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ABSTRACT

Mincer's Overtaking Point and the Lifecycle Earnings Distribution*

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 wellbeing. 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 U.S. as well as at least seven other countries.

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

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I. Introduction: Labor Economics Mincer-Style

When I first contemplated graduate school, I visited Columbia University just the day Reuben Gronau presented his Ph.D. dissertation research. His topic entailed a time-allocation model to estimate SST travel demand based on saving hours from faster speed. The Economics Department was in Fayerweather Hall, but the seminar took place a half dozen blocks away in a dingy drab second floor room of an old building on 114th Street. Gronau was seated at the head. Gary Becker and Jacob Mincer, the seminar leaders, were perpendicular to him on each side. Becker and Mincer were both brilliant, but both different; and the differences were stark.

Becker was outgoing, asking lots of questions and continually calling on students. By comparison, Mincer seemed taciturn, relatively reserved and introspective, questioning Gronau only sparingly and picking on students infrequently. I believe also at the seminar were Linda Edwards, Isaac Ehrlich, Victor Fuchs, Gill Ghez, Mike Grossman, Gioria Hanoch, Masanori Hashimoto, Marjorie Honig, John Claude Koeune, Arleen Liebowitz, Bob Michael, Dave O'Neill, June O'Neill, Beth Niemi (now deceased), John Owen, Mike (Carl) Rahm, and possibly Victor Fuchs and Finis Welch. I realized those present were the world's best, brightest and most talented young labor economists, whose brand of labor economics differed from the simple institutional approach I had seen and dismissed as an undergraduate. Obviously exciting major changes were occurring in labor economics and they were happening at Columbia University. Columbia was a place where labor economists ate, breathed, and dreamt economics. That's all they talked about; it was total emersion. By the time the seminar finished I was convinced that I wanted to be a part of that group. I knew Columbia was for me, so I enrolled; and I am glad I did.

Indeed, over the next year or two it got even better. Barry Chiswick and Bill Landes returned, with Bill bringing his wife Lisa. Jim Heckman arrived with immense curiosity and boundless energy. Soon Anne Bartel, Andrea Beller, George Borjas, Cynthia Brown Lloyd, Masatoshi Kuratani, Margaret Ludlum, Haim Ofek, Jacob Paroush, Cordelia Reimers, Mark Rosenzweig, Sue Ross (who unfortunately passed away just weeks before the conference), Fredericka Pickford Santos, Carmel Ulman (later to become Carmel Ullman Chiswick), Harriet Zellner, among others, joined the labor seminar. Columbia had the very best -- all in one place. I could see that Becker's and Mincer's advocacy for using the price theoretic approach as a tool to understand many social problems attracted the best of Columbia's students to labor economics. Anyone that was anyone in labor was at Columbia during the 1960's and early 1970's. I was lucky to arrive just at the peak.

Mincer was a perfectionist. Both in his own work and in guiding others. He professed solid theory with an eye toward rigorous empirics. As I'll mention later, Mincer's notion of rigorous empirical research was not necessarily sophisticated multi-equation, non-linear maximum likelihood estimation, but instead to apply a sound specification to a number of data sets to assess what you might call robustness, Mincer style. He was reluctant to let a student finish until he was convinced no stone was left unturned to verify a thesis' assertions.

Students, on the other hand, had another idea of rigor. They would introduce Mincer to their spouse and kids, somehow to convince him they needed a job to support their family. This they hoped would gain his approval for a dissertation defense, so finally they could get on with their life. Perhaps then, he would consent that yet an additional regression with still another data set might not really be necessary for the degree, "even though surely, it would be mandatory for publication". Even the paper Jacob and I did together didn't satisfy him until he completely redid the entire draft and reran the entire set of regressions stratified by three different educational groups. For the extra work, I owe deep gratitude to George Borjas, who served as the final research assistant for this latter stage of analysis.

But Mincer was a perfectionist, especially in his own work. When I first got to Columbia I took the typical core courses: Jacob's statistics course, Gary Becker's micro-theory course, Albert Hart's macroeconomics course and Philip Cagan's monetary theory course. During that first year, I attended a faculty student reception and asked Professor Mincer about labor economics. He said, "It's simple. There are supply and demand." Well, I took his labor course. The first semester we studied labor supply, and the second we studied how employees supply the market with human capital; but we never did get to labor demand. Finally, at Jacob's Columbia University retirement party in May 1990, I got the courage to ask him about labor demand. He said "Wait, there's still time." Well I'm happy to say that in Jacob's 1997 paper on changes in wage inequality (Mincer, 1997), he finally deals with how technology affects the demand for human capital. All I can say is that Jacob is such a perfectionist that it took him over 30 years to get supply in good enough shape to ultimately pursue demand.

Indeed Jacob Mincer was a perfectionist like no other. As I mentioned, his brand of perfection was to devise a theory. (It had to be rigorous, yet parsimonious, since Mincer was an ardent believer of Occam's razor.[2]) Then, Mincer meticulously tested his theory empirically. Unlike a number of today's economists, he thought you really didn't have a viable theory unless you could see its implications *strongly* from *OLS* estimation. Thus he didn't use fancy non-linear maximum likelihood estimation of the type that made Heckman famous, but instead he tested and re-tested his theory in as many ways as possible. Take School, Experience and Earnings as an example. Not only did he derive an earnings function and fit it with data using a multitude of specifications (e.g. linear and exponential decay functions), but also he looked at the theory's further implications regarding earnings distribution. For this reason, every theory Mincer developed is *robust*. Indeed probably the most frequently estimated equations in the history of economics are the "Mincer earnings equation" and the "Mincer female labor supply function." Both form the basis of all wage and employment studies.

To me, one of Mincer's most illuminating articles was his "Market Prices, Opportunity Costs, and Income Effects". The paper dealt with five topics (transportation costs, labor supply, the demand for domestic servants, fertility and search). Not only did each become a major field of labor economics research; but also when viewed more generally, the paper could be construed as the impetus for much of the empirical labor economics literature. This is especially true regarding all serious research on gender. As such, it would not be unreasonable to consider Mincer a founding father of modern labor economics *and* a founding father of gender economics. As father of modern labor

[2] Occam's (Ockham's) razor, the principle that a model's uncontested propositions should be minimal, was first formulated in the fourteenth century by William of Ockham. Ockham had several forms for the principle. The most common is: *Pluralitas non est ponenda sine necessitate.* See Philotheus Boehner (1958), p. 155.

economics, Mincer concentrated primarily on two major areas: labor supply and human capital. But within these major branches of labor economics he also wrote about education, on-the-job training (which he sometimes called post-school investment), wage floors, labor turnover, economic developments, technology, unemployment, and even on the accuracy of economic forecasting models. His important work on human capital and labor supply is put together in a two-volume set, Studies in Human Capital: Collected Essays of Jacob Mincer Volume I and Studies in Labor Supply: Collected Essays of Jacob Mincer, Volume II (Cambridge: Edward Elgar), 1993. But since then, he wrote additional articles, two of which are published in Research in Labor Economics.

In this paper, I concentrate on Mincer's path-breaking contributions how human capital theory explains the earnings distribution.

II. 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 employing only schooling, age, and annual weeks worked as variables, he was able to account for about 60 percent of the variation in U.S. 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 to 15% 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 i.e., 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.[3] 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 J. Mincer (1974): xiii). Adopting notions of Adam Smith's 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" [Mincer, 1974: 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 1950's, human capital's roots go back to Sir William Petty (1691) who, 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, 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

[3] 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]

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 and 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.

III. 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.[4]

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 Mincer's

[4] Also see Becker (1964) and Becker and Chiswick (1966).

measures of on-the-job training which are contained in his 1962 article, updated in Mincer (1993). On-the-job training accounts for between 11 and 15% 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. Whereas, 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 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 the next section of this paper, I update part of that survey. Then, in the section after, I turn to new interesting unexplored international evidence testing implications of Mincer's "overtaking" age concept.

