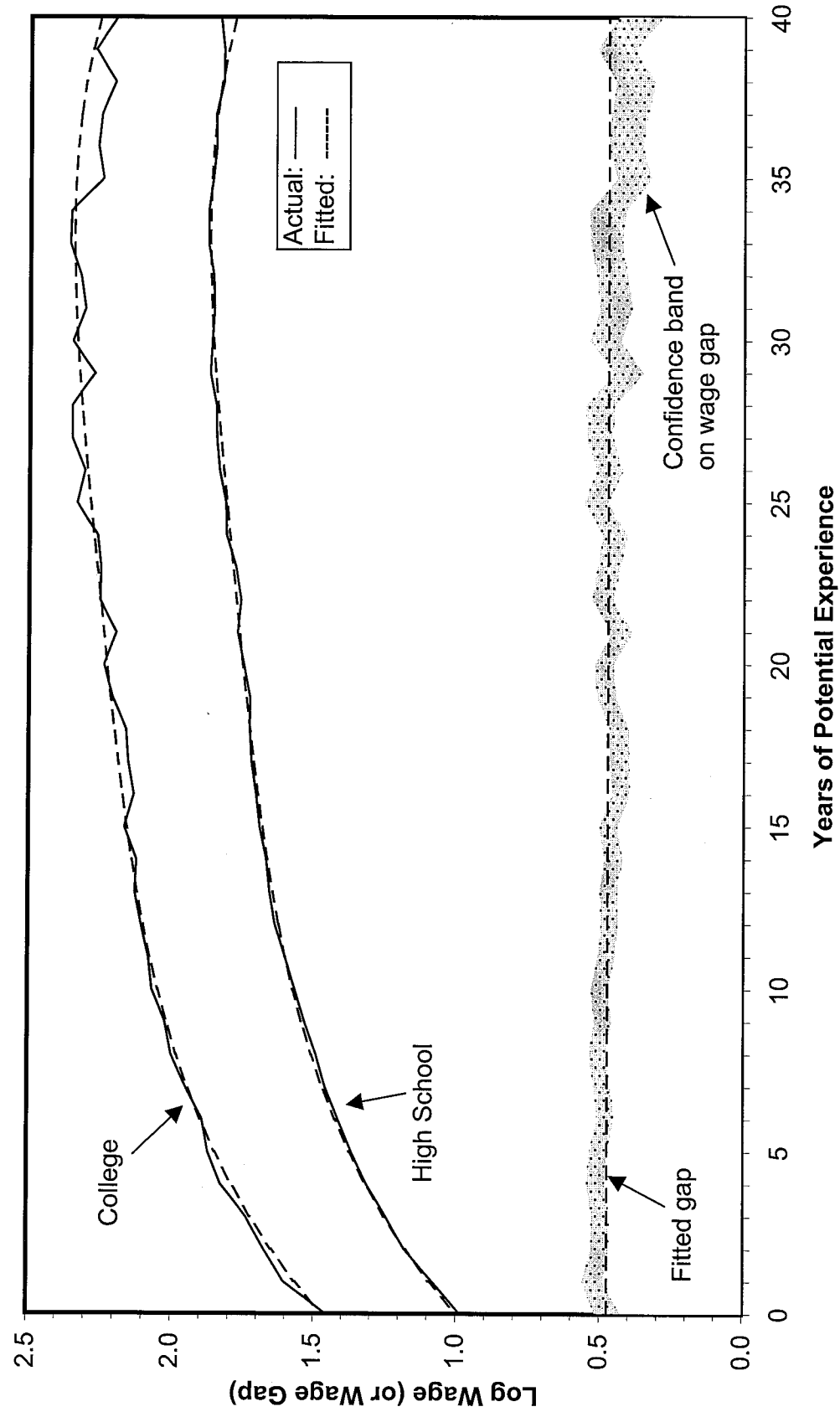


Figure 11: Experience profiles and Wage Gap for College and High School Graduates, 1999-2001 CPS

