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Mincer's Overtaking Point and the Life Cycle Earnings Distribution*

SOLOMON W. POLACHEK polachek@binghamton.edu
Department of Economics, State University of New York at Binghamton, Binghamton, NY 13902-6000, USA; Tel.: (607) 777-6866

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Abstract. In 1958 Jacob Mincer pioneered an important approach to understand earnings distribution. In the years since Mincer's seminal work, he as well as his students and colleagues extended the original human capital model, reaching important conclusions about a whole array of observations pertaining to human well-being. This line of research explained why education enhances earnings; why earnings rise at a diminishing rate throughout one's life; why earnings growth is smaller for those anticipating intermittent labor force participation; why men earn more than women; why Whites earn more than Blacks; why occupational distributions differ by gender; why geographic and job mobility predominate among the young; why unemployment is lower among the skilled; and why numerous other labor market phenomena occur. This paper surveys the answers to these and other questions based on research emanating from Mincer's original discovery. In addition, this paper provides new empirical evidence regarding Mincer's concept of the "overtaking age"—a topic not currently well-explored in the literature. In this latter vein, the paper shows that Mincer's original finding of a U-shaped (log) variance of earnings over the life cycle is upheld in recent data, both for the United States as well as at least seven other countries.

Keywords: human capital, earnings, overtaking age, well-being, Mincer

JEL Classification: B20, B31, D31, J24, J31, J33, J41, J6, J7

1. The topic: mincing the earnings distribution—a human capital approach

Mincer was not the first scholar to examine the distribution of earnings. But he *was* the first to use the analytical techniques of capital theory in an extremely innovative way. His discoveries clearly contributed more to understanding economic well-being than the work of any other individual. By developing a very parsimonious model

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employing only schooling, age, and annual weeks worked as variables, he was able to account for about 60 percent of the variation in US annual earnings for adult white men. His resulting functions have been applied in over 100 countries with the same resounding success achieved with US data. Invariably schooling rates of return are in the 5–15 percent range, exactly the same range as high-grade commercial investments. Similarly all cross-sectional earnings profiles proved concave, just as he predicted.

To understand worker earnings, as Mincer did, gets at the very core of economics, which entails understanding human well-being. Indeed comprehending the determinants of earnings helps policy makers develop tactics to promote wealth, to help ease poverty, and eventually to put countries on a path to increased growth and prosperity. Mincer's work shows that luck or decree do not lessen poverty, but instead concerted individual investments in human capital raise earnings and ease hardship. Even low-ability workers can benefit from training. Mincer's insights led to viable policies increasing overall wealth. As many have shown (e.g., Robert Barro and Xavier Sala-i-Martin, 1999), Mincer's insights have strong implications for economic growth.

Early economists looked at the functional distribution of income, that is, labor's share. But how labor's share is divided is also crucially important. Before 1958 (when Mincer published his first article on human capital based on his 1957 Columbia University dissertation), the reigning earnings distribution theories relied mostly on stochastic chance to determine who succeeded financially, and who did not. As such, theory offered no economic insights into the distribution process.[1] As Victor Fuchs states, "… The subject [of Mincer's classic *Schooling, Experience, and Earnings*] is earnings inequality, but the reader will look in vein for references to unions, monopsonists, minimum wage laws, discrimination, luck and numerous other institutional factors that are frequently introduced in such studies" (Fuchs, in Jacob Mincer, 1974, p. xiii). Adopting notions of Adam Smiths' theory of compensating differentials coupled with Friedman's notions of "tastes for risk and hence to choices among alternative [work options] differing in the probability distribution of the income they promise" (Jacob Mincer, 1974, p. 6), Mincer was able to come up with an entirely new theory. His innovation was to realize that these choices produced income streams easily evaluated using capital theory. As such, treating schooling and occupation as investment opportunities, Mincer ingeniously modeled the outcome of individual investment choices.

Although Mincer came up with these innovations in the late 1950s, human capital's roots go back to Sir William Petty who in 1691, according to B.F. Kiker, considered labor to be "the father of wealth" (Kiker, 1971, p. 61). Petty capitalized the wage bill (which he got by deducting property income from national income) to obtain an estimate of human wealth (Charles R. Hull, 1899, I, p. 108). Slightly later, the Spanish economist Gasper Melchor de Jovellanos (1744–1811), another very early human capital pioneer (Donald Street, 1988), dealt with the capitalized value of labor and applied his human capital ideas to redirect financing so that Spain could use education to solve its economic problems. Other early economists who considered human capital include Adam Smith, Jean Baptiste Say, Nassau William Senior, Friedrich List, Johann Heinrich von Thünen, Ernst Engell, Léon Walras, Irving Fisher (Kiker, p. 51), and Karl Marx (J.R. Walsh, 1935). Indeed, according to Kiker, "Human capital was somewhat prominent in economic thinking until Marshall discarded the notion as 'unrealistic' (ibid., p. 51) . . . since human beings are not marketable" (ibid., p. 60).

Of particular concern in much early work was applying the human capital concept to measure national wealth and the changes in national wealth caused by war (e.g., Yves Guyot, 1914; Harold Boag, 1916). Not considered in these works were life cycle aspects, though in 1924, Stanislav Strumlin calculated (without appropriate discounting) returns to education and on-the-job training for a group of Russian metal trade workers, and in 1935 Walsh produced tables essentially containing age-earnings profiles for law, engineering, and medicine. Later in 1945, Milton Friedman and Simon Kuznets examined the income structure in medicine, dentistry, law, accounting, and engineering during 1929–36.

2. The Mincer earnings function

Mincer in his quest to devise econometric techniques to estimate these returns, is the first to model human capital investment using capital theory's mathematical tools. By realizing that opportunity costs constitute the bulk of training costs and by making use of the fact that the internal rate of return emerges when individuals invest up to the point where investment costs just equal the present value of schooling gains, he obtained a simple and tractable econometric specification leading to the now famous log-linear earnings function. The so-called Mincer schooling model was published in 1958 and the more general model encompassing on-the-job training in 1970.[2]

Not only did this formulation provide a measure of private returns to schooling, but also it generalized to get at post-school on-the-job training, as well as Mincer's measures of on-the-job training.[3] On-the-job training accounts for between 11 and 15 percent of total worker compensation (ibid., p. 279).

Mincer's empirical work showed that a worker's wages rise over the life cycle at a decreasing rate until depreciation becomes more important than skill acquisition, yielding a concave earnings profile for most individuals. Not only does human capital theory explain this concavity, but human capital theory has strong implications concerning the rate at which earnings rise at each phase of the life cycle. Human capital theory also explains gender, race, and ethnic differences in earnings, geographic and job mobility, occupational choice as well as labor turnover, unemployment, and other labor market issues. But these applications came later in the development of human capital theory.

Before going on, let me note that other theories of earnings are now becoming popular. The most recent approaches involve incentive-based compensation schemes. In these models, firms provide an earnings contract to maximize effort and hence productivity. Some argue that these contract models complement human capital in explaining wages and other labor market phenomena; others argue that contract models substitute for the human capital model. In Solomon Polachek (1995), I laid out a unified framework nesting both type of models in order to determine the relative merits of each. In that article, I also surveyed tests of Mincer's human capital model along with extensions of the model. Now, in section 3 of this paper, I update part of that survey. Then, in section 4, I turn to new interesting unexplored international evidence testing implications of Mincer's "overtaking age" concept.

3. Proving Mincer right: tests of the human capital model

3.1. Education

By now all take for granted the positive correlation between earnings and schooling. Indeed there are so many empirical studies on the topic that it would be too difficult to do justice surveying even a subset. However, in a recent special edition of *Labor Economics* devoted to the topic, Orley Ashenfelter, Colm Harmon, and Hessel Oosterbeek (1999b) note that "these studies provide us strong evidence that schooling is a powerful investment in a wide variety of settings" (Ashenfelter, Harmon, and Oosterbeek, p. viii).[4] Barry R. Chiswick, Yew Liang Lee, and Paul W. Miller (2002) confirm this using data from the 1996 Australian Survey of Aspects of Literacy by in essence showing that "education is a value added process in which skills, including literacy and numeracy, are improved . . . ." Further, though there are different interpretations, data indicate that schools directly enhances real output. For example, Zvi Griliches (1963, 1964) used aggregate state (and regional) data to find far higher farm production in states with higher education levels. More recently, utilizing more appropriate micro-level information on 296 household farms in West Bengal, India, Subal Kumbhakar (1996, p. 188) showed "that education increases [actual] productivity" and that such effects increased farmer wages. Generalizing these results to economic growth, Barro and Sala-i-Martin (1999) find that the higher a population's education, the higher its gross domestic product (GDP) and GDP growth per capita. Also educated immigrants assimilate far more quickly into the US economy (George Borjas, 1993). Thus education has direct measurable effects on productivity and labor market success.[5]

3.2. Race, education and Black–White earnings differences

Prior to "Brown vs. the Board of Education," blacks in the United States were relegated to separate but "equal" schools. Finis Welch (1974) argued that at least a portion of the Black–White earnings gap is attributable to Black school quality deficiencies. Using data from several age groups, he shows dramatic increases in educational rates of return to "newer" vintage Black cohorts. Welch attributes these greater schooling returns to increases in Black school quality relative to Whites. He proceeds to make a case that school quality is an important aspect of the Black–White earnings gap. Despite its persuasiveness, the Welch study is limited because it contained no direct measures of per capita inputs for Black compared to White schools. By going back to state data, David Card and Alan Krueger (1992) rectified this deficiency by comparing direct measures of school quality. These include pupil–teacher ratios, annual teacher pay, and length of school term, all of which are linked to US Census data. Changes in school quality explain at least 50–80 percent of the relative increase in Black educational rates of return and at least 15–25 percent of the narrowing of the Black–White earnings gap between 1960 and 1980. In addition, David Card and Thomas Lemieux (1996) use changes in rates of return to explain Black–White differences over the 1980s. While some might offer explanations other than human capital, there is a striking consistency with human capital predictions: Education positively enhances labor market success, and better schools do the same.[6]

3.3 Earnings function concavity

Turning back to the earnings function and post-school investment, there is one finding that is virtually universal. This widespread result is "earnings function concavity."[7] For those continuously attached to the labor market, earnings rise at a decreasing rate throughout one's life until depreciation exceeds human capital accumulation.[8] Early studies (Mincer, 1974) tested this proposition using OLS regression with cross-sectional data. But the results hold when one adjusts for selectivity biases (Joop Hartog, Gerard Pfann, and Geert Ridder, 1989; B.F. Kiker and M. Mendes de Oliveira, 1992; Marjorie L. Baldwin, Lester A. Zeager, and Paul R. Flacco, 1994) and individual specific heterogeneity (Jacob Mincer and Solomon Polachek, 1978; Georg Licht and Viktor Steiner, 1991; Moon-Kak Kim and Polachek, 1994; Audrey Light and Manuelita Ureta, 1995).