IV. Proving Mincer Right: Tests of the Human Capital Model

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 *et al.* (1999) note that "these studies provide us strong evidence that schooling is a powerful investment in a wide variety of settings" (Ashenfelter *et al.*: viii).[5] Barry Chiswick, Yew Lee and Paul 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 school 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 (1996:188) 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 GDP and GDP growth per capita. Also educated immigrants assimilate far more quickly into the U.S. economy (Borjas, 1993, 1994). Thus education has direct measurable effects on productivity and labor market success.[6]

2. Race, Education and Black-White Earnings Differences

Prior to 'Brown vs. the Board of Education,' blacks in the U.S. were relegated to separate but 'equal' schools. 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. However, going back to state data, David Card and Alan Krueger (1992) rectified this deficiency by comparing direct measures of school quality.

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[5] Other recent work on this includes Card (1998) and Heckman *et al*. (1996).

[6] In addition, education positively affects non-labor market activities. For example, Robert 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.

These include pupil-teacher ratios, annual teacher pay, and length of school term, all of which are linked to U.S. Census data. Changes in school quality explain at least 50-80% of the relative increase in black educational rates of return and at least 15-25% 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.[7]

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". 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, et al., 1989; B. F. Kiker and M. Mendes de Oliveira, 1992; or Marjorie Baldwin, Lester Zeager and Paul Flacco, 1994) and individual specific heterogeneity (Mincer-Polachek, 1978; Georg Licht and Viktor Steiner, 1991; Moon-Kak Kim and Solomon Polachek, 1994; Audrey Light and Manuelita Ureta, 1995).

4. Earnings of Women

More interestingly, as the human capital model (Polachek 1975) predicts, female earnings profiles are lower and flatter (less concave). Further these age-earnings profile differences vary by marital status. Married women have 55% 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-thirty age group, finally rising at about the same rate as males (Mincer-Polachek, 1974, 1978; Mincer-Ofek 1982). In

[7] 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, he 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).

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 average over ten 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 (Polachek, 1975, Yoram Weiss and Reuben Gronau, 1981, and Claudia Goldin and Solomon Polachek, 1987). As a result the simple quadratic earnings function should be "segmented" into various work and non-work time periods to capture the appropriate investment patterns. The "segmented earnings function" developed in Mincer-Polachek (1974) established that earnings power depreciates ½-4 ½ 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 doesn't fully account for future work expectations (Polachek, 1975a and Goldin-Polachek 1987). 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-Polachek, 1974, Mincer-Ofek, 1982).

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

[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.

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 (Polachek, 1979, 1981). Workers expecting to drop out the longest minimize atrophy costs by choosing occupations with the lowest depreciation. Since on average women are more intermittent than men, they maximize by choosing occupations with lower atrophy rates. 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. Solomon Polachek and Francis Horvath (1978) 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) shows how performance related pay attracts high quality workers. 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]

6. The Human Capital Earnings Function and 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 independent of human capital (George Stigler, 1961), but in reality information is a form of human capital in which employees

[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.

and employers both invest. The more information each party obtains, the better the match and the higher are 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 bad matches, and 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 $e = u + v + w$, 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*, Polachek and 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.

V. 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 lifecycle when observed earnings just equals one's potential earnings at graduation, were there no post-school investment. As illustrated in Figure 1 (Mincer, 1974:17), the concave curve $Y_0 Y_j Y_P$ plotted over the lifecycle 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, i.e., $Y_{\hat{j}} = E_0 = Y_S$.

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.

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, page 17). 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,

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

[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.

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 $\hat{j} = \frac{1}{r}$. If C_t declines between time 0 and $\hat{j}$, then the overtaking number of years can be expressed as $\hat{j} \leq \frac{1}{r}$.

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.

2. Implication Regarding Earnings Distribution

Define $s^2(Y_j)$ to be the variance of earnings, and define $s^2(\ln Y_j)$ to be the *relative* earnings variance. According to Mincer, $s^2(Y_j)$ and $s^2(\ln Y_j)$ 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: 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 $s^2(Y_0) < s^2(Y_{\hat{j}})$ …"(Mincer, 1974:98). In contrast, $s^2(\ln Y_i)$ is more likely U-shaped (Mincer, 1974:103).

To see this more rigorously, Mincer defines earnings $(Y_{si}, Y_{\hat{j}i}, \text{and } Y_{pi})$, 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 lifecycle: (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 first year out in the labor force (C_{0i}). Earnings at the overtaking point $Y_{\hat{j}}$, depicted in (3), are simply (E_{si}). Finally, earnings at the profile peak (Y_{pi}), depicted in (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 ($\ln Y$):

(2) $$Y_{si} = E_{si} - C_{oi} \Rightarrow \sigma^2(E_s) + \sigma^2(C_o) - 2\rho(C_o, E_s)\sigma(E_s)\sigma(C_o)$$

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

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

and

(5) $$\ln Y_{si} = \ln E_{si} + \ln(l - k_{oi})$$

$$\Rightarrow \sigma^2(\ln Y_s) = \sigma^2(\ln E_s) + \sigma^2(\ln(1-k_o)) + 2\rho(\ln E_S, \ln(1-k_0))(\sigma(\ln E_s), \sigma(\ln(1-k_0))$$

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

(7) $$\ln Y_{pi} = \ln E_{si} + rK_{ti} \Rightarrow$$

$$\sigma^2(\ln Y_p) = \sigma^2(\ln E_s) + r^2\sigma^2(K_T) + 2r\rho(\ln E_S, K_T)\sigma(\ln E_s)\sigma(K_r).$$

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 over the working life in logarithmic earnings variances 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, 1974:103). 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 worthwhile to examine whether these patterns generalize to the U.S. 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 7 of that data's 26 countries, thereby testing whether the results generalize internationally.

3. Earnings Distribution in the United States, 1980 and 1990

I use the 1980 and 1990 Census to examine U.S. 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 earnings $s(Y)$ over the life cycle and another for the standard deviation in relative hourly earnings $s(\ln Y)$.

Several interesting observations are apparent. First, the standard deviation of the *logarithmic* wage profile is U-shaped. However, the lifecycle pattern of the standard

[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 lifecycle (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 for with the Canadian Surveys of Consumer Finance and the Canadian Census. Also see James Heckman and Robert 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.

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 ½ year 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 over-taking point $\hat{j}$ is consistent with rising human capital rates of return. (See Table 1 containing U.S. 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 13.9 years [$\hat{j}$ <(1/.061) = 16.4], and the 1990 experience level should be less than 10.5 [$\hat{j}$ <(1/.095) = 10.5]. Both are lower than the 19 and 12 ½ year troughs just observed in Figures 5 and 7. While bothersome, a number of factors can explain this incongruity. Most likely, the finding results from difference in rates of return between schooling and on-the-job training. On the one hand, schooling is subsidized which normally would imply higher 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 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. 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 eight countries chosen randomly.

[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.

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 $s(Y_{S,A})$ where S equals schooling level and A equals age. To get at non-linearities, 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 re-calibrated 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 re-calibrated age-specific $s(Y_{S,A})$ 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 earnings (Figures 8, 10, 12, 14, 16, 18, 20, 22, 24, and 26 with vertical axes denoted as stdh). The other is for the variance in *relative* earnings (Figures 9, 11, 13, 15, 17, 19, 21, 23, 25, and 27 with vertical axes denoted as stdl, standing for the standard deviation of the logarithm of earnings).

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 twenty-five years of experience. (Twenty-three when including Sweden, the one country with a rising log-variance experience profile). 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 given. 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.

As with the U.S., 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

[16] Those countries with no reported hourly wages have annual earnings.

underlying earnings function parameters vary across members of the population. 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 be explored in future work.

VI. Conclusions[17]

An individual's labor market success is probably the most important indicator of individual welfare. As such, how earnings are distributed across the population is of paramount importance. In his 1957 Ph.D. dissertation, followed by his 1958 *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. 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 to 15% higher earnings. It explained why earnings rise through one's life cycle at a diminishing rate. It explained how earnings power atrophies with intermittent labor force participation. It explained why earnings growth is smaller for those anticipating intermittent labor force participation. It explained why men earn more than women, why married women earn less than single women, and why whites earn more than blacks. It explained why occupational distributions differ by gender. It explained why geographic and job mobility predominates for the young more than the old. It explained why on-the-job tenure reduces turnover. It explained why unemployment is lower among the skilled. And, it explained many more phenomena, as well.

