Post Schooling Wage Growth: Investment, Search and Learning

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January 16, 2004

Abstract

The survey presents basic facts on wage growth and summarizes the main ideas on the possible sources of this growth. We document that wage growth happens mainly early in the life cycle and is then associated with increasing labor force participation and high job mobility. Wage growth during the first decade in the labor market, is about 50% for high school graduates and about 80% for those with college or more. This growth is comparable in size to the accumulated contribution of schooling for these two groups. We describe in detail models of wage growth that can explain these results, including investment in human capital, search and learning. We also discuss the roles of contracts in sharing the risks associated with learning about ability and varying market conditions. Evidence supporting investment is the U shaped life cycle profile for the variance of wages. However, heterogeneity matters and individuals with relatively high life time earnings have both a higher mean and a higher growth. Evidence supporting search is the high wage gains obtained from changing employers early in the career. Evidence for learning are the initially rising hazard of quitting and the rising rewards for AFQT scores that are mot observed by the market.

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1 Introduction

Perhaps the most widely estimated regression equation in economics is Mincer's log-earnings function that relates the log of individual earnings or wage to their observed measures of schooling and potential work experience, where the specification is linear in the years of schooling and quadratic in experience. This simple regression has been estimated in numerous studies, employing various data sets from almost every historical period and country for which micro data are available, with remarkably robust regularities. First, workers' wage profiles are well ranked by education levels; at any experience level, workers earn more, on average, as their level of schooling rises. Second, average wages grow at a decreasing rate until late in working lifetime. Most importantly, the estimated coefficients for schooling and experience in all these regressions, fall into a sufficiently narrow range to admit a common economic interpretation in terms of "rates of return" for investment in human capital. The estimated coefficients of the log-earnings function has been applied to a wide variety of issues, including the *ceteris paribus* "effect" of schooling on earnings, wage differentials by gender and race, and the evolution of earnings inequality. All these studies used Mincer's (1974) earning function as their statistical platform.[1]

The human capital approach to wage growth over the life cycle, as developed by Becker (1975), Mincer (1958, 1974) and Ben-Porath (1967), emphasizes the role of human-capital acquired in school and on the job. Workers face a given trade-off between current and future earnings, which is represented by a "production function" of human capital, and decide how much to invest. The wage offered to individuals is determined as a product of the worker's embodied stock of human capital and the market determined "rental rate". Markets operate competitively, and workers are compensated for their investments. If individuals are heterogenous, then compensation applies only at the margin, while non marginal workers receive rents for their scarce attributes. When market conditions change, due to technological changes for instance, the rental rate changes and possibly the production function that describes the investment opportunities, leading to adjustments in individual investment decisions that affect wage growth.

[1] Heckman, Lochner and Todd provide an insightful perspective of the Mincer earning regression, fifty years after.

Becker (1975), Griliches' (1977) and Rosen (1977) have questioned the interpretation that should be given to the regression coefficients of schooling and experience in the Mincer earning equation and the validity of drawing policy conclusions from them. The two main concerns are the role of individual heterogeneity in ability and access to the capital markets, and the role of market frictions and specific investments in human capital. These concerns affect the statistical estimation procedures, because unobserved individual attributes that influence investment decisions can bias the coefficients on schooling and experiences in Mincer's equation. Equally important is the recognition that if markets are non competitive, because of credit constraints or firm specific investments that create relational rents, then wages and productivity need not coincide, and the social and private rates of return for investment in human capital may diverge.

In parallel to the human capital approach, search models have been offered to deal with limited information and market frictions. At the individual level, these models explain wage growth and turnover as outcomes of the (random and intermittent) arrival of job offers that can be rejected or accepted (see, Burdett, 1978). These models also allow for investment in search effort, with the objective of generating job offers rather than to enhance productivity. When combined with learning, search models can provide a framework for explaining the separate roles of tenure and general market experience. (See Mincer and Jovanovic, 1981, Jovanovic, 1984, and Mortensen 1988). At the market level, search models can explain the aggregate level of unemployment and also the distribution of wages in the economy. The policy implications of these models concerning schooling and training may be quite different than those of the human capital model, because of the important role of externalities, relational rents and bargaining (see Mortensen and Pissarides, 1999, and Wolpin 2003).

A third important consideration that may explain wage growth is learning (see Jovanovic, 1979a, 1979b, Harris and Holmstrom, 1982, Gibbons and Waldman, 1999). Workers are heterogenous and it takes time to identify their productive capacity with sufficient precision. Therefore, employers must base their payments on predictions of expected output that are repeatedly modified by the worker performance. The arrival of new information which allows the market to sort workers can be individually costly, because it makes wages uncertain. This risk creates incentives for risk sharing between workers and firms. A possible outcome of this process is that the workers obtain partial insurance, that protects against wage reductions upon failures to perform well, but successful workers will be promoted, because information is public and other firms compete for workers based on this information. We thus have wage growth that is triggered by new information, rather than by the worker's actions or arrival of job offers.

Although investment search and learning have similar implications with respect to the behavior of mean wages, implying a rising and concave wage profiles, they can be distinguished by their different implications for higher moments, such as the *variance* of wages. For instance, it was pointed out by Mincer (1974) that compensation for past investment in human capital, creates a negative correlation between early and late earnings the life cycle, implying that the interpersonal variance of earnings over the life-cycle has a U-shape pattern. This is not true in the search and learning models, where workers that are initially homogenous, become increasingly heterogenous as time passes, due to their longer exposure to random job offers, implying an increasing variance of earnings within a cohort. If workers are heterogenous, the variance may first increase and then decline as workers are gradually sorted into their "right" place.

The purpose of this survey is to provide a synthesis of the alternative explanations for wage growth and relate them to the observed patterns in the data. The first part of the survey provides a first glance at the data on life cycle wage levels and rates of wage growth, based on cross section, synthetic cohorts and panel data. We use all these sources to illustrate the important distinction between life cycle effects and time effects, and to show that most wage growth occurs early in the work career and is associated with high turnover, in and out of the labor force and between employers, occupations and industries. We show that post schooling wage growth is quantitatively important and is as large as the wage growth attributed to schooling. Moreover, schooling and experience are strongly linked and more educated workers generally have higher wage growth and more stable employment. The second part of the survey presents models of wage growth based on investment, search and learning in a unified framework. This allows us to compare the alternative channels for wage growth and to identify the connections a amongst them. The third part of the survey provides a second glance, based on the main empirical papers in the area and our own examination of the data, with the purpose of identifying empirical tests that might distinguish alternative models of wage growth, while recognizing the role unobserved heterogeneity.

2 Wages and Employment Over the Life Cycle - A First Glance

In this section, we take a first glance at the available data on life cycle earnings. Our goal is to summarize the patterns of post schooling wages for workers of different educational attainments, without restricting ourselves to a particular functional form, such as the famous Mincer's wage equation that restricts mean (log) wages to be linear in schooling and quadratic in experience. We take advantage of large bodies of data collected over several decades, a privilege that early research did not have, for reproducing the basic facts on wages over the life cycle.

The data sources are the Current Population Surveys (CPS) for 1964 through 2002, the Panel Study of Income Dynamics (PSID) for the years 1968 to 1997 and the National Longitudinal Survey of Youth (NLSY) for the years 1979 to 2000. The CPS data is a sequence of cross sections, with only short follow up of the same individuals. The PSID has started with a cross-sectional national sample in 1968 who were interviewed every year until 1993 and then biannually until 1997. In contrast, the NLSY sample includes only individuals who were 14-21 of age when first interviewed in 1979 and observed until 2000. (A more detailed description of these data is available in the appendix).

From each source, we select white males with potential work experience (age-school years -6) of no more than 40 years. Observations are divided by school completion into five levels: (i) high school dropouts (ii) high school graduates with twelve years of schooling (iii) some college, (iv) college graduates with BA degree and (v) college graduates with advanced/professional education (MBA, Ph.D.). We then examine the hourly or annual wages, whichever is applicable, of fully employed workers.

By restricting ourselves to white males in the US, we can examine wage patterns for a relatively homogenous group over a long period of time, which allows us to abstract from institutional and social differences and to focus on the potential role of the economic forces that affect wage growth, such as investment, search and prices of skills.

2.1 The pooled data

Under stationary conditions, the chronological time of the observation would be irrelevant, so that we can pool data from different years and cohorts, paying attention only to the stage in the worker's life cycle, as indicated by his potential work experience. Figure 1a shows the mean weekly wage-experience profiles, by schooling, averaged over the 38 years of the March CPS data from 1964 to 2002, using a subsample of fully employed (full time and full year) workers. These (log) wage profiles have the general shape found in previous studies based on single cross sections (See Mincer, 1974, Murphy and Welch, 1988, Heckman Lochner and Todd, 2001). Average wages are well ranked by educational attainments. Mean wages increase rapidly over the first 10 to 15 years of a career (by approximately 80 percent). As the career progresses, we find little change in mean wages.

The sharp growth in wages is associated with a sharp increase in labor supply and the regularity of employment, as indicated by the life cycle profiles of the proportion of workers who work full time and the average annual hours in Figures 1b and 1c. Workers with higher level of schooling work more and reach a steady level much earlier than less educated workers. Thus, hours and wages move together over the life cycle, and earnings grow faster than wages.

2.2 Cohorts and Cross-Sections

In fact, the economy is not stationary and the wage structure had undergone major changes starting in the late 1970's, when workers with high level of schooling have started to gain relative to those with low levels of schooling, mainly as a result of the decline in the wage of low skill workers. Such changes in the returns to skill, imply different wage profiles for cohorts, where workers of the same birth year are followed over time, and for cross sections, where workers of different experience (and time of entry into the labor force) are observed at a given year.

Figures 2a and 2b show the wage-experience profiles for the cohort high school graduates born in 1951-1955 and the cohort of college graduates who were born in 1946-1950, respectively. These two groups entered the labor market at roughly the same time, 1971-1975, and we add to the graphs the evolution of the cross section wage-experience profiles in five year intervals from 1971 to 2000, where each such cross section profile shows the mean wages of workers with the indicated schooling and experience in a given time interval. These figures make it very clear that cohort based wage profiles are affected by the change in aggregate prices that shift the cross section profiles over time. These shifts differ by level of schooling. High school graduates of *all* experience levels earned lower wages during the period 1970-2000, which is the reason why the mean wage profile of the cohort of high school graduates born between 1951 to 1955, in Figure 2a, exhibits almost no wage growth after ten years of experience in the labor market. In contrast, workers with college degree or more, have maintained their earning capacity over time. Consequently, as seen in Figure 2b, the cross section and cohort wage profiles of college graduates are quite similar and rise through most of the worker's career.

Although the cross section profile is, by construction, free of time effects, its shape is not necessarily a reflection of life cycle forces, because the cohort "quality" can change over time. An important reason for this is that schooling is embodied in the worker early in life, and the quality of schooling may depend on the size and composition of the cohort with each level of schooling and the state of knowledge at the time of entry. It is impossible to separately identify time cohort and life cycle effects unless one uses some a-priori identifying assumptions.[2]

2.3 Panel Data

Panel data follows the *same* group of individuals over a period of time, in contrast to cohort data, where different individuals are sampled in every period. Having repeated observations for the same of individuals allows one to calculate individual rates of wage growth and examine their variance. The panel also allows to examine individual transitions among different employers and occupations.

[2]For instance, Borjas (1985) assumed that time effects are common to immigrants and natives to identify cohort effects for immigrants. Weiss and Lillard (1978) assume that time effect is constant and common to all experience groups to identify cohort effects for scientists.

Figures 3a and 3b show the average wage profiles from the PSID and NLSY. Basically, the patterns are similar to the synthetic cohorts displayed in figures 2a and 2b, except that the panel profiles are less likely to taper off and decline at the late in the life cycle for workers with less than college degree. Note that the NLSY sample follows only few cohorts of birth that are close to each other, while the PSID covers many cohorts. Therefore the NLSY profiles are less concave than the corresponding cross section profiles in the PSID that show a pattern that is more similar to the CPS cross section profiles.

Figures 4a and 4b display the life cycle patterns of the monthly proportions of workers that changed occupation and industry in the CPS, while Figure 4c shows the annual proportions of workers who changed employers in the NLSY. We see that, for all these dimensions of mobility, transitions decline quickly with potential experience and are generally more frequent among the less educated, especially at the early part of the career. The impact of schooling on movement across employers is weaker than on transitions across occupations or industries. Similar findings are reported by Topel and Ward (1992) Hall (1972), Blau and Kahn (1981), Mincer and Jovanovic (1981), Abraham and Farber (1987) Wolpin (1992) and Farber (1993).

An interesting feature of the transitions among employers is that the proportion of movers is initially rising, suggesting a period of experimentation on the job, and continues at a relatively high rate of about 15 percent per year until the end of the worker career.

2.4 Individual Growth Rates

Table 1 summarizes the main results on wage growth. For each individual, we calculate his annual wage growth and then present the averages and standard deviations of these rates, by experience and schooling. For comparison, we also present the predicted average growth rates that would be implied for the same individuals by using Mincer's quadratic specification for wage levels. We report these figures for the CPS short panel, the PSID and the NLSY samples. We include only observations in which workers were fully employed in the two consecutive years (see Appendix).

The average worker's career is characterized by three very different phases. The first, decade long, phase is characterized by sharp growth of wages. The second, five years long, phase is characterized by moderate wage growth and the late phase of the career has zero or negative growth. The growth rates are substantially higher for workers with high level of schooling. This general pattern is revealed in *all* the data sources that we have. However, the CPS shows somewhat lower rates of wage growth, because of the absence of time effects.

The average annual growth rate of wages in the initial ten years for the most educated group are 7.7 in the CPS short panel, and 11.0 and 9.6 in the PSID and NLSY panels, respectively. These rates are quite close to the wage growth that is associated with schooling. However, the contribution of experience declines with the level of schooling and for the high school graduates, the average growth rates during the first decade of post schooling experience are 5.6, 5.7 and 7.1 in the CPS, PSID and NLSY, respectively.

There is a sharp decrease in wage growth with labor market experience. As one moves across experience groups for the highly educated, the wage growth in the CPS short panel declines from 7.7 to 5.3 to 1.5. In the PSID sample, wage growth declines from 11.0 from to 1.3 to 1.9. The NLSY sample shows no such reduction mainly because it represents only few cohorts that all gain from the continuous rise in skill prices. For some college and below, we see a decline of wage growth with experience in all samples, because these groups gained less from the increase in skill prices.

The differences in the average growth rates by schooling levels are substantial. For instance, in the CPS and PSID samples, workers with advanced degrees enjoy during the first decade of their career a wage growth that is twice as high as that of workers with less than high school degree (.077 vs .039 and .110 vs. .043, respectively). This important interaction is not captured by the standard Mincer specification, but we allow for it here since we estimate the experience coefficients separately for each education group. As seen in Table 1, the averaged individual growth rates are generally higher than the wage growth obtained from Mincer's quadratic specification, especially at the early part of the career. As noted by Murphy and Welch (1990), the quadratic specification overestimates early wages and underestimates late wages. As a consequence of this misspecification, early growth rates are substantially biased downwards.

The variability in the rates of wage growth follows a U-shape pattern with respect to schooling. That is, the standard deviations are lower for workers with high school degree than for workers with more schooling or less, suggesting that middle levels of schooling are less risky, in this regard. However, there is no systematic pattern for the standard deviations of wage growth by level of experience.

In Table 2a, we show, for each experience and education group, the proportion of observations with a rise, a decline and no change in the reported *nominal* wage, and for each such subsample we calculate the average change in the *real* hourly wage. Using the CPS short panel, we see that, conditioned on a nominal increase, the average real hourly wage grows at a hefty rate of 25 percent per year. The corresponding figure for wage reductions are even larger, -33 percent per year. As experience rises, the proportion of gainers (workers with a wage rise) declines and the proportion of losers (workers with a wage decline) rises. However, the conditional means of these respective wage changes remain remarkably similar across experience groups. Similarly, as we compare education groups, the main reason for the higher growth rate among the educated is the larger proportion of workers with a nominal wage rise, but conditioned on such a change, the average increase is *independent* of the level of schooling. The same patterns are also seen in the NLSY and PSID samples, shown in Table 2b, where due to the smaller size of these samples we classify the data only by experience. Again, the main reason for the reduction of wage growth with experience, is the decline in the share of gainers, while the conditional means remain the same (except for gainers in the PSID that show some decline). These features strongly suggest that the average patterns are influenced by the arrival of positive or negative shocks, and it is the nature of such shocks (positive or negative) rather than their size that changes over the life cycle.

2.5 The Questions

Based on this preliminary look at the data, the following questions arise:

- What causes the large wage growth at the initial phase of the work career?
- Why does wage growth decline?
- What are the interrelationships between wage growth, job changes and the variations in labor supply?

- What causes the large variance in individual wage growth and who are the gainers and losers?

In the next section, we examine some theoretical models that address these issues. In the subsequent (and last) section, we shall present some further evidence and discuss the support that is provided to these explanations by the data.

3 Models Of Wage Growth

A basic tenant of modern labor economics is that the observed life cycle patterns of wages are to a large extent a matter of choice. Thus, each worker can influence his future wage by going to school, by choosing an occupation and by searching for a better job. Of course, wage levels and wage growth are also influences by factors beyond the worker's control and determined by market conditions, such as the aggregate demand and supply, the technology, the levels, form of competition and the institutional framework. Nevertheless, an understanding of individual choice in a given market situation is an important part of the equilibrium analysis of wage outcomes.

In this survey, we present some of the basic approaches that economists have used in the analysis of post schooling wage growth. The main ideas that we cover are investment, search, and learning. Our purpose is to illustrate how these ideas are used in a sufficient detail to enable the reader to use them as tools. We try to use as much as possible, a unified framework so as to make the conceptual connections and differences between these ideas transparent. To achieve this purposes within our space constraints we left out important ideas that require separate discussion. In particular, we focus on general training and do not discuss firm specific investments, mainly because of the difficulties in pinning down the wages. We also do not cover incentive contacts and the relations between wages and effort. The interested reader should consult other surveys for these important and complex issues (Malcomson,1997, 1999, Gibbons and Waldman, 1999, Prendergast, 1999). Finally, we do not discuss the important interrelationships between wages and hours worked (see Weiss, 1986, Blundell and MaCurdy, 1999).

3.1 Investment

Workers have a finite life, T, and time is discrete. Let Y_t the earning capacity of the worker with the *current* employer, $t, t = 1, 2..T$. We assume that

$$Y_t = R_t K_t, \tag{1}$$

where K_t is the worker's human capital and R_t is the rental rate. In a competitive world, without frictions, all firms pay the *same* rental rate.

Workers can accumulate human capital by investment on the job. Let l_t, be the proportion of earnings capacity that is forgone when the worker learns on the job, then current earnings are

$$y_t = R_t K_t (1 - l_t). \tag{2}$$

Following the Ben-Porath (1967) model, suppose that human capital evolves according to

$$K_{t+1} = K_t + g(l_t K_t), \tag{3}$$

where $g(.)$ is increasing and concave with $g(0) = 0$. Thus, a worker who directs a larger share of his existing capital to investment has lower current earnings but a higher future earning capacity.

Here we consider only the behavior of workers for a given "production function" $g(.)$. In a more general analysis, this function is influenced by market forces (see Rosen, 1972, and Heckman et al., 1998), but we do not attempt to close the model by deriving the equilibrium trade-off between current and future earnings.

To determine the worker's investment, we form the Bellman equation

$$V_t(K_t) = \underset{l_t}{Max}[R_t K_t (1 - l_t) + \beta V_{t+1}(K_t + g(l_t K_t))], \tag{4}$$

where β represents the discount factor and $\beta < 1$. This equation states that the value of being employed at wage Y in period t consists of the current earnings with this employer and the *option* to augment human capital through learning on the job. Each of these terms depends on the level of investment of the worker, and one considers only the optimal choices of the worker in calculating the value of the optimal program.

The first order condition for l_t in an interior solution is

$$\frac{R_t}{g'(l_t K_t)} = \beta V'_{t+1}(K_{t+1}). \tag{5}$$

The left hand side of (5) describes the marginal costs of investment in terms of forgone current earnings, while the right hand side is the marginal value of the additional future earnings. In the last period, T, investment is zero because there is no future periods left to reap the benefits.

Differentiating both sides of (4) w.r.t K_t and using (5) we obtain the rule of motion for the marginal value of human capital

$$V'_t(K_t) = R_t + \beta V'_{t+1}(K_{t+1}). \tag{6}$$

Using the end condition that $V_{T+1}(K_{T+1}) = 0$ for *all* K_{T+1} which means that human capital has no value beyond the end of the working period, we must also have

$$V'_T(K_T) = R_T. \tag{7}$$

The standard investment model assumes stationary conditions so that R_t is a constant that can be normalized to 1. Then, using (7) and solving (6) recursively, the value of an additional unit of human capital at time t is

$$V'_t(K_t) = \frac{1-\beta^{T+1-t}}{1-\beta}, \tag{8}$$

which is *independent* of K_t. It follows that the value of being employed at a given current wage *declines* with time, that is, $V'_t(K_t) \geq V'_{t+1}(K_{t+1})$ for all periods $t = 1, 2, ., ., T$. The shorter is the remaining work horizon, the less valuable is the current stock of human capital and the incentive to augment it declines. The lack of dependence on history that is implicit in the Ben-Porath (1967) specification is sufficient but not necessary for the result of declining investment, which holds under more general conditions (see Weiss, 1986).

The model can be easily generalized to the case in which R_t is variable over time. In this case equation (8) becomes

$$V_t'(K_t) = \sum_{\tau=t}^{T} \beta^{\tau-t} R_\tau. \tag{8'}$$

Comparing these expressions, it is seen that if R_t rises with time then the investment in human capital is higher every period. The reason is that investment is done when the worker receives a relatively lower price for his human capital. If the rental rate rises with time at a decreasing rate then this relative price effect weakens with time, and investment declines.[3]

The observable implications of this model are quite sharp.

- For a constant R, investment declines as the worker ages and approaches the end of his working life.
- Earning rise along the optimal investment path. This is caused by two effects that reinforce each other; a positive investment increases the earning capacity and a declining investment causes the rate of utilization to rise.
- If R varies with time, workers that expect an exogenous growth in their earning capacity invest at a higher rate and their wage rise at a higher pace. Investment declines if the rate of growth in the rental rate is deceasing.

3.2 Investment in school and on the job

Investment in school and on the job can be viewed as two alternative modes of accumulation of human capital that complement and substitute each other. Complementarity arises because human capital is self productive, so that human capital accumulated in

[3] Using (8') and (5) investment is determined by

$$\frac{1}{g'(l_t K_t)} = \sum_{\tau=t}^{T} \beta^{\tau-t} \frac{R_\tau}{R_t}.$$

If $\frac{R_\tau}{R_t}$ declines in t for all $\tau > t$ then changing prices creates an added incentive to invest early rather than late, which together with the effect of the shortening horizon implies that investment, $l_t K_t$, declines in t.

school is useful for learning on the job. Substitution arises because life is finite and if more time is spent in school, there is less time left for investment on the job. Although, the focus of this survey is on post schooling investments, the fact that these two modes are to some extent jointly determined lead us to expect interactions, whereby the wage growth of individuals with different levels of completed schooling will invest differentially on the job and therefore display different patterns of wage growth.

Investment on the job is usually done *jointly* with work, while schooling is done separately. As a consequence, one foregoes less earning when training on the job. However, in school, one typically specializes in the acquisition of knowledge and, as a consequence, human capital is accumulated at a faster rate. One can capture these difference by assuming different production (and cost) functions for these two alternative investment channels.

Let p_t be a participation indicator such that the individual works in period t if $p_t = 1$ and $p_t = 0$, otherwise. Suppose that when the individual does not work she goes to school and then accumulates human capital according to $K_{t+1} = K_t(1+\gamma)$ where γ is a fixed parameter such that $\gamma K_t > g(l_t K_t)$. We also assume that $(1+\gamma) > \frac{1}{\beta}$, which means that the rate of return from investment in human capital γ exceeds the interest rate. Otherwise such investment will never optimal. Assume stationary conditions and let $R_t = 1$. We can now rewrite the Bellman equation i the form

$$V_t(K_t) = \underset{p_t, l_t}{Max}[p_t K_t(1-l_t) + \beta V_{t+1}(K_t + p_t g(l_t K_t) + (1-p_t)\gamma K_t)]. \tag{9}$$

The linearity in p implies that the worker will usually specialize in one of the two training options. School is the preferred choice in period t if

$$\beta V_{t+1}(K_t(1+\gamma)) > K_t(1-l_t^*) + \beta V_{t+1}(K_t + g(l_t^* K_t))], \tag{10}$$

where the optimal level training on the job l_t^* is determined from (5). Finally the law of motion for the marginal value of human capital is modified to

$$V_t'(K_t) = p_t + \beta V_{t+1}'(K_{t+1})(1 + (1-p_t)\gamma). \tag{11}$$

This extension has several implications:

- The specialization in schooling occurs, if at all, in the first phase of life. It is followed by a period of investment on the job. In the last stage, there is no investment at all.[4]

- During the schooling period, there are no earning, but human capital is accumulated at the maximal rate $(1 + \gamma)$. During the period of investment on the job, earnings are positive and growing. In the last phase (if it exists) earnings are constant.

- The worker leaves school at the first period in which (10) is reversed. At this point it must be the case that $l_t^* < 1$, which means that at the time of leaving school, there must be a *jump* in earnings to a positive level. This realistic feature is present only because we assume different production (and cost) functions in school and on the job, whereby accumulation in school is faster but requires a larger sacrifice of current earning.

- A person with a larger initial stock of human capital, K_0, will stay in school for a shorter period and spend more time investing on the job. He will have higher earnings and the same earning growth throughout life.

- A person with a larger learning ability in school, γ, will stay in school for a longer period and spend less time investing on the job. He will also have higher earnings and the same earning growth throughout life.

Although these results depend heavily on the particular form of the production function (3), they illustrate that unobserved characteristics of the economic agents can create a negative correlation between the periods spent investing in school and on the job, while there need be no correlation between completed schooling and post schooling wage growth.[5] It should be noted, however, that wage growth is often higher for the more educated, which casts some doubt on the neutrality implied by (3). Uncertainty and

[4]This interval disappears if $g\prime(0) = \infty$.

[5]The crucial feature here is that investment depends only the time left to the end of the horizon is independent of the level of the capital stock. An additional simplification is that there is no depreciation, so that earning growth depends only on investment and is thus also independent of history. The results stated in the text, can be shown easily using the continuous time version of the problem described in the text, applying phase diagram techniques (see Weiss, 1986).

unexpected shocks can also affect correlation between schooling and investment. For instance, the introduction of computers may raise the incentive to invest on the job of educated workers to a larger extent than for uneducated workers, because the payoff from the investment may be lower for the second group.[6]

3.3 Search

In a world with limited information and frictions, firms may pay a different R, because workers cannot immediately find the highest paying firm and must spend time and money to locate employers. If a worker meets a new employer, he obtains a random draw $\tilde{R}$ from the given distribution of potential wage offers, $F(R)$. The worker decides whether to accept or reject this offer. To simplify, we assume here that workers are relatively passive in their search on the job. They receive offers at some fixed exogenous rate λ, but do not initiate offers through active job search.

We discuss here the case with homogenous workers and firms, assuming that workers are equally productive in all firms and their productivity is constant over time. However, firms may pay different wages for these identical workers. Specifically, if K is the worker's human capital, then the profits of a firm that pays the worker R are $K - R$. Firms that post a high R draw more workers and can coexist with a firm that posts a low R and draw few workers. In equilibrium, all firms must have the same profits (see Mortensen and Pissarides, 1999). Here we consider only the behavior of workers for a given wage distribution, $F(R)$ and do not attempt to close the model by deriving the equilibrium wage offer distribution. or the equilibrium trade-off between current and future earnings. In a more general analysis, the wage distribution is determined market forces (see Wolpin, 2003).

Lets us ignore investment for a moment and look at the implications of search alone. Consider a worker who earns R_t with his current employer in period t, so that $Y_t = KR_t$. Now imagine that during period t, the worker is matched with a new employer offering R. Because the worker can follow the same search strategy wherever he is employed, it is

[6] Weinberg (2003) shows that computer adoption is also related to experience. In industries with the greatest increase in computer use, the returns to experience have increased among high school graduates, but declined among college graduates.

clear that the offer will be accepted if $R > R_t$ and rejected if $R < R_t$. If the worker rejects the offer and stays with the current employer, his earning capacity remains the same and $Y_{t+1} = Y_t$. If the worker accepts the outside offer and moves to the new employer, his new wage, $Y_{t+1} = RK$, must exceed Y_t. The probability that the worker will switch jobs is $\lambda(1 - F(R_t))$ and is *decreasing* in R_t.

The observable implications of this model are :

- A job has an *option value* to the worker. In particular, he can maintain his current wage and move away when he gets abetter offer. Consequently, earnings rise whenever the worker switches jobs and remain constant otherwise.

- The higher is the worker's current wage, the more valuable is the current job and the offers that the workers accepts must exceed a higher reservation value. Therefore, the quit rate and the expected wage growth decline as the worker accumulates work experience and climbs up the occupational scale.

- A straight forward extension is to add involuntary separations. Such separations are usually associated with wage reduction and are more likely to occur at the end of the worker career, which may explain the reduction in average wages towards the end of the life cycle.

This model can be generalized by allowing the worker to control the arrival of new job offers by spending time on the job in active search (see Mortensen, 1986). Search effort declines as the worker obtains better jobs, and the qualitative results are the same. Towards the end of the career, a worker may reduce his search effort to a level that generates no job offers and, consequently, voluntary quits and wage growth cease.

The same search model can be motivated slightly differently by assuming that workers and firms are heterogenous. Let workers be ranked by their skill, K. Let firms be ranked by their *minimal* skill requirement R (see Weiss et al, 2003). Assume that a worker K employed by firm R produces R if $K \geq R$ and 0 otherwise. Because workers with $K \geq R$ on job R produce the same amount, irrespective of their K, we can set their wages to R (assuming zero profits). A worker K who is now employed at firm R_t and meets (with probability λ) a random draw from the population of employers, R, is willing to switch if and only if $R > R_t$. However the employer is willing to accept him only if $K \geq R$. So that transition into a better job occurs with probability $\lambda(F(K) - F(R_t))$.