3.4. Earnings of women

Interestingly, with respect to concavity, the human capital model (Polachek, 1975) predicts that female earnings profiles are lower and flatter. Furthermore age-earnings profile differences vary by marital status. Married women have 55 percent lower earnings profiles than married men. Additionally, married women's profiles are best fit by a cubic equation rising initially at a slow rate, then falling until the mid-30 age group, finally rising at about the same rate as males (Mincer and Polachek, 1974, 1978; Jacob Mincer and Haim Ofek, 1982). In contrast to these stark differences for the married, single men and women have roughly comparable profiles. Were discrimination the prime explanation for gender wage differences, one would need an alternative explanation why the discrimination model applies to married but not to single men and women. Thus discrimination cannot explain these marital status patterns, but human capital theory does.

At least in the past, the average woman exhibited intermittent labor force behavior, dropping out on an average over 10 years to bear and raise children. Such labor market patterns have implications for human capital investment. Discontinuous workers invest less, and their investments need not decline monotonically (Solomon Polachek, 1975a; Yoram Weiss and Reuben Gronau, 1981; Claudia Goldin and Solomon Polachek, 1987). As a result the simple quadratic earnings function should be "segmented" into various work and nonwork time periods to capture the appropriate investment patterns. The "segmented-earnings-function" developed in Mincer and Polachek (1974) established that earnings power depreciates 0.5–4.5 percent per annum during periods spent time out of the labor force (home time). Mincer and Polachek denote this to be a form of "atrophy" since it reflects earnings power deterioration when not using one's skills.

Because the estimation only makes use of past labor market experience, even the segmented function does not fully account for future work expectations (Polachek, 1975a; Goldin and Polachek, 1987; Kao et al., 1994). Failure to account for expectations leads to potential omitted variable biases in estimating male–female discrimination (Polachek, 1975b). This bias is evidenced by renewed human capital investment resulting in a rapid restoration of earnings power when intermittent workers permanently reenter the labor market upon completing home time (Mincer and Polachek, 1974; Mincer and Ofek, 1982).

3.5. Heterogeneous human capital and matching

Applying the above segmented-earnings-function to specific occupations enables one to compute occupation-specific depreciation rates. Such a framework implies that occupations differ from each other in skill content. Some skills deteriorate more quickly when not used, while others become obsolete as technology changes. As such, human capital is heterogeneous. In this structure, individuals select a type of human capital (occupation) to best match their attributes.[9]

This framework enables one to apply the human capital model to predict gender differences in occupational choice (Solomon Polachek, 1979, 1981). Workers expecting to drop out the longest minimize atrophy costs by choosing occupations with the lowest depreciation. Women maximize by choosing occupations with lower atrophy rates, since on average their labor force participation is more intermittent than men. This approach to occupational segregation has not been without controversy, but the latest evidence overwhelmingly supports the conclusions (John Robst and Jennifer VanGuilder, 2000).

Although initially applied to occupations, the same framework holds in other domains. For example, Morton Paglin and Anthony Rufolo (1990) show how one's comparative advantage in quantitative versus verbal ability affects college major. Polachek and Francis Horvath (1977) show how location and job attributes affect one's life cycle geographic and job mobility. Boyan Jovanovic and Jacob Mincer (1981) show how the quality of one's job match explains declining turnover with tenure on-the-job. Alison Booth and Jeff Frank (1999) show how performance-related pay attracts high quality workers. Gary Becker (1974) even carries this type matching one step further by considering assortive mating, thereby getting more generally at family investments in human capital.[10]

3.6. Incomplete employee and employer information

In a sense the whole matching process is a form of search. Labor force participants search for the best job matches and employers search for employees with the best skills. Search and matching models developed independently of human capital theory (George Stigler, 1961), but in reality, information is a form of human capital in which employees and employers both invest. The more information each party obtains, the better the match and the higher worker wages and productivity.

Search strategies have two implications: first, there is incomplete information because search is costly. Efficient search entails stopping rules that lead searchers to compromise by sufficing instead of ending up in the *best* job possible. (The same can be said for employers searching for the best-possible employee.) Second, incomplete information likely results in eventual job turnover because imperfect information on both sides can lead to improved matches when additional information is acquired by both sides with time on-the-job.

One can apply frontier estimation (Dennis Aigner, C.A.K. Lovell, and Peter Schmidt, 1977) to Mincer earnings functions to separate observed wage dispersion into purely random variation (noise in the data), variation due to incomplete employee information, and variation due to incomplete employer information (Solomon Polachek and Bong Yoon, 1987). To get at these facets, simply estimate Mincer's earnings function with an error term containing three components $\varepsilon = u + v + w$, such that $-\infty < u < \infty$, $-\infty < v < 0$, and $0 < w < \infty$, as indicated below:

$$\ln Y = a_0 + a_1 S + a_2 t + a_3 t^2 + u + v + w.$$

The error component u represents the typical two-sided error term representing pure noise. The negative error term v represents a worker's incomplete information since it represents the difference between the wage a worker receives and the wage that could have been attained given knowledge of a higher paying firm. The positive error term w represents a firm's incomplete information since it represents the difference between the wage a firm pays and the wage it could have paid had it known of workers willing to work at lower wages. By introducing independent direct measures of workers' knowledge of the *World of Work*, Solomon Polachek and John Robst (1998) verify that this generalization of Mincer's earnings function can be used to actually measure incomplete market information, thus illustrating yet another application of the Mincer earnings function.

4. Mincer's overtaking age revisited

Perhaps one of the more unique, interesting, but rarely explored concepts to emerge from Mincer's earnings function formulation is the "overtaking point." The overtaking point is the point in one's life cycle when observed earnings just equals one's potential earnings at graduation, were there no post-school investment. As illustrated in Figure 1 (Mincer, 1974, p. 17), the concave curve $Y_0 Y_j Y_P$ plotted over the life cycle reflects observed earnings, which are potential earnings (E_j depicted by curve $Y_S\, E_j Y_P$) minus (net) human capital investments C_j.[11] At the overtaking point $\hat{j}$, observed earnings $Y_{\hat{j}}$ equal potential earnings upon graduation, that is, $Y_{\hat{j}} = E_0 = Y_S$.

As is the case for many profound discoveries, the overtaking point should have been obvious. Early in one's career, the typical person takes a job below Y_S, say Y_0, to finance post-school investment. Eventually earnings grow higher than Y_0, surpassing Y_S as one reaps returns from investments C_j. Figuring out the overtaking point merely implies solving for the age at which this occurs.

4.1. Mincer's derivation of the age at overtaking

To derive the overtaking point, Mincer rigorously specifies the experience level at which observed earnings just equals one's earnings potential at graduation. This is point $\hat{j}$ when $Y_S = Y_{\hat{j}}$ (again refer to Figure 1, taken from Mincer, figure 1.2, p. 17).

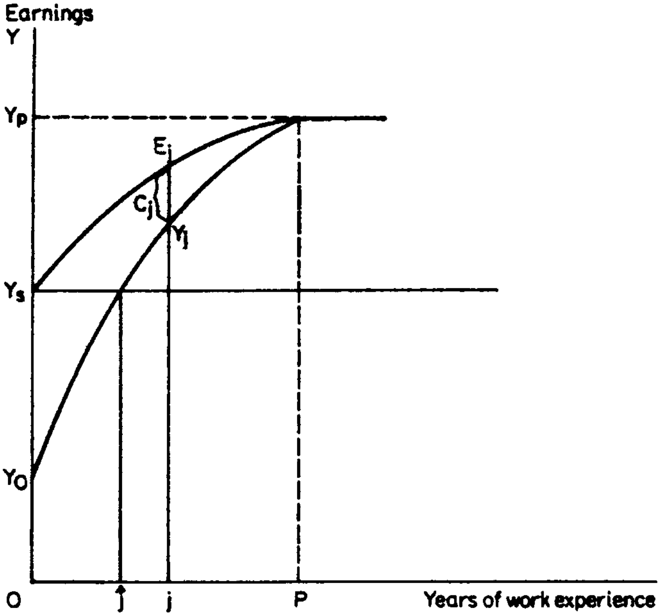

Figure 1. Earnings profiles. Source: Jacob Mincer, *Schooling, Experience, and Earnings.*

Recall that upon graduation, one invests a portion of potential earnings Y_S in on-the-job training. This investment lowers observed earnings to $Y_0 = Y_S - C_0$. Observed earnings then rise as one begins to accumulate the returns from investments C_t. Thus according to Mincer,

$$Y_{\hat{j}} = Y_s + r\sum_{t=0}^{j-1} C_t - C_j = Y_s$$

occurs when $r\sum_{t=0}^{j-1} C_t = C_j$. If human capital investment (C_t) occurring from $t = 0$ through $t = \hat{j}$ is constant, then $r\hat{j}C_j = C_j$ implying $\hat{j} = 1/r$. If C_t declines between time 0 and $\hat{j}$, then the overtaking number of years can be expressed as $\hat{j} \leq 1/r$.

The overtaking point is important because it enables one to observe what one would have earned upon graduation at each level of schooling. This knowledge facilitates computing schooling rates of return. Simply compare $Y_{\hat{j}}$ at each schooling level S_i. Percentage earnings differences reflect the impact of schooling and define rates of return (assuming all schooling costs are opportunity costs). Indeed at $\hat{j}$ the Mincer "Schooling Model" should work best. Empirical tests (Charles Brown, 1980) somewhat (but not completely) corroborate this.

The overtaking point is also important for another reason. Mincer uses it to get at some interesting implications regarding earnings distribution.

4.2. Implication regarding earnings distribution

Define $\sigma^2(Y_j)$ to be the variance of earnings, and define $\sigma^2(\ln Y_j)$ to be the *relative* earnings variance. According to Mincer, $\sigma^2(Y_j)$ and $\sigma^2(\ln Y_j)$ must vary over the life cycle. The pattern of variation depends on the dispersion in post-school investments and the correlation between post-school investment and earning capacity (Mincer, 1974, pp. 98–103). "If ... the correlation between (dollar) schooling and post-school investment is positive ... dollar variances must rise from overtaking to peak earnings. In addition, dollar variances will rise throughout if $\sigma^2(Y_0) < \sigma^2(Y_{\hat{j}})$ ..." (Mincer, 1974, p. 98). In contrast, $\sigma^2(\ln Y_i)$ is more likely to be U-shaped (Mincer, 1974, p. 103).