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 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 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's not obvious they account for the specific concave shape.

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 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 lifecycle log-variance of earnings profile. No alternative model gives this prediction. In this vein, the paper not only replicates Mincer's original findings using U.S. Census 1980 and 1990 data, but also using nine other countries.[19] As Mincer predicted, I find U-shaped earnings variance profiles for relative earnings, but not for nominal earnings.

[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 requir "surplus labor … to justify the zero price paid to labor quantity units." I thank one of the journal referees for pointing out this reference.
[19] Australia, Belgium, Canada, Czech Republic, France, Mexico, Republic of China (Taiwan), Spain and Sweden.

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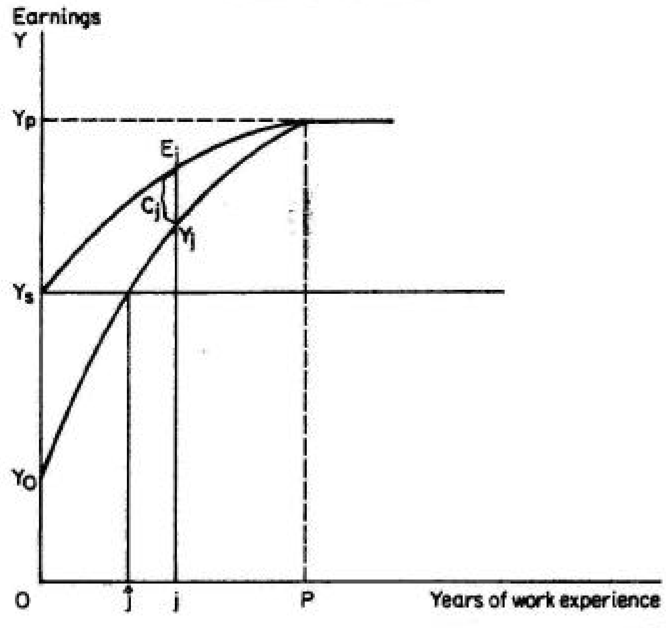
FIGURE 1

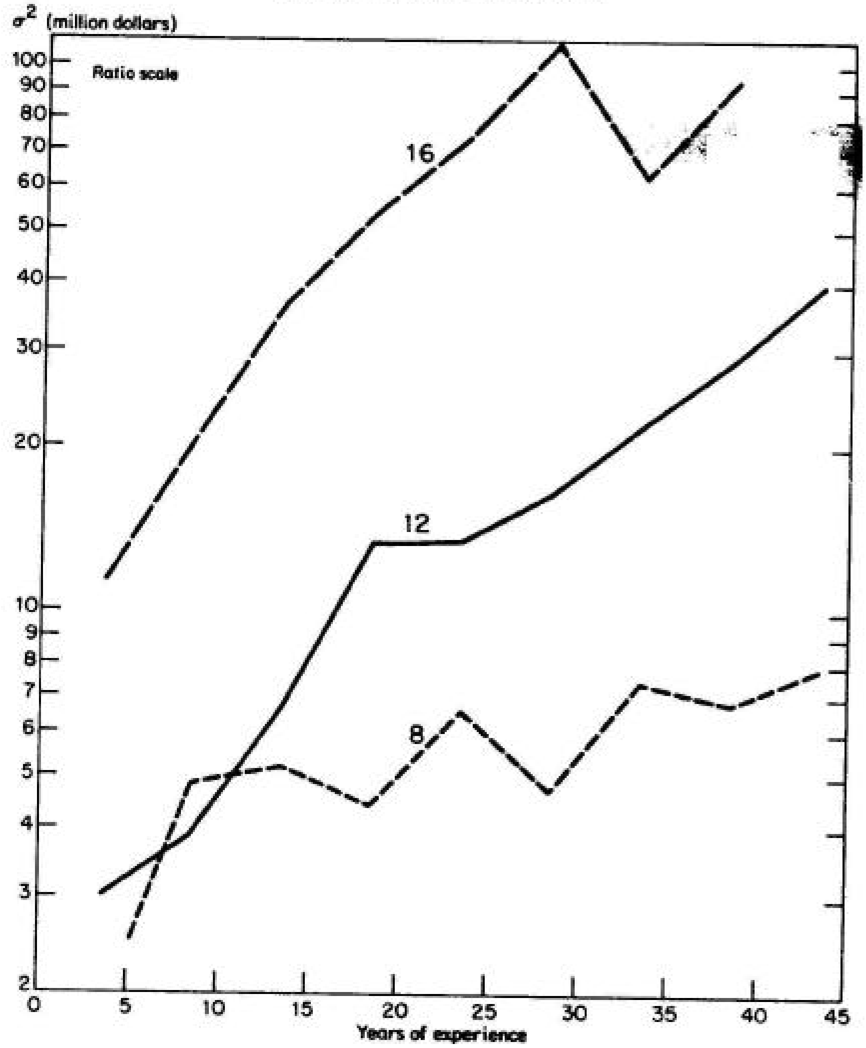
EARNINGS PROFILES



Source: Jacob Mincer, <u>Schooling, Experience, and Earnings</u>.

Figure 2

Experience Profiles of Variances of Annual Earnings of White, Nonfarm Men, 1959

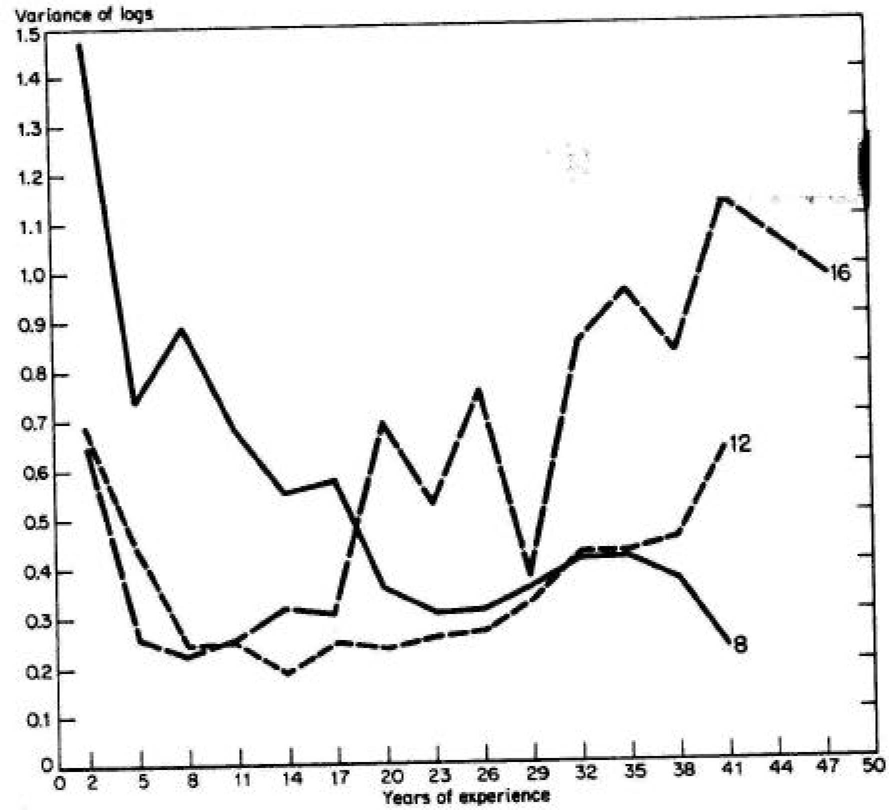


Note: Figures on curves indicate years of schooling completed.
Source: 1/1,000 sample of U.S. Census, 1960.

Source: Jacob Mincer, Schooling, Experience and Earnings.

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: 1/1,000 sample of U.S. Census, 1960.

Source: Jacob Mincer, Schooling, Experience and Earnings.