3.4 Comparison of investment and search

The two models have similar empirical implications for the *average* growth in earnings, i.e., a positive and a declining wage growth. In the investment model, the reason for the wage growth is that the worker chooses to spend some of his time learning. However, investment declines as result of the shortening of the remaining work period, which causes wage growth to taper off. In the search model, wage growth is an outcome of the option that workers have to accept or reject offers. Acceptance depends on the level of earnings that the worker attained by tine t so that history matters. Two workers of the same age may behave differently because of their different success records in meeting employers. But the general trend is for wage growth to decline, because workers who attained a higher wage have a lower incentive to search and are less likely to switch jobs.

Although investment and search have similar implications to wage growth, they can be distinguished by the different patterns in the *variance* of wages and the correlations between wages at different points of the life cycle. As shown by Mincer (1974), the variance in wages first declines and then rises, as we move across age groups in across section or follow a cohort. The reason is that a currently low wage is compensated by a future high wage, so that workers who invest more intensely will *overtake* those with a lower investment rate. The minimal variance occurs in the middle range of experience, where the individual earning profiles cross. Under search, the cause for variability is not differential investment, but different success record in meeting suitable job matches. Workers that are initially homogenous, become increasingly heterogenous as time passes, due to their longer exposure to random job offers, implying an increasing variance of earnings within a cohort. If workers are heterogenous, the variance may first increase and then decline as workers are gradually sorted into their "right" place. The investment model suggests a negative correlation between the wage level and wage growth in the beginning of the worker's career and a positive correlation between wage growth and wage level late in the worker's career, while the search model implies a negative correlation between current wage and wage growth at *any* point of the life cycle.

Search and investment also have similar implications for quits, especially if investment has a firm a specific component. To the extent, that specific investment can be described by a stochastic learning on the job, as in Jovanovic (1984) and Mortensen (1988), then both wage growth and mobility can be outcomes of either internal shocks in the form of changes in the quality of a match, or external shocks in the form of outside offers. The average patterns of wage growth and separations will be the same under specific investment or search. However, higher moments, such as the wage variances among stayers and movers, can indicate the importance of specific capital and search, respectively.

3.5 Putting the two together

We now consider the possible interaction between search and investment behavior. To simplify, we continue to assume that workers can reject or accept offers as they arrive at an exogenous rate λ, but cannot initiate offers by investing in search. However, the option to search passively changes the incentives to invest in human capital.

The Bellman equation becomes

$$\begin{aligned} V_t(R_t, K_t) &= \underset{l_t}{Max}\{R_t K_t(1-l_t) + \beta[\lambda E\{\max[V_{t+1}(R_t, K_{t+1}), V_{t+1}(R, K_{t+1})] \\ &\quad +(1-\lambda)V_{t+1}(R_t, K_{t+1})]\}. \end{aligned} \tag{12}$$

Because a worker with a given K can follow the same search and investment strategy on any job, it is clear that he will switch jobs if $R > R_t$. Given this reservation value strategy, we can write

$$E\{\max\left[V_{t+1}(R_t, K_{t+1}), V_{t+1}(\tilde{R}_{t+1}, K_{t+1})\right]\} = F(R_t)V_{t+1}(R_t, K_{t+1}) + \int_{R_t}^{\infty} V_{t+1}(R, K_{t+1})f(R)dR, \tag{13}$$

where $f(R)$ is the density of wage offers The first order condition for l_t is now

$$\frac{R_t}{g'(l_t K_t)} = \beta V_{k,t+1}(R_t, K_{t+1}) + \lambda\beta \int_{R_t}^{\infty} (V_{k,t+1}(R, K_{t+1}) - V_{k,t+1}(R_t, K_{t+1})) f(R) dR, \quad (14)$$

where $V_{k,t}$ denotes the partial derivative of $V_t(.,.)$ with respect to K_t. The interaction between investment and search decisions is captured by the second term in equation (14) that shows that the incentives to invest now include the *capital gains* that the worker obtains if he changes employers.[7]

This extended model has the following features:

- As long as the worker stays with the same firm, investment in human capital declines, because of the shortening of the work period.
- On any such interval, the worker invests more than he would without search and a fixed R. This result reflects the upward drift in the R that is inherent in the search model and is qualitatively similar to the result in the regular investment model when R rises exogenously.
- Investment drops when the worker switches to a new job with a higher R, because the option value of switching to a new job becomes less valuable.

3.6 Human Capital and Skills

Human capital, K, is an aggregate which summarizes individual skills in terms of productive capacity. Different skills are rewarded differentially at different occupations and

[7] We can simplify these expressions by showing that the value function is *linear* in K_t and can be written in the form

$$V_t(R_t, K_t) = K_t A_t(R_t) + B_t$$

Hence, investment in period t is determined by

$$\frac{R_t}{g'(l_t K_t)} = \beta A_{t+1}(R_t) + \lambda\beta \int_{R_t}^{\infty} (A_{t+1}(R) - A_{t+1}(R_t)) f(R) dR,$$

where $A_t(x)$ is a sequence of functions that are increasing in x and decreasing in t, with $A_T(x) = 1$ for all x.

we assume that this aggregate may be represented as

$$\ln K_j = \sum_j \theta_{sj} S_s, \tag{15}$$

where, S_s is the quantity of skill s possessed by the individual and θ_{sj} are non negative parameters that represent the contribution of skill s in occupation j. Firms reward individual skills indirectly by renting human capital at the market determined rental rate, R. Thus, the parameter θ_{sj} is the proportional increase in earning capacity associated with a unit increase in skill x_s if the individual works in occupation j. Having assumed that θ_{sj} are independent of the quantity of skill s possessed by the individual, these coefficients may be viewed as the implicit "prices" (or "rates of return") of skill s in occupation j.[8]

Because we are interested here in the timing of occupational changes, it will be convenient to set the problem in continuous time. We denote by T the duration of the worker's lifetime and by t a point in time in the interval $[0,T]$. We define $h_j(t)$ as the portion of available time that is spent spent in work in occupation j at time t, so that $0 \leq h_j(t) \leq 1$ and $\sum_j h_j(t) = 1$. The worker will typically work in one particular occupation in each point in time but is free to switch occupations at any time. The worker's earning capacity is

$$Y(t) = R \sum_j h_j(t) K_j(t). \tag{16}$$

Skills are initially endowed and can then be augmented acquiring experience. We consider here a "learning by doing" technology whereby work at a rate $h_j(t)$ in a particular occupation j augments skill s by $\gamma_{sj} h_j(t)$. Thus, the change in skill s at time t is

$$\dot{S}_s = \sum_s \gamma_{sj} h_j(t). \tag{17}$$

Note the joint production feature of this technology. Working in any one occupation j can influence many skills that are useful in other occupations. Yet, such experience may

[8] Each worker can be viewed as a bundle of skills. Because these skills cannot be unbundled from the worker, the law of one price does not apply and different skills can have different implicit prices in different uses, depending upon the technology of production. It is only human capital that can be moved freely across uses and, therefore, commands a single price.

be more relevant to some particular skills. In this way, we obtain that work experience is transferable but not necessarily general.

In the static version of this model (the Roy model), individual skills are constant ($\gamma_{sj} = 0$ for all s and j) and the main issue is the mapping between skills and earnings that results from the different occupational choices of workers with different skills. The basic principle that applies here is that each individual will spend *all* his work time in the occupation in which his bundle of skills commands the highest reward (see Heckman and Honore, 1991). Unexpected changes in the prices of skills, θ_{sj}, can cause the worker to switch occupations, but under static conditions there would be no occupational mobility. In the dynamic set up that we outline here, skills vary with time, and this variation is influenced by the career choices of the worker. In such a context, *planned* occupational switches can arise, even in the absence of shocks, if experience is sufficiently transferable across occupations.

To simplify the exposition, we consider the case of two occupations and two skills[9] and examine the conditions for a single switch. Given our simplifying assumptions, the earning capacity of the worker at the different occupations, K_j grow at constant rates that depend on the occupation at which the worker specializes. Suppose that the worker switches from occupation 1 to occupation 2 at time x and then stays there for the rest of his life. Then, in the early phase, prior to time x, $h_1(t) = 1$ and

$$\begin{aligned} \frac{\dot{K}_1}{K_1} &= \theta_{11}\gamma_{11} + \theta_{21}\gamma_{21} \equiv g_{1,1}, \\ \frac{\dot{K}_2}{K_2} &= \theta_{12}\gamma_{11} + \theta_{22}\gamma_{21} \equiv g_{2,1}. \end{aligned} \tag{18}$$

In the later phase, after x, $h_2(t) = 1$ and

$$\begin{aligned} \frac{\dot{K}_1}{K_1} &= \theta_{11}\gamma_{12} + \theta_{21}\gamma_{22} \equiv g_{1,2}, \\ \frac{\dot{K}_2}{K_2} &= \theta_{12}\gamma_{12} + \theta_{22}\gamma_{22} \equiv g_{2,2}. \end{aligned} \tag{19}$$

[9] More generally, we are interested in the case where there are more occupations than skills. Otherwise some skills will be redundant (see Welch, 1969).

The expected lifetime earnings of the worker is

$$V(x) = R\{K_1(0)\int_0^x e^{-rt+g_{1,1}t}dt + K_2(0)\int_x^T e^{-rt+g_{2,1}x+g_{2,2}(t-x)}dt\}. \quad (20)$$

For a switching at time x to be optimal, it is necessary that $V'(x) = 0$ and for $V''(x) < 0$. It can be shown that if work experience in each occupation raises the worker's earning in that same occupation by more than in the alternative occupation (that is, $g_{1,1} > g_{2,1}$ and $g_{2,2} > g_{2,1}$) then $V'(x) = 0$ implies that $V''(x) > 0$, so that the worker will *never* switch occupations.[10] Instead, the worker will specialize in one occupation throughout his working life and concentrate all his investments in that occupation (see Weiss, 1971). However, some occupations require a preparation period in other occupations that serve as stepping stones (see Jovanovic and Nyarko, 1997). For instance, it is not uncommon that successful managers have started as engineers or physicians, rather than junior managers.

Specifically, suppose that

$$\gamma_{11} > \gamma_{12}, \quad \gamma_{21} > \gamma_{22}, \quad \theta_{11} < \theta_{12}, \quad \theta_{21} < \theta_{22}. \quad (21)$$

Then it is easy to verify that, depending on initial conditions, the worker may start in occupation 1 and then switch to occupation 2 because skill 1 is more important in occupation 2, $\theta_{12} > \theta_{11}$, but occupation 1 is the better place to acquire skill 1, $\gamma_{11} > \gamma_{12}$. It does not pay to specialize in occupation 1, because then the worker will not exploit

[10] The first derivative can be written in the form

$$\begin{aligned} V'(x) &= R\{K_1(0)e^{-rx+g_{1,1}x} - K_2(0)e^{-rx+g_{2,1}x} + (g_{2,1} - g_{2,2})K_2(0)\int_x^T e^{-rt+g_{2,1}x+g_{2,2}(t-x)}dt \\ &= Re^{-rx+g_{2,1}x}K_2(0)\{e^{D+(g_{1,1}-g_{2,1})x} - 1 + (g_{2,1} - g_{2,2})\int_0^{T-x} e^{-r\tau+g_{2,2}\tau}d\tau\} \end{aligned}$$

using $\frac{K_1(0)}{K_2(0)} = e^{S_1(0)(\theta_{11}-\theta_{12})+S_2(0)(\theta_{21}-\theta_{22})} \equiv e^D$ and a change of variable, $t-x = \tau$. The second derivative evaluated at this point is given by

$$V''(x) = Re^{-rx+g_{2,1}x}K_2(0)\{(g_{1,1} - g_{2,1})e^{D+(g_{1,1}-g_{2,1})x} - (g_{2,1} - g_{2,2})e^{(-r+g_{2,2})(T-x)}\}.$$

his acquired skills. Nor is it usually optimal to specialize in occupation 2, because then the worker will not acquire sufficient skills. However, a worker with a large endowment of skill 1 or skill 2 may jump to occupation 2 immediately.

This model illustrates quite clearly the main features of occupations that serve as stepping stones. Basically, these occupations enable the worker to acquire skills that can be used later in other occupations in a cheaper or more effective way.[11] Although this jobs pay less for *all* workers with *given* skills, some workers may still enter them as an investment in training.[12]

The pattern of earnings growth that is implied by this sequence of occupational choices is easy to summarize. At the point of switch, x, earnings *rise* instantaneously, where the proportional jump is $S_1(0)(\theta_{11} - \theta_{12}) + S_2(0)(\theta_{21} - \theta_{22}) + (g_{1,1} - g_{2,1})x$. The growth rate of earnings may either rise or decline following this change, because the restrictions in (21) are consistent with either $g_{1,1} > g_{2,2}$ or $g_{1,1} < g_{2,2}$. If we assume, however, that the differences between the two occupations in the learning coefficients (the $\gamma's$) are more pronounced than the differences in the prices of skills (the $\theta's$) then $g_{1,1} > g_{2,2}$ and the growth rate in earnings will decline, which is the more realistic case.

3.7 Wages, productivity and contracts

The presumption, so far, was that the wage of the worker is closely tied to his productivity. However, the relation between these two variables may be quite complex, especially when workers and firms develop durable relationships. In such a case, wages and productivity are still tied in terms of long term averages but, in the short run, there may be systematic differences between wages and productivity that represent credit and risk sharing arrangements, or incentives to exert effort. We shall not attempt to describe the complex issues associated with incentive for effort, for which several excellent recent surveys exist.

[11] Because this model assumes learning by doing, the opportunity cost of investment are the forgone earnings that one could receive by switching earlier to the higher paying occupation. This stands in some contrast to the cases discussed above, where the costs were the loss of effective work time, in the occupation that one has.

[12] Booth et al (2002), show that fixed term temporary jobs serve as stepping stones to permanent jobs. Female workers who held 3 consecutive one year fixed term contracts, are initially paid lower wages than comparable workers on permanent jobs, but appear to overtake them after about 10 years. Among men, there is higher wage for workers who follow the same pattern but overtaking is not observed.

However, the issues associated with credit and risk sharing are easy to explain.

Trade between the workers and employers that extends over time is motivated by some basic asymmetry between the parties. Specifically, firms may have better access to the capital market and may be able to pool some risks. If the output of the worker varies over time, and he has no access to the capital market, the firm may smooth his consumption by offering a flat wage profile which effectively means that the worker borrows from the firm. Similarly, if the output of the worker is subject to shocks, the firm may accept these risks and provide the worker with insurance that stabilizes his income. As we shall now show, the ability of firms to provide such arrangements is limited by the commitments that workers (and firms) can make.

Consider a worker with a fixed bundle of skills and suppose that, because of random variations in the prices of skills, his\her human capital is subject to capital gain or loss. Specifically,

$$K_{t+1} = \begin{cases} K_t(1+g) & \text{with probability} \quad p \\ K_t(1-\delta) & \text{with probability} \quad 1-p \end{cases}, \tag{22}$$

where g and δ are fixed parameters that govern the size of the capital gain and loss, respectively. We denote by $Q_t(K_{t-1})$ the expected present value of the worker's output over the remainder of his work life, $T-t$. Let h_t be sequence of zeros and ones, where 1 for the τ element, $\tau = 1, 2, ..t$, indicates the occurrence of a positive shock and a 0 indicates the occurrence of a negative shock in period τ. We refer to such a sequence as the history or sample path. Let $y_t(h_{t-1})$ be the wage that a firm promises to pay a worker with history h_{t-1} in period t and let the present value of the expected payments over the remainder of the work life from t to T be denoted by $Y_t(h_{t-1})$.[13] We can think of $Y_t(h_{t-1})$ as the *contractual* assets of the worker.

A risk neutral firm is indifferent between all contingent contracts that yield the same

[13]For simplicity assume that the interest rate is zero. Then, $Q_t(K_{t-1})$ satisfies the difference equation

$$Q_t(K_{t-1}) = RK_{t-1} + pQ_{t+1}(K_{t-1}(1+g)) + (1-p)Q_{t+1}(K_{t-1}(1-\delta)),$$

and can be solved recursively, using the end condition that $Q_{T+1}(K_T) = 0$ for all K_T. Similarly,

$$Y_t(h_{t-1}) = y_t(h_{t-1}) + pY_{t+1}(h_{t-1}, 1) + (1-p)Y_{t+1}(h_{t-1}, 0)),$$

can be solved recursively, using the end condition that $Y_{T+1}(S_T) = 0$ for all S_T.

expected value. However, a risk averse worker with no access to the capital or insurance markets would prefer that the payment stream will be as stable as possible. If the worker can commit to stay with the firm, the competition among firms will force them to offer wage contracts that smooth the wage payments over time and across states of nature. In practice, workers cannot legally bind themselves to stay with the firm and their option to leave the firm limits the insurance and consumption smoothing that firms can provide. (see Harris and Holmstrom, 1982, and Weiss, 1984)

A competitive payment scheme must maximize the expected utility of the worker given the expected profits of the firms and the outside options of the workers. Therefore, the contract that survives must solve the following program

$$\begin{aligned} V_t(K_{t-1}, Y_{t-1}) \quad = \quad & \underset{y,x_1,x_0}{Max}\{(u(y) + pV_{t+1}(K_{t-1}(1+g), S_{t-1} + x_1) \\ & +(1-p)V_{t+1}(K_{t-1}(1-\delta), Y_{t-1} + x_0)\}, \end{aligned} \tag{23}$$

subject to

$$y + px_1 + (1-p)x_0 = 0, \tag{24a}$$

$$Y_{t-1} + x_1 \geq Q_{t-1}(K_{t-1})(1+g)) - a, \tag{24b}$$

$$Y_{t-1} + x_0 \geq Q_{t-1}(K_{t-1})(1-\delta)) - a, \tag{24c}$$

where a is a parameter that represents the costs of mobility across firms, such as loss of firm specific capital.[14] The state variables at period t are the worker's human capital and the expected payments from the firm under the existing contract. The control variables, y, x_1, x_0 represent possible revisions of that contract that can make the worker better off, keeping the expected profits of the firm constant and keeping the worker with the firm. Constraint (24a) requires that the revisions maintain the cost of the contract to the firm (because Q_{t-1} is fully determined by K_{t-1} this implies that expected profits are unchanged). The constraints (24b) and (24c) imply that other firms cannot bid the worker away. If the firm changes the contract in such a manner that its obligation fall short of the worker's expected output it cannot maintain the worker, because another

[14]For simplicity, we treat the mobility cost as a fixed cost. In general, these costs depend on the stock of human capital and the skill composition.

firm can offer a superior contract and still make non negative profits.

The first order conditions are

$$u'(y) - \lambda = 0, \tag{25a}$$

$$\frac{\partial V_{t+1}(K_{t-1}(1+g), Y_{t-1} + x_1)}{\partial Y_t} - \lambda + \frac{\mu_1}{p} = 0, \tag{25b}$$

$$\frac{\partial V_{t+1}(K_{t-1}(1-\delta), Y_{t-1} + x_0)}{\partial Y_t} - \lambda + \frac{\mu_2}{1-p} = 0, \tag{25c}$$

where λ, μ_1, μ_2 are the time-variable non- negative Lagrange multipliers that are associated with the constraints (24a), (24b) and (24c), respectively.

Differentiating (23) with respect to Y_{t-1} and using conditions (25a) to (25c) we have

$$\frac{\partial V_t(K_{t-1}, Y_{t-1})}{\partial Y_{t-1}} = \lambda, \tag{26}$$

which implies that in each period and any possible state the marginal utility of consumption $u'(y)$ is equated to the marginal value of the contractual assets, $\frac{\partial V_t(K_{t-1}, Y_{t-1})}{\partial Y_{t-1}}$, of the worker. Because the Lagrange multipliers μ_1 and μ_2 are non-negative, it follows from conditions (25b) and (25c) that the payment stream is arranged in such away that the marginal value of contractual assets never rises, which also means that the wage payments never decline as the successive realizations of human capital unfold.

These results have a simple economic interpretation. A worker who may suffer either a capital gain or a capital loss, when skill prices change, would like the firm to transfer wages from the "good" states with high income and low marginal utility of income to the "bad" state when income is low and the marginal utility of income is high. The firm is willing to do so only if the expected present value of wage payments does not rise, as a consequence. Thus, paying a higher current wage in a bad state implies a wage reduction in some future good state. However, the firm can commit to such a transfer policy only if it is able to keep the worker and collect the payment for the insurance that it provides the worker now.

If the cost of mobility across firms, a, is sufficiently high to prevent mobility, then constrains (24b) and (24c) will not bind and $\mu_1 = \mu_2 = 0$. Then, the optimal contract implies that y is a constant, which means that the firm provides *perfect* insurance and consumption smoothing. However, if the cost of mobility across firms, a, is sufficiently low, the constraint (24c) that corresponds to a positive shock will bind, because such a shock makes the worker more attractive to other firms. The wage profile that emerges in this case is one in which the wage rises when the worker receives a positive shock but remains unchanged when a negative shock occurs. This way, the worker receives *partial* insurance from the firm. When a positive shock occurs, the wages is raised up to the minimal level that is required to retain the worker. When a negative shock occurs the wage is set above the worker's productivity. This policy requires that the worker should pay for the insurance by excepting an initial wage that falls short of his productivity upon joining the firm.

If the costs of mobility across firms are low, and the worker must be induced to stay with the firm, then her *average* wage rises *faster* than her average productivity. This result is reversed if there are substantial costs of mobility across firms and the worker is locked to the firm, which allows the firm to provide perfect insurance. In this case, of course, average wages grow at a *lower* rate than productivity.

In equilibrium, there is no mobility across firms. However the *option* of workers to leave the firm affects the wage growth. Paradoxically, the worker is better off when the costs of mobility are high. This holds for two related reasons. First, with high mobility costs, the worker is effectively locked in with the firm so that the firm is assured that the worker will stay and therefore will provide perfect rather than partial insurance. Second, because information is public and workers are equally productive in all firms, mobility serves no productive role. Thus the most efficient arrangement is for the workers to stay with their employer. A more complex situation arises if the worker can influence the skill acquisition and use via occupational switches. Then, a worker will receive less insurance from the firm, but can obtain higher wage growth because of investment in skills acquisition. In addition, the worker may try to create a more balanced portfolio of skills which may also induce mobility and possible multiple job holding.

An important feature of the wage contract is that the wage in period t, generally depends on the whole history of shocks and not simply on the accumulated human capital at time t. In particular, $y_t(h_{t-2}, 1, 0)$ may exceed $y_t(h_{t-2}, 0, 1)$. While in both cases the worker has the same productive capacity in period t, there is a wage gain from having *early* success. This is because an early success provides an opportunity for sharing risk with potentially more productive realizations in the future that are not available to a worker who had an early failure. More generally, conditions at the time at which the commitments are taken, e.g., when the worker entered the firm, can cause wage differences between workers who are equally productive identical.[15]

3.8 Unobserved Productivity and Learning

The productivity of a particular worker may be unknown to the worker and potential employers. Over time, the performance of the worker is observed and one may use this information to make inferences about the worker's "true" skills. This learning process can create negative and positive shocks to the worker's perceived productivity similar to those discussed above. However, the learning model has further implications concerning mobility. In particular, workers will experiment for a while in an occupation where learning about ability is possible and then, as their ability is gradually revealed, sort themselves into different occupations, based on their realized performance.

Let there be two occupations, a low skill and high skill occupation, and let there be two types of workers, high ability workers and low ability workers. All workers perform equally well in the low skill occupation and produce one unit of output per period, irrespective of ability. Workers differ in their ability to perform the required jobs in the high skill occupation, and we denote the expected output, per period of time, as q_l and q_h for the low and high ability workers, respectively. However, neither the workers nor the employers know whether a particular worker is of high ability or low ability. The common prior probability that a worker is of low ability is denoted by π_0. With time, as the performance of the worker is observed by all agents (including the worker himself) all

[15] Two basic features of this model have been demonstrated empirically. First, nominal wages are indeed rigid downward (see Baker et al., 1994a, and McLaughlin, 1994). However, the prevalence of real wage reduction is problematic for the contracting model. Second, history dependence is in fact present (See Baker et al., 1994a, and Beaudry and DiNnardo, 1991). There is also evidence that risk aversion reduces wage growth (Shaw, 1996).

agents modify this common prior.[16] Although the worker's productivity remains constant over time, the new information can affect his wages and employment.

We may model the realized output as a simple Bernoulli trials so that q_i is the fixed probability that type i, $i = l, h$ will produce one unit of output in period t and $1 - q_i$ is the probability that type i will produce nothing in period t. Let $n(t)$ be the (random) number of successes that a worker has accumulated up to period t, then based on this information, one can update the probability that he is the low ability type. Specifically, the posterior probability is

$$\pi(t,r) \equiv \Pr\{q = q_l / n(t) = r\} = \frac{\pi_0 q_l^r (1-q_l)^{t-r}}{\pi_0 q_l^r (1-q_l)^{t-r} + (1-\pi_0) q_h^r (1-q_h)^{t-r}}, \tag{27}$$

and the updated expected output per period is

$$q(t,r) = q_l \pi(t,r) + q_h[1 - \pi(t,r)]. \tag{28}$$

>From (27), it follows that $\pi(t,r)$ rises in t for a given r and declines with r for a given t. That is, if a worker did not perform well, a low $n(t)$ up to a given time t, the posterior probability that he is of low ability rises. In contrast, if the worker has a favorable record, the posterior probability that he is of high ability rises. Correspondingly, the perceived (expected) output of the worker is modified downwards or upwards. In this respect the model is similar, to the one discussed in the previous section, except that the informational value of the shocks (success or failure) decays over time. With sufficient time, the process reveals the true identity of the worker.[17]

Consider first the case in which workers are risk neutral and assume that workers are paid their current perceived output at each point of time. Because all workers are ex

[16] We examine here only learning that is general for all firms in a particular industry. As we already noted, firm specific learning, involves some complex issues about the nature of the competition among firms that we cannot cover here. See, however, Jovanovic (1979a,1979b,, 1984), Mortensen (1988), Harris and Felli (1996, 2003) and Munasinghe (2003).

[17] Rewrite

$$\pi(t,r) = \frac{1}{1 + \frac{1-\pi_0}{\pi_0}(\frac{q_h}{q_l})^r (\frac{1-q_h}{1-q_l})^{t-r}}.$$

Then, holding r fixed, $\pi(t,r)$ approaches 1 and $q(t,r)$ approaches q_l as t rises. Similarly, holding $t - r$ constant, $\pi(t,r)$ approaches 0 and $q(t,r)$ approaches q_h as t and r rise together.

ante identical, they will all start at the risky high skill occupation, attempting to learn their true ability. As the public information about each worker accumulates, workers are separated in terms of wages and employment. Those with inferior performance, will get lower wages and some of them will choose to leave. Those with superior records will get higher wages and will choose to stay. Because of the finite horizon and costs of mobility, workers will not move at the end of their career, although their perceived output and wages continue to fluctuate. This mobility pattern continues to hold if workers are risk averse and firms provide partial insurance so that wages are rigid downwards. However, an important difference is that such insurance can induce the workers to stay in the skilled sector even if their output in that occupation is low. In an efficient contract, such workers must be forced out, i.e., denied tenure (see Harris and Weiss, 1984).

The "pure" learning model has some strong implications for wage growth that hold for any distribution of the shocks, provided that we continue to assume that the shocks are independent across time. In particular, suppose that workers i performance in period t is given by

$$y_{it} = \eta_i + \varepsilon_{it}, \tag{29}$$

where η_i is a fixed parameter that is unknown to the firm, and ε_{it} is a random *iid* shock with zero mean. Now if firms pay wages based on the workers perceive output at time t, that is $w_{it} = E(y_{it}/I_t) = E(\eta_i/I_t)$, where I_t is any information available at t then, because expectations are linear operators, it follows that $E(\eta_i/I_t) = E(E(\eta_i/I_{t+1})/I_t)$ and

$$w_{it} = E(w_{i,t+1}/w_{it}). \tag{30}$$

This martingale property implies that the innovations in the wage process wage process $w_{i,t+1} - E(w_{i,t+1}/I_t) = w_{i,t+1} - w_{it}$ are serially uncorrelated. Intuitively, any particular piece of the agents information that the researcher observes has already been used by the agents and cannot change the predicted outcome. (see Farber and Gibbons, 1996). However, if one adds contracting and downwards rigidity, due to risk aversion, then conditioned on the current wage history matters. In particular, early start implies higher wages throughout the worker's career. Nevertheless, if a person with an early success is compared to a person with a late success in the past, but the *same current wage* then the late beginner will have the higher expected wage for the future. (see Chiappori et al, 1999). That is, the fact that the early beginner has the same wage as a late beginner speaks against him. In this respect, "what have you done for us lately" matters more.

Farber and Gibbons (1996) and Altonji and Pierret (2001), discuss some further empirical implications of such models of public learnings. In particular, they distinguish between information available to an outside observer (econometrician) and the information available to the economic agents. If the econometrician can observe a variable that is correlated with ability but not observed by the agents then this variable will have an affect on wages that rises with time, reflecting the accumulation of information by the agents. In contrast, the effect of outcomes that employers observe, beside the worker's output, and are correlated with ability (such as schooling) will decline over time, as their marginal informational content diminishes.

4 Basic Findings and their Interpretation

In this section we provide a second look at the data, with emphasis on findings that have some bearing on the alternative models of wage growth.

4.1 Mincer's Earnings Function

Jacob Mincer discovered an important empirical regularity in the wage (earnings) structure. Average earnings of workers (in a given schooling-experience group) are tied to schooling and work experience in a relatively precise manner as summarized, by the now familiar, Mincer equation

$$\ln Y_{it} = \alpha + \beta s_i + \gamma(t - s_i) - \delta(t - s_i)^2 + ... \tag{31}$$

where Y_{it} are the annual earnings (or the weekly or hourly wage) of person i in year t, s_i are the years of completed schooling of person i and $(t - s_i)$ are the accumulated years of (potential) work experience of person i by year t.