To see this more rigorously, Mincer defines earnings (Y_{si}, $Y_{\hat{j}i}$, and Y_{pi}), and the log of earnings ($\ln Y_{si}$, $\ln Y_{\hat{j}i}$, and $\ln Y_{pi}$) as well as earning variance at three points in the life cycle: (1) at graduation, point S; (2) at the overtaking point $\hat{j}$; and (3) at point p, when the earnings profile peaks. Accordingly, as depicted in equation (2) below, earnings upon graduation (Y_{si}) for any individual i equal earnings potential (E_{si}) minus investments made in the first year out in the labor force (C_{0i}). Earnings at the overtaking point $Y_{\hat{j}}$, depicted in equation (3), are simply (E_{si}). Finally, earnings at the profile peak (Y_{pi}), depicted in equation (4), are initial earnings potential upon graduation (E_{si}) plus the returns to all past post-school investments (rC_T). Equations (5)–(7) give comparable definitions for relative earnings ($\ln Y$) where k is time-equivalent investment ($k = C/E$) and K is time-equivalent human capital stock ($K_t = \sum_{j=0}^{t-1} k_j$):

$$Y_{si} = E_{si} - C_{0i} \Rightarrow \sigma^2(E_s) + \sigma^2(C_0) - 2\rho(C_0, E_s)\sigma(E_s)\sigma(C_0) \tag{2}$$

$$Y_{\hat{j}i} = E_{si} \Rightarrow \sigma^2(Y_{\hat{j}}) = \sigma^2(E_s) \tag{3}$$

$$Y_{pi} = E_{si} + rC_T \Rightarrow \sigma^2(Y_p) = \sigma^2(E_s) + r^2\sigma^2(C_T) + 2r\rho(C_T, E_s)\sigma(E_s)\sigma(C_T) \tag{4}$$

and

$$\begin{aligned} \ln Y_{si} &= \ln E_{si} + \ln(l - k_{0i}) \\ \Rightarrow \quad &\sigma^2(\ln Y_s) = \sigma^2(\ln E_s) + \sigma^2(\ln(1 - k_0)) \\ &\qquad + 2\rho(\ln E_S,\ \ln(1 - k_0))(\sigma(\ln E_s), \sigma(\ln(1 - k_0)) \end{aligned} \tag{5}$$

$$\ln Y_{pi} = \ln E_{si} \Rightarrow \sigma^2(\ln Y_{\hat{j}}) = \sigma^2(\ln E_s) \tag{6}$$

$$\begin{aligned} \ln Y_{pi} &= \ln E_{si} + rK_{ti} \\ \Rightarrow \quad &\sigma^2(\ln Y_p) = \sigma^2(\ln E_s) + r^2\sigma^2(K_T) + 2r\rho(\ln E_s, K_T)\sigma(\ln E_s)\sigma(K_r). \end{aligned} \tag{7}$$

Variances of earnings (and relative earnings) across all i individuals at each of these three points are also given in equations (2)–(7). Note, as just indicated above, the variances (or standard deviations) depend on the correlation between school and post-school investments. For dollar earnings, these are generally positively correlated, leading to the possibility that the earnings distribution widens throughout life (or more specifically from graduation, to the overtaking point, and finally to the point where the earnings profile peaks). But changes in logarithmic earnings variances over the working life depend on the correlation between $\ln E_S$ and $\ln(1 - k_0)$. As Mincer states, "If the correlations are weak, $\rho_1 = \rho_2 = 0$ and the profile of log variances is U-shaped, with the bottom at [the] overtaking [age]" (Mincer, 1974, p. 103). Mincer illustrates the validity of these conjectures in two figures, reproduced below as Figures 2 and 3.

Given the uniqueness of these results, I think it is worthwhile to examine whether these patterns generalize to the US economy today, so many decades after Mincer's original contribution in this area. Investigating these earning distributions is the point of the remainder of this paper. But, in addition to exploring the United States, I utilize the Luxembourg Income data to also analyze a random set of nine of that data's 26 countries, thereby testing whether the results generalize internationally.

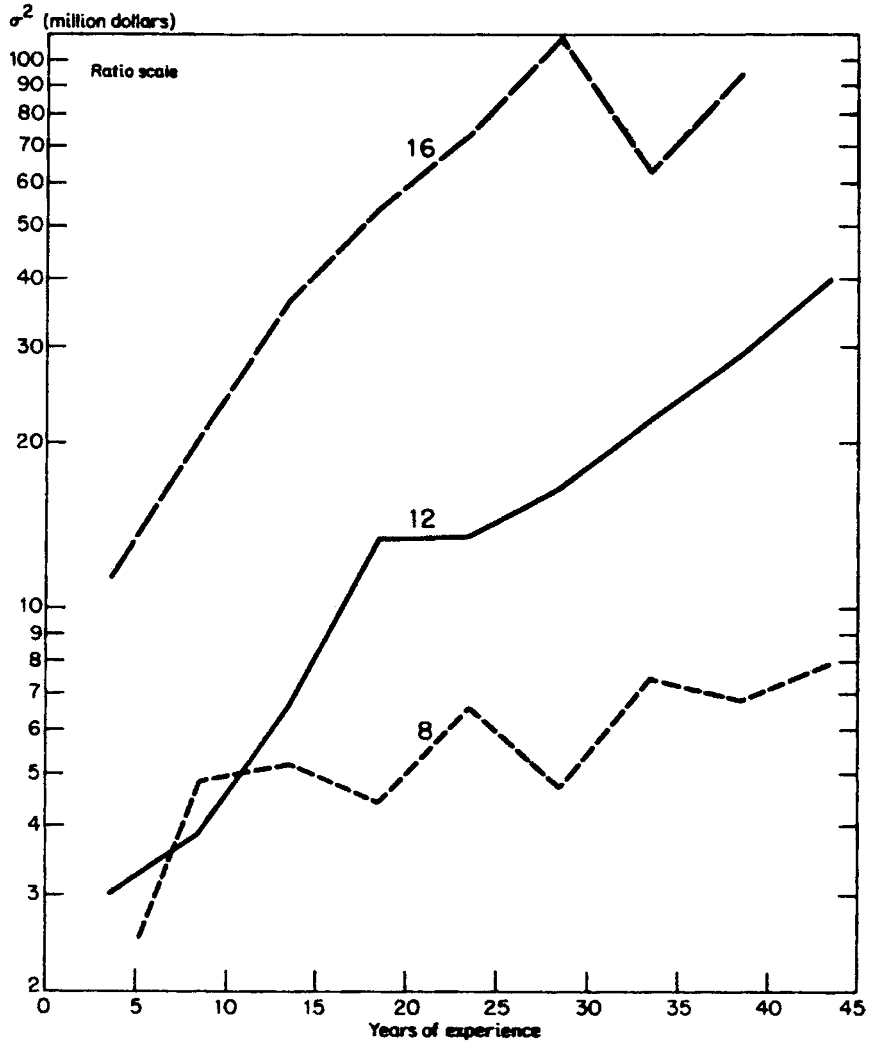

Figure 2. Experience profiles of variances of annual earnings of White, nonfarm men, 1959. Note: Figures on curves indicate years of schooling completed. Source: Jacob Mincer, *Schooling, Experience, and Earnings.*

4.3. Earnings distribution in the United States, 1980 and 1990

I use the 1980 and 1990 census to examine US earnings variations over the life cycle.[12] To avoid confounding earnings distribution with gender and race and to conform to Mincer (1974), I concentrate on White males.[13] And to circumvent labor supply issues, I examine hourly earnings (computed as annual earnings divided by a measure of hours worked per year). The final graphs are given in Figures 4–7.[14] Two figures are presented for each decade: one for the standard deviation of dollar hourly

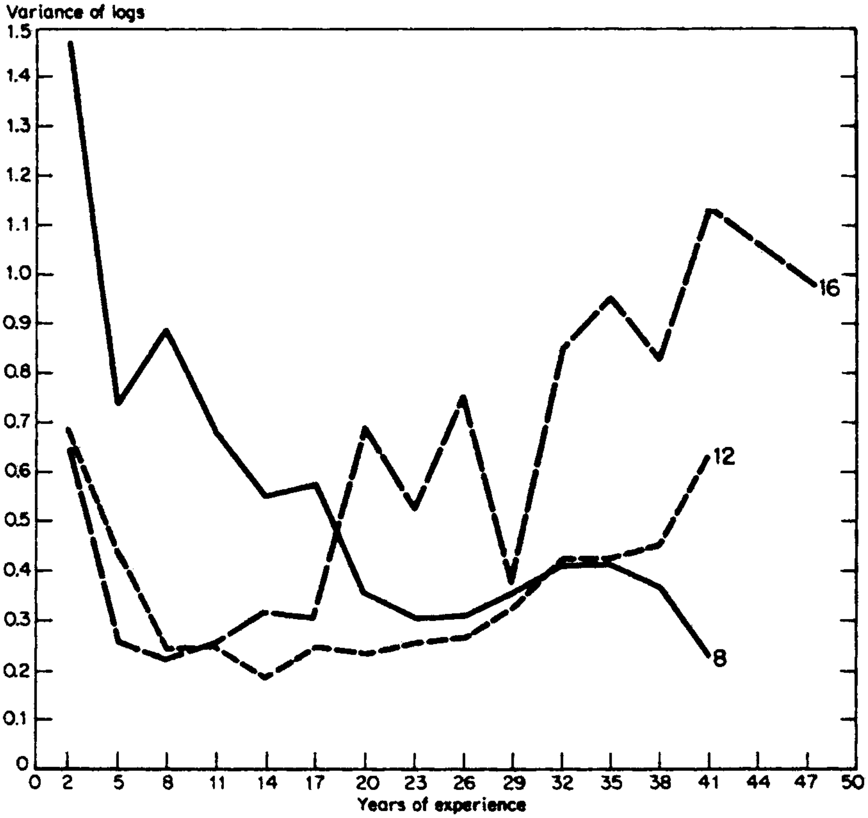

Figure 3. Experience profiles of log variances of annual earnings of White, nonfarm men, 1959. Note: Figures on curves indicate years of schooling completed. Source: 1/1000 sample of U.S. Census, 1960. Source: Jacob Mincer, *Schooling, Experience and Earnings.*

earnings $\sigma(Y)$ over the life cycle and another for the standard deviation in relative hourly earnings $\sigma(\ln\ Y)$.