Figure 4: Standard Deviation of Hourly Earnings Over the Life Cycle

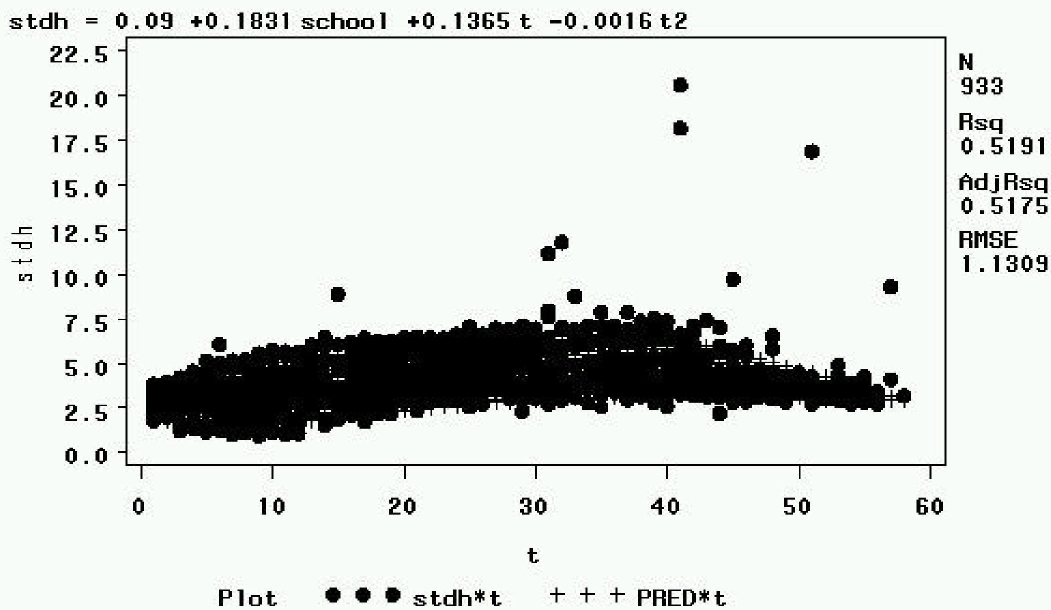


Figure 5: Standard Deviation Ln Hourly Earnings Over the Life Cycle

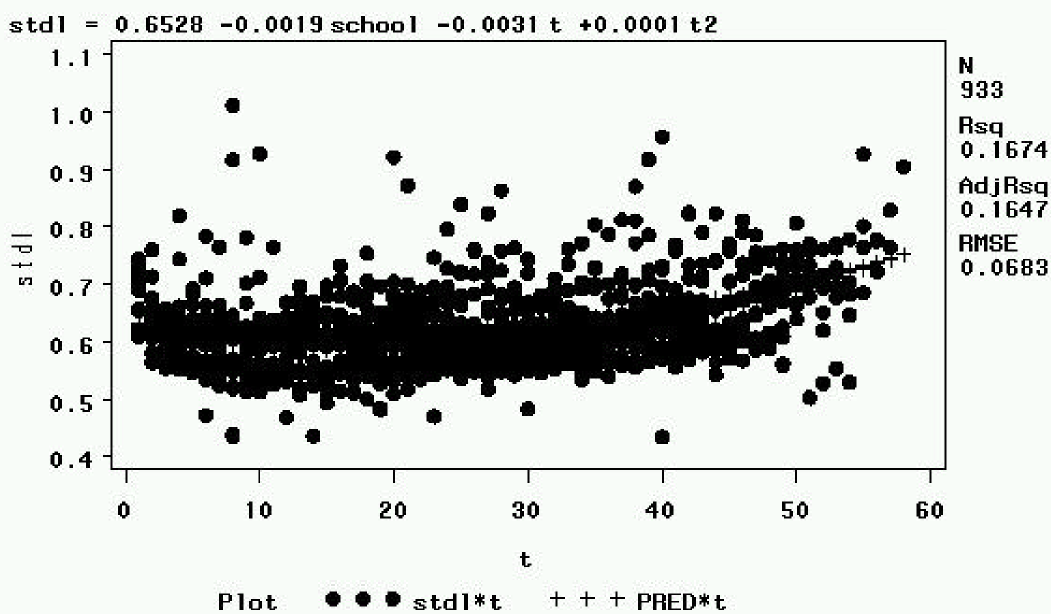


Figure 6: Standard Deviation of Hourly Earnings Over the Life Cycle

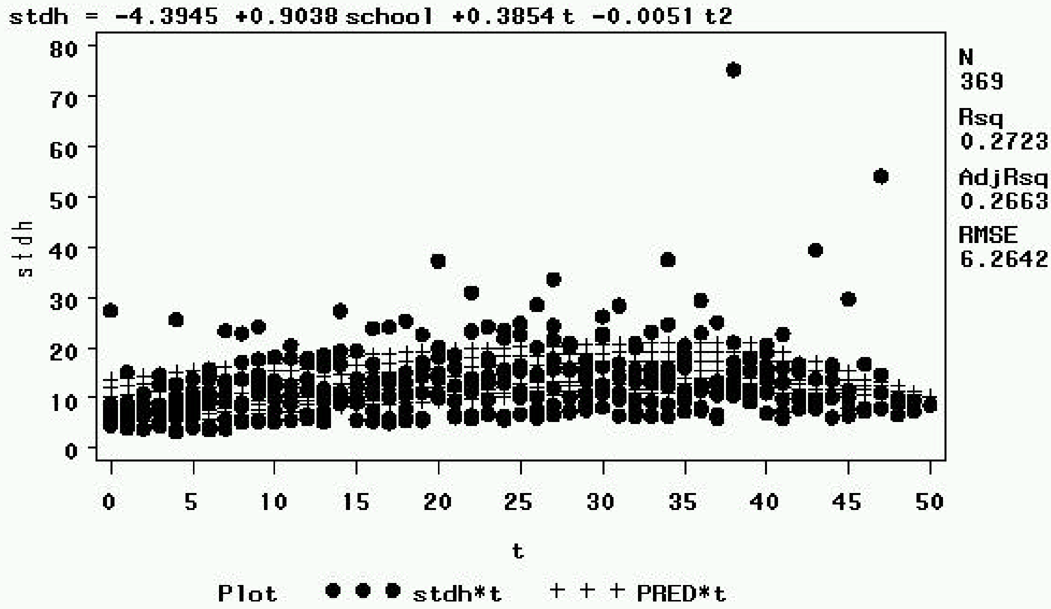


Figure 7: Standard Deviation Ln Hourly Earnings Over the Life Cycle

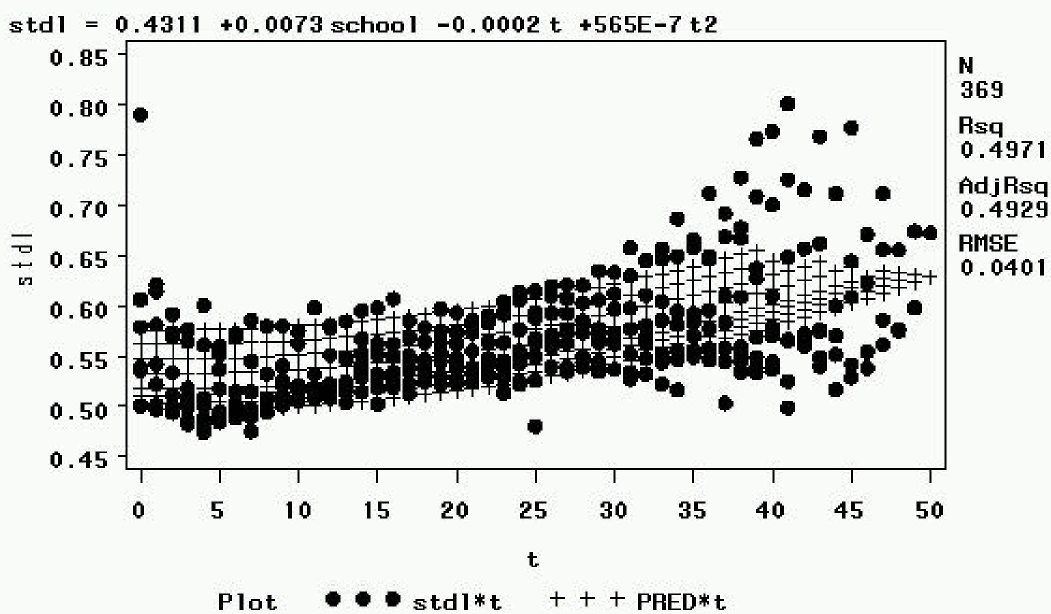


Figure 8: Standard Deviation of Ln Gross Annual Earnings Over the Life Cycle, Australia, 1981