In his 1974 book, Mincer has estimated this specification for a sample of about 30.000 employed males from the US 1960 census and reports a coefficient of .107 for schooling and .081 and $-.0012$ for the two experience coefficients. Including weeks worked as explanatory variables, the effects of experience become .068 and $-.0009$, implying that wages grow less than earnings. The same equation has since been estimated in many countries, for different periods and sectors with similar results.[18]

Mincer's important insight was that this stability is no accident but rather a reflection of powerful and persisting economic forces. In an early (1958) paper, he writes "The starting point of an economic analysis of personal income distribution must be an exploration of the implications of the theory of rational choice...An implication of rational choice is the formation of income differences that are required to compensate for various advantages and disadvantages attached to the receipts of incomes. This principle, so eloquently stated by Adam Smith has become a common place in economics. What follows is an attempt to cast one important aspect of this compensation principle into an operational model that provides insights into some features of the aggregative income distribution and into a number of decompositions of it which recent empirical research has made possible. The aspect chosen concerns differences in training among members of the labor force."

To apply the compensation principle to the data, Mincer considers long lived individuals who operate in a stationary economy with access to a capital market and maximize the present value of their life time incomes. Suppose that the different occupations (jobs) pay wages that depend on the worker's schooling and experience and can be described by some earnings (wage) function of the form $Y_j(s, t-s)$. Given that workers can choose schooling and then among occupations (jobs) that require different levels of training, what form should these functions have in equilibrium? One basic condition is that the present value of different life time earnings streams must equal. Otherwise, all workers will be attracted to the highest paying j, s option, and no one will choose any other option. This condition alone puts strong restrictions on the equilibrium wage structure and, in particular, it that the the marginal contribution of schooling is the *same* for all occupations, irrespective of the time shape of the experience profile, which is a form of separability. A simple functional form that satisfies these requirements for a large T, is $Y_j(s, t-s) = e^{rs} y_j(t-s)$,

[18] Mincer has estimated several variants of this equation. Apart from alternative time shapes for the experience profiles, he was also concerned whether schooling has a diminishing impact, the interaction between schooling and experience and the role of labor supply. These are empirically important issues, but the version in the text has become most popular in subsequent applications.

where $\int_0^\infty e^{-r\tau} y_j(\tau) d\tau$ is a constant that is independent of j.[19] Taking logs, one gets that

$$\log Y_j(s, t-s) = y_0 + rs + \log y^e(t-s) + \varepsilon_{tj}, \tag{32}$$

where $y^e(t - s_j)$ is the mean effect of experience and and $\varepsilon_{tj} = \log y_j^e(t-s) - \log y^e(t-s)$ are deviations caused by differences in on the job training across occupations.

This simple model highlights several general points:

- The effect of schooling on the log of wages is pinned down by the prevailing interest rate, reflecting the delay in receiving income that is implied by investment in schooling. Under these interpretation, it is important that schooling should be measured in years. Moreover, if workers care only about income, and leisure has little value, earnings rather than hourly (or weekly) wages should be the dependent variable.

- The average log earnings profiles of workers with different schooling are parallel, reflecting the separability of investment decisions in school and on the job.

- Individual earnings profile intersect because they must provide the same present value of life time earnings. To the extent that a common effect for experience is used to describe earnings, the errors must be correlated over the life cycle, so

[19] Letting $T = \infty$ and writing

$$V_j(s) = \int_s^\infty e^{-rt} Y_j(s, t-s) dt = e^{-rs} \int_0^\infty e^{-rt} Y_j(s, t) dt,$$

we see that

$$V_j'(s) = -rV_j(s) + e^{-rs} \int_0^\infty e^{-rt} \frac{\partial}{\partial s} Y_j(s, t) dt.$$

Thus, the conditions that $V_j(s)$ is a constant for all s and j and $V_j'(s) = 0$ imply together that $e^{-rs} \int_0^\infty e^{-rt} \frac{\partial}{\partial s} Y_j(s, t) dt$ is a constant for all s and j. Proceeding in this fashion, we get similar conditions for all higher order derivatives. The specification in the text satisfies all these requirments, provided that $\int_0^\infty e^{-rt} y_j(t) dt$ is independent of j.

that early negative residuals imply positive late residuals and the variance of these residuals must be a U- shaped as a function of experience.

- These features are independent of demand conditions and should hold as long individuals are homogenous and schooling and occupation can be freely chosen, without barriers to entry. In particular, they may hold in different countries or periods, with different technology and different demand for educated workers. In this respect the model is classical. Prices are determined by an infinitely elastic supply and demand determines only the number of workers of each type.

Mincer then used results on optimal investment in human capital, by Becker's (1967, Woytinsky lecture) and by Ben-Poarth (1967) to put restrictions on the average contribution of experience to earnings, $y^e(t-s)$. He notes that "learning from experience is an investment in the same sense as the more obvious forms of on the job training, such as, say, apprenticeship programs. Put in simple terms, an individual takes a job with an initially lower pay than he could otherwise get because he knows that he will benefit from the experience gained in the job taken." (1993, vol.1, p. 102). He then notes that "Generally speaking, the fact that age-earnings profiles slope upward over part of the life cycle is a consequence of the tendency to invest in human capital at young ages... Investments are spread over time because the marginal costs of producing them is upward sloping in each period. They decline over time because marginal benefit decline and because the marginal cost curve shift upward" (1993, v. 1, p. 44). The decline in benefits reflects the fact that one can only exploit human capital by "renting" it out, but not by selling it. The increase in costs reflects the fact that investment in human capital requires the person's own time that is diverted from work.[20].

Let $k(t) = \frac{Y(t)}{K(t)}$ denote the portion of earning capacity that is utilized in the form of actual earnings, then, by definition, $Y(t) = K(t)(1-l(t))$. Assume that $\frac{\dot{K}(t)}{K(t)} = rl(t)$ and that the investment ratio $l(t)$ equals 1 during the schooling and then declines linearly with

[20]These two features are the main differences between the theories of investment in human and physical capital.

experience during the work period, i.e., $l(t) = a - b(t-s)$ for $t \geq s$, one obtains

$$\ln Y(s, t-s) \cong \ln K(0) + rs + r \int_0^{t-s} (a - bx)dx - (a - b(t-s)), \tag{33}$$

which has the same functional form as the earnings function specified in (31).

It his 1974 book, Mincer used these considerations to provide a direct economic interpretation for the coefficients of his estimated "human capital earnings function". In particular, the estimated coefficient on the schooling in equation (30) reflects "the rate of return for schooling" and the coefficients of experience reflect the shape of the investment profile of the average person. The reduction in investment is thereby tied to the observed slope and concavity of a log earnings-experience profiles.[21]

As pointed out by Rosen (1977), under the strict assumptions of the model, in particular the assumption that all earnings profiles yield the same present value, the life cycle pattern of earnings is undetermined. Thus, to use the human capital model, one must specify a particular trade-off between current and future earnings, usually called the "production function" of human capital. That is $\dot{K} = g(c)$, where $c = lK$ and $g(.)$ is rising and concave. The assumptions that $g(.)$ rises and Y declines in c maintain the idea of compensation, because one must sacrifice current earnings in order to increase his earning capacity (and future earnings). The added assumption of concavity can be justified by the fact that one must use his own resources to augment his earning capacity. But this would force identical individuals to choose the same investment path on the job. The differences in individual earnings profiles cannot then be simply attributed to differences in investments, and individual attributes such as ability or access to the capital market that affect the individual "propensity to invest" must be introduced. In this case, it is no longer true that, in equilibrium, all income profiles are equivalent and that the observed wage ratios are independent of demand.

Mincer has often relied on Becker's analysis (in his 1967 Woytinsky lectures) of the roles of ability and access to the capital market as factors that affect individual differences

[21] It is, of course, not necessary to assume investment in human capital to obtain such results. Rising and concave earning profiles can be also motivated by various forms of selection, such as the dismissal of unsatisfactory workers (see Flinn, 1997).

in investment. He is quite explicit in starting "Once ability and opportunity are introduced as determinants of investment, earning differentials can no longer be considered as wholly compensatory. Rents or "profits" from investment in human capital arise.." (1993, vol. 1, p. 59) and these rents depend on the individual's attributes and on how much he chooses to invest. He thus often refers to the estimated returns for schooling and experience as average returns.

Nevertheless, the role of individual heterogeneity raised a major debate about the economic interpretation of the coefficients in the Mincer earnings functions. Given that these rates are based on comparison of different individuals who choose different levels of schooling the casual effects of schooling is not identified, because it may simply reflect the impact of omitted (unobserved) ability and a positive correlation between ability and schooling (Griliches, 1977). This debate was further stimulated by the theoretical criticisms, based on asymmetric information and signaling, showing that schooling may have a positive effect even if it has no impact on the worker's output. More generally, to the extent that schooling is mainly a sorting device, social rates of return may be far lower than the private returns that one captures in the cross section.

There have been a huge research effort based on twin data, natural experiments, and variety of instrumental variable methods that try to identify the causal effect of schooling. These studies generally follow Becker's scheme and assume that the individual level of schooling is determined by equating the marginal lifetime benefits from schooling to the marginal costs of financing it. The object of interest in these studies is the expected increase in average annual log earnings if a random sample in the population acquired an additional unit of education. The same interpretation of the rate of return holds in Mincer's compensating differences model, at the individual level. A person who is arbitrarily moved to a schooling program that is requires one additional year will have proportionally higher future annual earnings (and output) given by the common interest rate, although there is no gain in lifetime earnings (or output). The crucial difference is that Mincer provides a market level analysis in which the contribution of schooling to earning is determined, rather than taken as given. It is quite amazing that, after all this work, it was found that the impact of ability on the estimated rates of return is apparently not large and Mincer's estimates of the average rates of return to schooling survived unscathed (see Card, 1999, 2001).

It must be recognized, however, that individual differences in ability can change the equilibrium structure in a basic way. The supply of workers of different skills is now positively sloped and the slope depends on the distribution of ability in the population. In this case, the rate of return to schooling depends on demand conditions. In addition, workers with different ability invest differentially and have different life time earnings. Only "marginal" workers will be compensated for their investment, while other workers obtain ability rents. Further complications arise if ability is not unidimensional, and different workers fit different jobs (as in Willis and Rosen, 1979) or if ability is not observed by employers (as in Altonji and Pierret, 2001).

Similar problems arise with regards to the estimated impact of work experience on wage growth. To what extent does it reflect differences in individual attributes, and how much of it is a reflection voluntary choices along a given market trade off between current and future incomes and, moreover, how is this trade-off determined in equilibrium. These issues are more difficult to resolve in the case of post schooling investments, because the observed outcome is a whole wage profile rather than a single wage level and, in contrast to schooling, investment on the job is not observed. Nevertheless, using panel data, one may examine properties of individual life cycle profiles to tease some qualitative answers.

4.2 The Variance Covariance Structure of Earnings

An important finding of Mincer (1974) is that the variance of the residuals from his estimated wage function form a U-shaped function of potential work experience. This finding is quite surprising, given that many simplistic models of life time earnings, such as random walk, would predict a monotonically increasing variance. Mincer has interpreted this result as a consequence of compensating wage differences. That is, individual variation in the "propensity to invest" generate substantial differences at the early and the late stages of the life cycle, whereby workers who choose to invest first pay for their training and later on receive the benefits. Mincer (1974) provide evidence supporting his U-shape prediction. Again, Mincer's early findings appear surprisingly robust. Three decades later, Heckman, Lochner and Todd (2001) confirmed Mincer's findings in later data and

Polacheck (2003) bring evidence for such patters across countries. Figures 5a to 5e show the gap in log wages between the 90th and 10th quntiles within education and experience categories, using the repeated cross-section data for the periods 1964-1979 and 1980-2001. Like Mincer (1974) and Heckman, Lochner and Todd (2001) we find that the interpersonal wage dispersion exhibits a U-shape pattern, which is less pronounced at higher levels of schooling. As in Placheck (2003), we find that, in recent years, the "break-even point" at which the variance is at its minimum (i.e., the experience level at which the earnings of investors and non-investors coincide) is quite early in the career, approximately after 3 to 5 years in the labor market. The higher variability in the second period, 1980-2001, reflects the general increase in wage inequality due to changing skill prices. Nevertheless, the U-shape pattern persists in both periods.

The PSID and NLSY panels are too small to provide reliable estimates of the experience (time) patterns of the variance within education cells. We, therefore, follow Mincer (1974) and examine the variance of the residuals from a log wage regression equation that is linear in school years and quadratic in experience. For both panels, we obtain that the variance rises with labor market experience. It is only when we add individual fixed effects and consider the deviations for each person around his ample mean, that we get the U-shape pattern for the residual variance emerges (see figures 6a and 6b). Moreover, the minimum variance in both panels occur at about ten years of experience, which is very close to Mincer's theoretical prediction. This suggests the presence of heterogeneity, whereby individuals who invest more also have higher potential wage in the absence of investment. To address this possibility, one must go beyond the comparisons of different individuals, observed at different points of their career, and examine the properties of individual life cycle profiles, using panel data.

In figures 7a -7e, we take a first glance at the correlations between wage growth and wage levels. The figures show the estimated coefficients and confidence intervals from a regression of wage growth on prior wage level by experience and education. To reduce the role of measurement errors, we look at three year averages of these variables. We see that within each experience group, there is a *negative* correlation between the current wage level and the subsequent wage growth. This pattern is consistent with search behavior, because high wage individuals are less likely to obtain superior offers. The investment model would suggest that the correlation is initially negative, because low wage implies high investment, and then becomes positive as the high investment results in overtaking. Yet, the fact that the correlations weaken as we move to higher experience groups speaks in favor of investment considerations.

To further examine the role of investment, we need to take a closer look at the covariance between earning levels at different points of time. The correlation matrices in Table 3 display the correlations between wages (and residuals obtained from the estimated Mincer's wage equation, with and without individual fixed effects) at different stages of the life cycle. We use a balanced panel from the NLSY, where we again take three year averages. The correlation between income level at different stages of the life cycles decays with the time distance, but is always positive. This holds true also when we take residuals, eliminating the effects of schooling and experience. It is only when we eliminate the fixed effect of each person and consider the residual variation around the individual means (over all time periods), that we find negative correlations between early and late residuals. Moreover, these correlations become more negative as the time distance increases, providing a clear evidence for compensation, whereby an early wage that is below the individual mean is associated with a late wage that is above the individual mean.

Thus, to identify compensation one must eliminate the heterogeneity among individuals. Obviously, if individuals differ permanently in their earning capacity there will be a positive correlation between early and late wages within a cohort, because individuals who are above the mean are likely to remain above the mean, irrespective of investment. However, there may be more complex forms of heterogeneity that interact with experience. In particular, there may be "systematic heterogeneity", whereby individuals with higher initial earning capacity also tend to invest more.[22] As explained in Mincer (1974, ch. 2) such heterogeneity tends to raise the within cohort variance in earnings with the passage of time and may offset the effects of compensation.[23]

[22] Notice that the initial earnings understate the individual's initial earning capacity and the bias depends on the propensity to invest. Mincer proposed to estimate the initial earning capacity by the level of earnings at the "break even point", which he estimated to be about 10 years of work experience.

[23] Consider a sample of individuals with given level of schooling, s, where individuals differ by their initial stock of human capital and investment patterns on the job. The post schooling investment ratio of person i is $l_i(t-s) = a_i - b_i(t-s)$, where, by optimality, $a_i - b_i(T-s) = 0$. Using (31) in the text, post schooling earnings are then given by

Figure 8a displays estimated coefficients from regressions of the individual level effects on the individual fixed growth effects, where the level effects are evaluated at two different points in the life cycle. When the level effect is the usual individual fixed effect, i.e., the mean wage residual during the individual career, the relationships between level and growth are significantly positive in all schooling groups and stronger among the highly educated. In this case, we can interpret the level as a proxy for the individual initial earning *capacity* and can conclude that individuals with high "ability to learn" also have higher "ability to earn". However, if one evaluates the fixed effect as the intercept of the individual residual profile at the beginning of the worker career, the relation becomes negative. In this case, the level effect also reflects investment, and the negative correlation reflects the fact that individuals with a higher propensity to invest give up a larger proportion of their initial earning capacity.[24]

In Figure 8b we present the regression coefficients of the individual slope and level (evaluated at the mean) on AFQT, which is an observable measures of individual ability. We see that *both* the level and growth effects are positively correlated with AFQT, which supports our interpretation of the previous results whereby individuals with higher "ability to learn" also have higher "ability to earn". [25] However, we do not find strong

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$$\begin{aligned}\ln Y(s,t-s) &\cong \ln K_i(0) + rs + r\int_0^{t-s}(a_i - b_i x)dx - (a_i - b_i(t-s)) \\ &= \ln K_i(s) - a_i + (ra_i + b_i)(t-s) - \frac{rb_i}{2}(t-s)^2 \\ &= \ln K_i(s) + a_i f(\tau),\end{aligned}$$

where τ is experience and

$$f(\tau) = \tau(r + \frac{1}{T-s} - \frac{r}{2}\frac{1}{T-s}\tau) - 1$$

is an increasing function, with $f(\tau) = -1$ and $f(T-s) = \frac{r}{2}(T-s)$. Now, if individuals vary only in their investment propensity the variance of earnings is $f(\tau)^2 Var(a_i)$ which is initially declining and then rises with τ. However, if $\ln K_i(s)$ varies too and is positively correlated with a_i then a positive term that is rising in τ, $2f(\tau)Cov(a_i, \ln K_i(s))$, must be added to the variance.

[24] Baker (1997) and Haider (2001) report a *negative* correlation between individual slopes and intercepts that evaluates the individuals deviation from the mean at *zero* experience. In contrast, Lillard and Weiss (1979) report a *positive* correlation between the individual slopes and the mean residual (averaged over all experience levels). These findings are not inconsistent and indicate the presence of both heterogeneity and compensation.

[25] Although the impact of AFQT on the slope is significant only among the highly educated, it becomes

evidence that the differences in investment magnify the differences in initial human capital endowments in terms of the present value of lifetime wages. This is indicated by the fact that the *initial* residual levels associated with higher wage growth are sufficiently negative to render the total impact on the present value of life time earnings to be rather small. [26]

4.3 Labor mobility and wage growth

Search theory not only competes with the theory of human capital but also complements it. The challenge is to understand the interactions between these two processes. Mincer and Jovanovic (1981) provide the first attempt to integrate these processes. They describe the potential impact of search as follows "Perhaps the best way to summarize the life cycle relation between wages and mobility is to recognize that initial (first decade ?) job search has two major purposes: to gain experience, wages, and skills by moving across firms; and to find sooner or later a suitable job in which one can settle and grow for along time. The life cycle decline in mobility is, in part, evidence of successful initial mobility, an interpretation which is corroborated by corresponding life cycle growth in wages."

To identify the actual impacts of search and investment, they consider two different aspects of work experience, tenure in a given firm, T, and general work experience, X. They then examine two jointly determined outcomes; the wage, $w(T, X)$, and the separation rate, $s(T, x)$. The latent variables in this system are the investments in general and firm specific training and in search. They use panel date and run regressions of wages and separations on tenure in the current job and potential work experience. To partially correct for the endogeneity of tenure, they add the number of past moves across firms as an indicator of the individual "propensity to move".

The main results are:

- Tenure has a separate positive and declining effect on wages, which is as important as the effect of total work experience. The tenure effects are much more important

significantly positive when we control for the initial level of the individual intercept. This suggests that the propensity to invest is related not only to ability but also to taste parameters, such as discounting.

[26] Rubinstein and Tsiddon (2004) use parents education as a proxy for ability and show that within education workers with more educated parents have higher wage levels and higher wage growth. Huggett et al (2002) show how a positive correlation between learning ability and earning ability can explain the rising variance and skewnwss of the earnings distribution within cohorts.

for young workers.

- Experience and tenure have negative impacts on separation, but the negative effect of tenure is much larger.
- Past moves have positive effects on separation, suggesting heterogeneity, but have only weak negative effects on the wage.
- Accounting for both experience and tenure, education has a negative effect on mobility.
- The positive impact of schooling on wages is unaffected by the inclusion of mobility variables such as tenure and past moves, but the experience effects among young men are reduced. This suggests that search mainly affects the size and interpretation of the experience effect but has little bearing on the returns from schooling.

Subsequent work in this area tried to address the potential biases that arise in the estimation of tenure effect and the impact of occupational moves. Potential biases arise from a variety of selection issues (who are the movers and stayers) and in part from the assumed imperfect information and specific investments that create relational rents and give scope to bargaining and other noncompetitive behavior. There is a rather broad range of estimates for the size of the tenure effects ranging from of approximately 7 to 35 percent per ten years of seniority (see Topel 1991, and Altonji and Williams (1996, 1998). Data on wage loss following plan closure also indicate that the loss of wages is higher for workers with more tenure, yielding a tenure effect of about 14 percent (see Farber 1999). A positive tenure effect is often attributed to firm specific human capital that is shared if the worker stays with the firm and lost if he changes employers, but it is not entirely clear why and how wage growth should respond to the accumulation of such specific capital.

A simple indication for the complexity of the relationship between wage growth and mobility is that on the average wage growth is associated with mobility, yet when we look at individual data movers have lower wage growth than stayers (see Figure 9). There are several possible explanations for this discrepancy: (1) If moving is a personal attribute, then firms are less likely to invest in prospective movers. (2) If jobs differ by the quality of match, successful and more productive matches are less likely to break. (3) If the firm is subject to exogenous shocks, the better workers are selected to stay with the firm. (4) If the continuation of the match is jointly profitable, the sharing of the gains will depend on outside options. Therefore, the *threat* of mobility rather than realized mobility can cause wage growth, and much of this is captured by the stayers. This threat is reflected by the *average* trends in mobility within a cohort.

Topel and Ward (1992), who examined the mobility and wage growth of young workers find that

- Wage growth within firms is quite high (7 percent on the average) and declines with both tenure and experience.
- Jobs that are going to last longer currently offer higher wage growth.
- Wage growth across jobs is substantial (20 percent on the average) and declines with tenure (at previous job) and experience.
- Higher wage growth at transition is obtained when one moves to a job with a higher prospective tenure.
- The exit rate from a given job declines with experience and the wage level. However, conditioned on the wage, the effect of experience on the rate of job exit is positive.

Together these findings provide a strong support to the importance of search at the early stage of the worker's career.

Changes in occupation and industry are also channels for wage growth. If one ranks occupations or industries by their average wage level at the "prime" ages, 36-45, then one can identify the direction of moves on this scale. We find that the occupational and industry changes of the less educated involve transition to higher paying occupations, while highly educated workers move across similar occupations and industries in terms of their mean wage.[27] In this respect, there is a substitution between learning in school and on the job (see figures 10a and 10b). In contrast, highly educated workers obtain higher wage growth when they change employers, suggesting that education and search

[27]To examine moves across industry and ocupation, we use the CPS monthly files from January 1998 to December 2002. Overall we have in our data 473 occupation categories and 236 industries.

are complements.[28] These results are consistent with the findings of Sicherman (1991) and Neal (1999) that educated workers are less likely to make a career change and they also experiment with fewer employers prior to making such a change. A partial explanation is that educated workers learn about their ability in school, which facilitates their career choice. However, educated workers may take more time in finding an employer that matches their skills. In fact, workers that report that their education exceeds the requirement of the job they hold, are on average more educated and less experienced.

One must bear in mind that wage gains or losses that one observes upon job changes are partial and possibly misleading indicators of the total value of such moves, because workers may anticipate consequences of the moves that occur later in their career. Studies of the mobility patterns over the business cycle, show that movers who obtained wage gains during booms often leave their new jobs and suffer a wage loss during recession (see Keane, Moffitt and Runkle, 1988; Barlevy, 2001). There is, however, no evidence that young movers accept jobs in low wage industries in exchange for future prospects in that industries (see Bils and McLaughlin, 2001).[29]

4.4 Learning

When employers and workers are uncertain about each other attributes, it takes time to reduce this uncertainty through experimentation. Such learning can occur within a firm or at the market at large.

As noted by Jovanovic 1979b, learning at the firm level can be inferred from the shape of the hazard of leaving the firm. In particular, if the workers and firms wish to learn on the quality of the match they would spend an initial period together, then the weak matches terminate and the good ones survive. As time passes, learning has been accomplished and the proportion of good matches rises, so that the hazard function is first rising and than declines. This is a rather sharp test because sorting model based on the survival of

[28] Holding constant experience and previous wage, movers in the NLSY with higher than college degree have the same wage growth as comparable stayers. Movers, with lower levels of schooling have a substantially lower wage growth than comparable stayers.

[29] Rubinstein and Tsiddon (2003) show that the affect of recessions on labor market outcomes varies by education and parents education categories. While educated workers who were born to better educated parents do not lose wages or jobs during recessions. Less educated workers lose both.

the fittest usually imply a declining hazard. The hazard function in Figure 11 displays such a pattern, showing that the probability of separation conditioned on the length of the employment relationship peaks at about 15 months. A similar finding is reported by Booth et al. (1999). In contrast, the data on young men used by Topel and Ward (1992) show a decline in the hazard by tenure (and experience) right from the beginning of the employment relationship. This of course does not exclude experimentation, but shows that sorting is more important.[30]

As noted by Gibbons and Farber (1996) and Atonji and Pierret (2001) public learning can be inferred from the impact on wages of individual attributes that are not directly observed by employers. As time passes and employers observe the worker's performance, they learn the worker's true productivity and the impact on wages of variables that are observed by the researcher but not by the firm, such as AFQT rises, while the impact on wages of early signals of ability such as schooling declines. These authors bring evidence that support this prediction, and further evidence is provided by Lange (2003) who concludes that employers learn quickly and, therefore, the signalling value of schooling is small. In Figures 12a to 12d, we show the marginal impact of AFQT on earning by experience within educational groups.[31] The graphs show an increase in the impact of AFQT at early years of experience, especially for High School graduates, suggesting that learning about ability is more relevant for this group.

Generally speaking, it is relatively difficult to tease the impact of learning from the data based on the impact of AFQT scores on wage growth[32] Apart from the problems of separating learning from investment, where AFQT as an indicator of ability can affect both the level and growth of wages, there are some deeper problems related to the connection between indicators of ability such as AFQT and wages. It has been shown by Willis and Rosen (1979) and Heckman, Hsee and Rubinstein (2003) that a two factor model that

[30]It is interesting to note that a rising hazard that peaks after 3 years was found in the context of divorce (see Weiss and Willis, 1997), suggesting perhaps that it is somewhat more difficult (or useful) to learn about the quality of marriage than the quality of the job.

[31]Workers are classified by their completed schooling as of age 30. In each education group, and for each year of experience, we run regression with AFQT scores and year effects as explanatory variables. The figures record the estimated coefficient on the AFQT score.

[32]Farber and Gibbons (1997) and Altonji and Pierret (2001) get sharper results using more heterogenous samples that include women and blacks.

recognizes the role of comparative advantage is more suitable to explain schooling choices and wage outcomes. Figures 8a and 8b show the strong positive interaction between schooling and AFQT, suggesting that ability is more important among workers that are more educated and thus placed at more "responsible" jobs. Alternatively, the interaction indicates that high ability individuals who do not acquire high level of schooling may be lacking noncognitive valuable traits. Similar issues arise in the context of the impact of AFQT on wage growth. It is quite possible that, conditioned on a low level of schooling, high AFQT shows that the worker is lacking in some other important dimension, such as motivation, and as time passes this is confirmed by performance, which may explain the low impact of AFQT among workers with some college, and the initially negative interaction between AFQT and experience for this group.

Learning must also influence the variance of wages within a cohort of workers, as workers are gradually sorted out. It is generally difficult to separate this force for increasing variability from the other considerations such as investment that we discussed above. In special cases, however, such a separation is possible. An interesting example is when workers move to a new labor market and can be followed based on their time spent in the new country. Eckstein and Weiss (2003) provide such analysis for the mass immigration from the former USSR to Israel. The issue there was that employers were uncertain about the quality schooling imported from the former USSR, a factor that affects all immigrants, and also of the quality of particular immigrants. The results show that initially all immigrants are treated alike and receive the same wage, irrespective of the experience and schooling brought from abroad. As time passes and the market learns about the immigrant's quality, the returns for imported skills rise and immigrants are gradually sorted by their observed attributes. At the same time, the residual variance reflecting unobserved attributes rises too. The outcome is that both the mean and variance of immigrant wages rise with time spent in the new country.

One issue of interest in learning models is whether individuals move from high risk to low risk occupations or vice-versa. It has been shown by Johnson (1978) and Miller (1984) that if workers are unsure about their ability to perform a job, or the quality of the worker-job match, young workers will willingly try out jobs where success is rare, which the more experienced have already quit having found out that they are unsuitable.

However, Jovanovic and Nyarko (1997) has shown that if what one learns from experience is how to perform the job, rather than about own ability or the quality of the job, then the direction of mobility is reversed and the young would first try the safe jobs, as long as experience is sufficiently transferable, because it is better to learn in jobs where mistakes are less costly. In figures 13a and 13b, we show the standard deviations at the occupations and industries at which individuals are employed at different stages of the life cycle. We see that these measures of risk are stable under occupational moves but *decline* as the worker changes industries. Suggesting that some learning is done concerning skills that are transferable across industries.

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5 Data Appendix: Data and Sample-Inclusion Criteria

5.1 The CPS individual-level repeated cross-section data set

These data come from a series of 39 consecutive March Current Population Surveys (hereafter: March CPS) for survey years 1964 to 2002. These data provides information on employment and wages in the preceding calendar year. Thus, the annual data - from the CPS demographic supplement - cover the period of 1963 to 2001. The individual-level repeated cross-section data set is restricted to men with zero (0) to forty (40) years of potential experience, where potential experience is defined as age-6-school years completed.

The main advantage of the March CPS is that micro data samples are available from the mid-1960s onward. On the minus side, the March CPS has no "point-in-time" measure of the wage rate. Wage rates, in many of studies using the March CPS data, are often constructed by dividing total annual earnings in the previous year by an estimate of weeks or hours of work. The task is made harder by the absence of information on usual hours of work per week prior to 1976. For these reasons we further restrict this sample to include – Full-Time-Full-Year workers (hereafter: FTFY) - full-time workers (35+ hours per week) who report working at least 51 weeks of the previous year.