Several interesting observations are apparent. First, the standard deviation of the *logarithmic* wage profile is U-shaped. However, the life cycle pattern of the standard deviation in *dollar* wage is not. Second, the trough in 1980 is at about 19 years of experience, while the trough in 1990 is at about 12.5 years of experience. Both observations are consistent with Mincer's expectation. That the log-variance profile is more U-shaped is consistent with a lower correlation between time-equivalent investment and initial earnings. Also, observing an earlier 1990 than 1980 overtaking point $\hat{j}$ is consistent with rising human capital rates of return. (See Table 1 containing US earnings profile parameters including the rate of return to schooling for 1980 and 1990.) Third, and perhaps inconsistent, is the exact age when overtaking takes place. According to Mincer, the 1980 experience level at overtaking should be less than 16.4 years [$\hat{j} < (1/0.061) = 16.4$], and the 1990 experience level should be less than 10.5

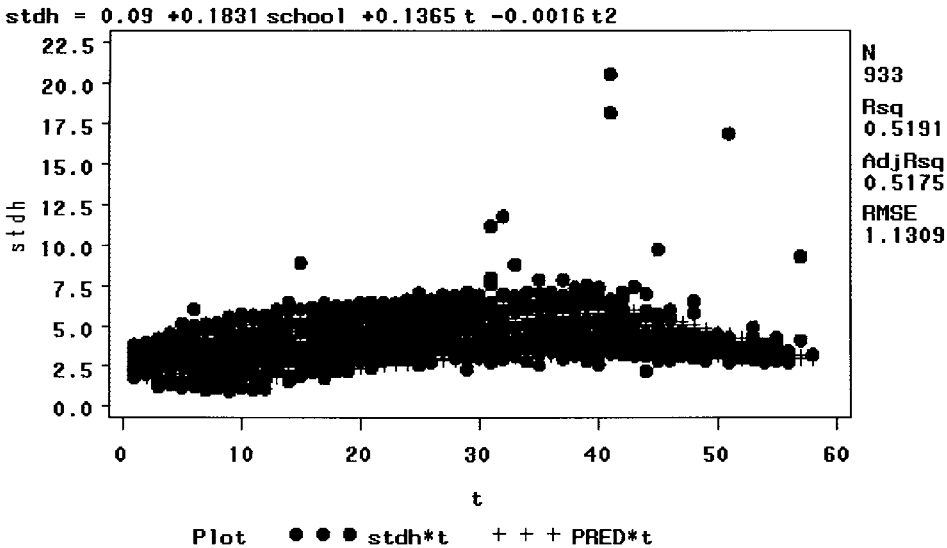

Figure 4. Standard deviation of hourly earnings over the life cycle.

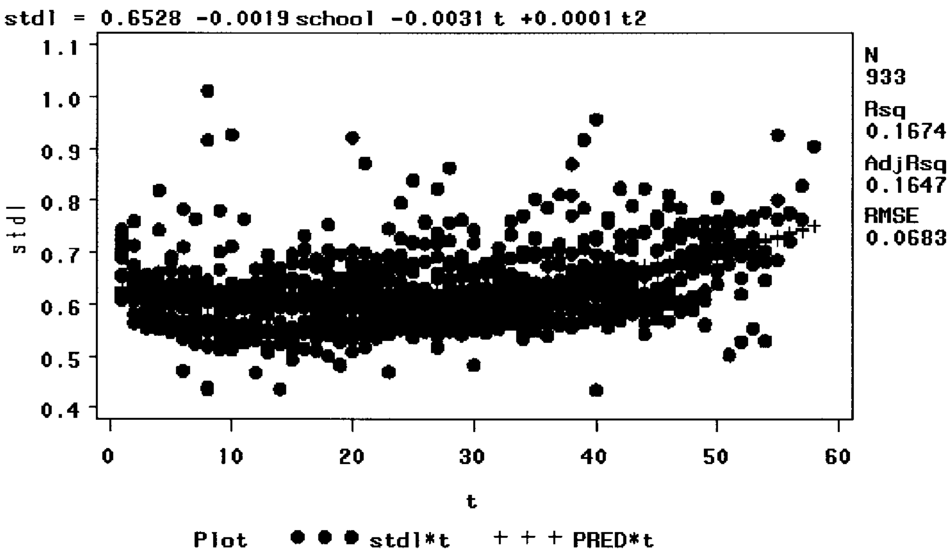

Figure 5. Standard deviation of ln hourly earnings over the life cycle.

[$\hat{j} < (1/0.095) = 10.5$]. Consistent with Mincer, both are higher than the troughs just observed in Figures 5 and 7. However, a number of factors can lead to biases trying to discern the difference in rates of return between schooling and on-the-job training. On the one hand, schooling is subsidized which normally would imply higher

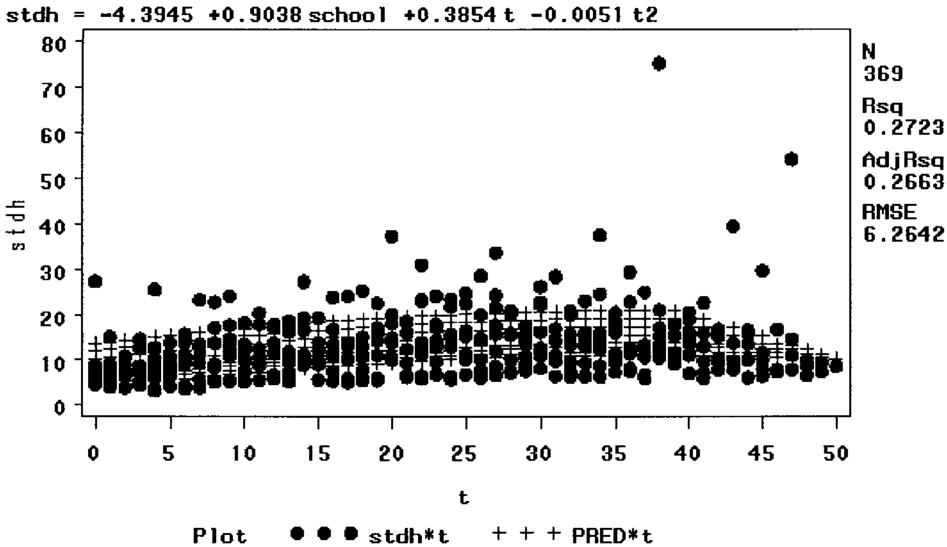

Figure 6. Standard deviation of hourly earnings over the life cycle.

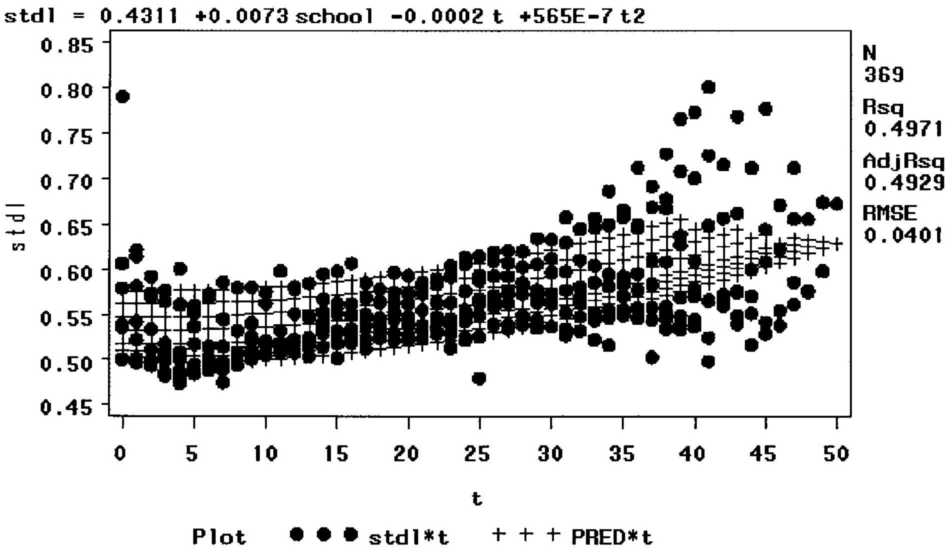

Figure 7. Standard deviation of ln hourly earnings over the life cycle.

investment levels and possibly lower rates of return. On the other hand, subsidization lowers costs and raises returns. Thus it is conceivable that schooling rates of return exceed on-the-job training rates of return, thereby leading to downward biased estimates of the overtaking age. Obviously other issues are also

Table 1. Earnings function paramters by country and year.

Country	Year	cnst	*t*-value	school	*t*-value	Experience	*t*-value	Experience-squared	*t*-value	*R*-sqaured
Australia	1981	8.26	175.6	0.062	18.6	0.058	26.7	−0.0011	−25.5	0.11
Australia	1994	7.86	97.4	0.095	16.3	0.11	25.1	−0.0021	−21.0	0.24
Belgium	1997	4.66	65.3	0.096	26.2	0.041	10.2	−0.0005	−6.4	0.33
Canada	1997	0.636	13.9	0.09	27.6	0.072	41.2	−0.0012	−30.1	0.19
Canada	1998	1.099	51.3	0.082	52.6	0.05	57.9	−0.0008	−39.5	0.34
Czech Republic	1996	−2.051	−92.9	0.091	55.2	0.038	33.2	−0.0007	−30.2	0.2
France	1994	2.087	28.2	0.089	24.1	0.063	13.6	−0.00089	−9.9	0.14
Mexico	1984	−3.752	−86.8	0.116	35.6	0.065	20.4	−0.001	−16.4	0.3
Mexico	1998	0.22	7.1	0.139	56.1	0.0606	26.8	−0.0009	−20.2	0.32
ROC-Taiwan	1995	11.21	329.3	0.087	37.9	0.083	61.5	−0.0017	−72.6	0.42
Spain	1980	11.55	313.1	0.121	56.1	0.044	56.1	−0.0008	−24.7	0.25
Spain	1990	11.76	421.1	0.111	59.4	0.077	50.1	−0.0012	−38.7	0.31
Sweden	1995	3.519	49.3	0.057	14.7	0.0316	6.8	−0.00066	−6.7	0.05
United States	1980	0.681	16.1	0.061	18.5	0.0552	31.24	−0.001	−17.6	0.13
United States	1990	0.709	30.1	0.095	61.6	0.047	44.0	−0.0007	−31.7	0.2

Source: LIS data and 1980 and 1990 US Census.

involved. For example, using cross-sectional rates of return estimates for a lifecycle phenomenon might bias rates of return, but the whole econometric issue that evolved on how to appropriately estimate Mincer's earnings functions is not the focus of this paper.

4.4. International data

The Luxembourg Income Study (LIS) is a collection of household data compiled from ongoing statistical surveys in 26 countries.[15] The database provides statistics on demographic, income, and expenditure variables on three levels: households, persons, and children. I concentrate on extracting education, age, and earnings data for White males from the person files of the countries, at least half of which contain information on hourly earnings.[16] Of those, I concentrated on nine countries chosen randomly.