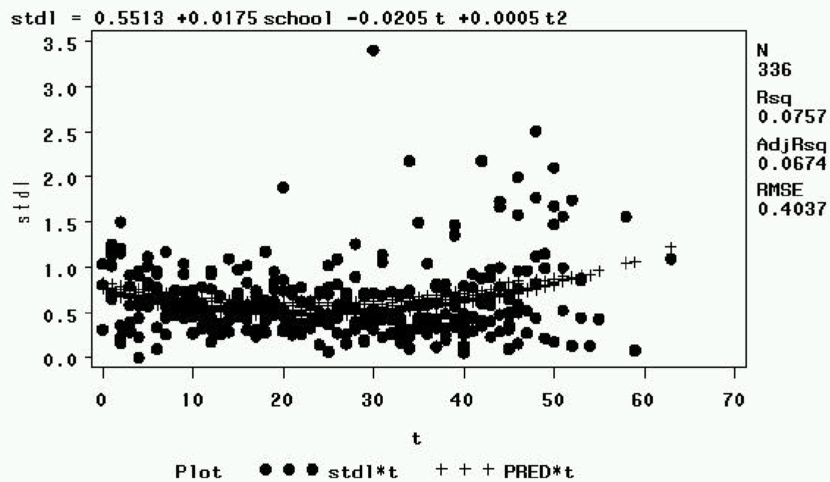


Figure 9: Standard Deviation of Gross Annual Earnings Over the Life Cycle, Australia, 1981

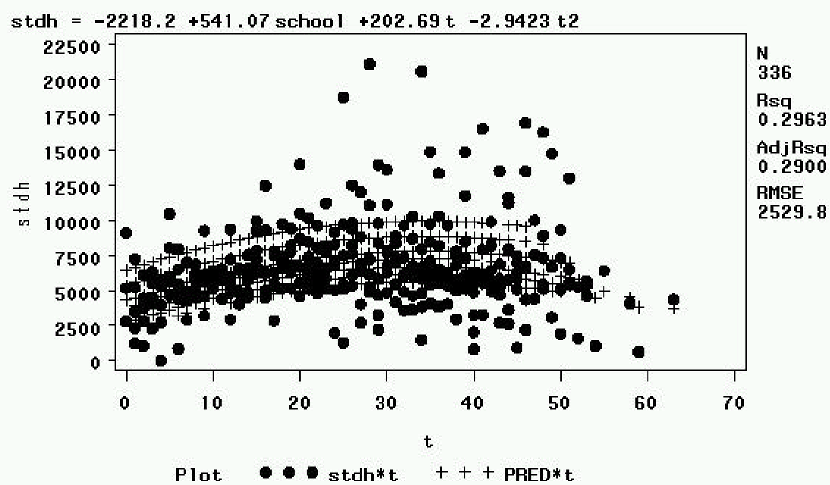


Figure 10: Standard Deviation of Ln Gross Annual Earnings Over the Life Cycle, Australia, 1994

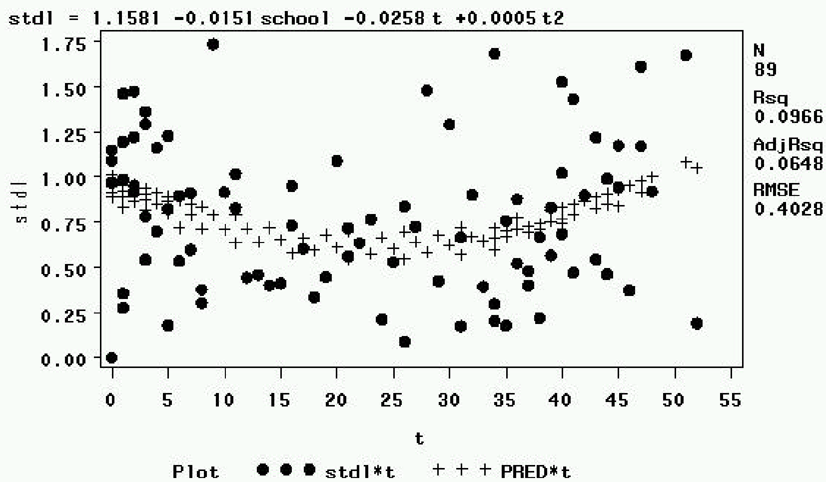


Figure 11: Standard Deviation of Gross Annual Earnings Over the Life Cycle, Australia, 1994

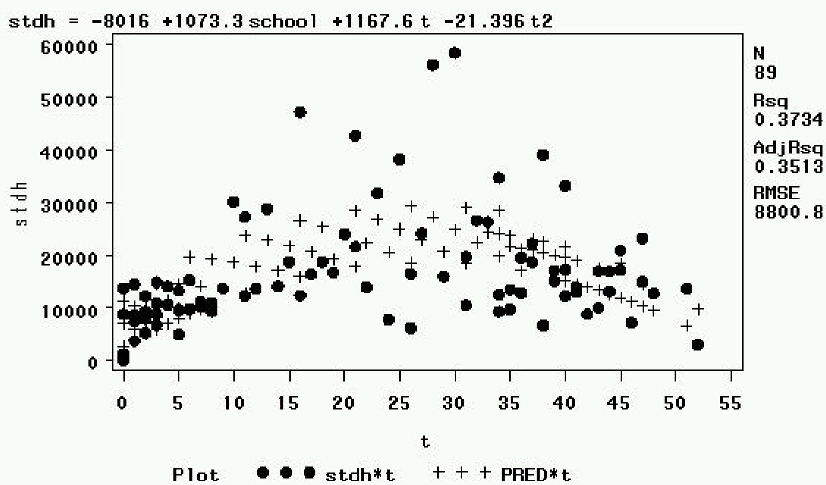


Figure 12: Standard Deviation of Ln Hourly Earnings Over the Life Cycle, Belgium, 1997

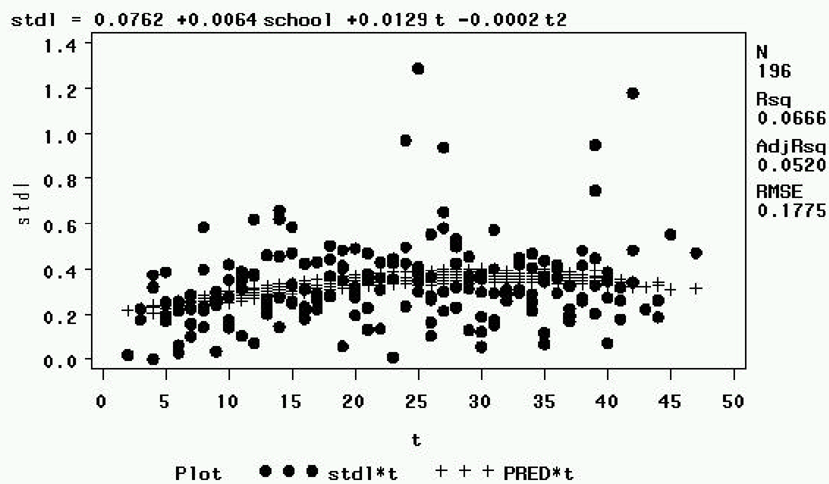


Figure 13: Standard Deviation of Hourly Earnings Over the Life Cycle, Belgium, 1997