The wage measure in the March CPS data set that we use throughout this paper is the average weekly wage computed as total annual earnings divided by total weeks worked. Top coding had been changed over the years. Until the 1995 survey the imputed wages/earnings of top-code workers were set to be equal the cutoff point. Since 1996, the top-coded group imputed wages are based on the conditional mean earnings of these workers conditional on characteristics such as race, gender and region of residence. In order to deal with the top-coding issue we employ a unified rule for all years. We calculate for each worker his rank/position on the wage distribution on the year observed and exclude those coming from either the lower 2 percent or the top 2 percent each year.

Observations are divided by school completion, when interviewed, into five sub-groups: (i) high school dropouts – less than twelve grades, (ii) high school graduates (iii) some college completed, (iv) college graduates with 16 years of schooling (BA) and (v) college graduates with advanced/professional education (MBA, Ph.D.)

5.2 The CPS Monthly longitudinally matched data

The vast majority of empirical analyses of the Current Population Surveys either use a single cross-section data point, or a series of consecutive CPS surveys, treating them as a series of repeated cross-sections. The CPS data have, in fact, a longitudinal component. In this paper we take advantage of the CPS basic monthly files - a probability sample of housing units in the US - to construct a panel data.

The CPS divides housing units into eight representative subsamples called "rotation groups". Each unit is interviewed for four consecutive months, followed by two quarter of break, and then by another four monthly interviews. Overall, each unit is being interviewed for 8 times over 16 months. The CPS monthly files we employ - from the years 1998 to 2002 - include a set of identifier variables which enable us to follow the same housing unit over 16 months. If there is no change in the composition of individuals residing in a particular unit, we have a panel of individuals. Yet, since people do switch locations, it might be the case that the same id number was being shared by two (or more) individuals over time. Therefore, we follow Madrian and Lefgren (1999) procedure, whereby individuals are identified in our panel data not only by their id number but also by matching a set of time-invariant characteristics. This way we are quite confident that we do not combine different persons into one artificial observation.

Weekly wage data is collected only during the fourth and the eighth interview - among what is known as the "outgoing rotation groups." Data on schooling, employment, occupations and industries, is available for the entire sample. For the March CPS monthly data we constructed two major data sets sub-divided as follows:

1. Cross section data sets using white male data:
    (a) All white male.
    (b) Only workers using all interviews.
    (c) Only workers with wage data. In this sample we exclude those who
        i. earn less than 4$ (2000 CPI adjusted) or more than 2000$ per hour.

ii. part-time workers.

iii. enrolled in school.

iv. worked less than 35 weeks last year.

2. Panel data sets using white male data:

   (a) All white male with more than one observation.

   (b) Only workers using all interviews with more than one observation.

   (c) Individuals with 2 wage data points, both satisfying the criteria specified in (1c).

We use the cross-sections for studying the time patterns of the mean expected wages by occupation and industry. We use the panel data to study mainly individual (i) transitions, (ii) wage change.

5.3 The Panel Study of Income Dynamics

The Panel Study of Income Dynamics (PSID) is a national longitudinal survey. Since the PSID is well known, we shell be brief. The PSID is a panel data set on members of the same families since 1968.[33] As far as we know, the PSID is the only American panel data which follows more then one cohort from the late 1960s and includes information on education, labor market outcomes and family background. We include only white men, born in the USA with non-missing data on schooling.

When we discuss wage data we exclude:

1. Individuals with hourly wage of less than 4$ (adjusted for 2000 CPI) or more than 2000$.

2. Workers who worked less than 35 weeks or less than 1000 annual hours.

   In the study of wage levels we restrict the sample according (1) and (2). When using wage differences we restrict the sample according (1) and (2) in both consecutive years.

[33] For more detailed information about the PSID look at http://www.isr.umich.edu/src/psid/.

Observations are divided by school completion into five sub-groups - similar to our definitions using the CPS data.

6 National Longitudinal Survey of Youth (NLSY)

The National Longitudinal Survey of Youth (NLSY) is a randomly chosen sample of U.S. youths and a supplemental sample that includes economically disadvantaged young people. The data that we use are from the 1979-2000 waves of the . Interviewees have been surveyed annually since the initial wave of the NLSY survey in 1979, when sample members all ranged between age 14 and 21.

Our sample is restricted to white males who were in the random sample. We limit ourselves to observations with complete data on (i) schooling, (ii) Armed Forces Qualifying Test (AFQT), (iii) parents' education and (iv) year of birth. We exclude individuals who are currently enrolled in school.

We construct two major subsets:

1. All white male.
2. Workers:
   (a) All workers
   (b) Workers who worked at least 35 weeks and more than 1000 annual hours. We restrict this sub-sample to include only those with hourly wage higher than 4$ (2000 CPI adjusted) and less than 2000$.

When using wage differences, we include only observations for whom 2(b) holds for both consecutive years.

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Source: CPS, 1998-2002, NLSY 1979-2000, PSID, 1969-1997.

Note: The numbers in the "diff" columns are cell means and standard deviations. The numbers in the "level" columns are the growth rates implied by the estimated coefficients of the experience and experience squared terms in Mincer's wage equation.

Table 2a: Annual Growth Rates of Individual Wages and Proportions for Gainers and Losers, by Education and Experience

Source CPS 1998-2002

Table 2b: Annual Growth Rates of Individual Wages and Proportions for Gainers and Losers, by Experience

Source: PSID 1969-1997, NLSY 1979-2000.

Note: Gainers (losers) had a nominal wage increase (decrease).

Table 3a: Correlations of Wage Levels (three year averages) at different Stages of the Life-cycle

Source: : NLSY, 1979-2000.

Table 3b: Correlations of Residuals in Mincer's Wage Function (three year averages) at different Stages of the Life-cycle

Source: NLSY, 1979-2000.

Table 3c: Correlations of Residuals in Mincer's Wage Function with Fixed Effects (three year averages) at different Stages of the Life-cycle

Source: NLSY, 1979-2000.

Figure 1a:
The Mean Weekly Wages (in logs) by Education and (potential) Experience,
White Males, Full-Time Full-Year Workers (52 weeks),
CPS, March Supplement, 1964-2002

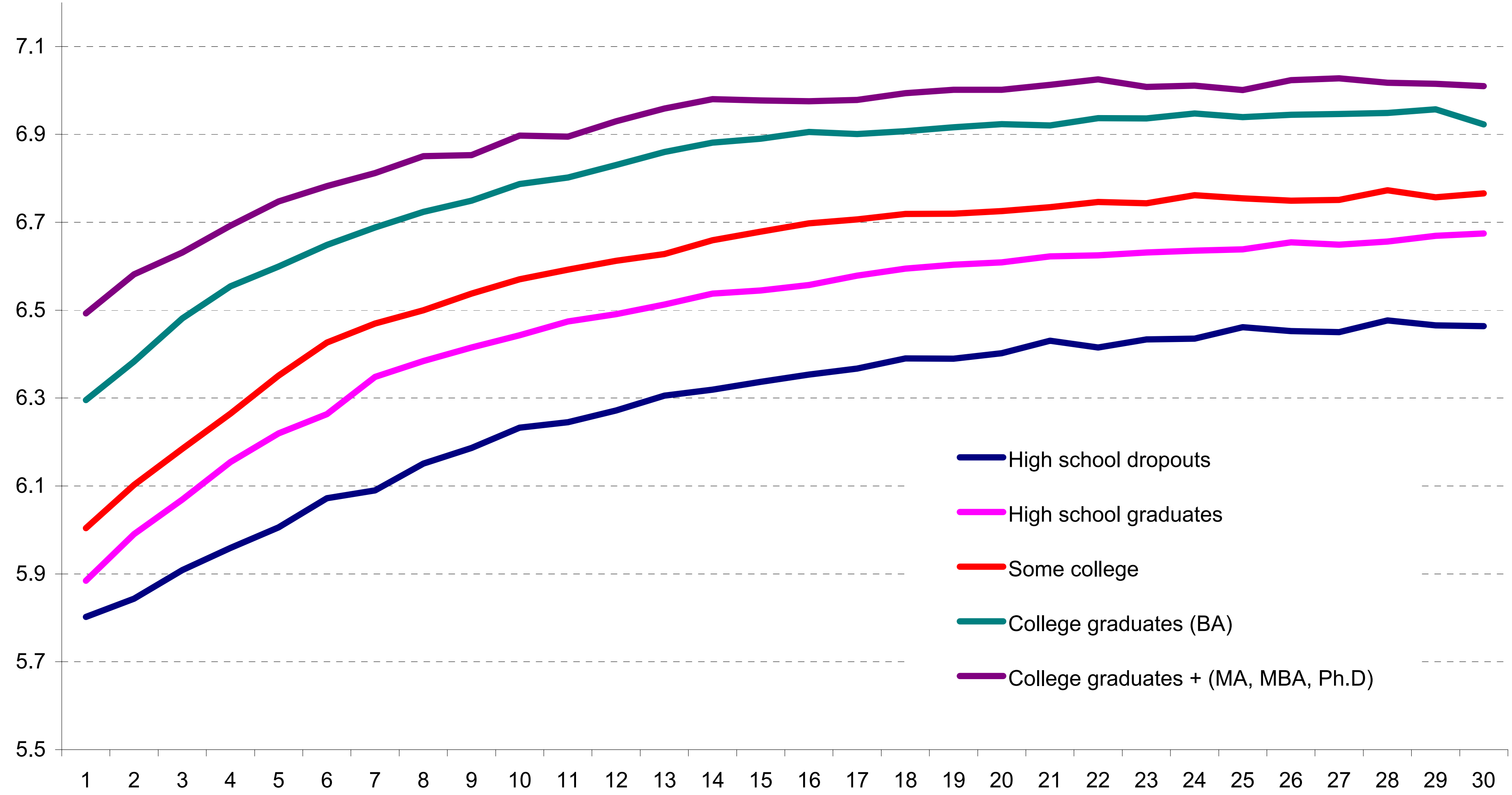


Figure 1b:
The Fraction of Full-Time Full-Year Workers by Education and (potential) Experience among Employed
White Males,
CPS, March Supplement, 1964-2002

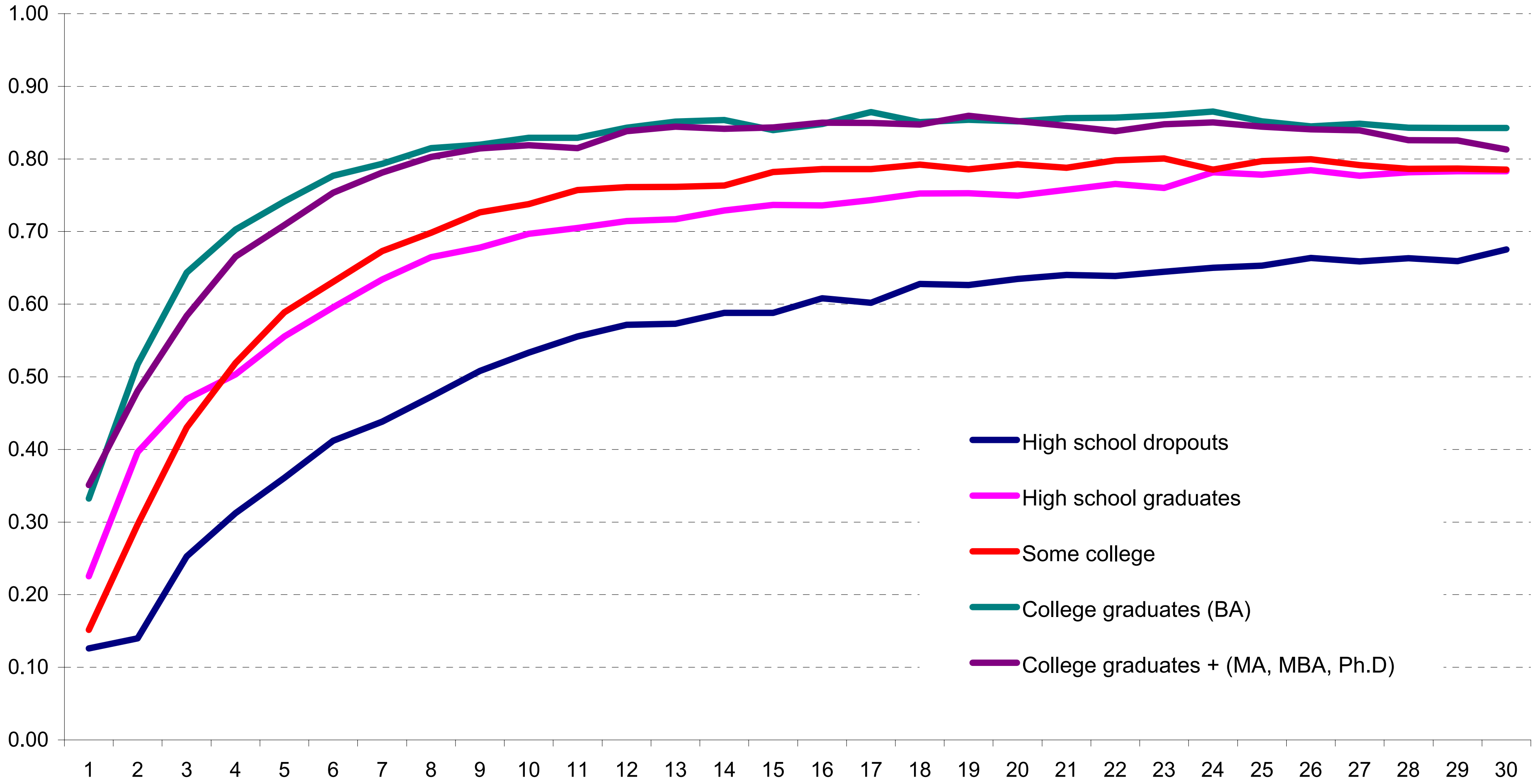


Figure 1c:
Average Weekly Hours of Employed White Males by Education and (potential) Experience, CPS, March Supplement, 1964-2002

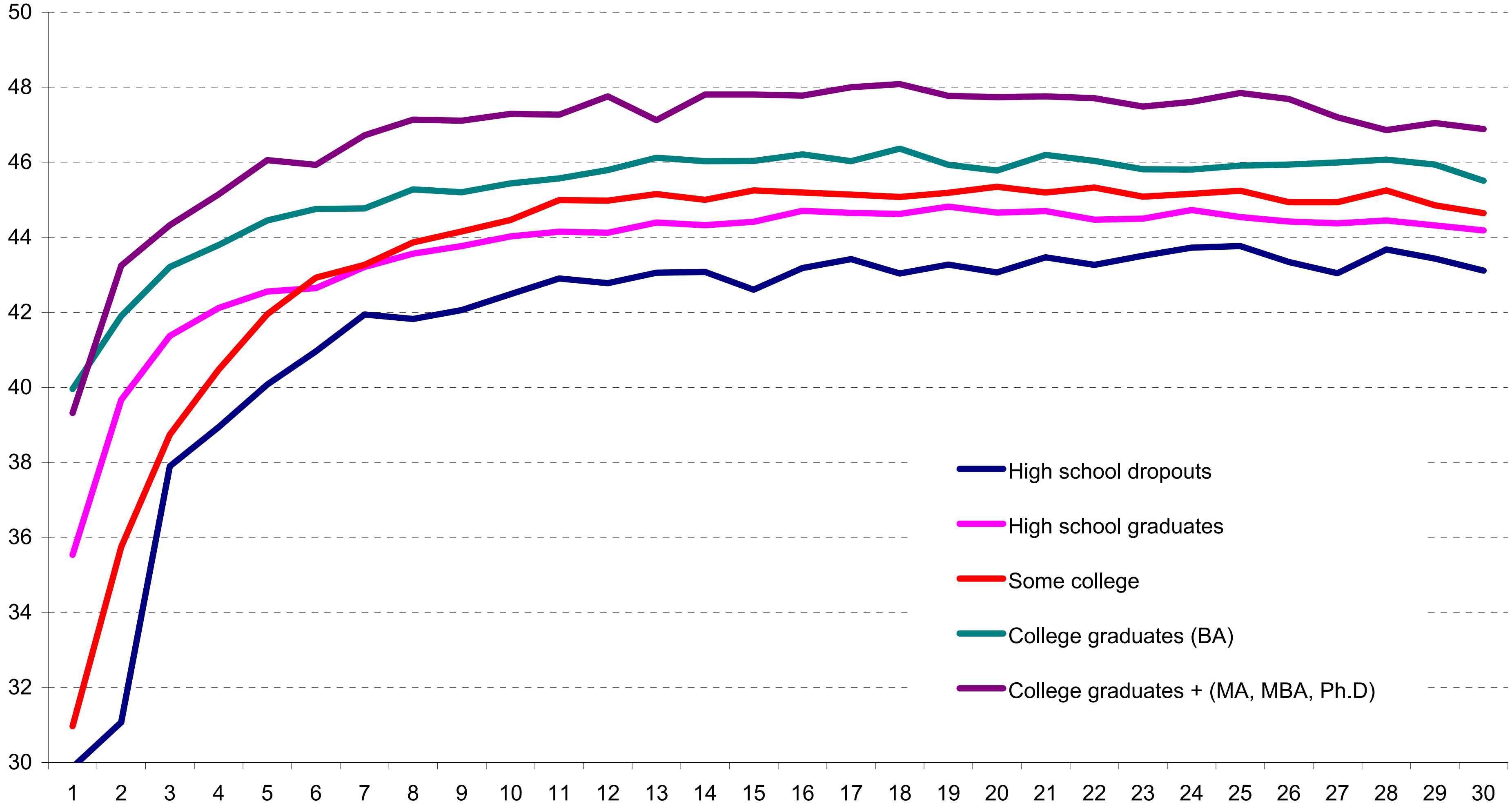


Figure 2a:
Cohort and Cross Section Wage Profiles for Highs School Graduates Born in 1951-55,
White Males, CPS, March Supplement, 1964-2002

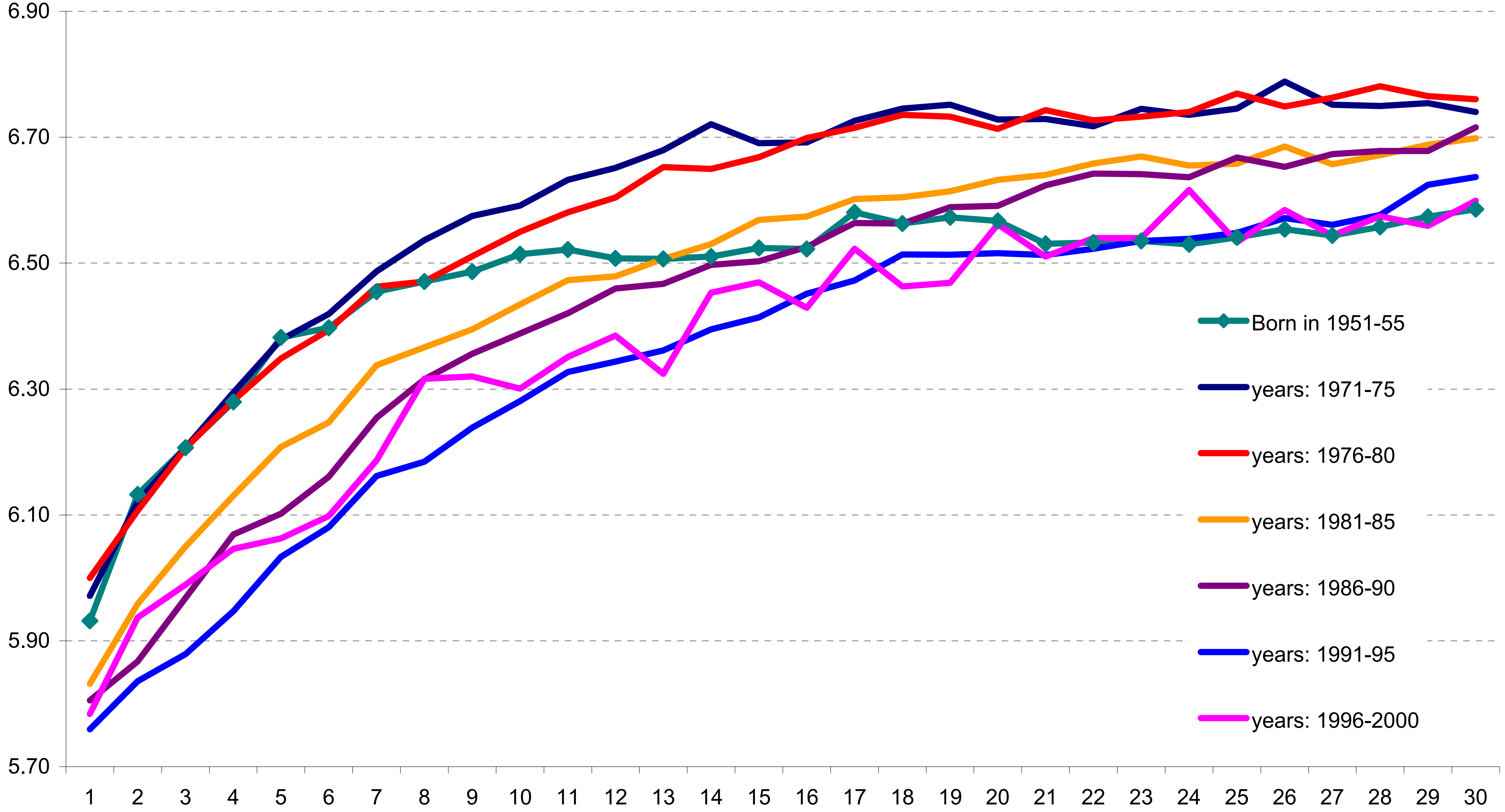


Figure 2b:
Cohort and Cross Section Wage Profiles for College Graduates Born in 1946-50, White Males, CPS, March Supplement, 1964-2002

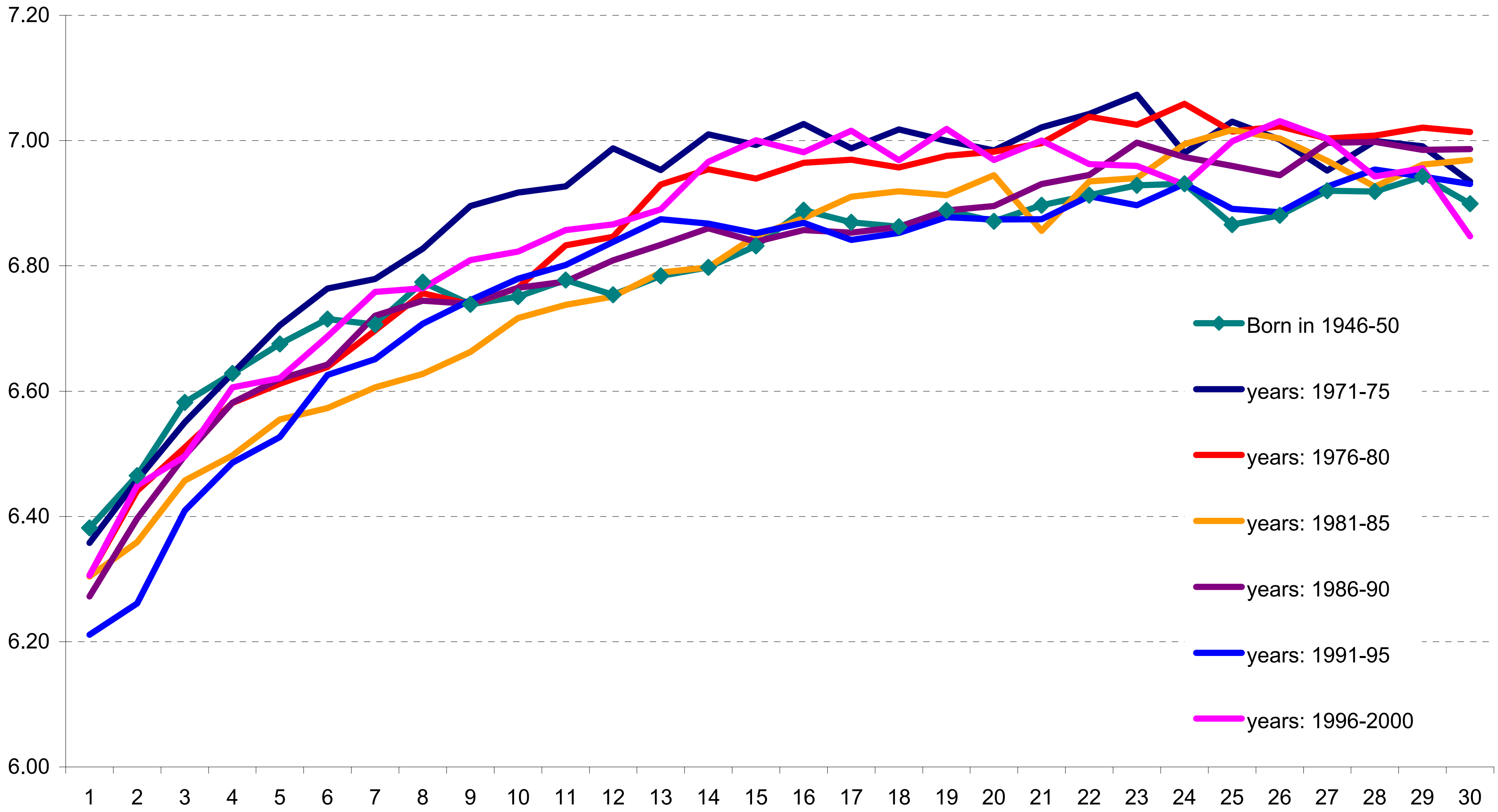


Figure 3a:
The Mean Hourly Wages (in logs) by Education and (potential) Experience
White Males Working at least 1000 Annual Hours*,
PSID, 1968 to 1997

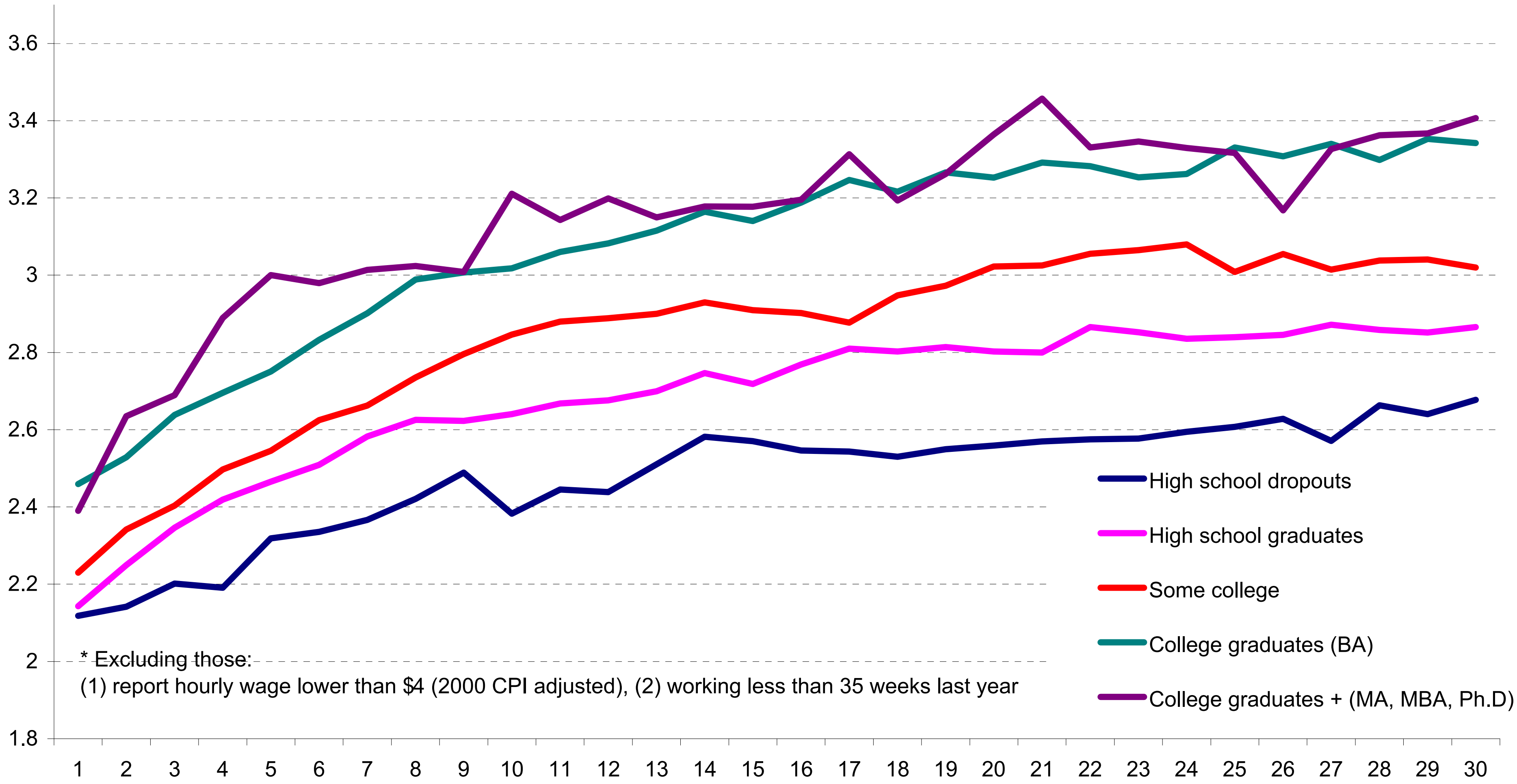


Figure 3b:
The Mean Hourly Wages (in logs) by Education and (potential) Experience
USA, White Males Working at least 1000 Annual Hours*,
NLSY, 1979 to 2000