For each of these countries, I first ran an earnings profile for the entire sample. These are reported in Table 1. Then I stratified by education and age to compute age-specific earnings variations. As such, I computed $\sigma(Y_{S,A})$ where S equals schooling level and A equals age. To get at nonlinearities, I plotted an age-specific earnings variation profile (both in log and dollar formats). For each profile I fitted a sixth-degree polynomial in age. (These are available on request.) To preserve space, I recalibrated each profile with potential experience level (rather than age) and graphed them on one diagram. I followed the same procedure for each country. Finally, I fit a quadratic equation for the final recalibrated age-specific $\sigma(Y_{S,A})$ points. The predicted values from these equations along with the original data points are contained in Figures 8–27. For each country, there are two figures. One figure is for the standard deviation of *relative* earnings (Figures 8, 10, 12, 14, 16, 18, 20, 22, 24, and 26, with vertical axes denoted as stdl, standing for the standard deviation of the logarithm of earnings). The other is for the variance in earnings (Figures 9, 11, 13, 15, 17, 19, 21, 23, 25, and 27 with the vertical axes denoted as stdh).

A number of patterns emerge. First, *relative earnings* standard deviation profiles tend to be U-shaped. *Dollar* standard deviation profiles are not. Second, the troughs of the U-shaped profiles tend to hover around 25 years of experience. Figure 28, which graphs each country's rate of return against trough experience levels, implies a negative correlation between these troughs (i.e., the experience levels at these troughs) and rates of return. This result implies that countries with high rates of return tend to have lower overtaking points, just as Mincer predicted. Third, as Mincer finds, *dollar* variance profiles rise as schooling increases. However, while *relative* variance profiles tend to rise with schooling, this is not the case for every country.

The experience levels associated with each trough are somewhat larger than expected, given estimated rates of return. Of course, one reason may be that schooling returns overstate post-school investment returns. Another may be that underlying earnings function parameters vary across members of the population.

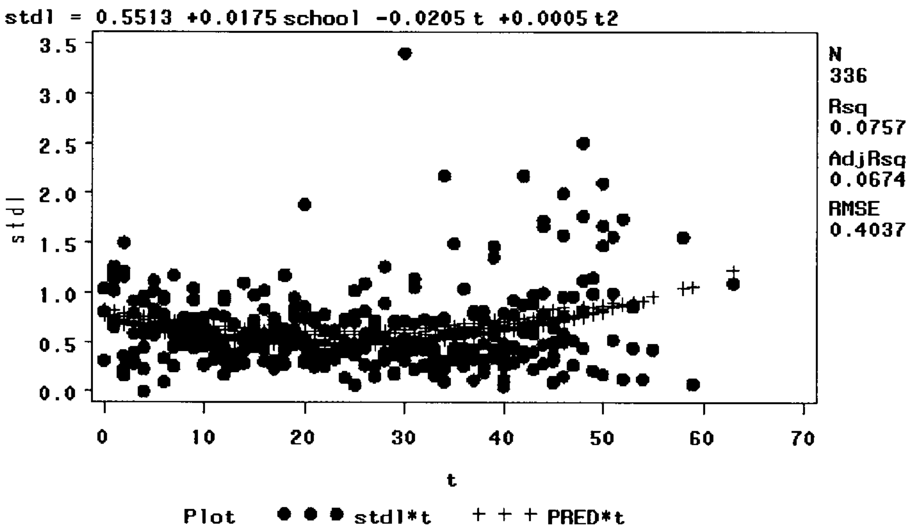

Figure 8. Standard deviation of ln gross annual earnings over the life cycle, Australia, 1981.

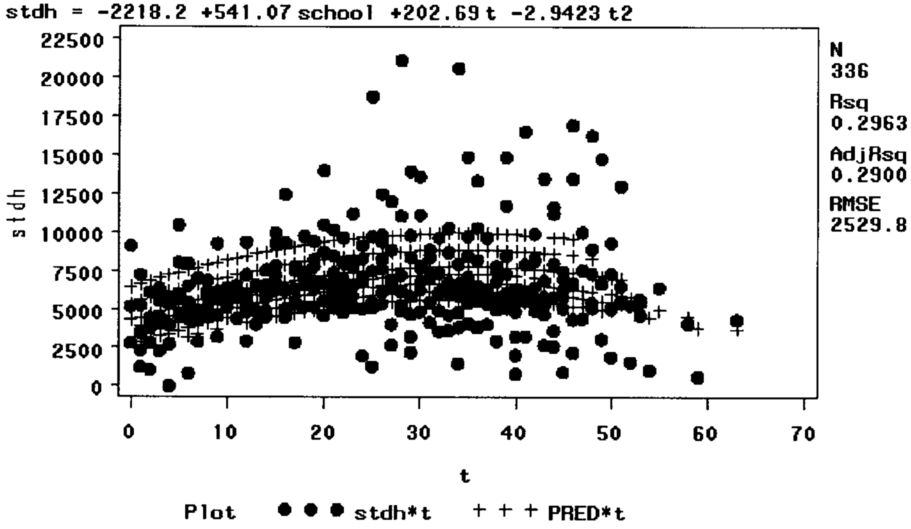

Figure 9. Standard deviation of gross annual earnings over the life cycle, Australia, 1981.

This heterogeneity adds to earnings dispersion, making the overtaking point less discernable. Still another reason may be that rates of return depend on investment level, which could alter the shape of the earnings-dispersion-experience profile. Clearly, these possibilities need to be explored in future work.

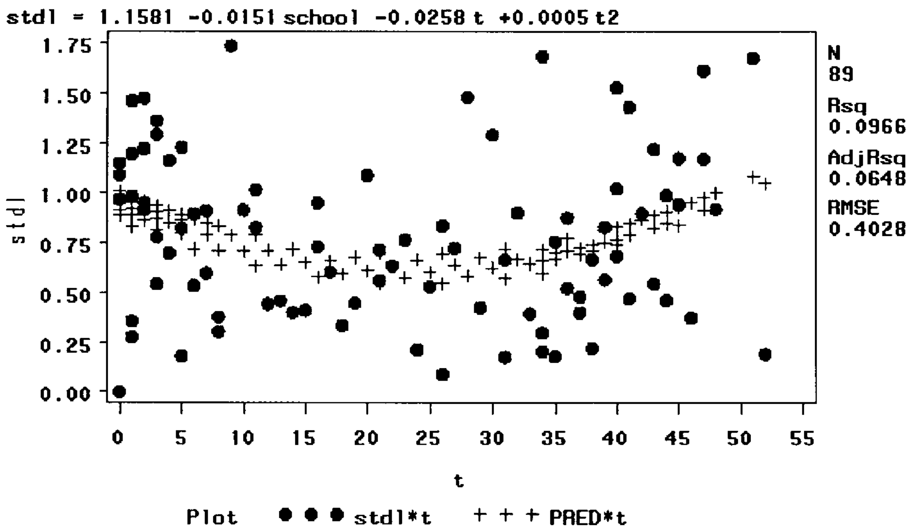

Figure 10. Standard deviation of ln gross annual earnings over the life cycle, Australia, 1994.

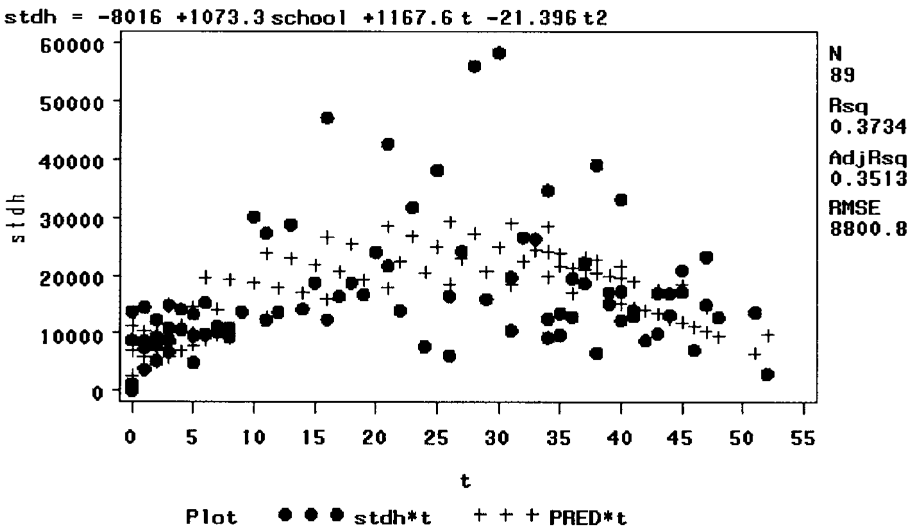

Figure 11. Standard deviation of gross annual earnings over the life cycle, Australia, 1994.

5. Conclusions

An individual's labor market success is probably the most important indicator of individual welfare.[17] As such, how earnings are distributed across the population is of paramount importance. In his 1957 Ph.D. dissertation, followed by his 1958

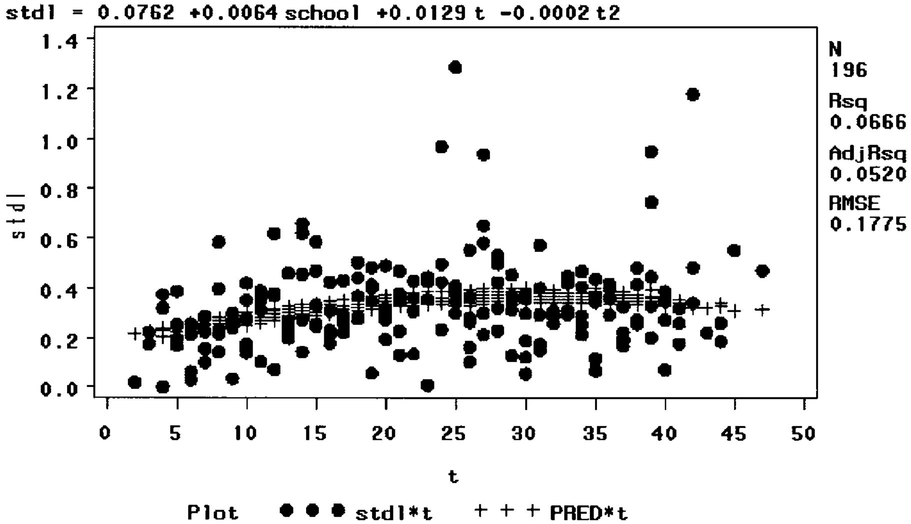

Figure 12. Standard deviation of ln hourly earnings over the life cycle, Belgium, 1997.