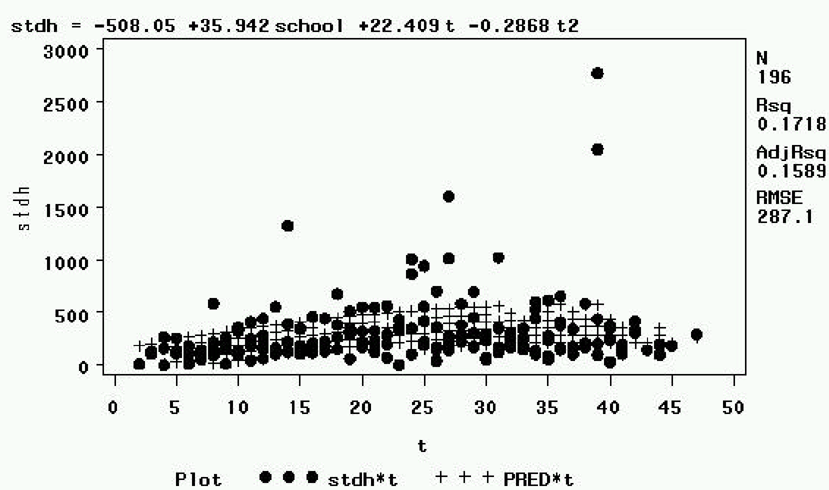


Figure 14: Standard Deviation of Ln Hourly Earnings Over the Life Cycle, Canada, 1997

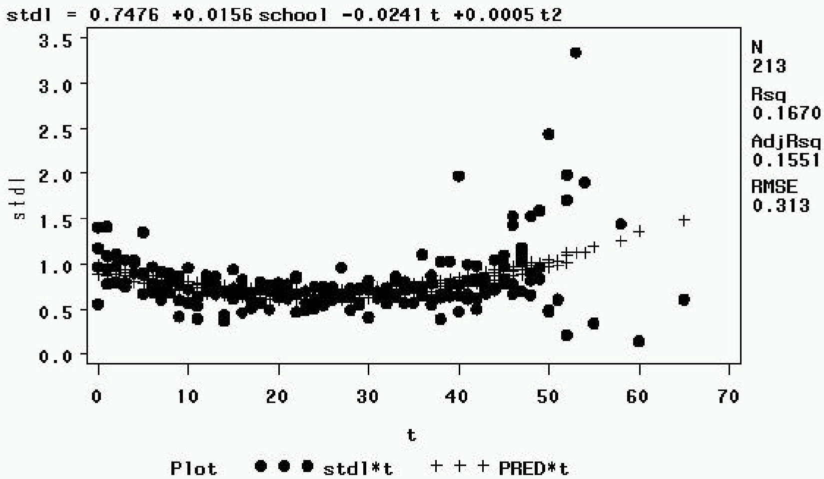


Figure 15: Standard Deviation of Hourly Earnings Over the Life Cycle, Canada, 1997

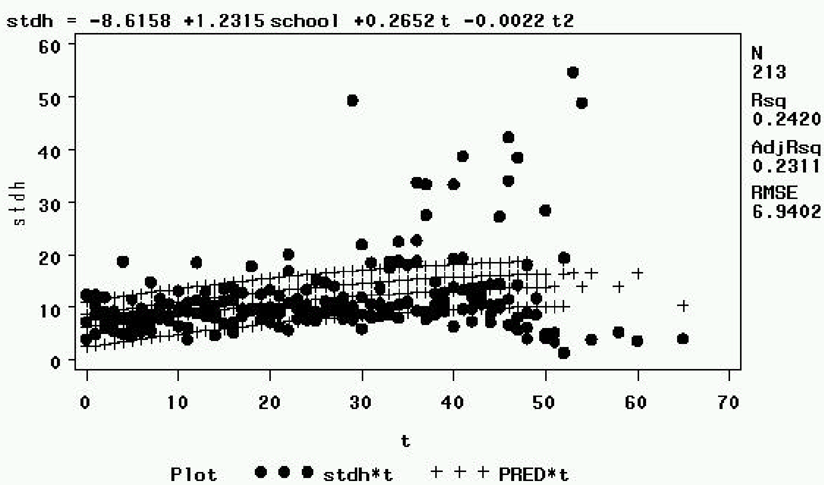


Figure 16: Standard Deviation of Ln Hourly Earnings Over the Life Cycle, Czech Republic, 1996

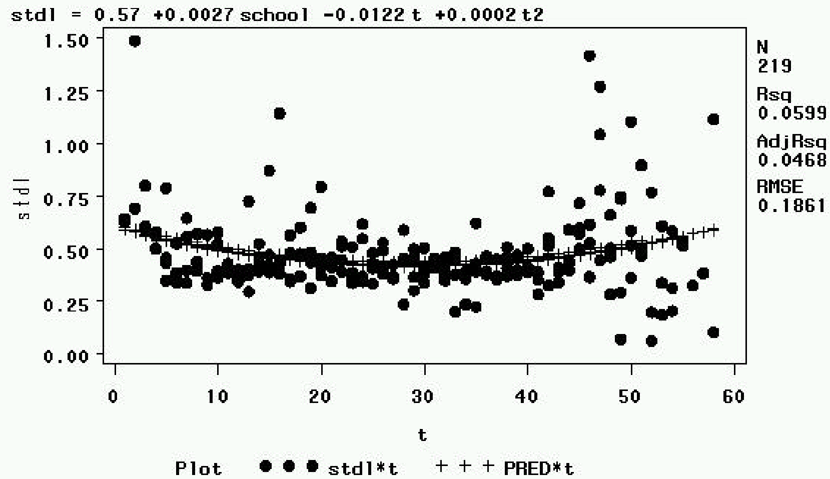


Figure 17: Standard Deviation of Hourly Earnings Over the Life Cycle, Czech Republic, 1996

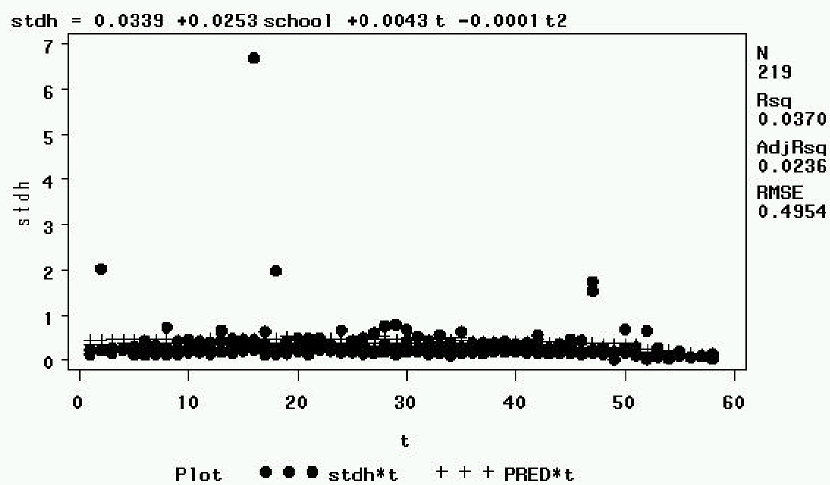


Figure 18: Standard Deviation of Ln Hourly Earnings Over the Life Cycle, France, 1994

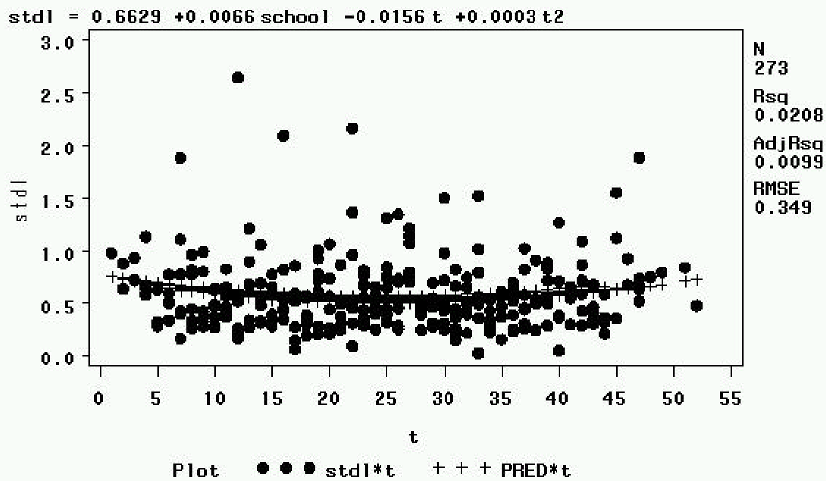


Figure 19: Standard Deviation of Hourly Earnings Over the Life Cycle, France, 1994