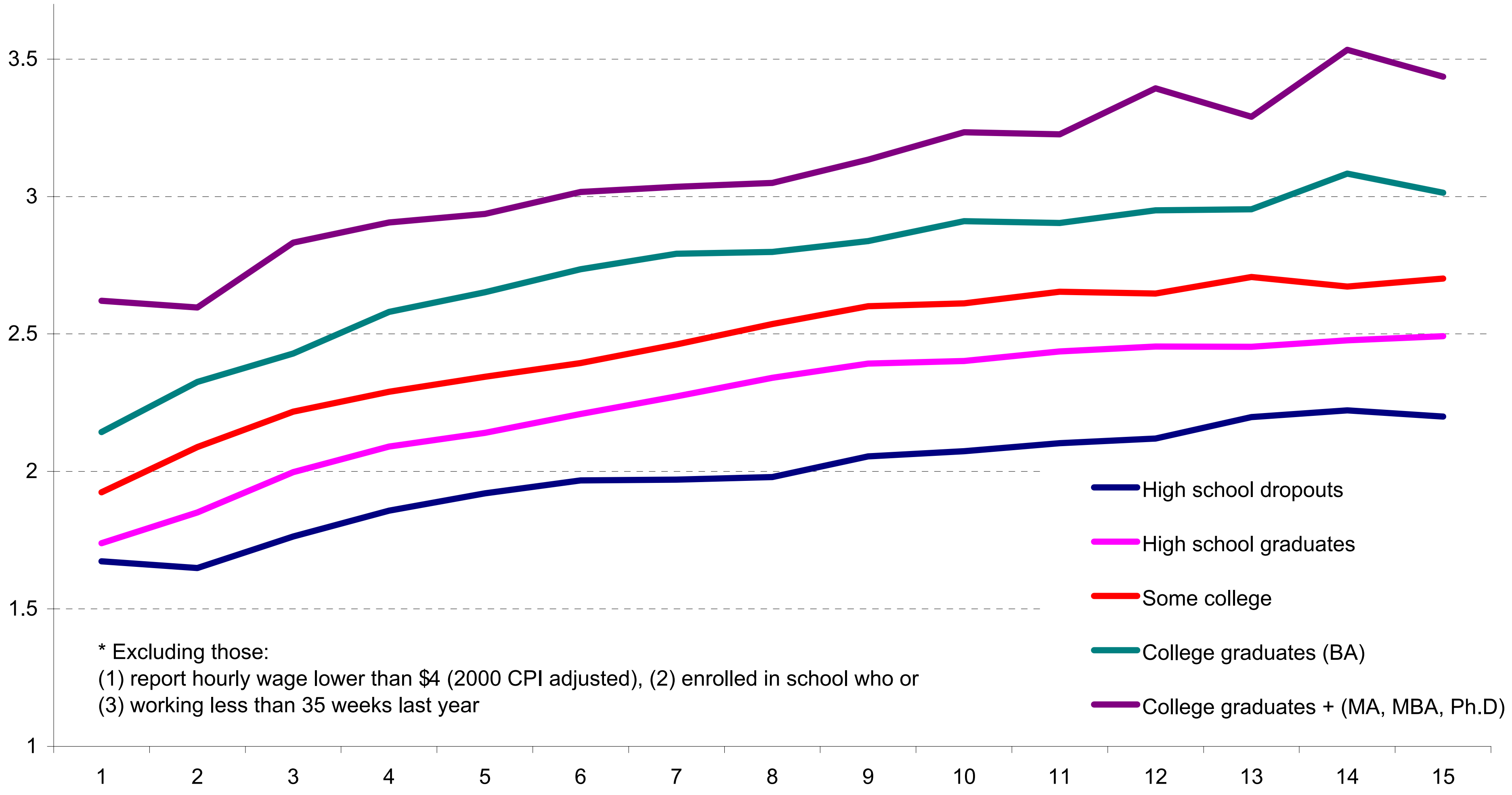


Figure 4a:
The Proportion of Workers who Change Occupation (within a month) by Education and Experience, White Males, Full-Time Workers, CPS Monthly Data, 1998-2002

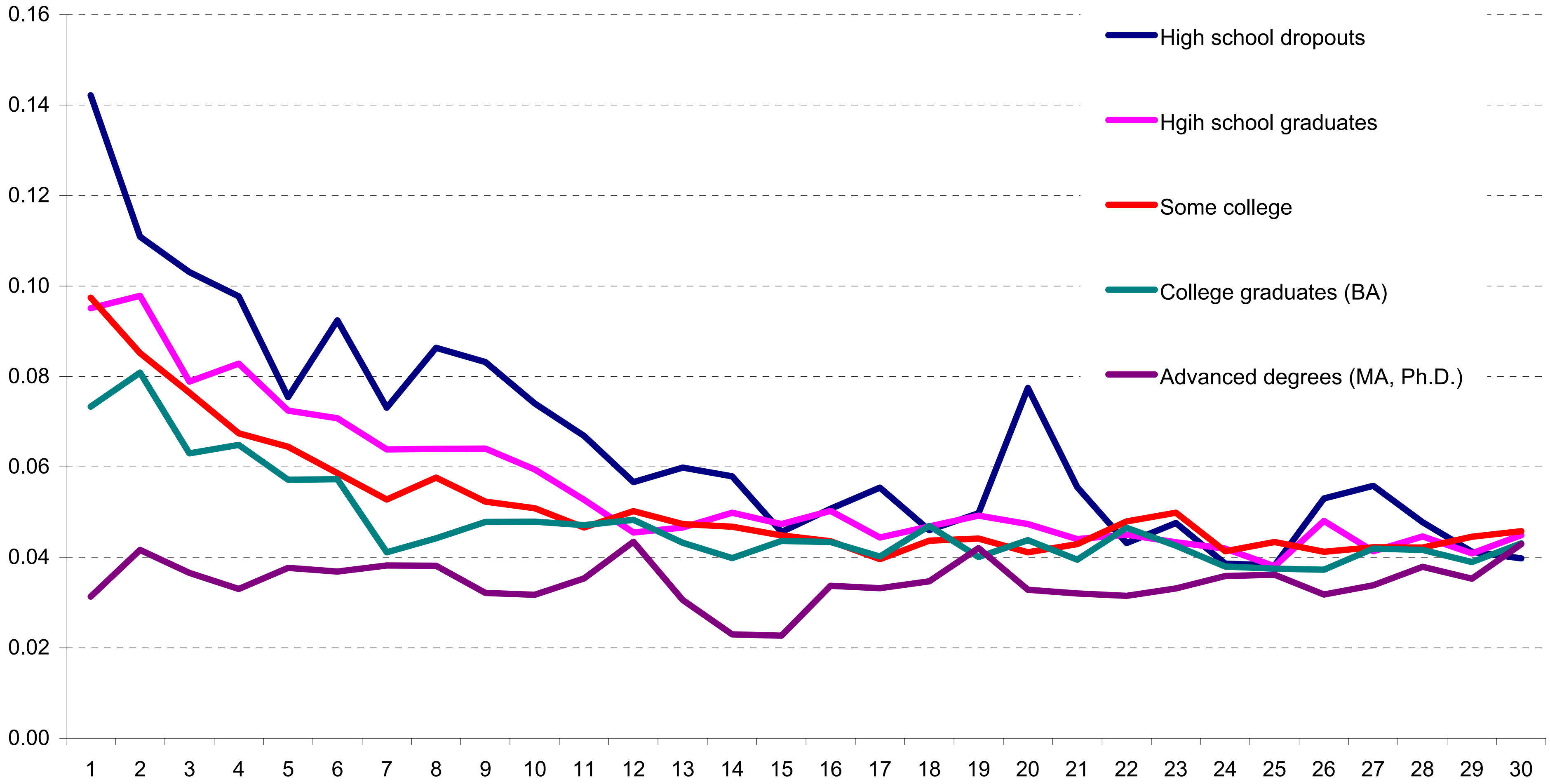
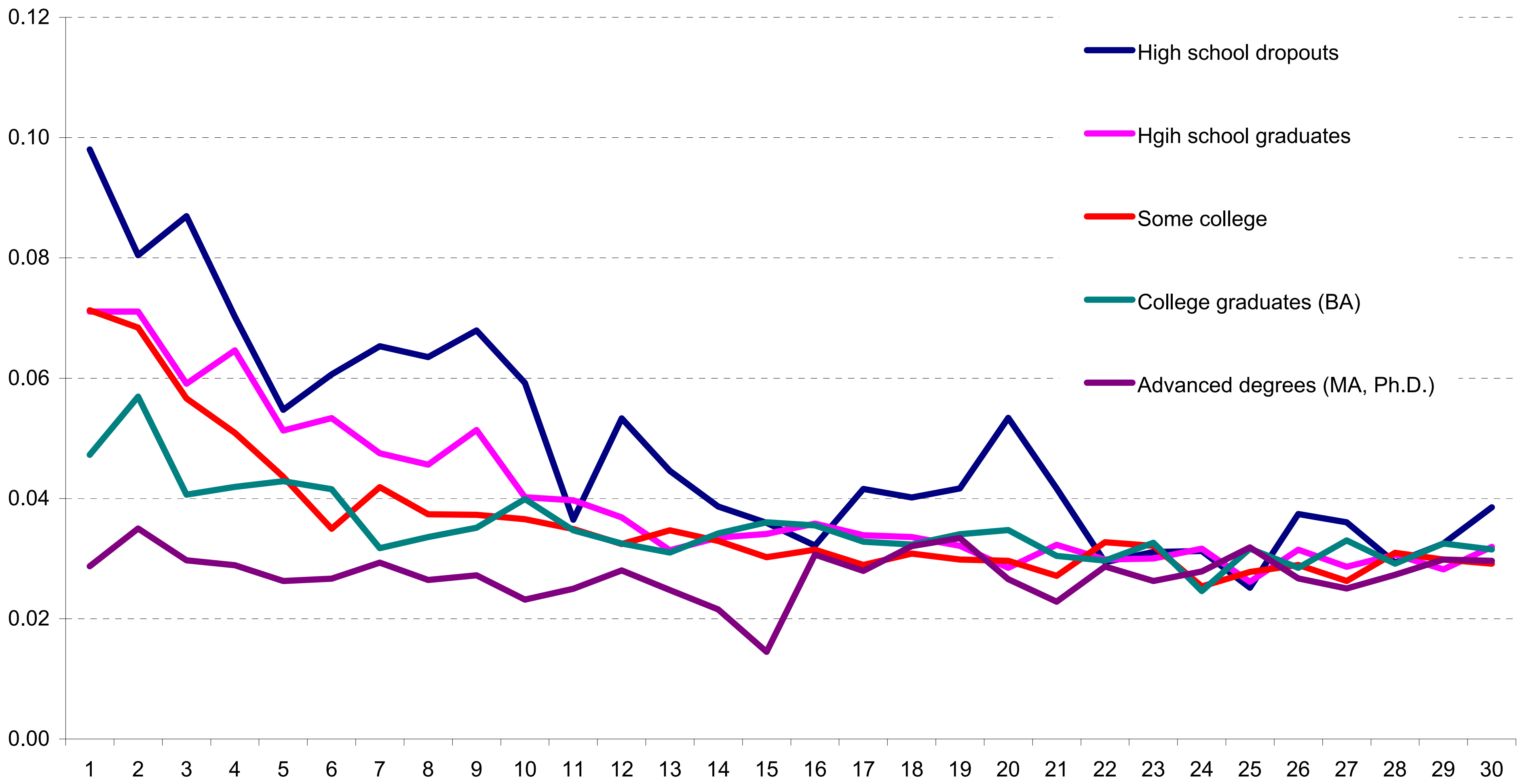


Figure 4b:
The Proportion of Workers who Change Industry (within a month) by Education and Experience,
White Males, Full-Time Workers,
CPS Monthly Data, 1998-2002.



Figures 4c:
The Proportion of Workers who Change Employers (within a year) by Education and Experience, White Males,
NLSY, 1979-2000

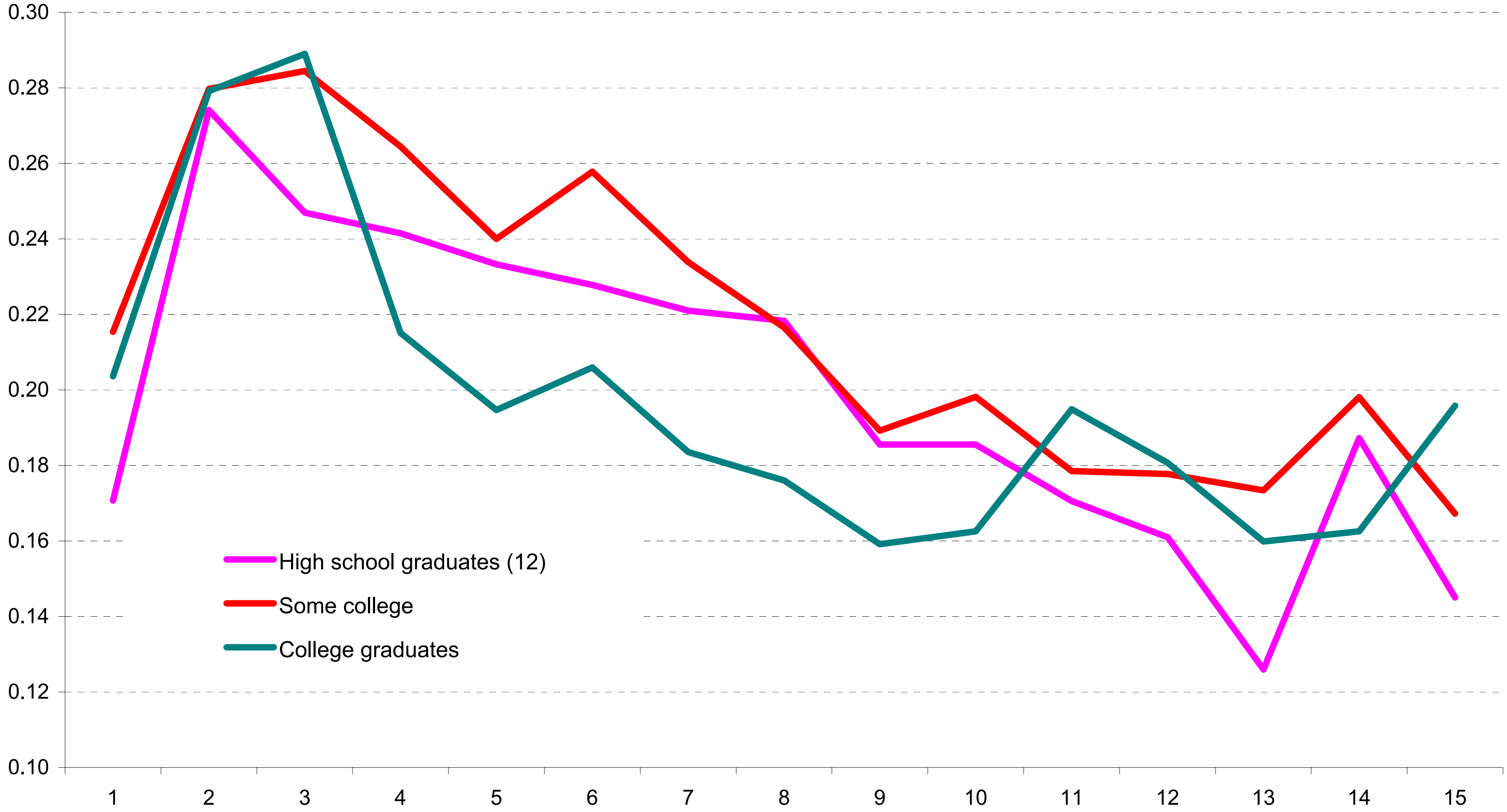


Figure 5a:
The Gap Between White Male Workers coming from the 90'th and 10's Perecntiles of the Residual Wage Distribution for the Periods 1964-1979 and 1980-2002
High School Dropouts
March CPS Supplements, 1964 to 2002*

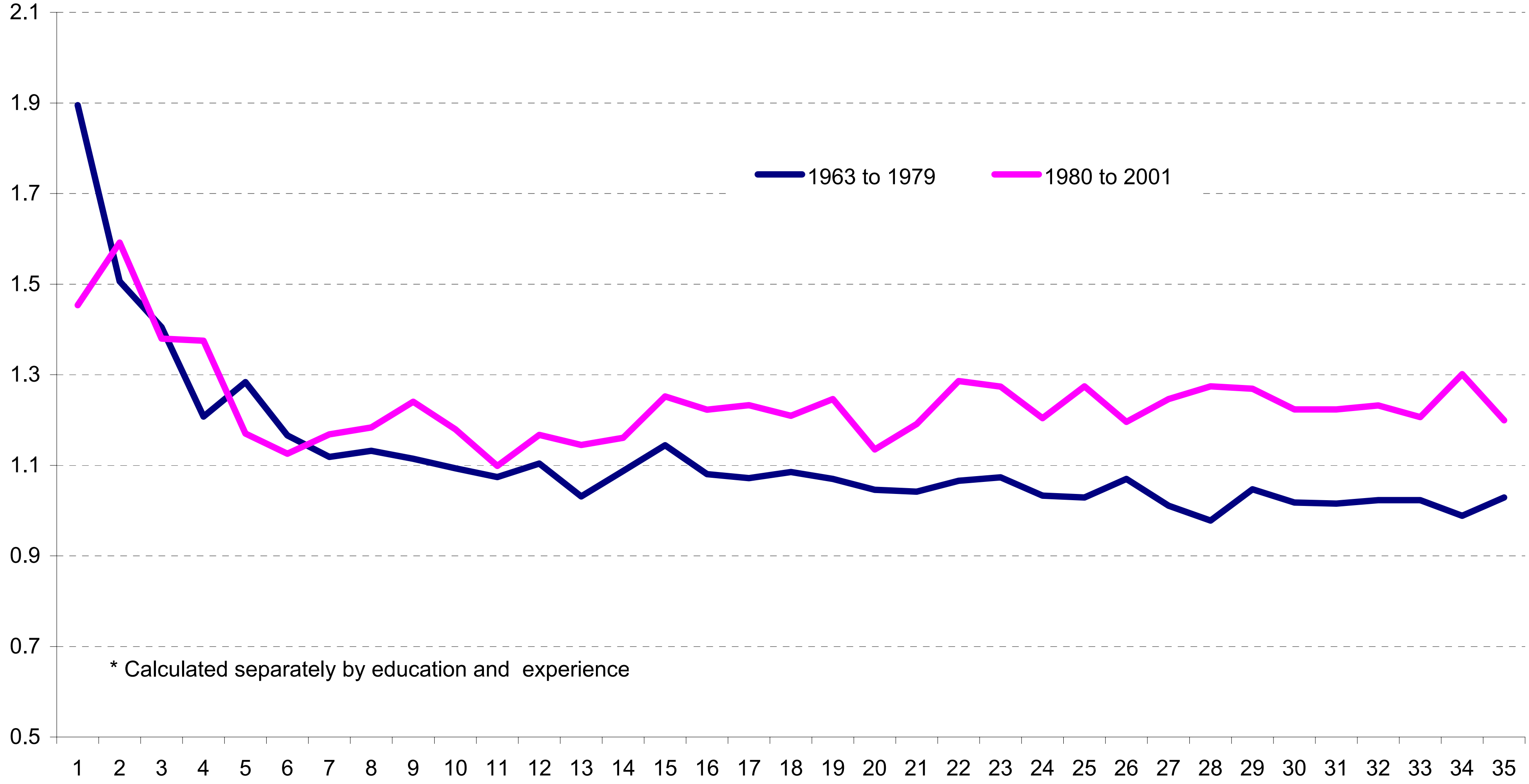


Figure 5b:
The Gap Between White Male Workers coming from the 90'th and 10's Perecntiles of the Residual Wage Distribution for the Periods 1964-1979 and 1980-2002
High School Graduates
March CPS Supplements, 1964 to 2002*

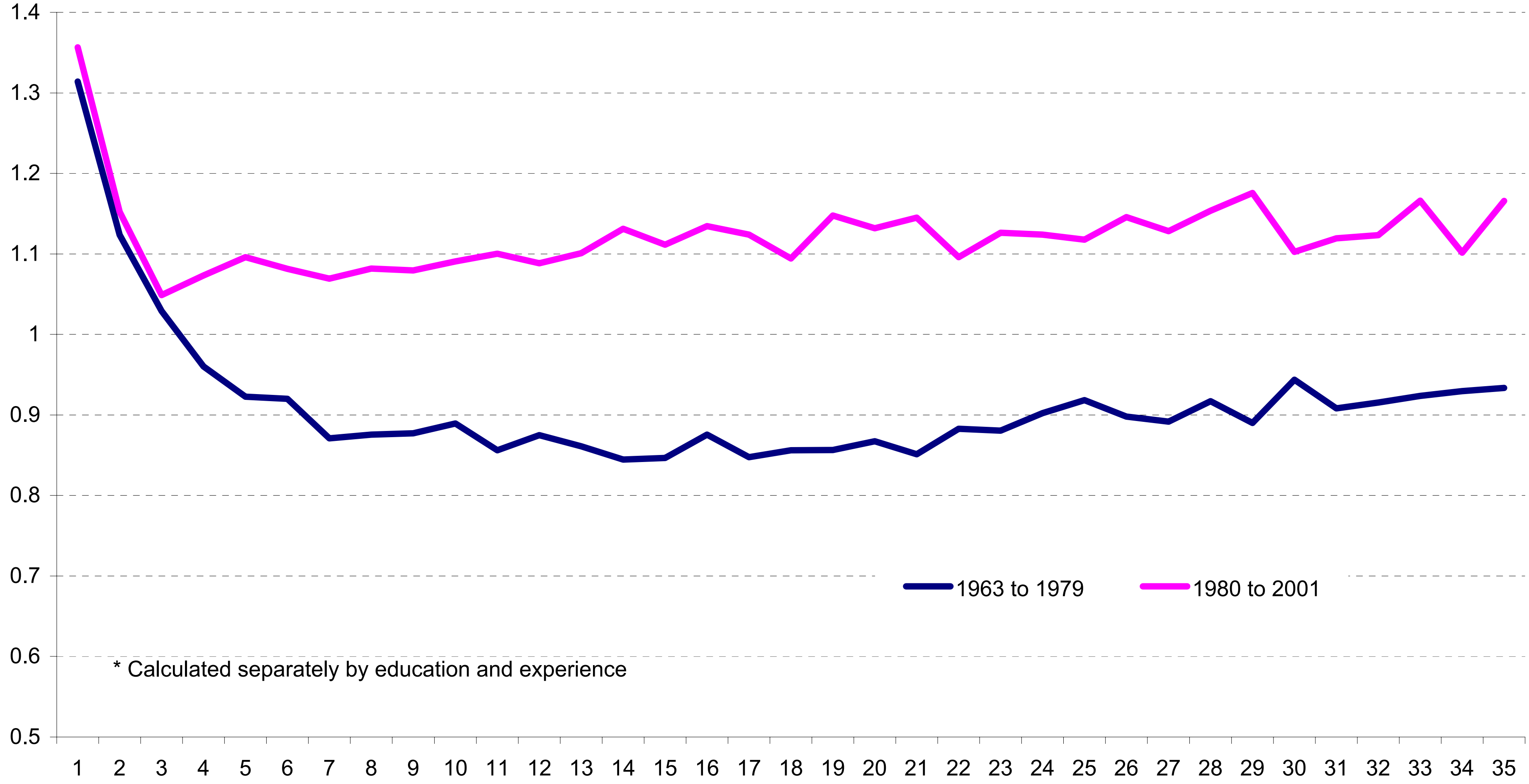


Figure 5c:
The Gap Between White Male Workers coming from the 90'th and 10's Perecntiles of the Residual Wage Distribution for the Periods 1964-1979 and 1980-2002
Some College
March CPS Supplements, 1964 to 2002*

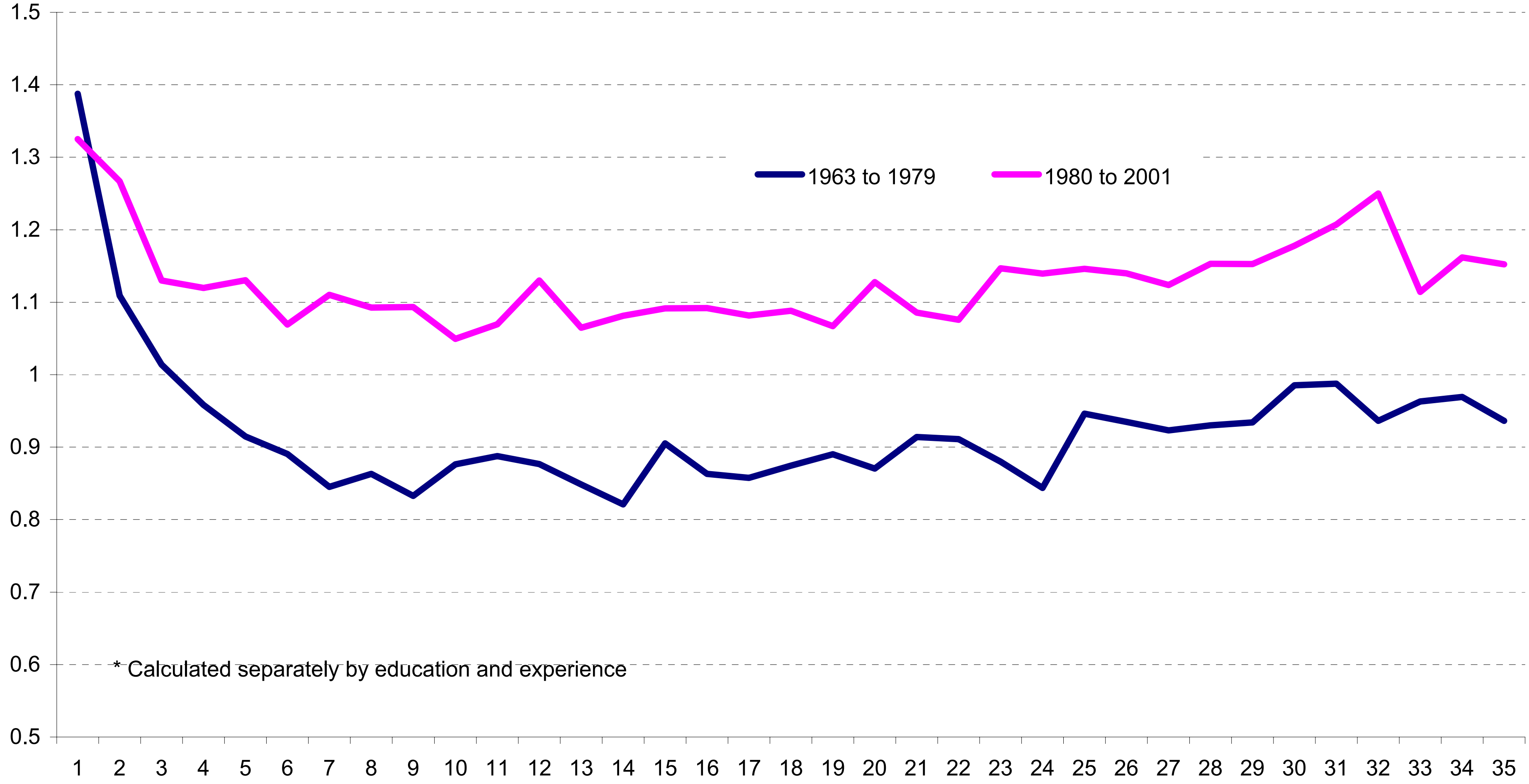


Figure 5d:
The Gap Between White Male Workers coming from the 90'th and 10's Perecntiles of the Residual Wage Distribution for the Periods 1964-1979 and 1980-2002
College Graduates (excluding advanced degrees)
March CPS Supplements, 1964 to 2002*

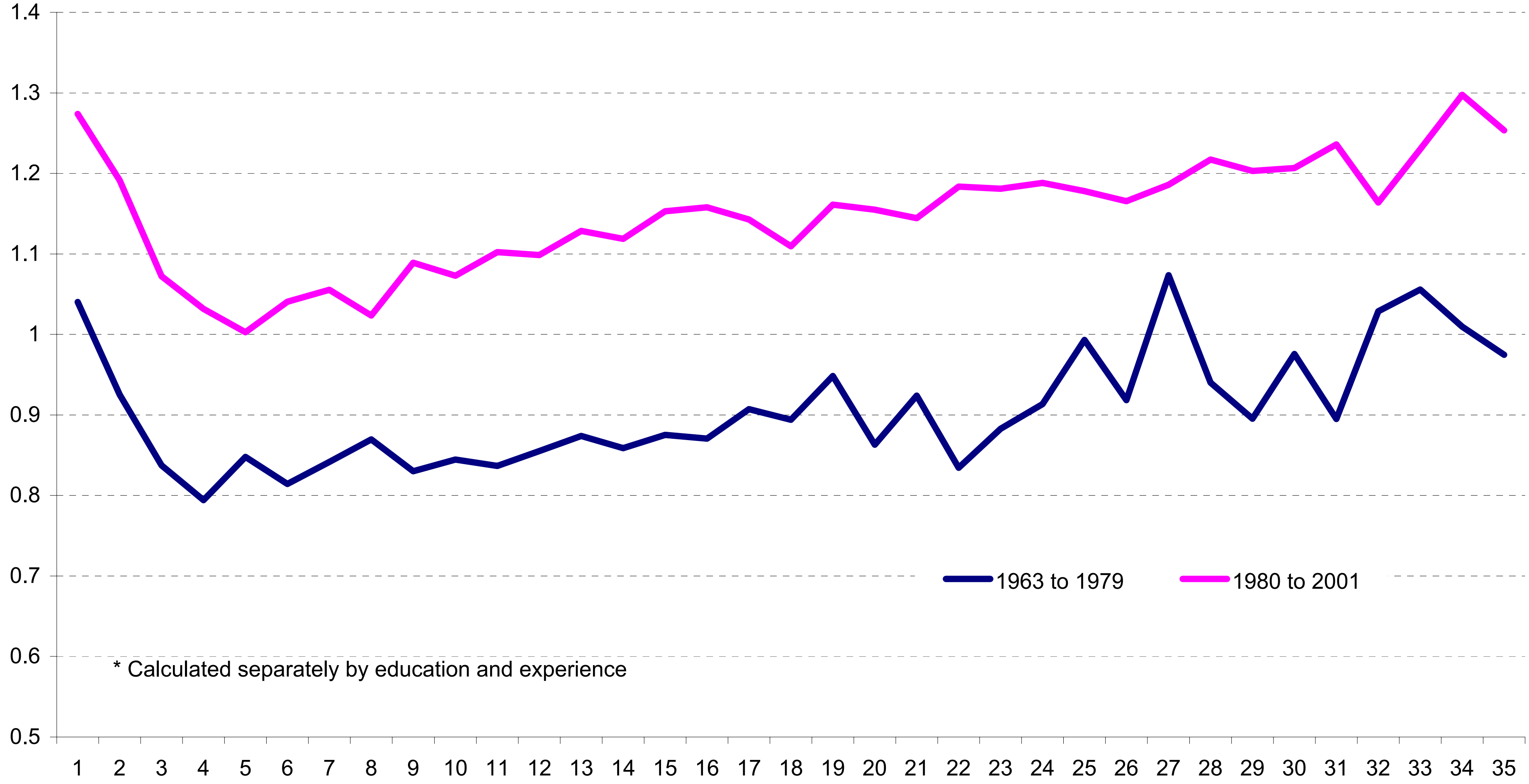


Figure 5e:
The Gap Between White Male Workers coming from the 90'th and 10's Perecntiles of the Residual Wage Distribution for the Periods 1964-1979 and 1980-2002
Advanced Degrees (MA, Ph.D.)
March CPS Supplements, 1964 to 2002*