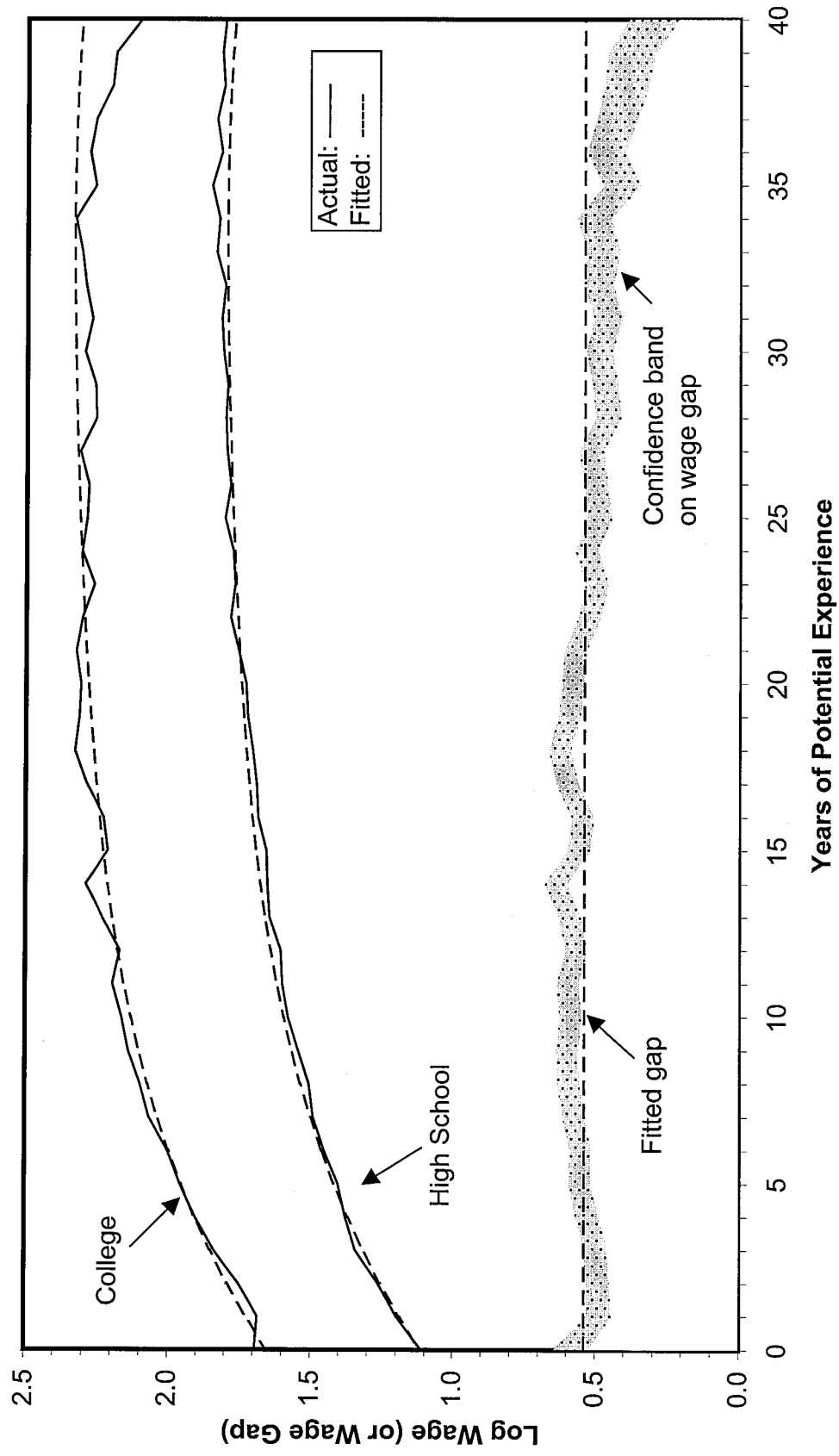


Figure 12: College-High School Wage Gap by Age Group and Year