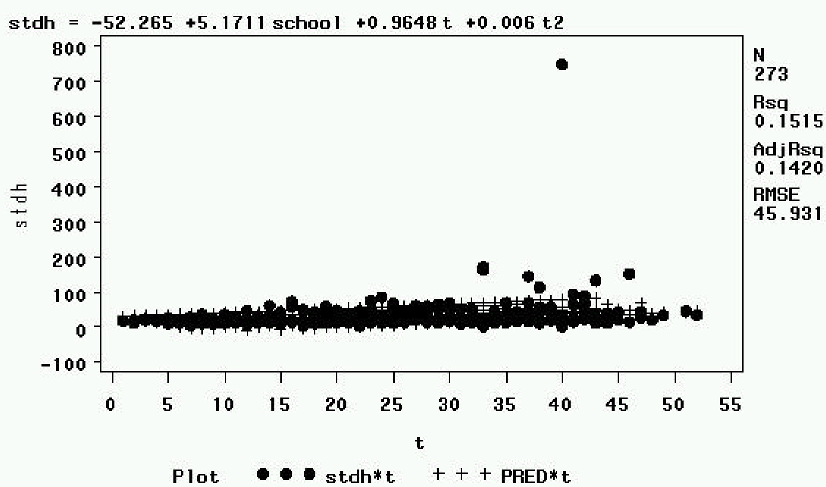


Figure 20: Standard Deviation of Ln Hourly Earnings Over the Life Cycle, Mexico, 1988

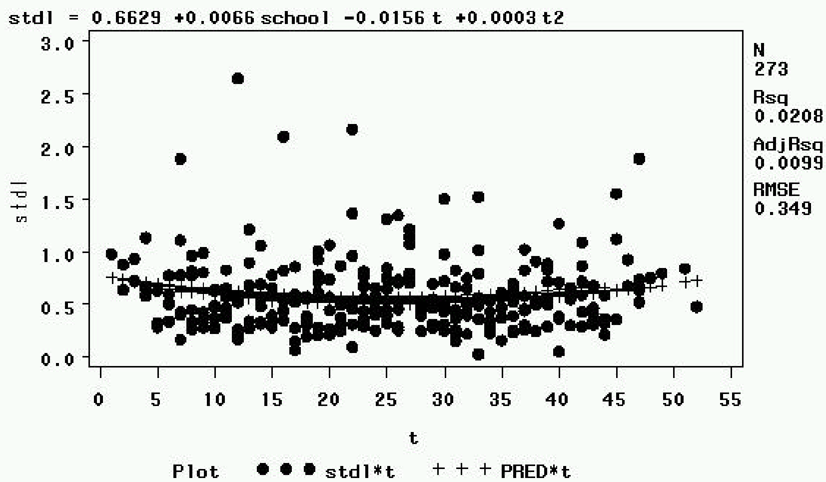


Figure 21: Standard Deviation of Hourly Earnings Over the Life Cycle, Mexico, 1988

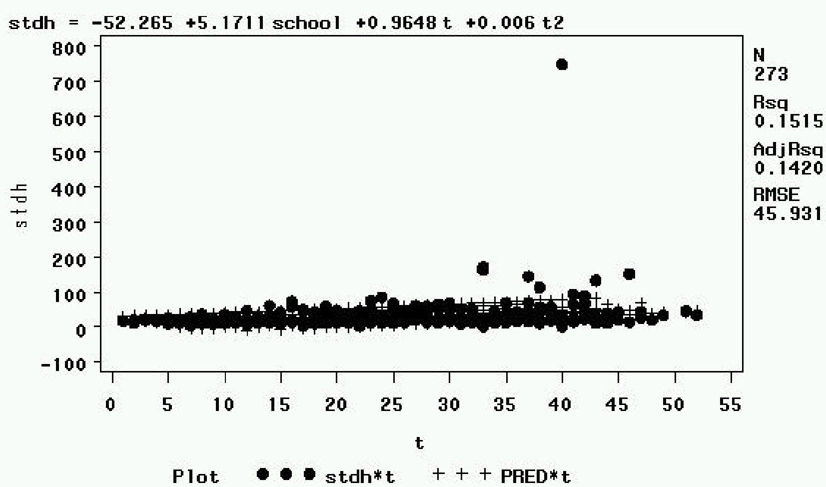


Figure 22 Standard Deviation of Ln Gross Annual Earnings Over the Life Cycle, Taiwan, 1995

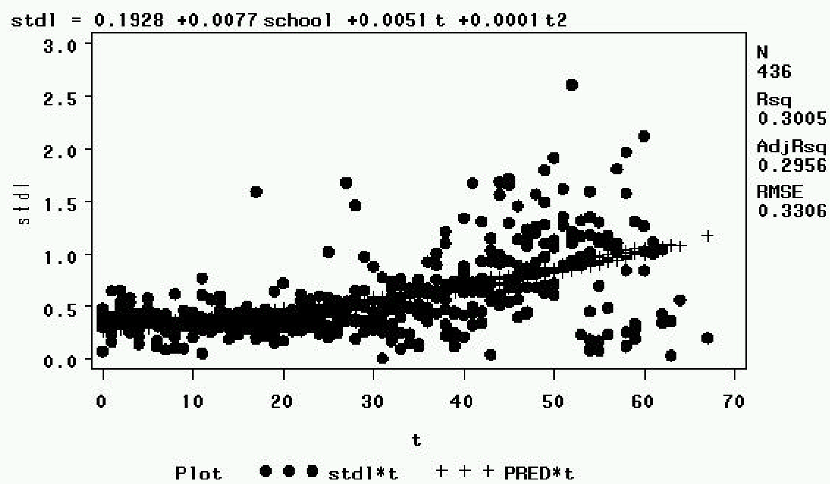


Figure 23: Standard Deviation of Gross Annual Earnings Over the Life Cycle, Taiwan, 1995

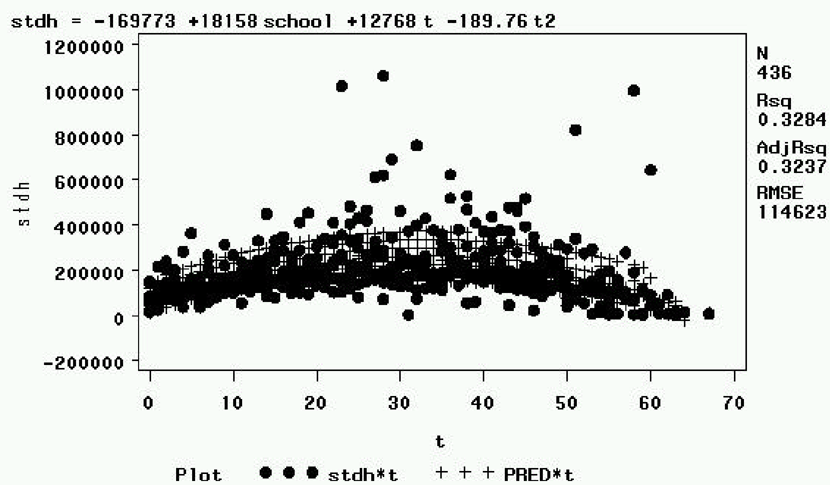


Figure 24: Standard Deviation of Ln Net Annual Earnings Over the Life Cycle, Spain, 1990

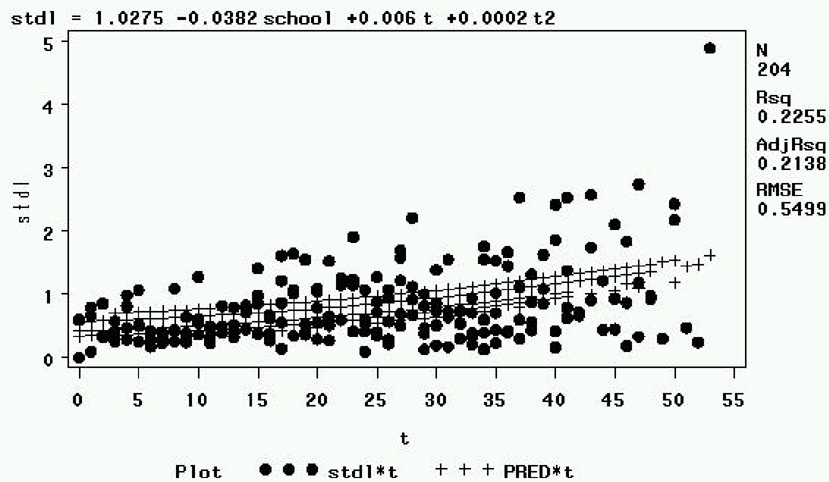


Figure 25: Standard Deviation of Net Annual Earnings Over the Life Cycle, Spain, 1990