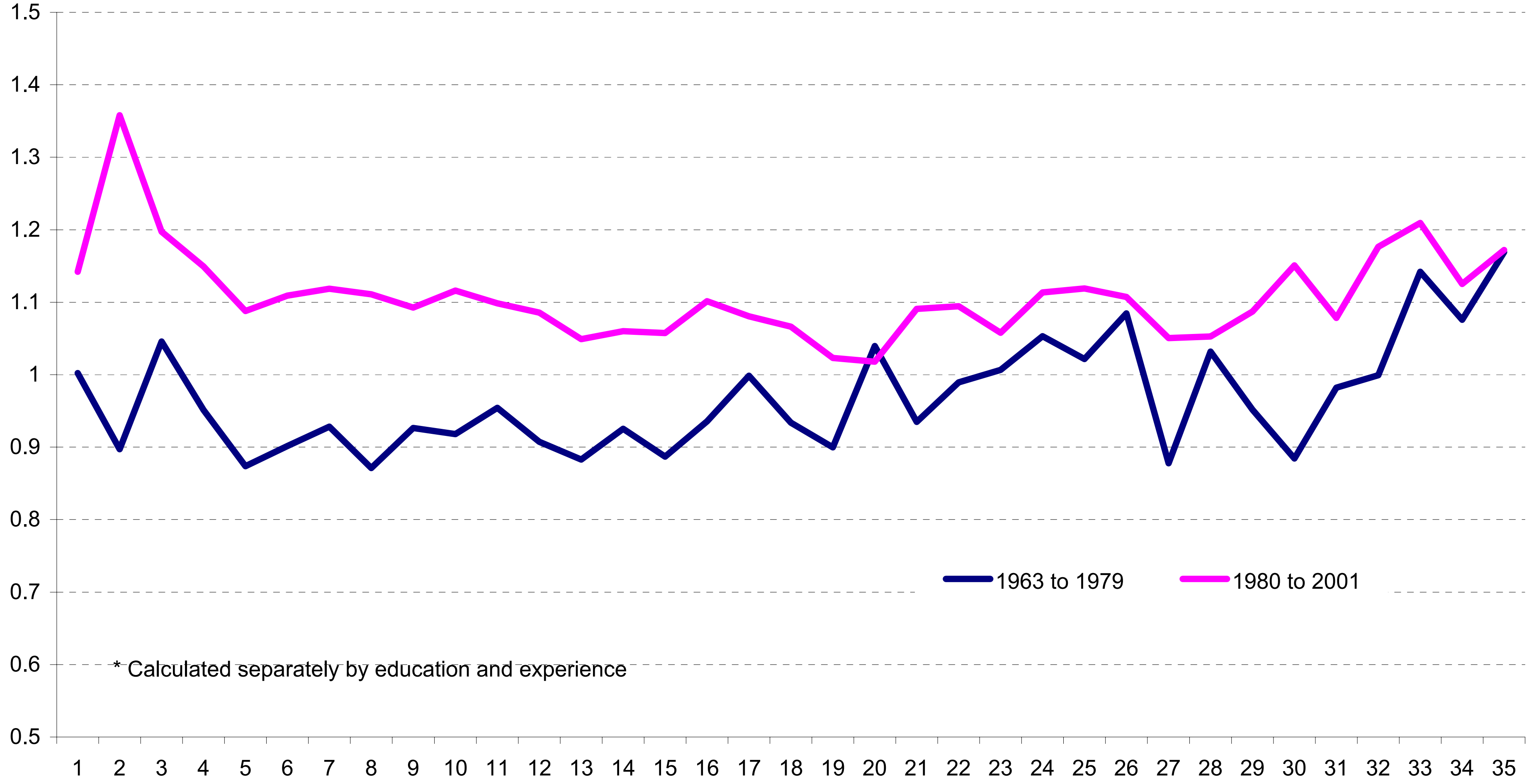


Figure 6a:
The Standard Deviation the Residuals in Mincer's Wage Equation by Experience
with and without Fixed-Effects
White Males*
PSID, 1968-1997

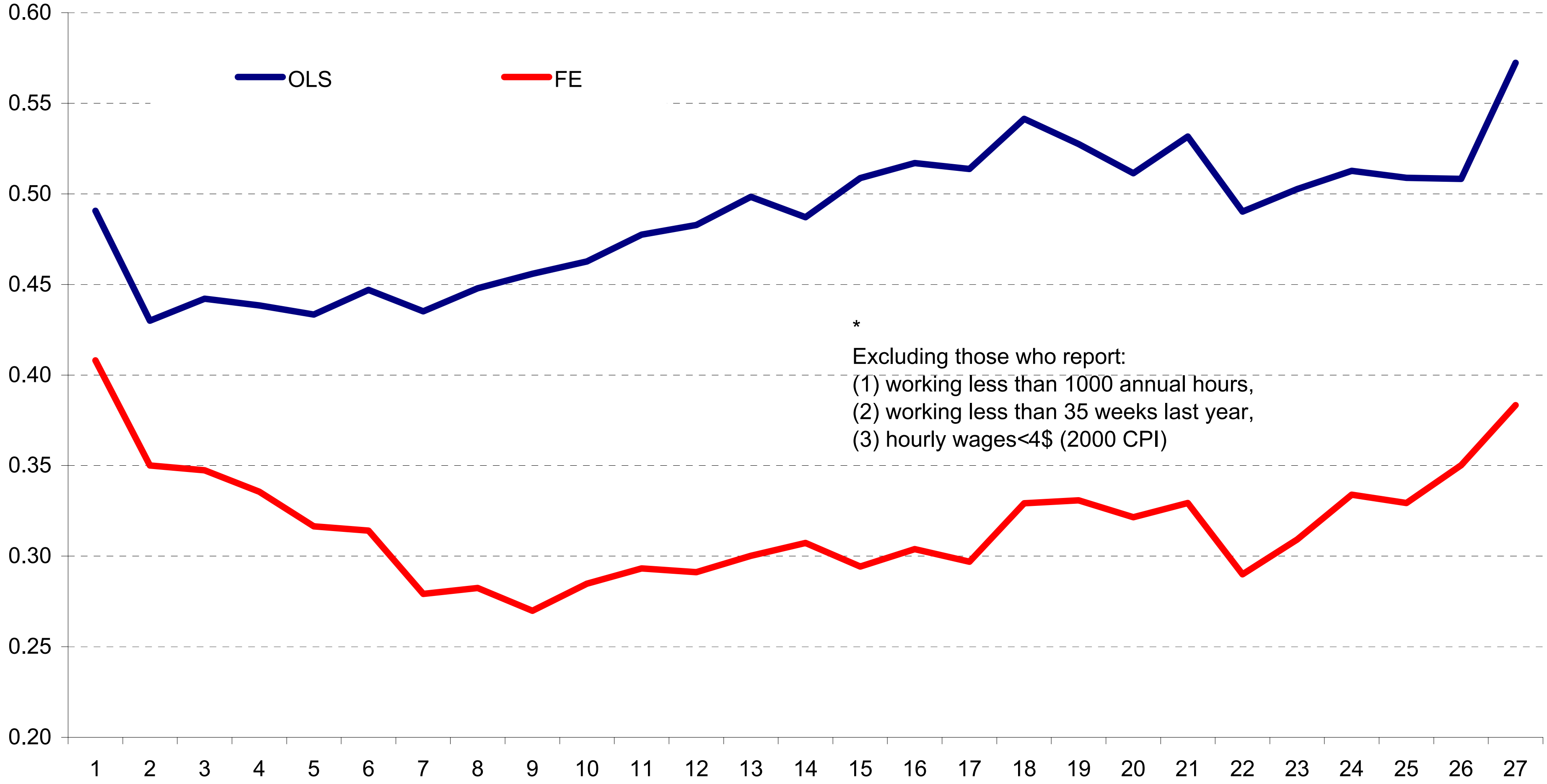


Figure 6b:
The Standard Deviation the Residuals in Mincer's Wage Equation by Experience with and without Fixed-Effects
White Males*
NLSY, 1968-1997

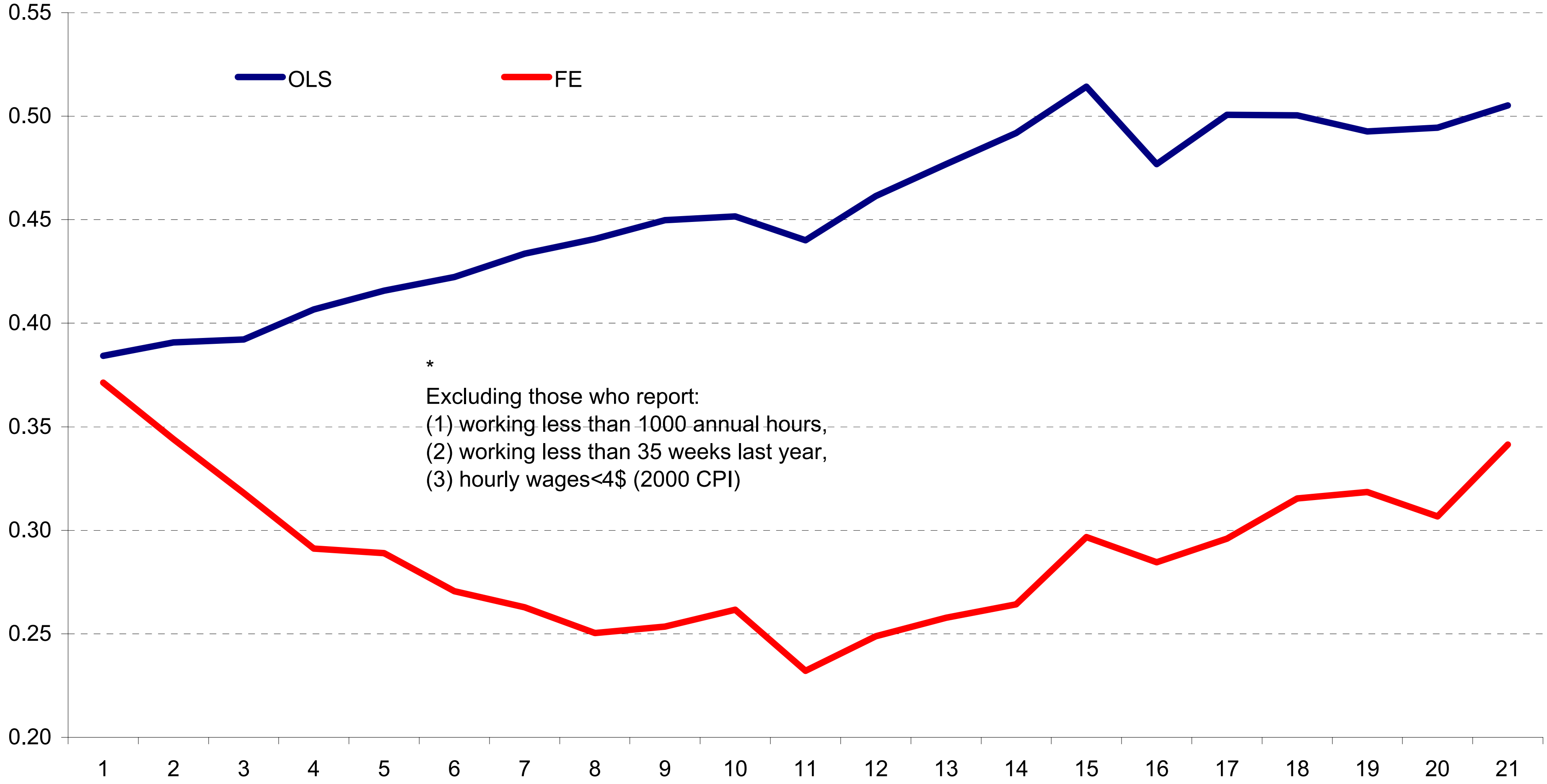


Figure 7a:
Regression Coefficents and Confidence Intervals of Annual Wage Growth Rates on Wage Levels in Prior Period (three year averages) by Experience, White Males
High School Dropouts
NLSY, 1979-2000

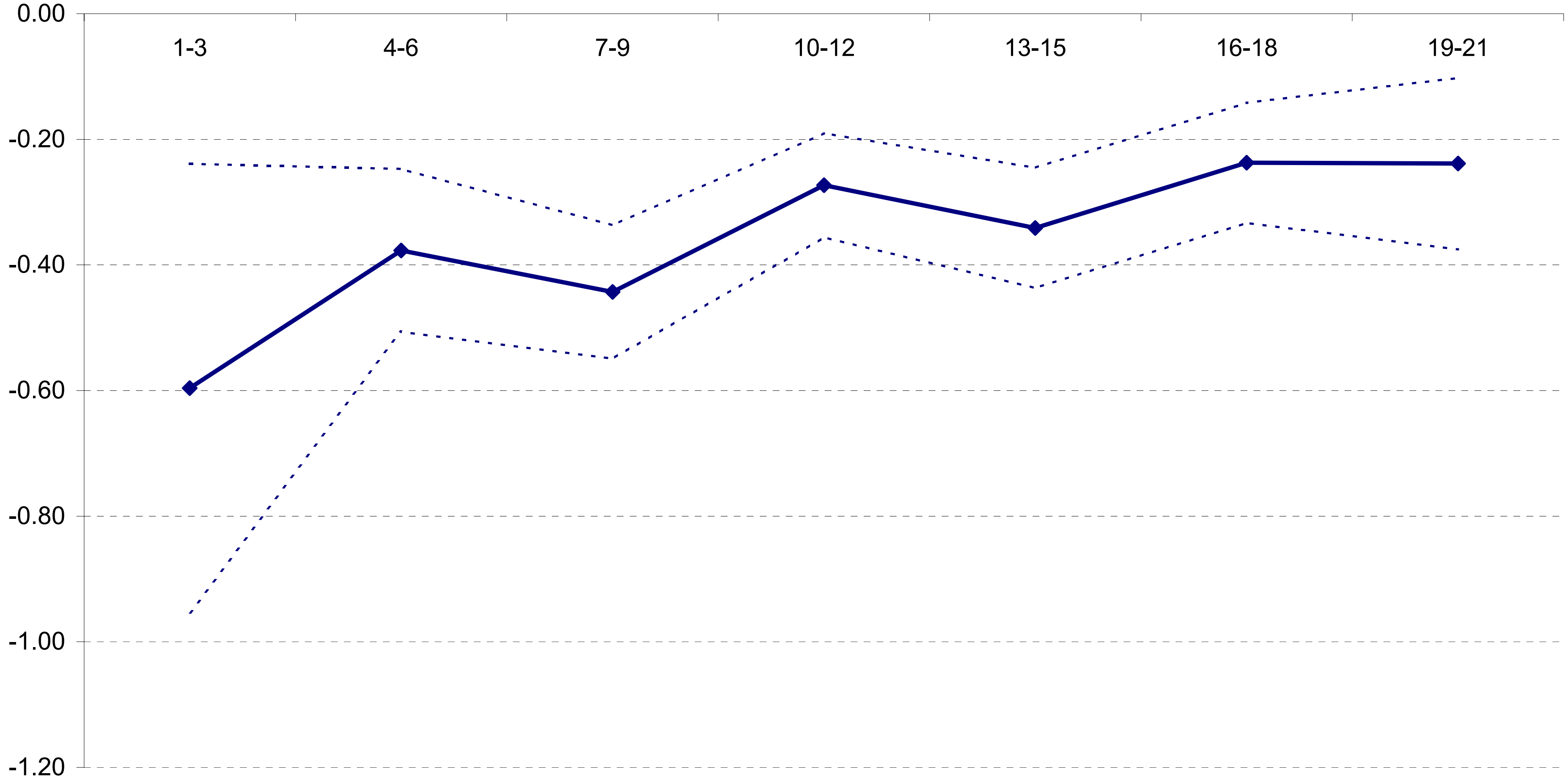


Figure 7b:
Regression Coefficents and Cofidence Intervals of Annual Wage Growth Rates Wage Levels in Prior Period (three year averages) by Experiemce, White Males
High School Graduates
NLSY, 1979-2000

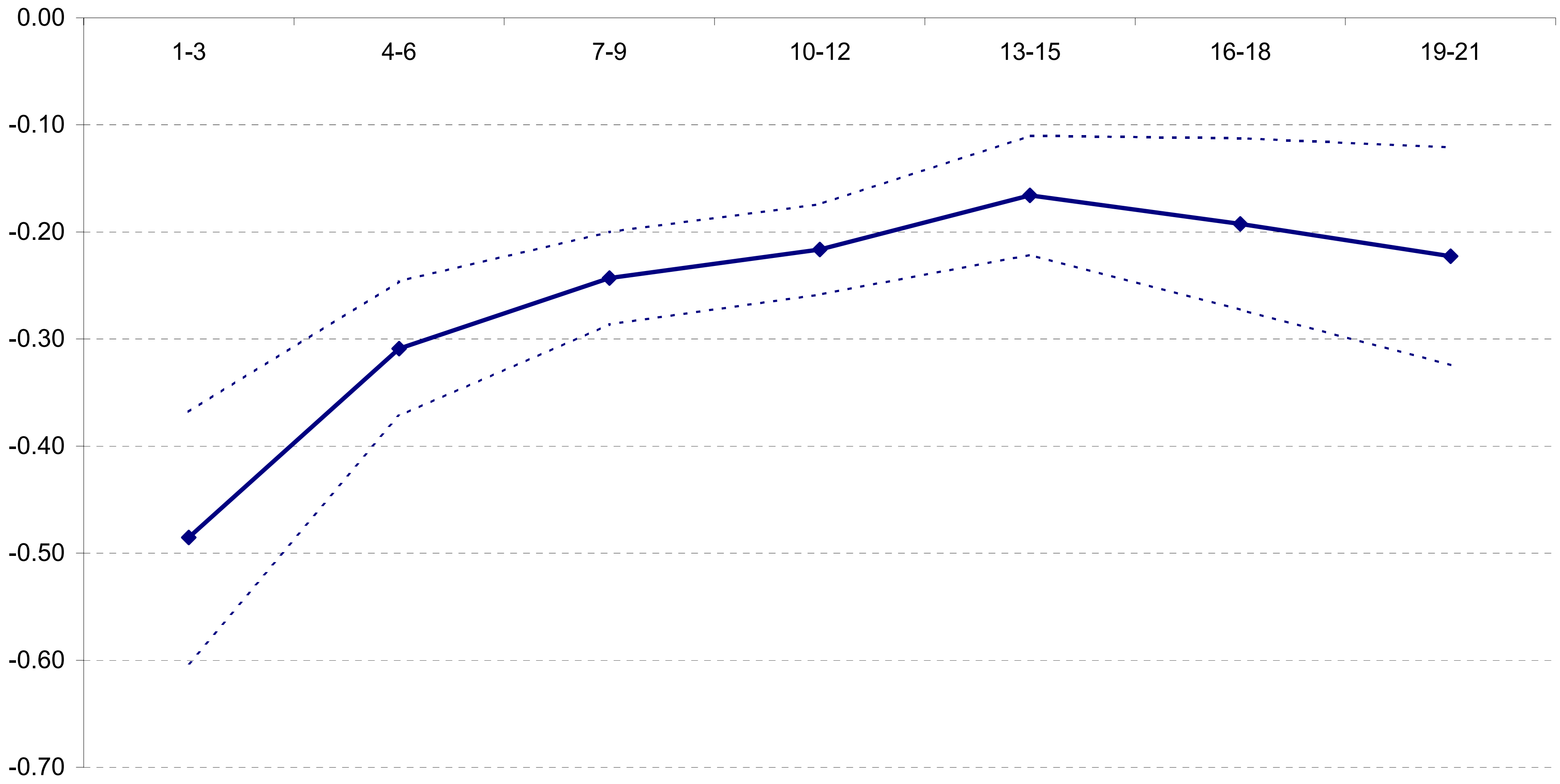


Figure 7c:
Regression Coefficents and Cofidence Intervals of Annual Wage Growth Rates on Wage Levels in Prior Period (three year averages) by Experience, White Males
Some College
NLSY, 1979-2000

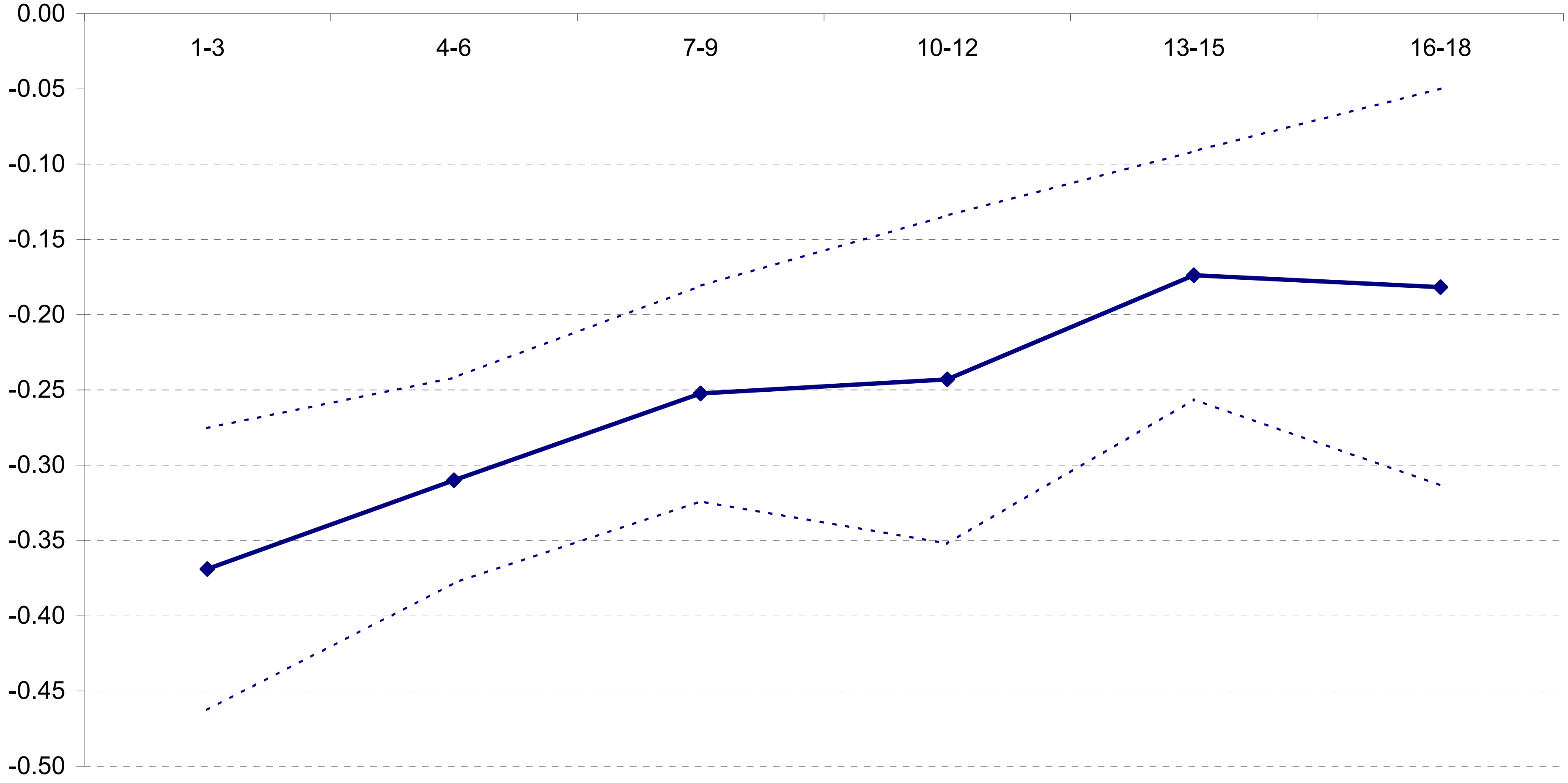


Figure 7d:
Regression Coefficents and Cofidence Intervals of Annual Wage Growth Rates on Wage Levels in Prior Period (three year averages) by Experience, White Males
College Graduates (excluding advanced degrees)
NLSY, 1979-2000

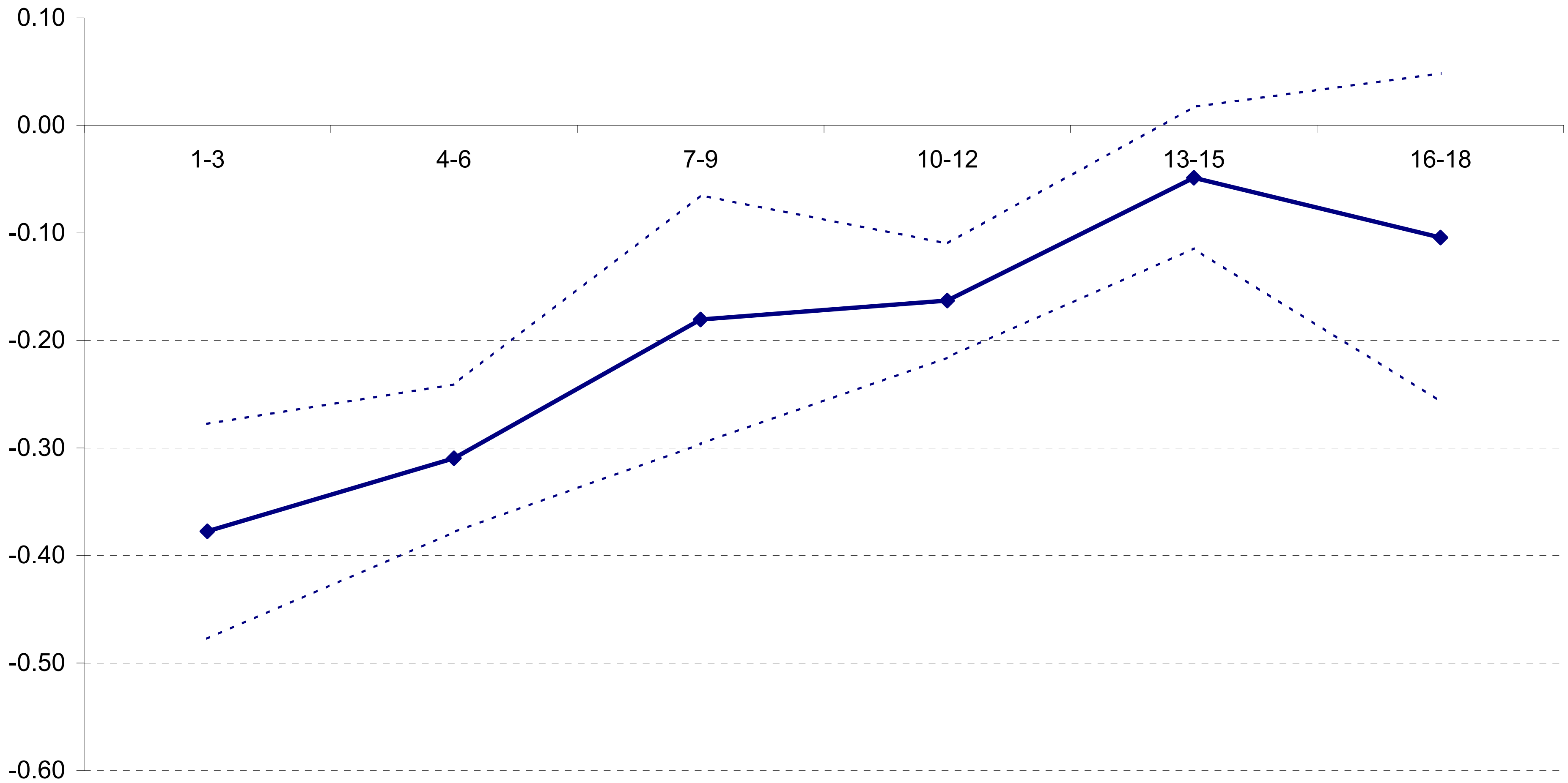


Figure 7e:
Regression Coefficents and Confidence Intervals of Annual Wage Growth Rates on Wage Levels in Prior Period (three year averages), by Experience, White Males, Advanced Degrees (MA, Ph.D.)
NLSY, 1979-2000