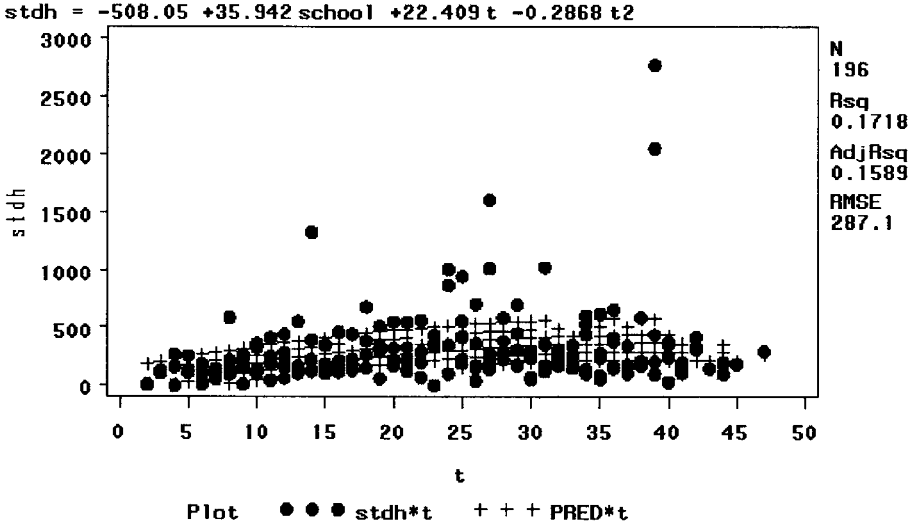

Figure 13. Standard deviation of hourly earnings over the life cycle, Belgium, 1997.

Journal of Political Economy article, Jacob Mincer pioneered an important approach to understand earnings distribution. In the years since this seminal work, he, his colleagues, and his students extended the original model, reaching important conclusions about a whole array of observations pertaining to worker well-being.

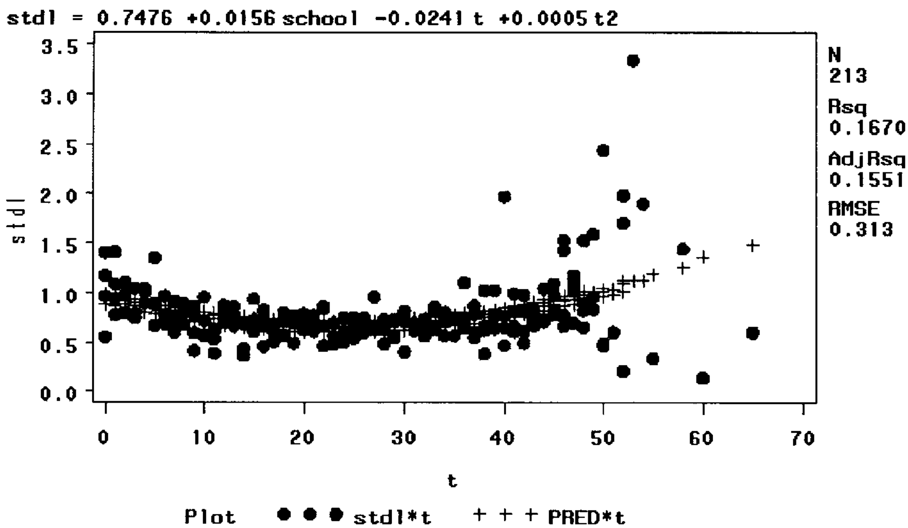

Figure 14. Standard deviation of ln hourly earnings over the life cycle, Canada, 1997.

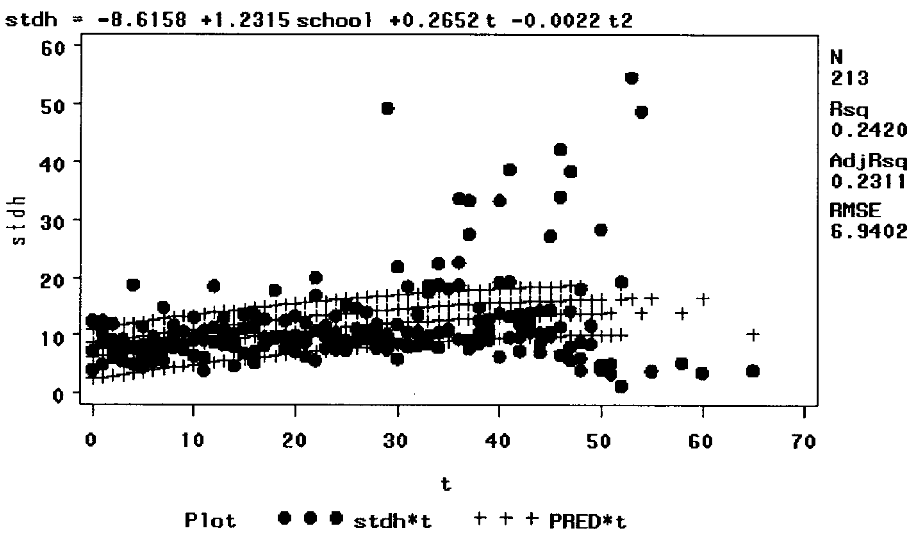

Figure 15. Standard deviation of hourly earnings over the life cycle, Canada, 1997.

The line of research proved powerful and robust because it explained many important earnings-related phenomena. For example, it explained why education enhances earnings so that an extra year of school provides approximately 5–15 percent higher earnings; why earnings rise through one's life cycle at a

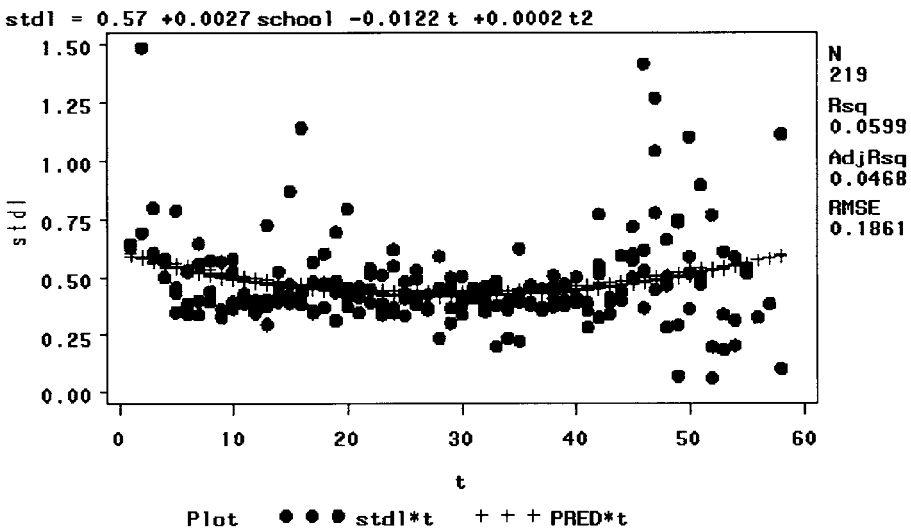

Figure 16. Standard deviation of ln hourly earnings over the life cycle, Czech Republic, 1996.

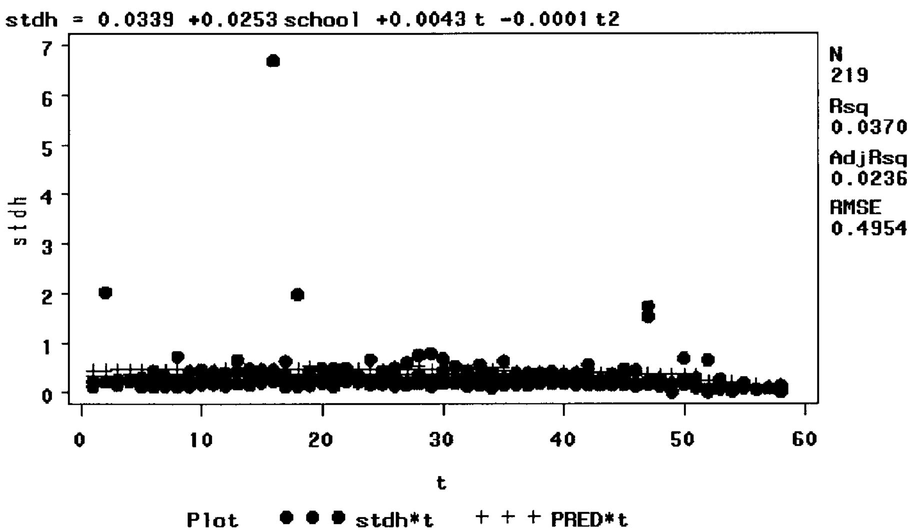

Figure 17. Standard deviation of hourly earnings over the life cycle, Czech Republic, 1996.

diminishing rate; how earnings power atrophies with intermittent labor force participation; why earnings growth is smaller for those anticipating intermittent labor force participation; why men earn more than women; why married women earn less than single women; why Whites earn more than Blacks; why occupational

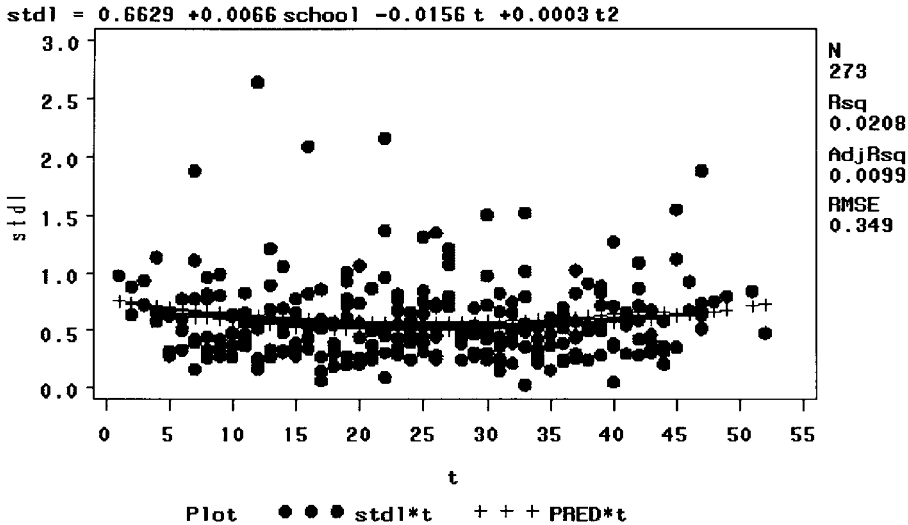

Figure 18. Standard deviation of ln hourly earnings over the life cycle, France, 1994.