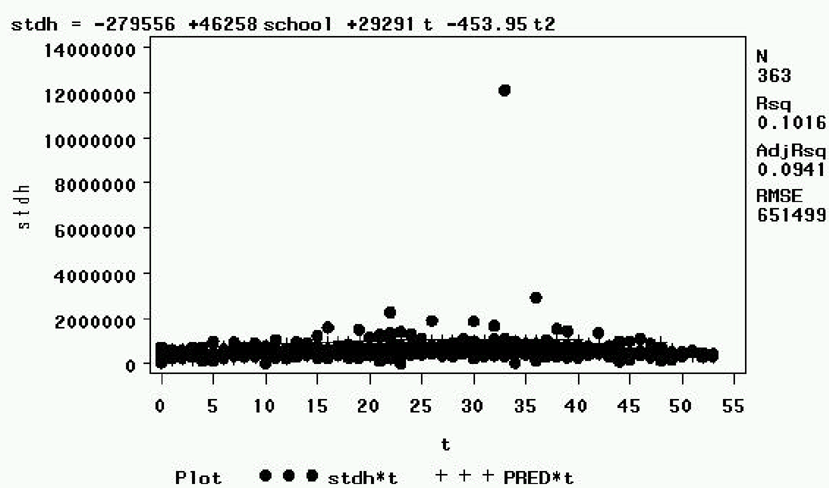


Figure 26: Standard Deviation of Ln Hourly Earnings Over the Life Cycle, Sweden, 1995

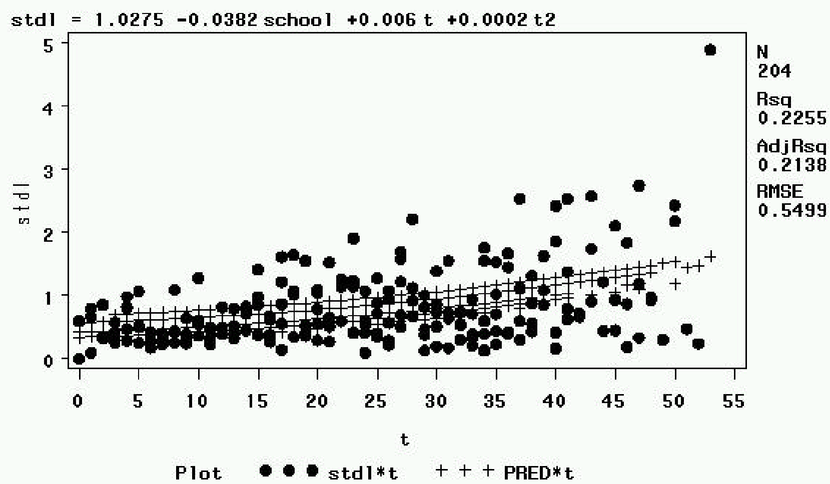


Figure 27: Standard Deviation of Hourly Earnings Over the Life Cycle, Sweden, 1995

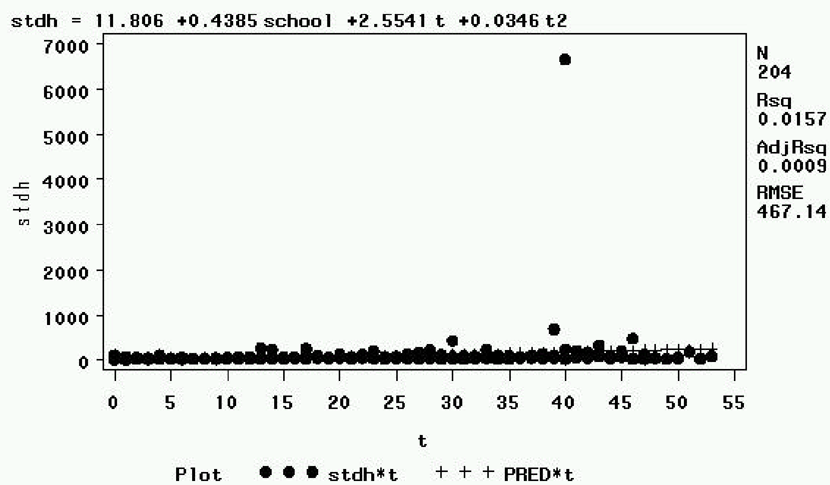


Figure 28
Overtaking Age Versus Rate of Return

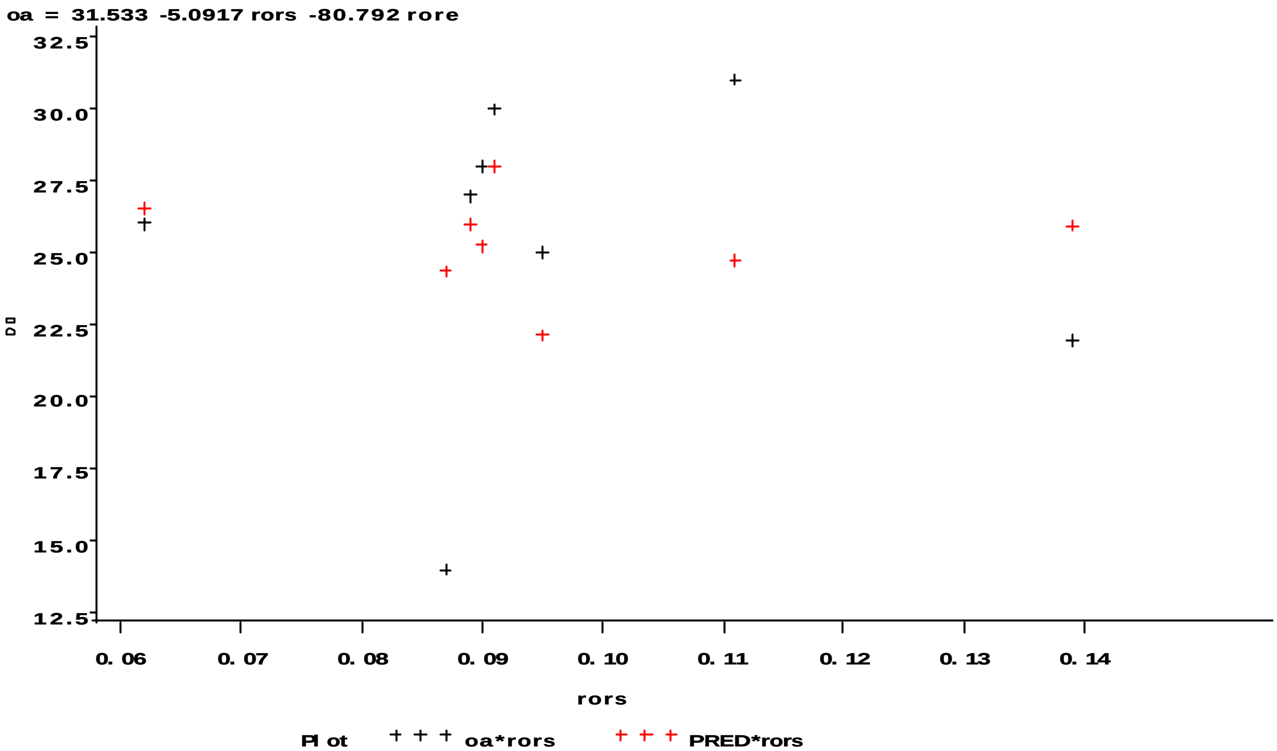


Table 1

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	0.24
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	-0.0007	-31.7	0.2

Source: Luxembourg Income Study (LIS) Data and 1980 and 1990 U.S Census

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