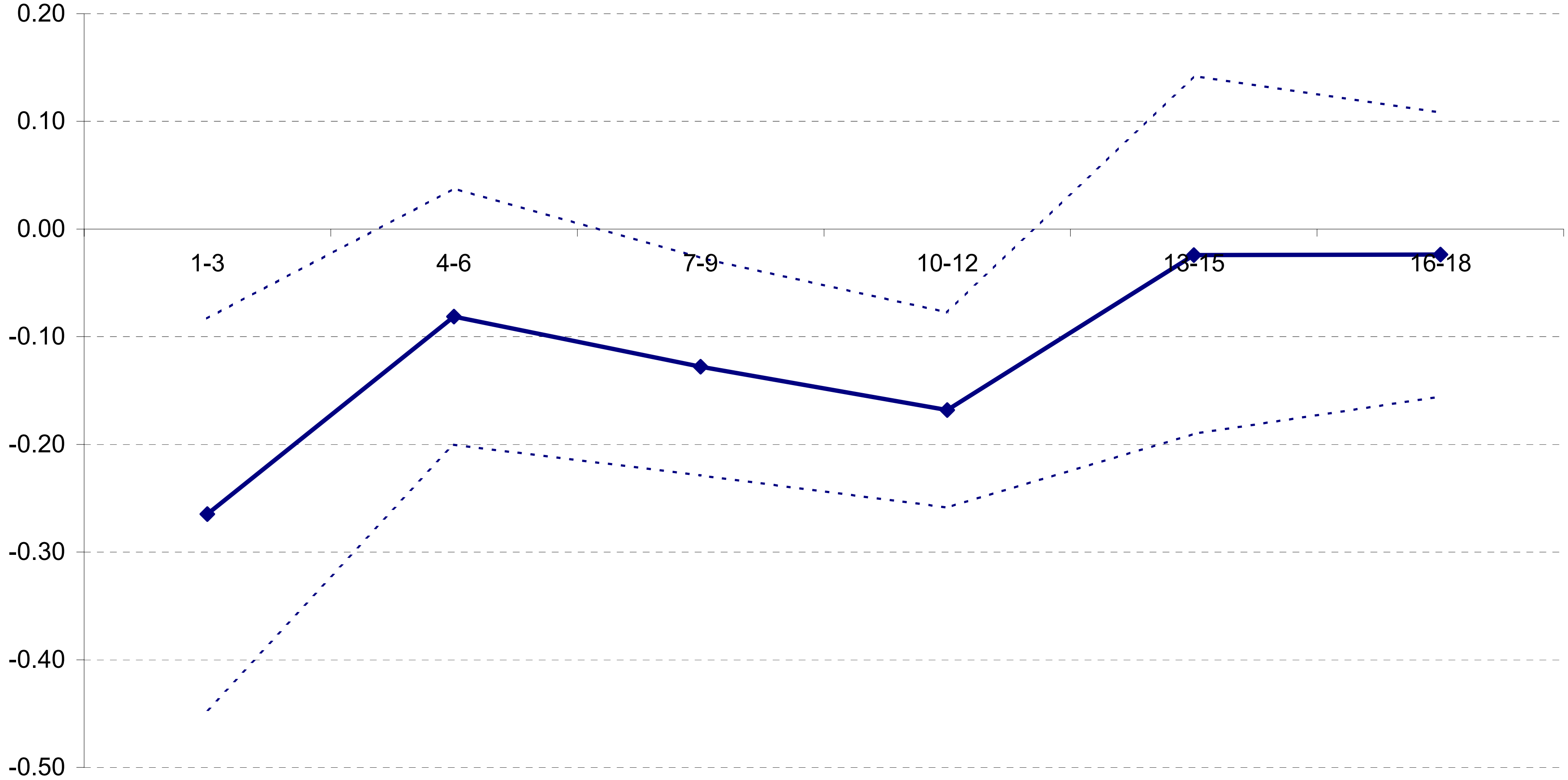


Figure 8.a:
Regression Coefficients and Confidence Intervals of Individual Fixed Growth on Level Effects, Evaluated at the Mean and at Zero Experience, by Schooling Level, White Males Working Full-Time in the Current and the Previous Year, NLSY, 1979-200

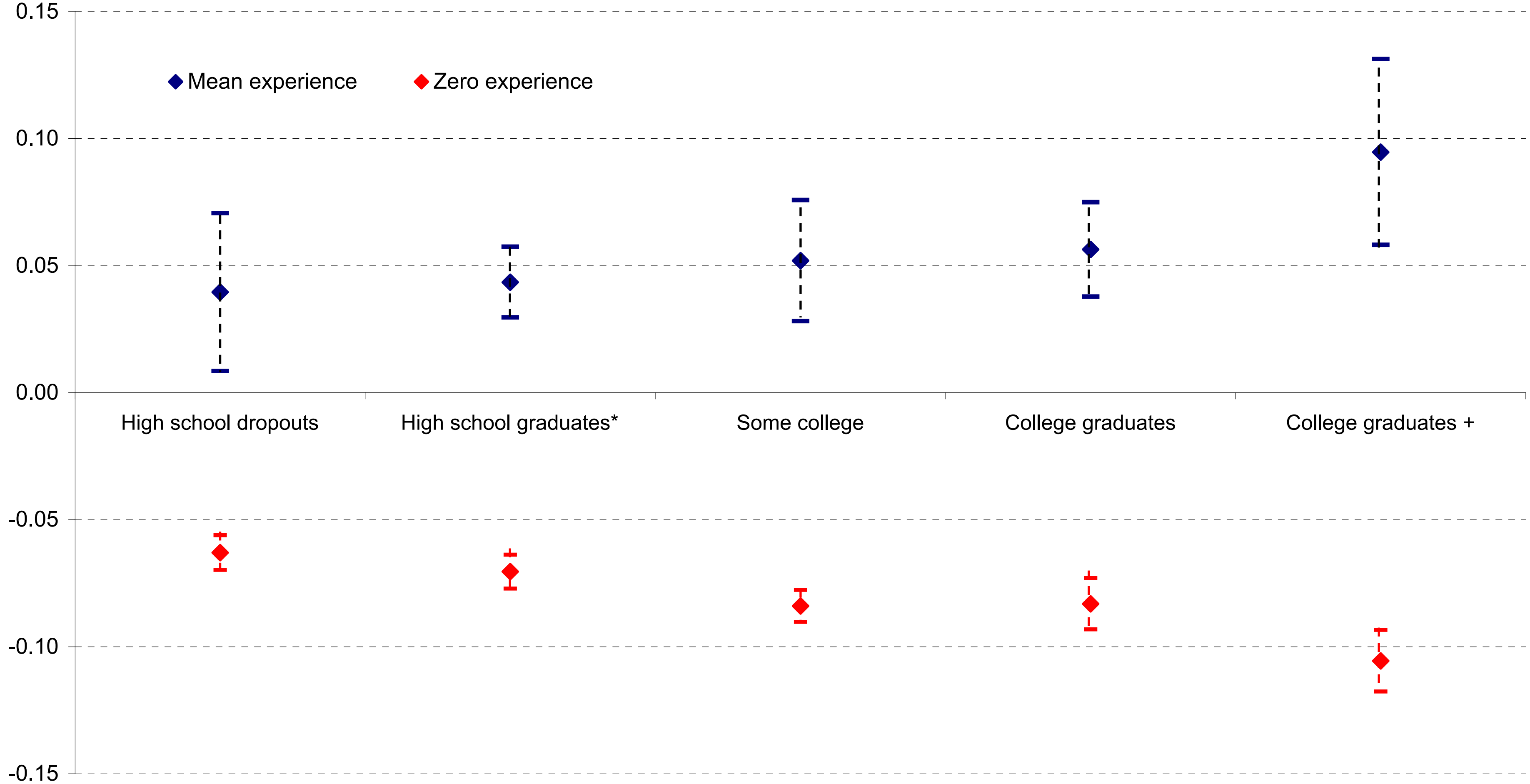


Figure 8.b:
Regression Coefficients and Confidence Intervals of Individual Fixed Level and Growth Effects on AFQT by Schooling Level, White Males Working Full-Time in the Current and the Previous Year, NLSY, 1979-2000

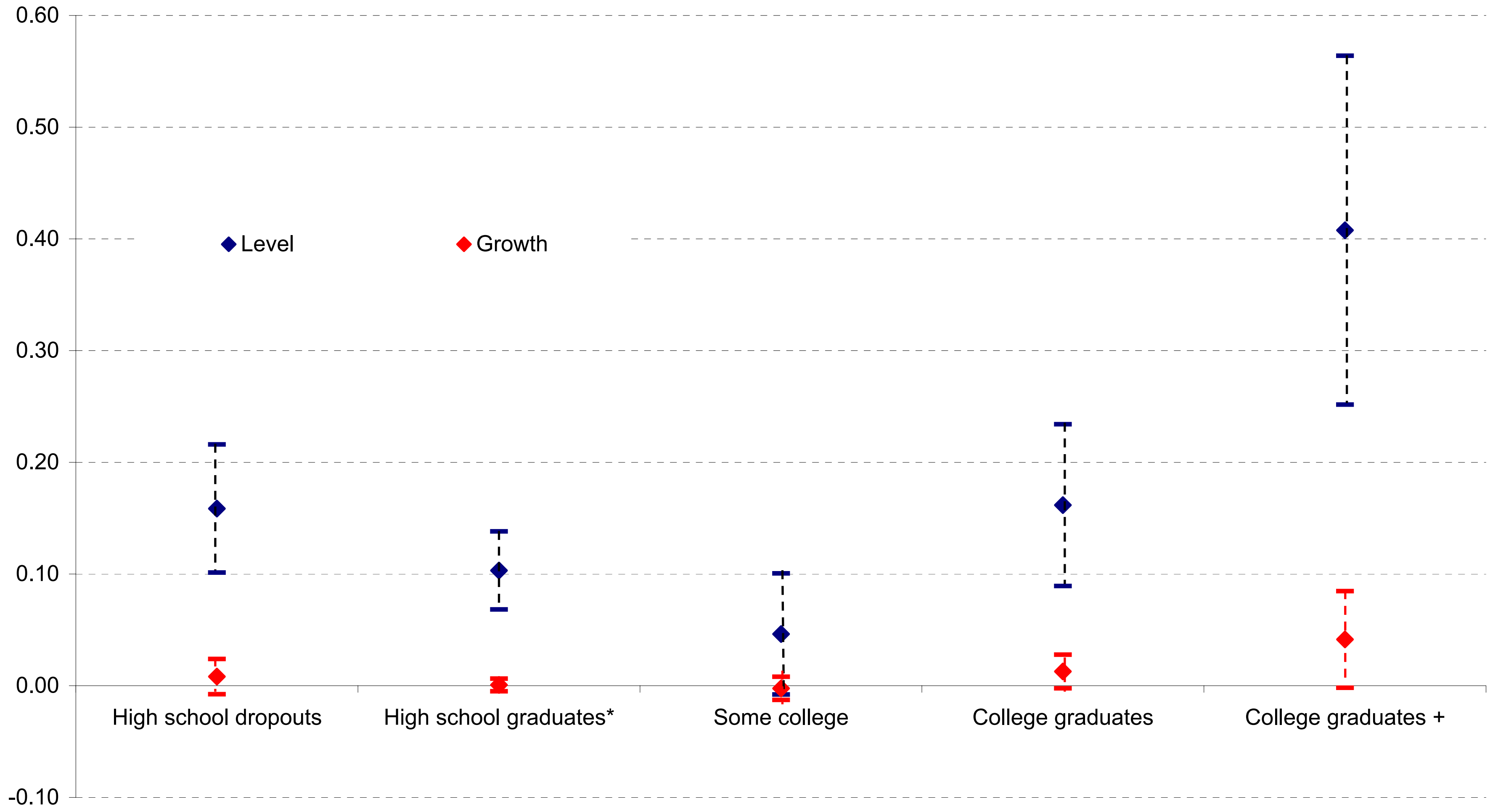


Figure 9:
The Fraction of Movers and the Annual Growth Rates in the Hourly Wages of Movers and Stayers by Hourly Wage in the Previous Year, White Males,
NLSY, 1979-2000.

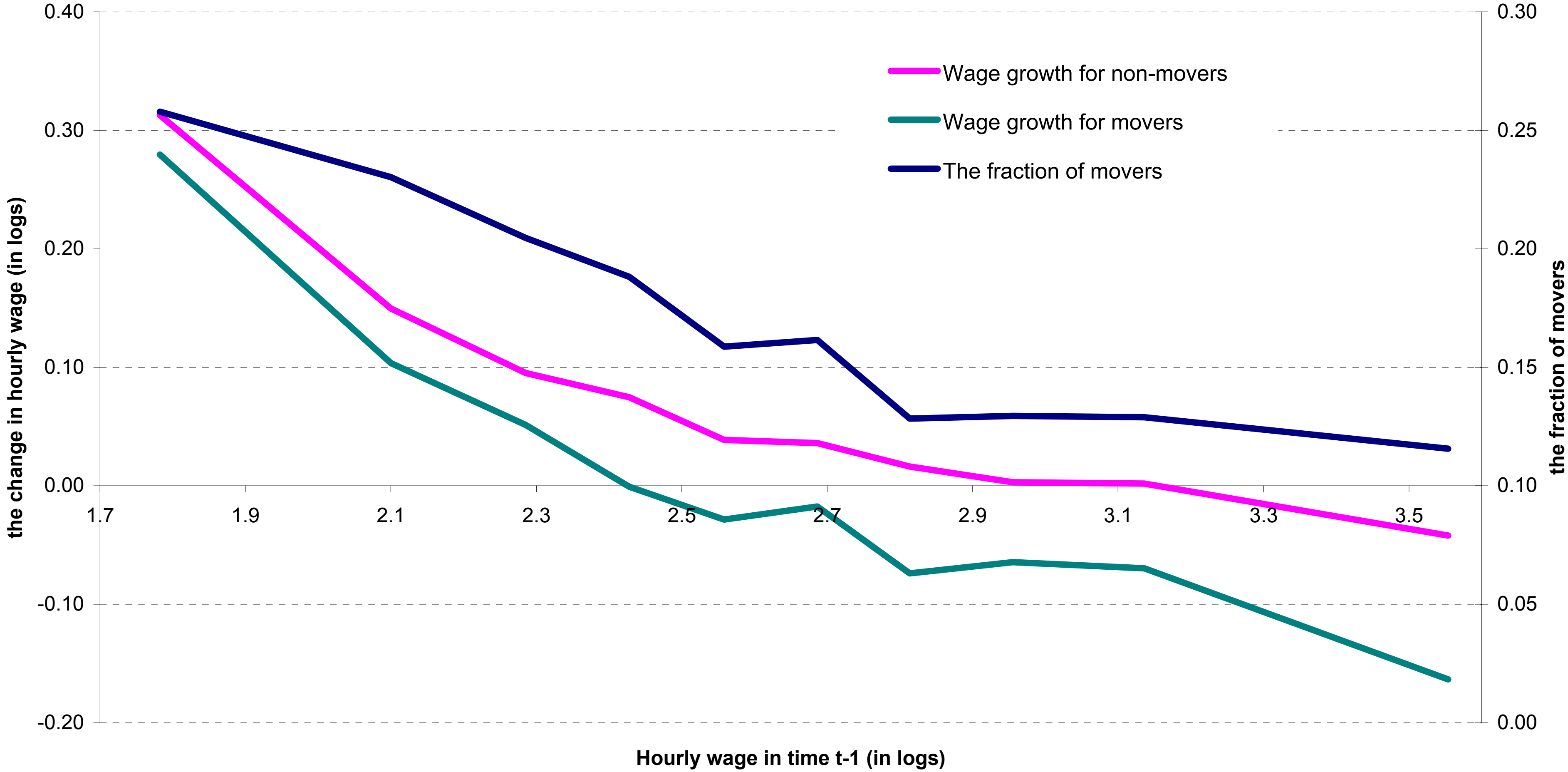


Figure 10a:
The Mean Hourly Wage (in logs) of Prime Aged Workers (36-45) in the Industry Currently held by Workers with different levels of Education and Experience,
CPS, Monthly Data, 1998 through 2002

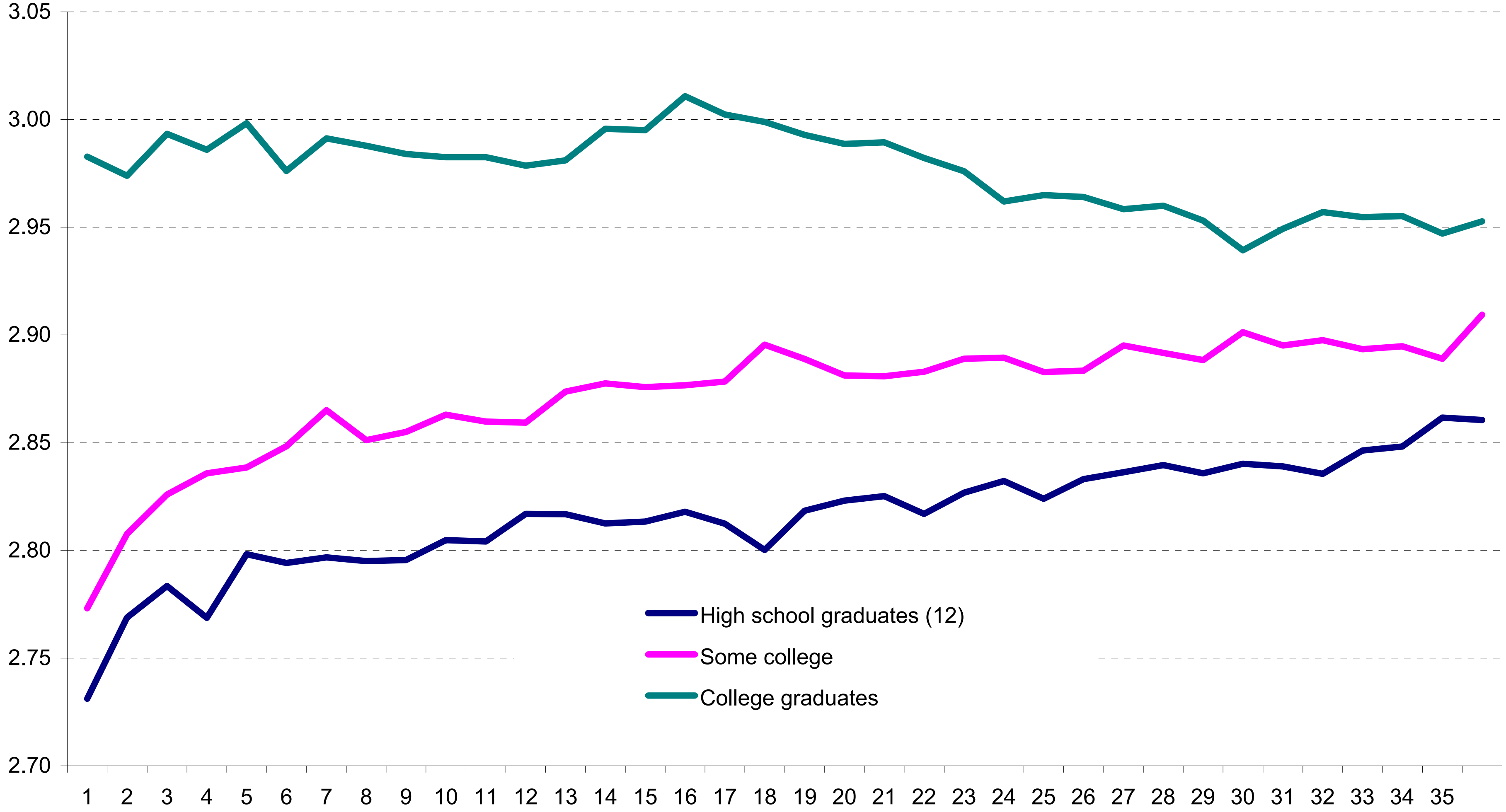


Figure 10b:
The Mean Hourly Wage (in logs) of Prime Age Workers (36-45) in the Occupation Currently held by Workers with different levels of Education and Experience, CPS, Monthly Data, 1998 through 2002

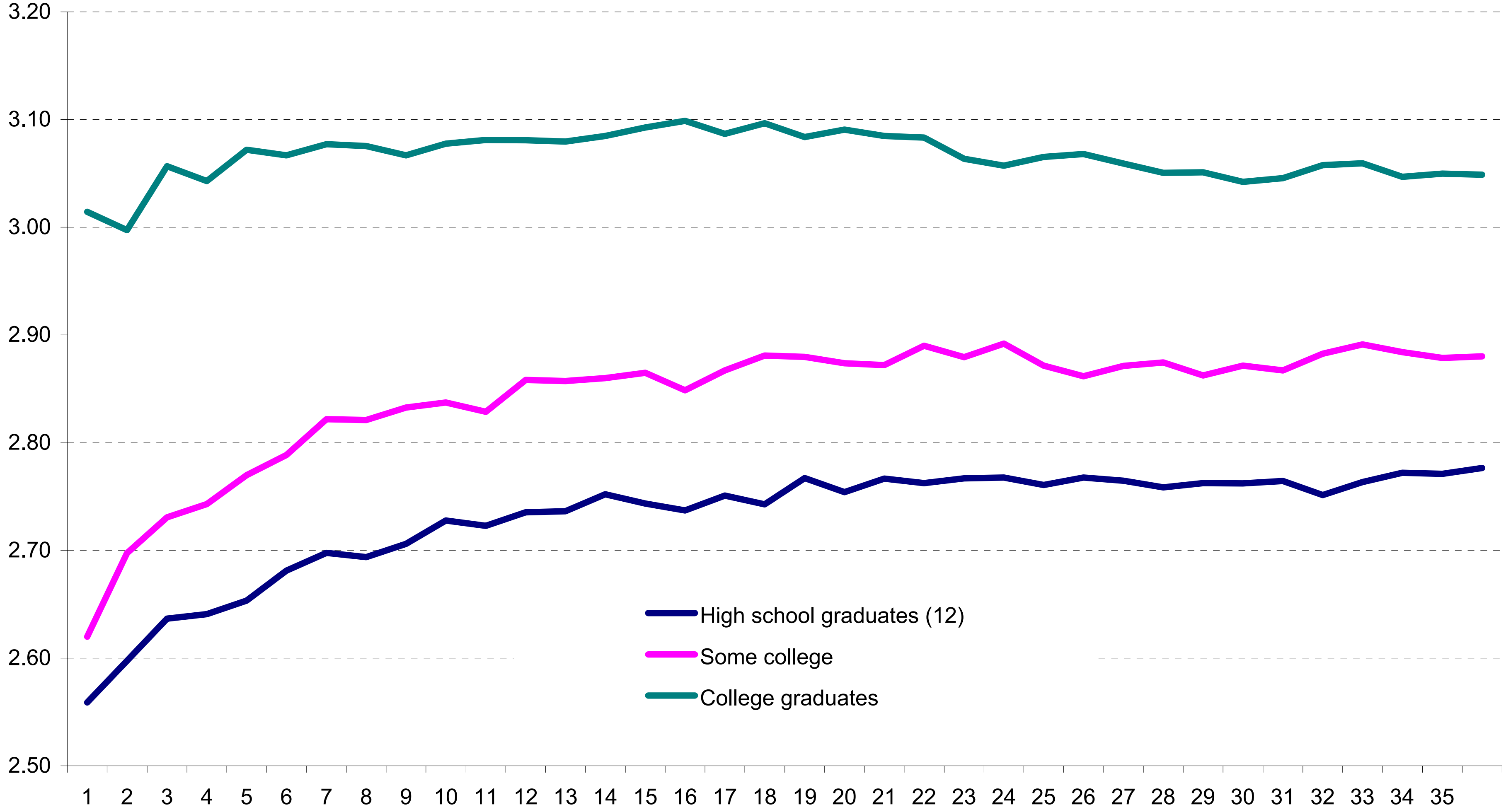


Figure 11:
The Hazard Function of Separation from the Current Employer (in annual terms)
NLSY, 1979-2000

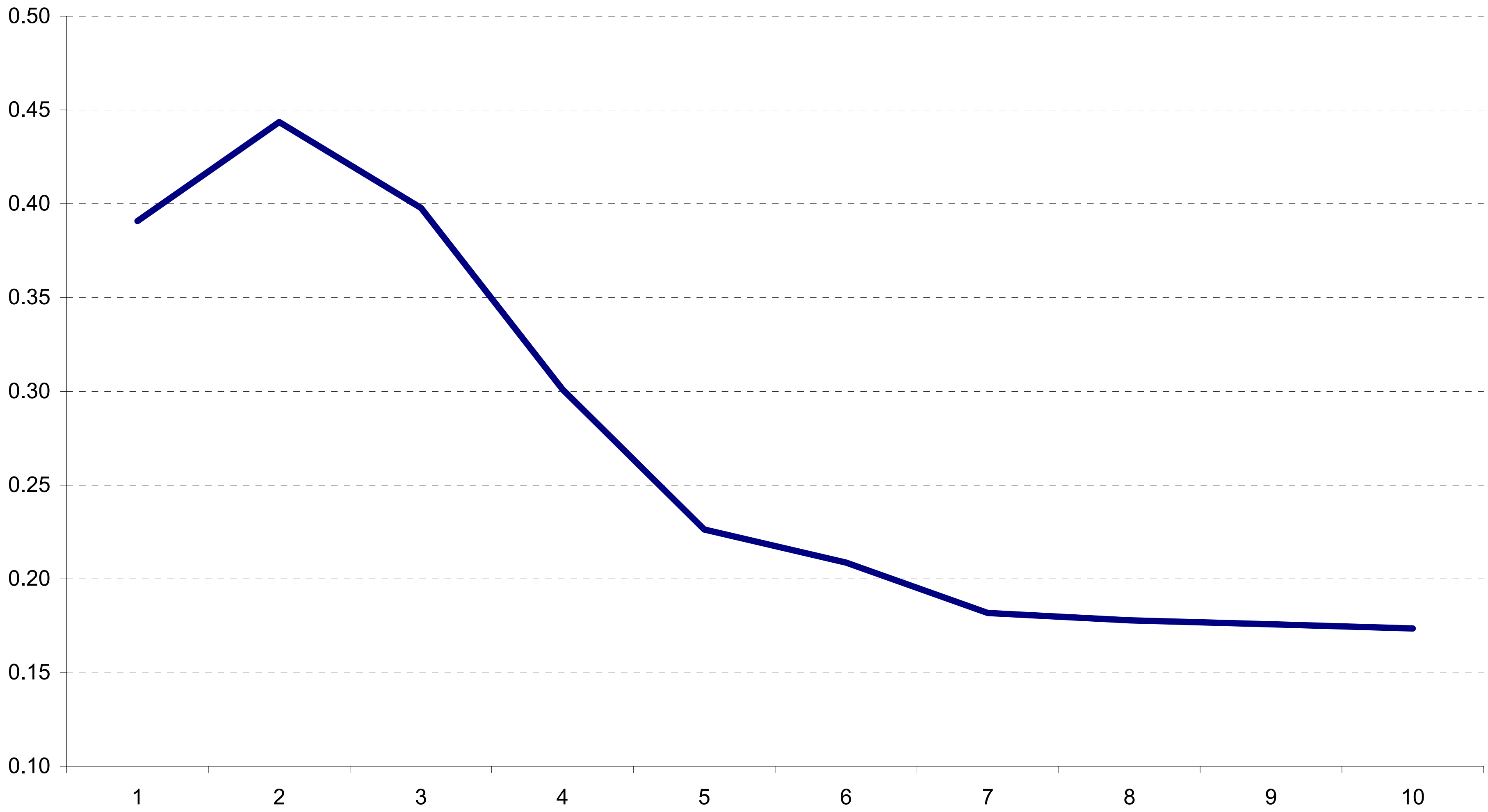


Figure 12a:
The Effect of AFQT by Experience (Relative to the AFQT Effect at 5 Years of Experience), Point Estimates and Confidence Intervals, White Males Working at least 1000 Annual Hours, High School Dropouts
NLSY, 1979-2000

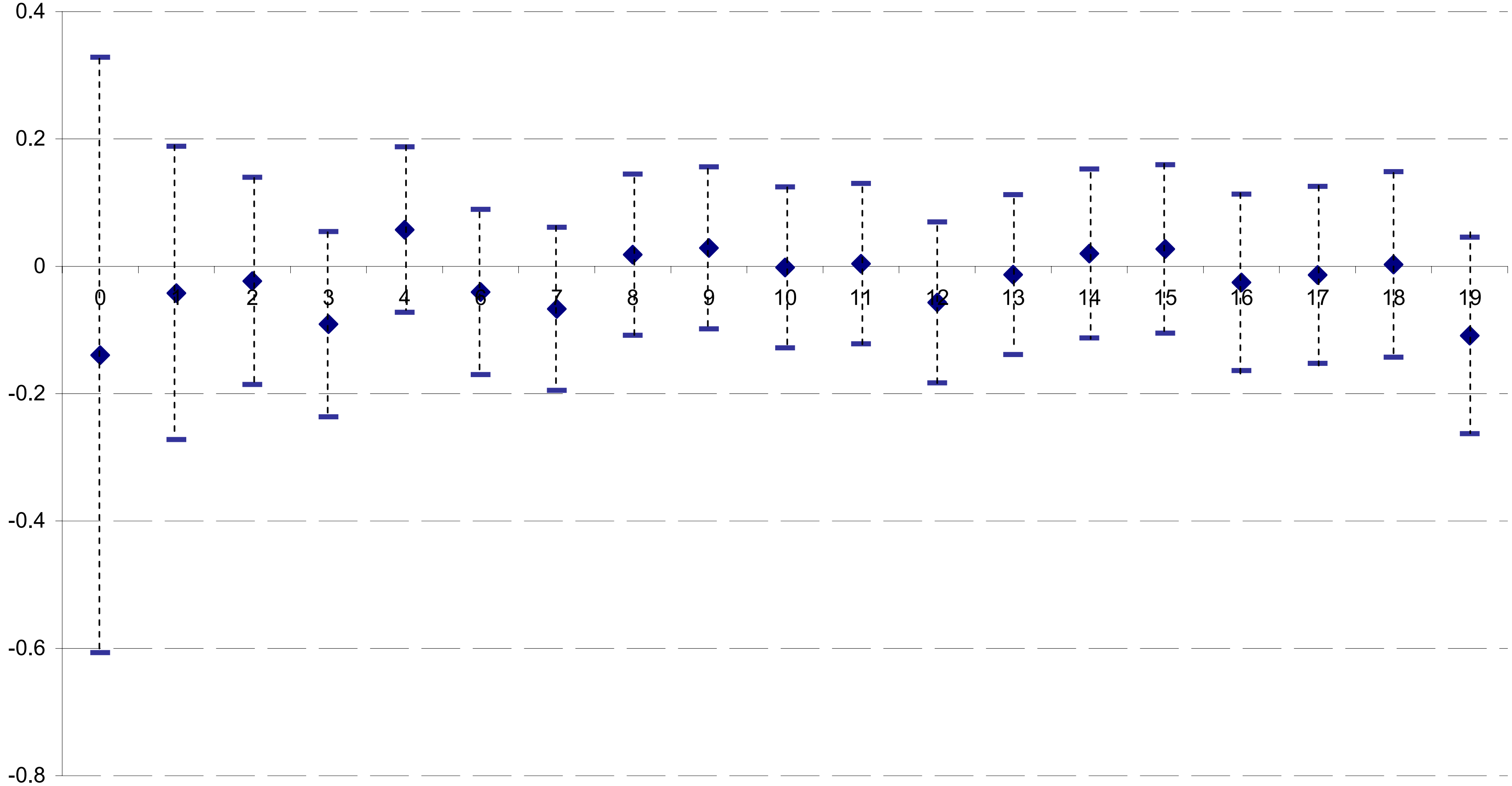


Figure 12b:
The Effect of AFQT by Experience (Relative to the AFQT Effect at 5 Years of Experience), Point Estimates and Confidence Intervals, White Males Working at least 1000 Annual Hours, High School Graduates
NLSY 1979-2000