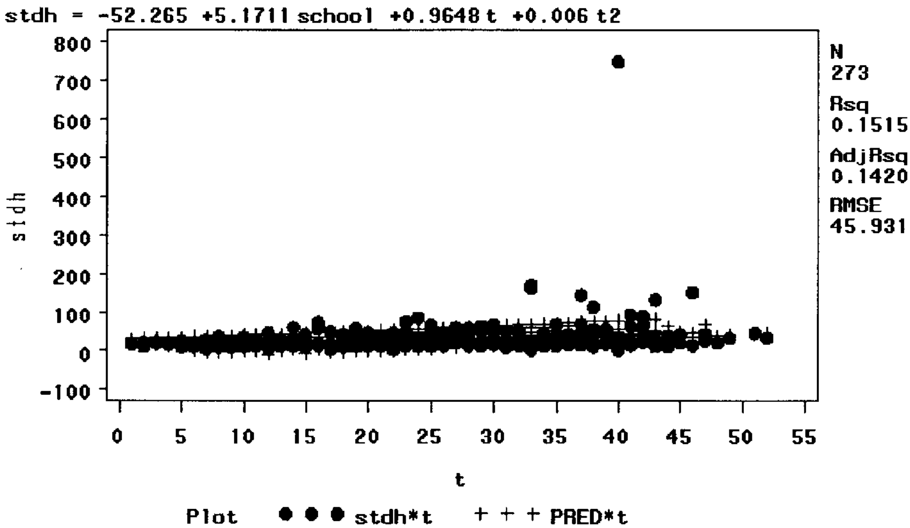

Figure 19. Standard deviation of hourly earnings over the life cycle, France, 1994.

distributions differ by gender; why geographic and job mobility predominates for the young more than the old; why on-the-job tenure reduces turnover; and why unemployment is lower among the skilled.

However, also in the years since Mincer's ground-breaking work, a number of alternative theories were developed to explain *subsets* of the patterns mentioned

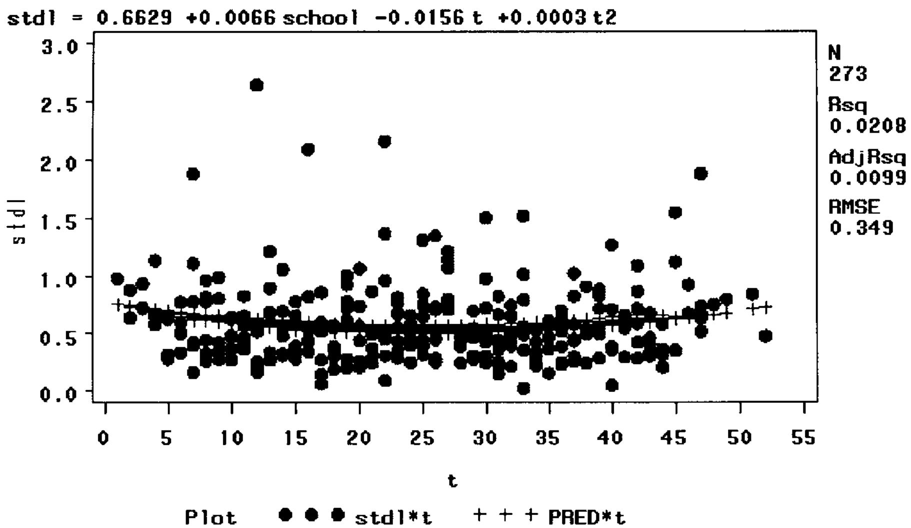

Figure 20. Standard deviation of ln hourly earnings over the life cycle, Mexico, 1988.

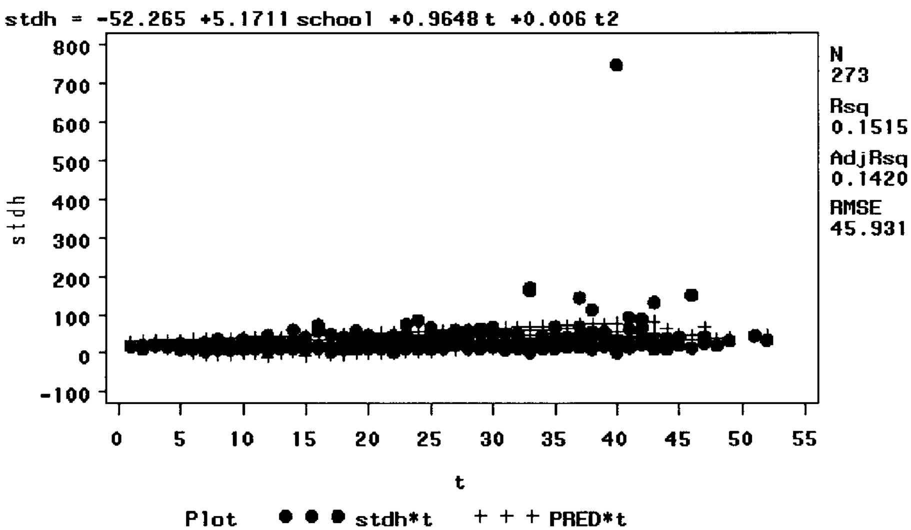

Figure 21. Standard deviation of hourly earnings over the life cycle, Mexico, 1988.

above. For example, screening models look at why education raises earnings. Occupational segregation models attempt to get at why the male occupational distribution differs from the female occupational distribution. Efficiency wage models hypothesize why an economy sustains unemployment, but not necessarily

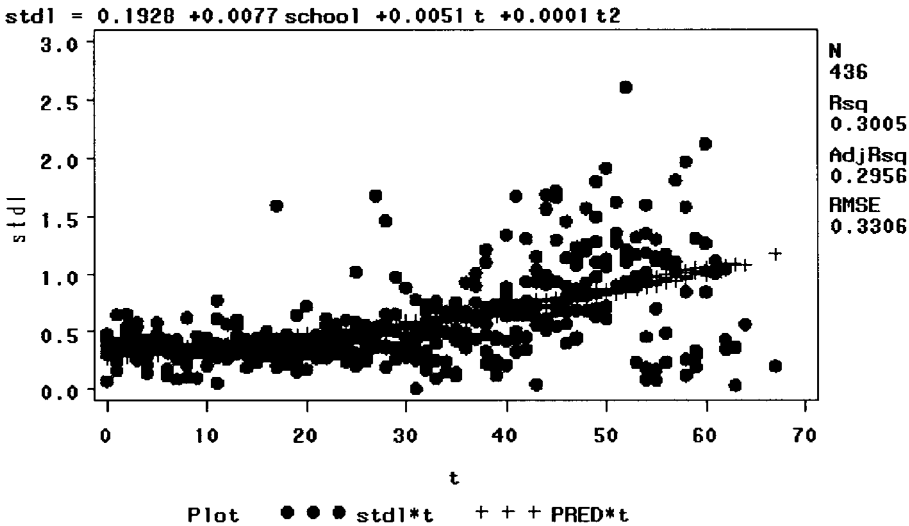

Figure 22. Standard deviation of ln hourly earnings over the life cycle, Taiwan, 1995.

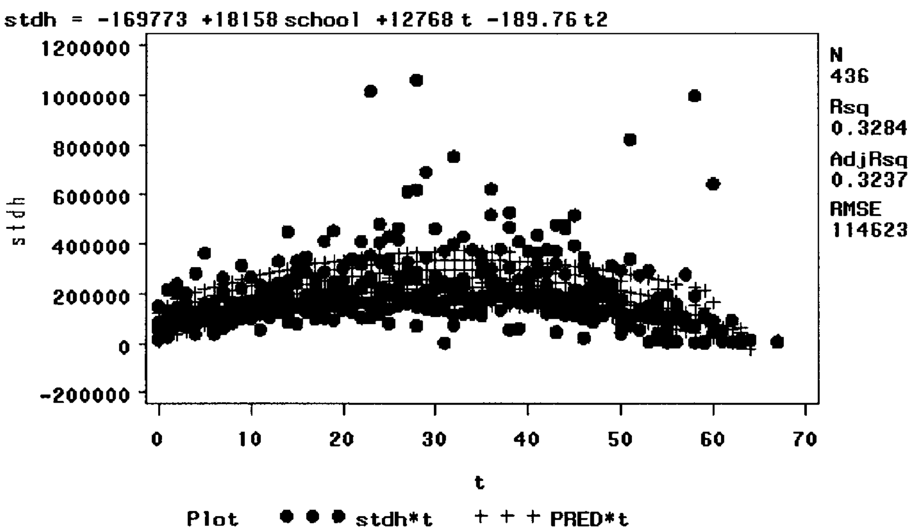

Figure 23. Standard deviation of hourly earnings over the life cycle, Taiwan, 1995.

how unemployment is distributed across the population.[18] And, effort-enhancing contract models emerged to offer an alternative explanation to upwardly sloped earnings profiles, though it is not obvious they account for the specific concave shape.

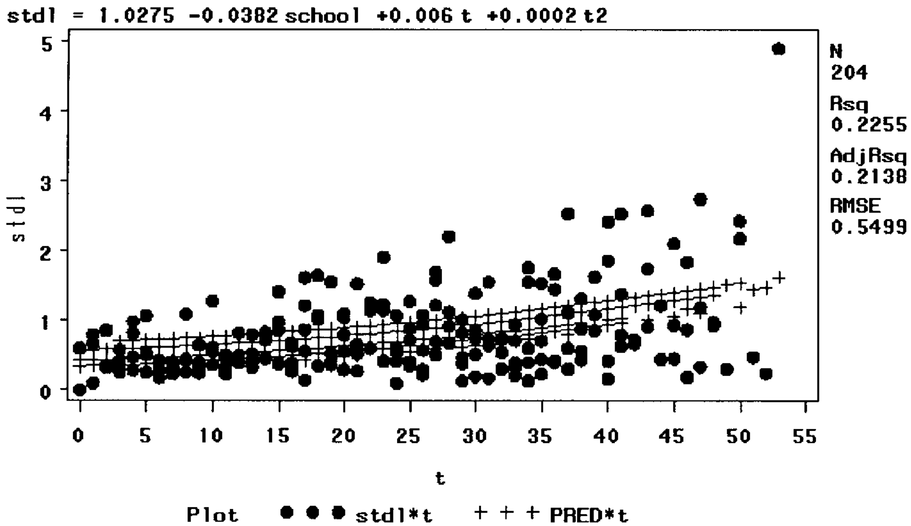

Figure 24. Standard deviation of ln net annual earnings over the life cycle, Spain, 1990.

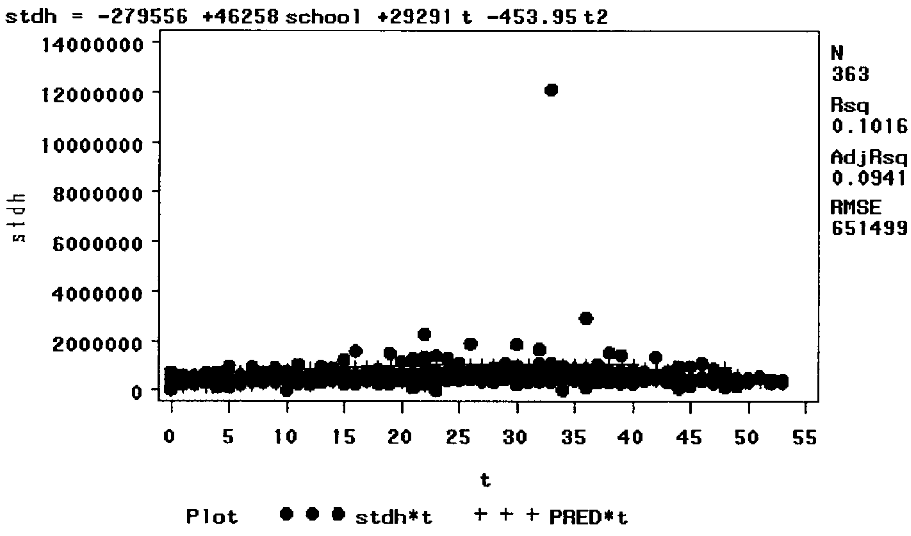

Figure 25. Standard deviation of net annual earnings over the life cycle, Spain, 1990.

Only one theory—the human capital theory—seems to explain *each* phenomenon. The human capital theory is well-grounded in standard neoclassical economic theory and subject to much econometric testing across time (over 40 years) and across space (over 100 countries). This paper surveys human capital theory related to Mincer's

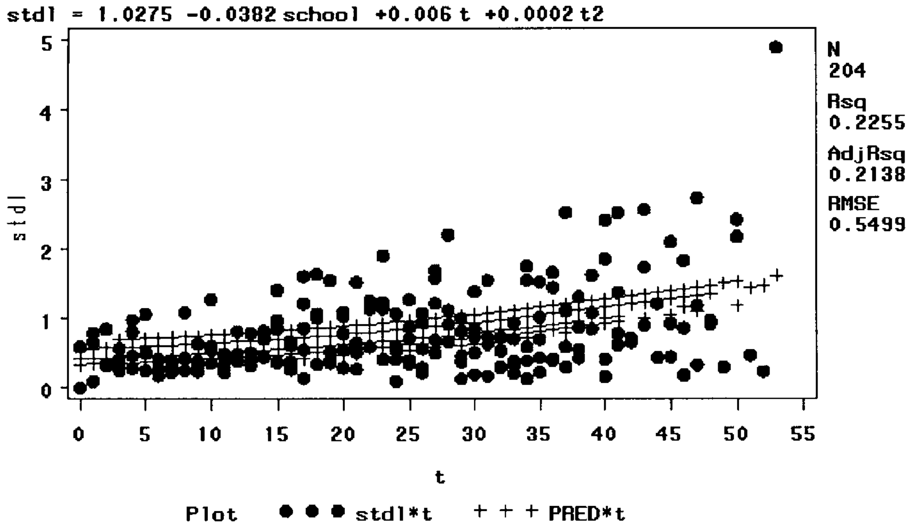

Figure 26. Standard deviation of ln hourly earnings over the life cycle, Sweden, 1996.

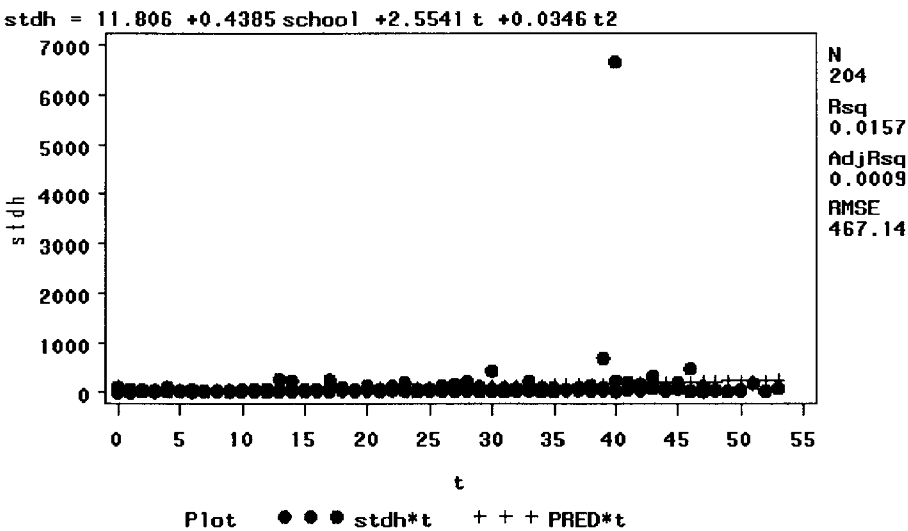

Figure 27. Standard deviation of hourly earnings over the life cycle, Sweden, 1996.

earnings function. In addition it provides new empirical work regarding the overtaking age. Its main substantive contribution is to reexamine one implication of this concept as it relates to the earnings distribution, particularly Mincer's prediction of a U-shaped life cycle log-variance of earnings profile. No alternative model gives this prediction. In this vein, the paper not only replicates Mincer's original findings

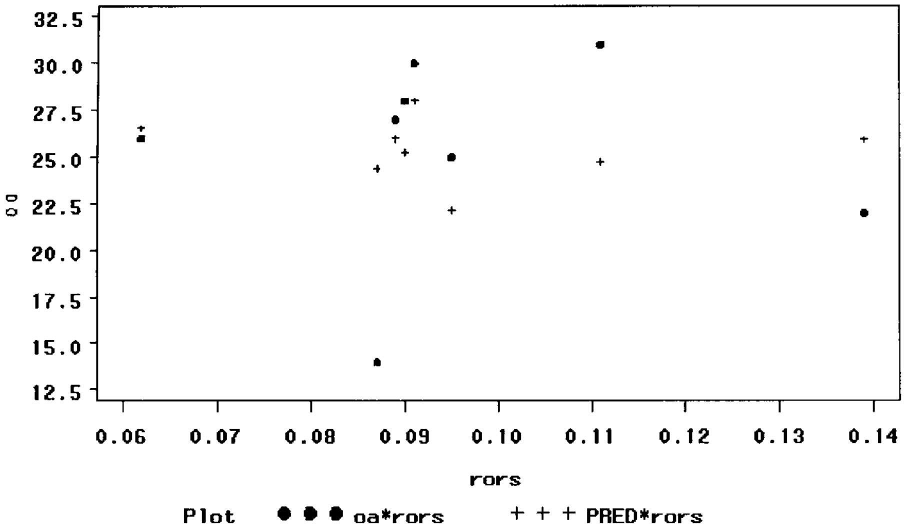

Figure 28. Overtaking age (oa) vs. educational rate of return (rors).

using US Census 1980 and 1990 data, but also using nine other countries. As Mincer predicted, I find U-shaped earnings variance profiles for relative earnings, but not for nominal earnings.

Notes

1. Perhaps most well-known was Gibrat's theory modified by Kalecki and Rutherford. These theories point out that a log-normal income distribution results when individuals are bombarded annually with random percent income augmentations, perhaps as a result of "luck" or "chance." The distribution's overall variance is preserved over time/stays constant either "if there is 'a negative correlation between the size of the random shock and the level of income (Kalecki)' [Mincer, p. 5] or if the random shock is applied 'without restriction separately to age cohorts throughout their life histories" '(Mincer, p. 5).
2. Also see Gary Becker (1964) and Gary Becker and Barry Chiswick (1966).
3. See Jacob Mincer (1962), which is updated in Jacob Mincer (1993).
4. Other recent work on this includes James Heckman, Anne Layne-Farrar, and Petra Todd (1996) and David Card (1998).
5. In addition, education positively affects nonlabor market activities. For example, Robert T. Michael (1973) shows that education improves one's efficiency in consuming every day commodities. Dora Polachek and Solomon Polachek (1989) illustrate "reverse intergenerational transfers" by showing that even one's children's education positively affects the way one consumes.
6. One should note contrasting views on school quality. For example Eric Hanushek (1996) states that specific educational programs are not consistently related to student performance. On the other hand, Eric Hanushek, John Kain and Steven Rivkin (2002) find that special education boosts mathematics achievement for learning disabled students. However, how these educational achievements translate into market success requires further study, according to Eric Hanushek, James Heckman, and Derek Neal (2002).
7. This result is obtained from the negative α_3 coefficient found when estimating the well-know quadratic Mincer earnings function: $\ln Y = a_0 + a_1 S + a_2 t + a_3 t^2 + u$. The variable $\ln Y$ = the logarithm of

earnings, S = years of schooling, t = labor market experience, t^2 = experience squared, and u = the typical randomly distributed normal error term. See Heckman and Polachek (1974) for more information on the validity of the ln-linear functional form.

8. Some exceptions are in panel data, but one can question how to adjust for price changes. Another exception is in executive pay late in some individuals' career paths.
9. See David Autor (2001) for implications regarding new labor market institutions that might evolve from this matching process.
10. See Raquel Fernandez and Richard Rogerson (2001) for a recent generalization and Robert Nakosteen and Michael Zimmer (2001) for an empirical analysis of marital selection. An early matching application I first heard described in a conversation with James Heckman (while he was at Columbia University) views women who choose the occupation "wife" as being matched with men who demand various levels of "wife services." This was later implemented by Amyra Grossbard-Shechtman (1984).
11. Net investment equals *gross* human capital investments minus *depreciation*. See Solomon Polachek and W. Stanley Siebert (1993) chapter 2 for an exposition and diagrams contrasting gross and net investment.
12. For consistency as well as because of data limitations (particularly with the international data which will be used shortly), I follow Mincer's approach of using a "cross-sectional" cohort. This means I compare earnings data for variously aged individuals in a given year. Interpreting these age comparisons to reflect purely life cycle (age) effects requires one to assume that both cohort effects and time-period effects are negligible. Thus one must assume that observations on each successive age group represents the effect of a given cohort of individuals getting older and not the effect of being born in the following year (cohort effect) or the effect of having earnings measured in a successive year (time-period effect). Researchers have long recognized that true cohort and cross-sectional profiles differ. Further it would be a mistake to simply add general growth rates of real earnings to growth rates of earnings associated with age, because at least recently, age-earnings profiles grew differently for individuals with higher levels of education than those with lower levels of education. For example, see Paul Beaudry and David Green (2000) who illustrate this with the Canadian Surveys of Consumer Finance and the Canadian Census. Also see James Heckman and Richard Robb (1985).
13. Using women would be interesting but the results would not be comparable because on average their lifetime labor force participation is so different than males that their human capital investment function is non-monotonic resulting in lower and flatter non-concave earnings functions (Polachek, 1975a). Most likely these earnings profile differences also affect women's earnings *distributions*.
14. The regression results underlying the figures are available upon request.
15. An appendix containing a list of the countries contained in the LIS data is available from the author upon request. Also available is an appendix with the particular country surveys comprising the data.
16. The following countries were analyzed: Australia, Belgium, Canada, Czech Republic, France, Mexico, Republic of China (Taiwan), Spain, and Sweden. Annual earnings were substituted for those countries with no reported hourly wages.
17. This section extends the conclusions reached in Polachek (1995).
18. Carmel Chiswick (1986) argues that efficiency wage models actually *assume* rather than explain unemployment because they require "surplus labor ... to justify the zero price paid to labor quantity units." I thank one of the journal referees for pointing out this reference.

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