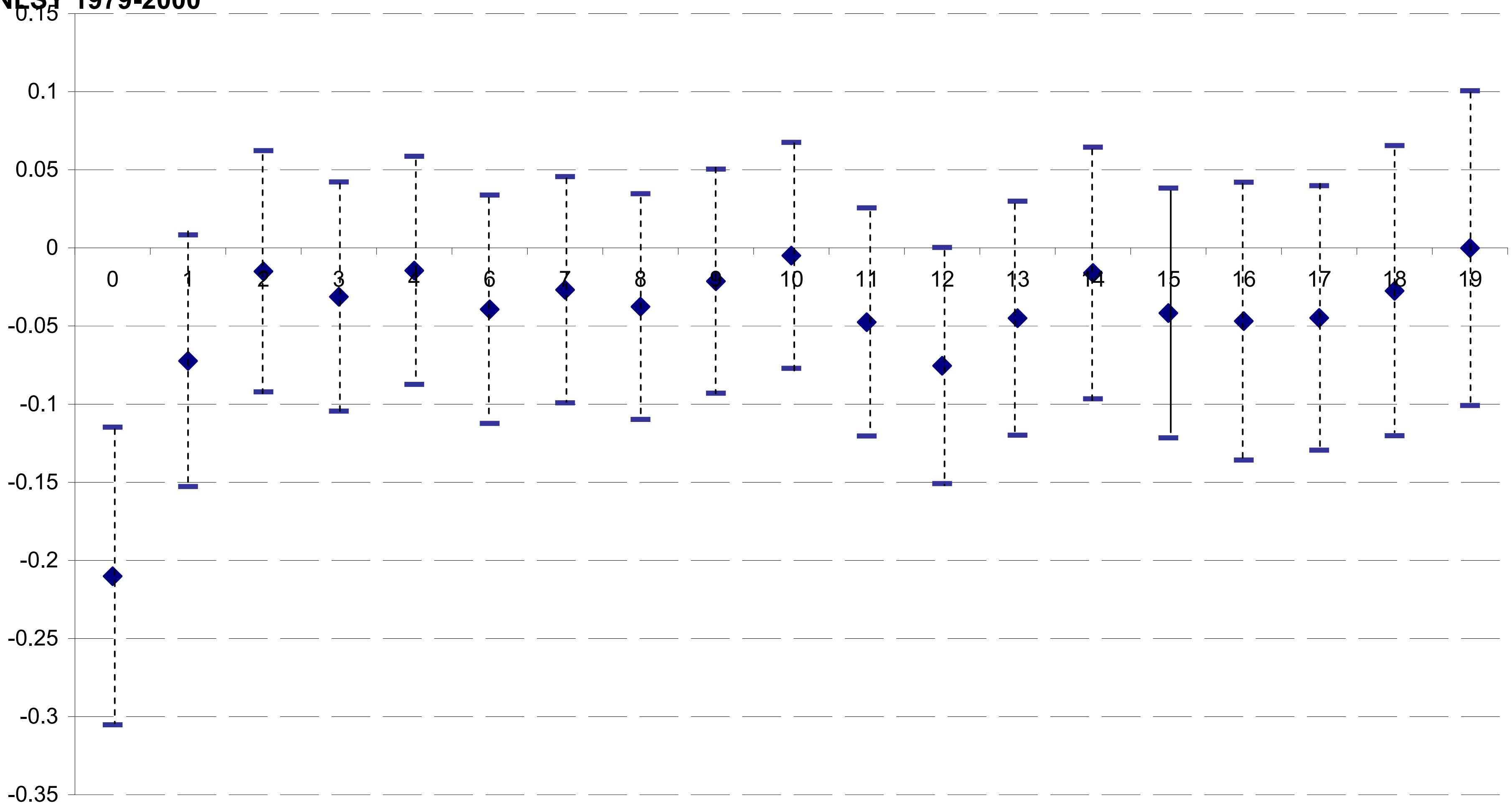


Figure 12c:
The Effect of AFQT by Experience (Relative to the AFQT Effect at 5 Years of Experience), Point Estimates and Confidence Intervals, White Males Working at least 1000 Annual Hours, Some College
NLSY 1979-2000

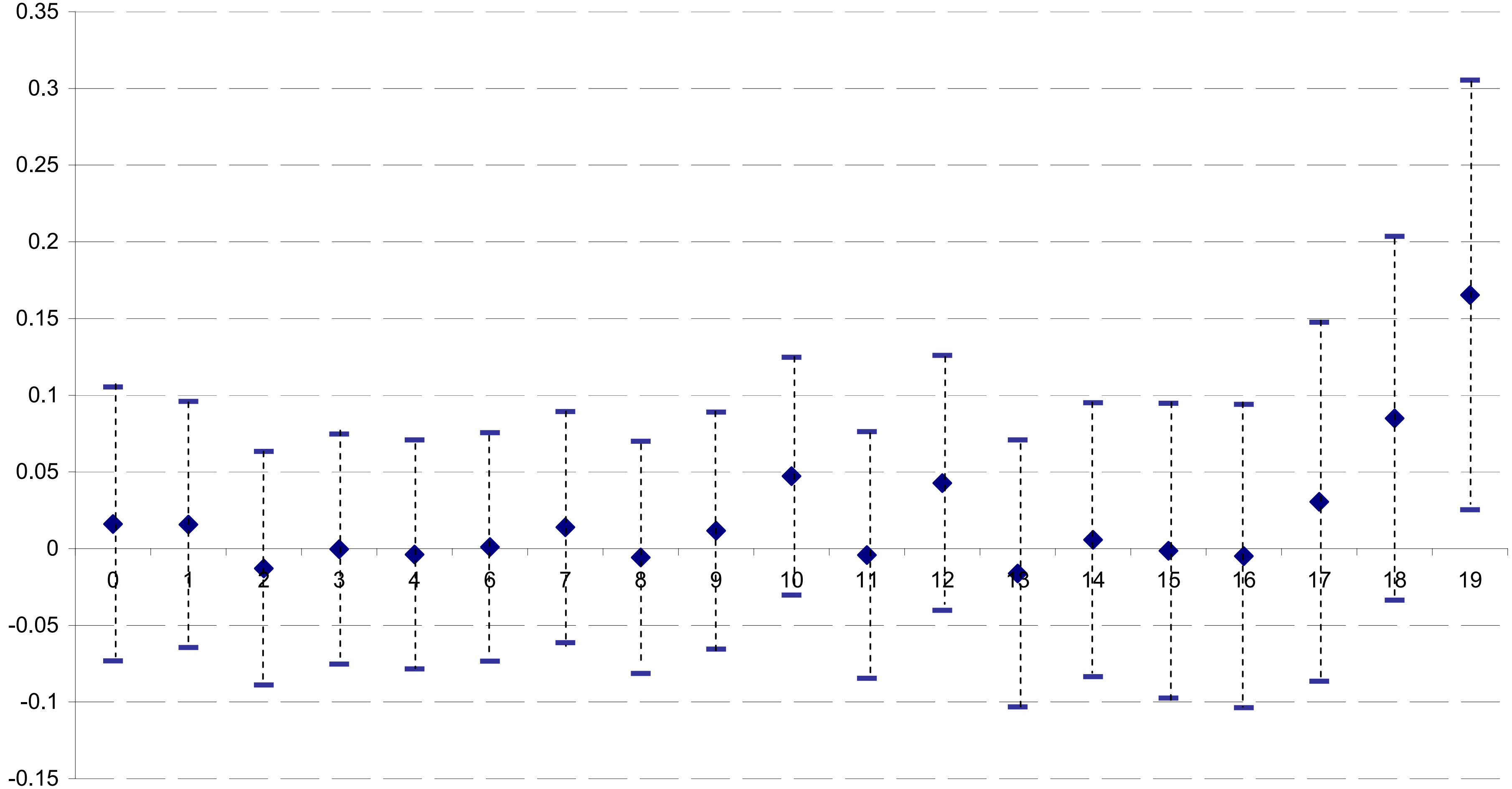


Figure 12d:
The Effect of AFQT by Experience (Relative to the AFQT Effect at 5 Years of Experience), Point Estimates and Confidence Intervals, White Males Working at least 1000 Annual Hours, All College Graduates
NLSY 1979-2000

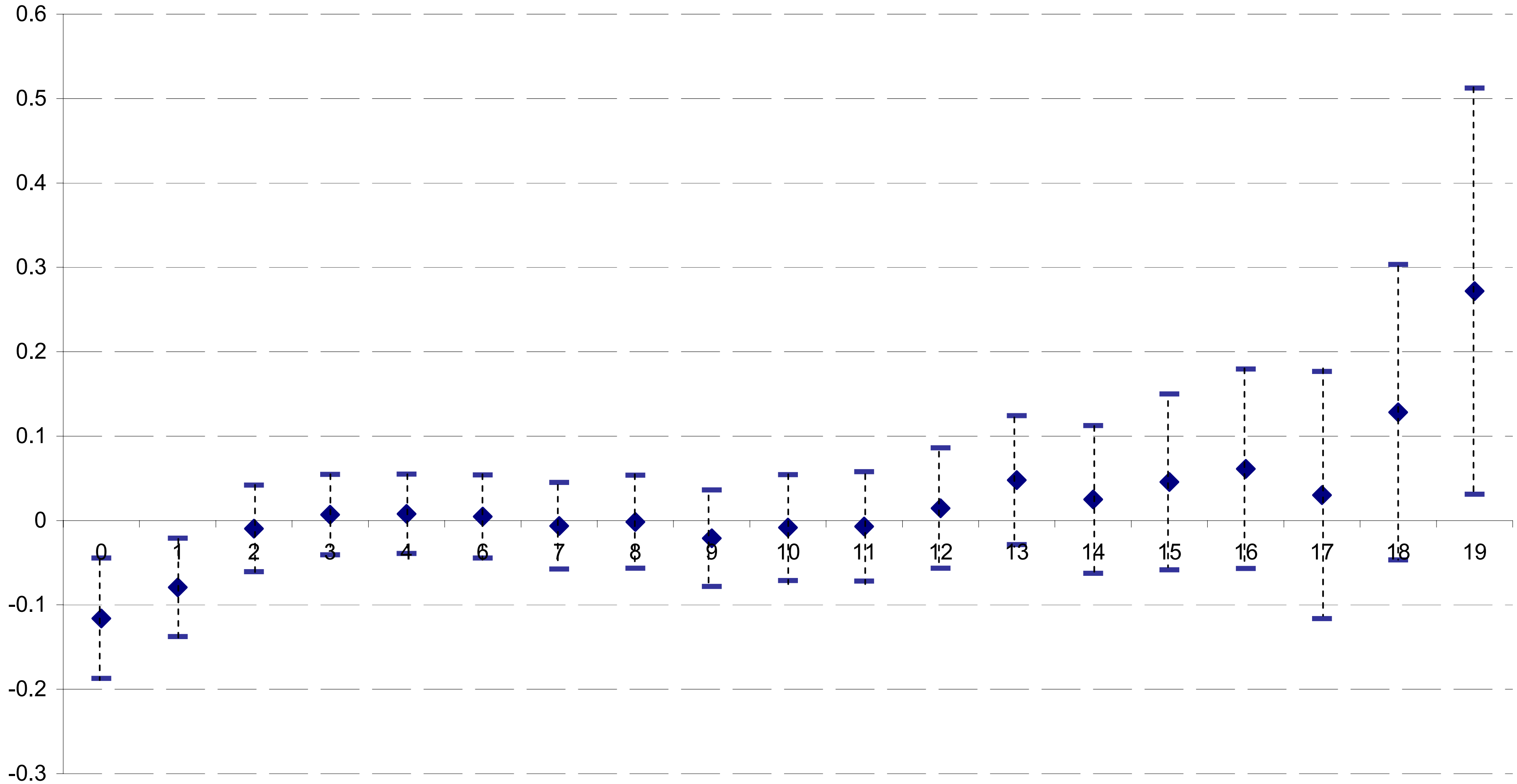


Figure 13a:
Standard Deviations of the og Hourly Wages of Prime Age Workers (36-45) at the Industry in which the Worker is Currently Employed, by Education and Experience, CPS, 1998 to 2002

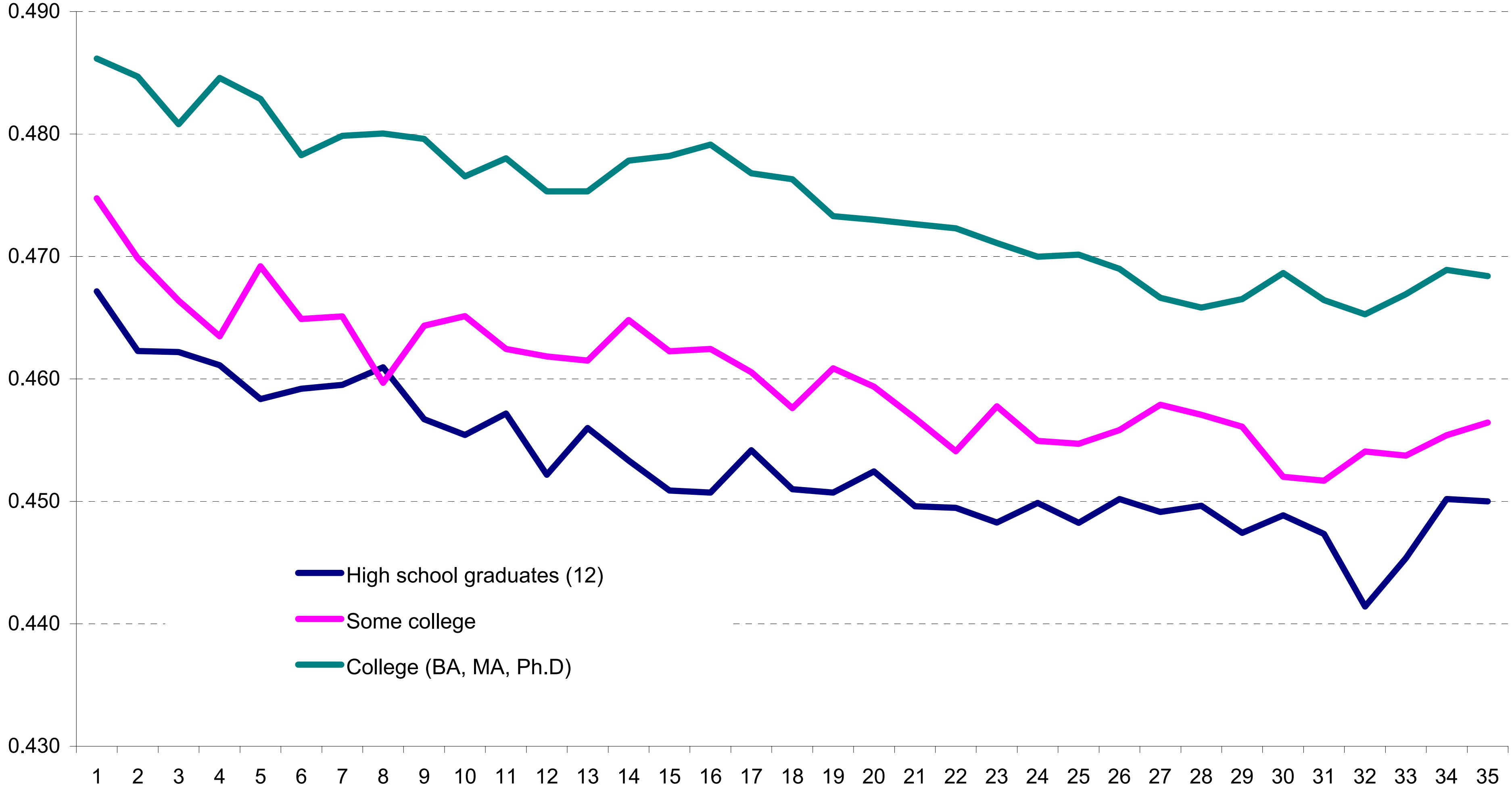


Figure 13b:
Standard Deviations of the log Hourly Wage of Prime Age Workers (36- 45) at the Occupation in which the Worker is Currently Employed, by Education and Experience, CPS, 1998 to 2002

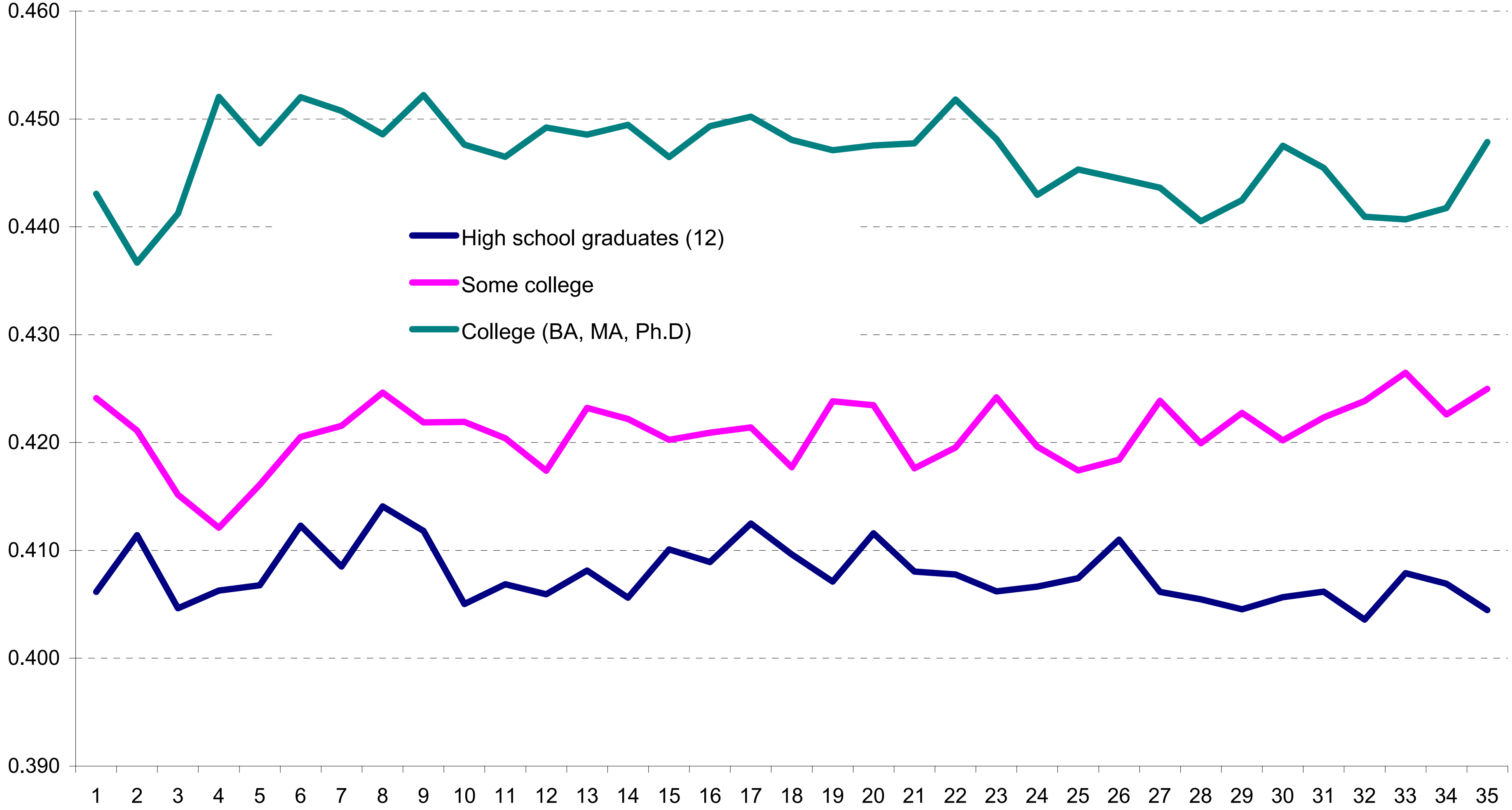


Table 1:
The Average Wage Growth by Education, Experience, Specification and Data Sources

Expirience	**Data Source**	**Education categories**									
		Less than HSG		HSG (12)		Some College		College Graduates		MA, Ph.D.	
		Level	Dif	Level	Dif	Level	Dif	Level	Dif	Level	Dif
0-10											
	CPS	0.024	0.039	0.032	0.056	0.033	0.063	0.036	0.063	0.029	0.077
		(0.003)	(0.029)	(0.001)	(0.010)	(0.001)	(0.010)	(0.002)	(0.011)	(0.003)	(0.017)
	PSID	0.028	0.043	0.030	0.057	0.038	0.065	0.039	0.076	0.032	0.110
		(0.003)	(0.007)	(0.002)	(0.003)	(0.003)	(0.005)	(0.003)	(0.004)	(0.006)	(0.021)
	NLSY	0.024	0.065	0.034	0.071	0.046	0.081	0.052	0.082	0.055	0.096
		(0.006)	(0.010)	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.009)	(0.012)
11-15											
	CPS	0.016	0.007	0.022	0.033	0.022	0.055	0.022	0.045	0.018	0.053
		(0.002)	(0.034)	(0.001)	(0.011)	(0.001)	(0.012)	(0.001)	(0.012)	(0.001)	(0.020)
	PSID	0.019	0.030	0.020	0.021	0.026	0.021	0.027	0.029	0.022	0.013
		(0.002)	(0.007)	(0.001)	(0.004)	(0.002)	(0.005)	(0.002)	(0.005)	(0.004)	(0.016)
	NLSY	0.013	0.024	0.023	0.019	0.026	0.024	0.035	0.067	0.039	0.123
		(0.002)	(0.008)	(0.001)	(0.004)	(0.002)	(0.007)	(0.004)	(0.009)	(0.009)	(0.018)
16-25											
	CPS	0.010	0.052	0.013	0.022	0.012	0.026	0.009	0.026	0.009	0.015
		(0.001)	(0.021)	(0.000)	(0.007)	(0.000)	(0.008)	(0.001)	(0.009)	(0.001)	(0.012)
	PSID	0.011	0.010	0.012	0.010	0.015	0.014	0.017	0.026	0.014	0.019
		(0.001)	(0.004)	(0.001)	(0.003)	(0.001)	(0.004)	(0.001)	(0.004)	(0.003)	(0.009)
	NLSY	0.003	0.035	0.014	0.038	0.009	0.065	0.021	0.111	0.025	0.044
		(0.004)	(0.009)	(0.003)	(0.005)	(0.005)	(0.013)	(0.009)	(0.015)	(0.022)	(0.035)
25 +											
	CPS	-0.002	0.025	-0.004	0.011	-0.005	0.002	-0.014	-0.002	-0.009	0.012
		(0.003)	(0.017)	(0.001)	(0.007)	(0.001)	(0.008)	(0.002)	(0.011)	(0.003)	(0.013)
	PSID	-0.003	0.004	-0.005	0.006	-0.005	0.010	-0.003	0.000	-0.001	0.011
		(0.001)	(0.003)	(0.002)	(0.003)	(0.003)	(0.005)	(0.004)	(0.005)	(0.005)	(0.006)
	NLSY	-0.015	0.034	-0.003	0.034						
		(0.012)	(0.042)	(0.007)	(0.041)						

Table 2.a:
Annual Growth Rates of Individual Wages and Proportions for Gainers and Losers, by Education and Experience.
Source: CPS, Monthly Files, 1998-2002

	Experience and Wage Change Category											
	Gainers (wage up)				**No change in nominal wage**				**Loseres (wage down)**			
	0-10	**11-15**	**16-25**	**26-40**	**0-10**	**11-15**	**16-25**	**26-40**	**0-10**	**11-15**	**16-25**	**26-40**
High School Graduates												
Fraction	0.602	0.588	0.562	0.546	0.048	0.048	0.049	0.053	0.349	0.363	0.389	0.401
Wage growth - unconditional	0.056	0.033	0.022	0.011	0.056	0.033	0.022	0.011	0.056	0.033	0.022	0.011
Wage growth - conditional	0.263	0.247	0.266	0.253	-0.022	-0.017	-0.018	-0.028	-0.289	-0.306	-0.325	-0.314
Some College												
Fraction	0.621	0.589	0.582	0.555	0.043	0.056	0.053	0.055	0.336	0.355	0.364	0.391
Wage growth - unconditional	0.063	0.055	0.026	0.002	0.063	0.055	0.026	0.002	0.063	0.055	0.026	0.002
Wage growth - conditional	0.255	0.254	0.257	0.261	-0.035	0.001	-0.036	-0.037	-0.279	-0.267	-0.334	-0.361
College Graduates (BA)												
Fraction	0.643	0.602	0.567	0.536	0.055	0.081	0.090	0.085	0.301	0.317	0.342	0.378
Wage growth - unconditional	0.063	0.045	0.026	-0.002	0.063	0.045	0.026	-0.002	0.063	0.045	0.026	-0.002
Wage growth - conditional	0.263	0.259	0.268	0.287	-0.025	-0.026	-0.031	-0.026	-0.350	-0.343	-0.359	-0.405
MA, Ph.D.												
Fraction	0.667	0.590	0.567	0.545	0.080	0.090	0.083	0.099	0.253	0.320	0.349	0.356
Wage growth - unconditional	0.077	0.053	0.015	0.012	0.077	0.053	0.015	0.012	0.077	0.053	0.015	0.012
Wage growth - conditional	0.253	0.274	0.250	0.265	-0.003	-0.038	-0.007	-0.020	-0.361	-0.329	-0.363	-0.366

Notes:
Gainers (losers) had a nominal wage increase (decrease).

Table 2.b:
Annual Growth Rates of Individual Wages and Proportions for Gainers and Losers, by Experience.
Source: CPS: 1998-2002, PSID 1969-1997, NLSY 1979-2000.

Data Set	Experience	Fraction	Wage growth	
			All	by group
CPS (1998-2002)				
Gainers (wage up)	0-10	0.627	0.062	0.259
	11-15	0.593	0.044	0.254
	16-25	0.568	0.024	0.264
	26-40	0.547	0.007	0.264
No wage change	0-10	0.053	0.062	-0.023
	11-15	0.065	0.044	-0.020
	16-25	0.065	0.024	-0.023
	26-40	0.066	0.007	-0.029
Losers (wage down)	0-10	0.319	0.062	-0.312
	11-15	0.342	0.044	-0.309
	16-25	0.367	0.024	-0.339
	26-40	0.388	0.007	-0.351
NLSY				
Gainers (wage up)	0-10	0.718	0.077	0.176
	11-15	0.644	0.033	0.144
	16-25	0.662	0.049	0.168
No wage change	0-10	0.071	0.077	-0.044
	11-15	0.097	0.033	-0.040
	16-25	0.082	0.049	-0.041
Losers (wage down)	0-10	0.211	0.077	-0.221
	11-15	0.259	0.033	-0.217
	16-25	0.255	0.049	-0.232
PSID				
Gainers (wage up)	0-10	0.726	0.063	0.163
	11-15	0.689	0.024	0.122
	16-25	0.667	0.015	0.118
No wage change	0-10	0.040	0.063	-0.040
	11-15	0.048	0.024	-0.030
	16-25	0.056	0.015	-0.046
Losers (wage down)	0-10	0.234	0.063	-0.228
	11-15	0.263	0.024	-0.224
	16-25	0.277	0.015	-0.220

Notes:
Gainers (losers) had a nominal wage increase (decrease).

Table 3:
Correlations of Wages and Residuals
at Different Stages of the Life Cycle (three years averages),
White Males, Full-Time Workers,
NLSY, 1979-2000

3a: Wage Levels

Time	1	2	3	4	5	6	7
1	1.000						
2	0.631	1.000					
3	0.496	0.725	1.000				
4	0.455	0.649	0.846	1.000			
5	0.385	0.578	0.793	0.848	1.000		
6	0.380	0.501	0.717	0.775	0.871	1.000	
7	0.447	0.537	0.665	0.703	0.759	0.813	1.000

3b: Residuals of Mincer's Wage Function

Time	1	2	3	4	5	6	7
1	1.000						
2	0.604	1.000					
3	0.457	0.699	1.000				
4	0.388	0.598	0.826	1.000			
5	0.324	0.527	0.769	0.827	1.000		
6	0.315	0.440	0.683	0.745	0.855		
7	0.363	0.458	0.610	0.650	0.720	0.785	1.000

3c: Residuals of Mincer's Wage Function with Fixed Effects

Time	1	2	3	4	5	6	7
1	1.000						
2	0.402	1.000					
3	-0.139	0.143	1.000				
4	-0.319	-0.175	0.213	1.000			
5	-0.565	-0.467	-0.075	0.175	1.000		
6	-0.533	-0.633	-0.321	-0.089	0.389	1.000	
7	-0.336	-0.450	-0.427	-0.303	-0.029	0.294	1.000