technische universität
dortmund

Lecture 5a:
Investment in Education: Human Capital

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Empirical Economics

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Investment in Education: Human Capital

1. Motivation and Basic Trends
2. Human Capital Model
   a. Theoretical foundations of the Mincer model
   b. Extensions to the Mincer Model
3. Empirical Challenges to the Mincer Wage Equation
4. Challenges to Human Capital Theory of Education

Motivation and Basic Trends

- Labour supply deals with quantities of labour supplied, but there is also a quality aspect to labour, which can be enhanced by investment in education
  - Literacy and numeracy are the first goals of education
- Investments in education have long been seen to be key to economic well-being and growth
  - Education policies are important instruments towards economic growth
  - Basic education is indeed subsidized in most industrialized countries
  - Moreover, schooling is compulsory until 15–16 years of age in many countries
  - More recently, policies have also focused on early childhood learning

Motivation and Basic Trends

- More highly educated workers are paid more than less educated workers
  - Why?
  - Why isn't everyone getting a Ph.D.?
- The benefits of education are seen not only in term of a more productive workforce, but also in term a healthier population, a more political engaged one, and a happier one!
  - There are social as well as private returns to education

Motivation and Basic Trends

A Few Motivating Facts

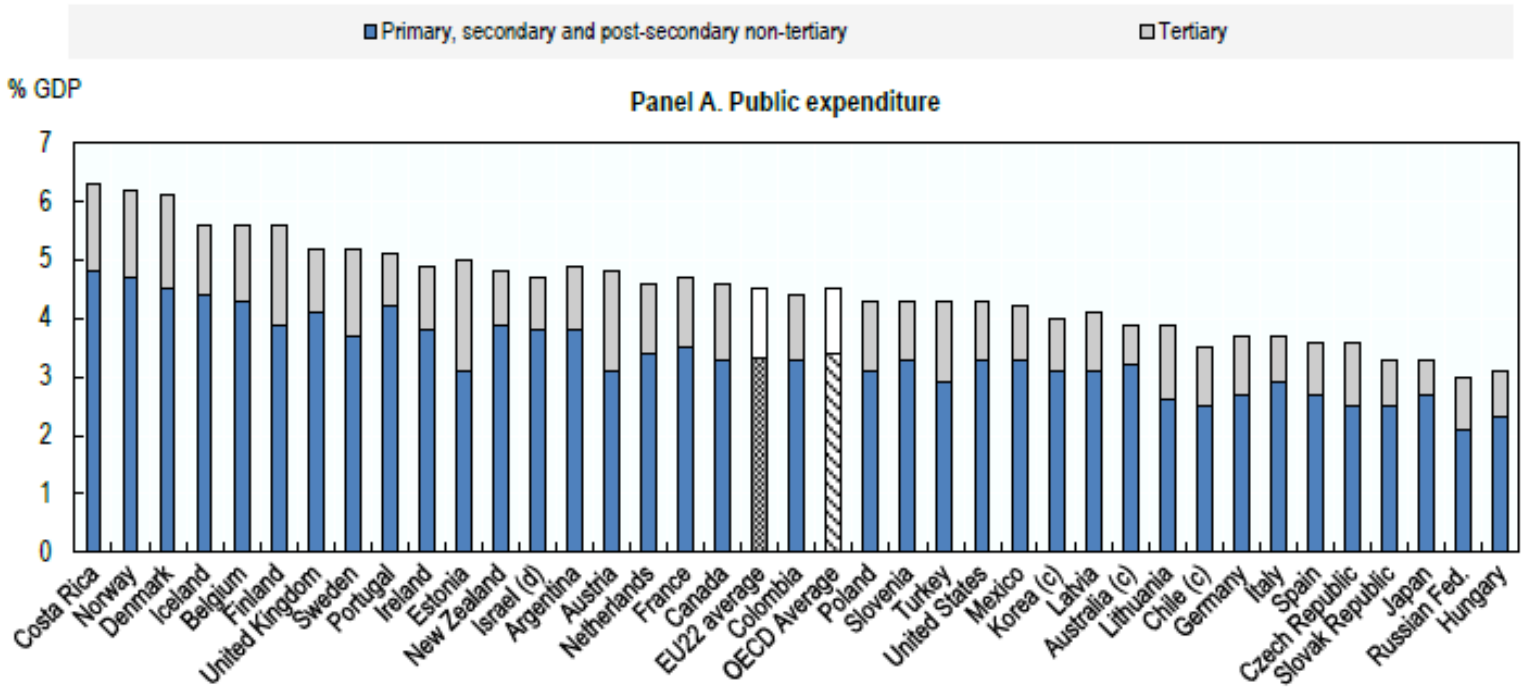
- There is a lot of empirical evidence that schooling, literacy/numeracy skills, and many other indicators of human capital correlate positively with income and other outcomes
- Positive correlation holds at the individual, group, or country level
- Large increase in educational achievement through most of the 20th century, but much less changes in more recent decades, despite increasing returns to education.

Motivation and Basic Facts

Countries spend large amounts (relative to GDP) on education:

- Expenditure share particularly high in Scandinavian countries
- Relative expenses rather low in Germany

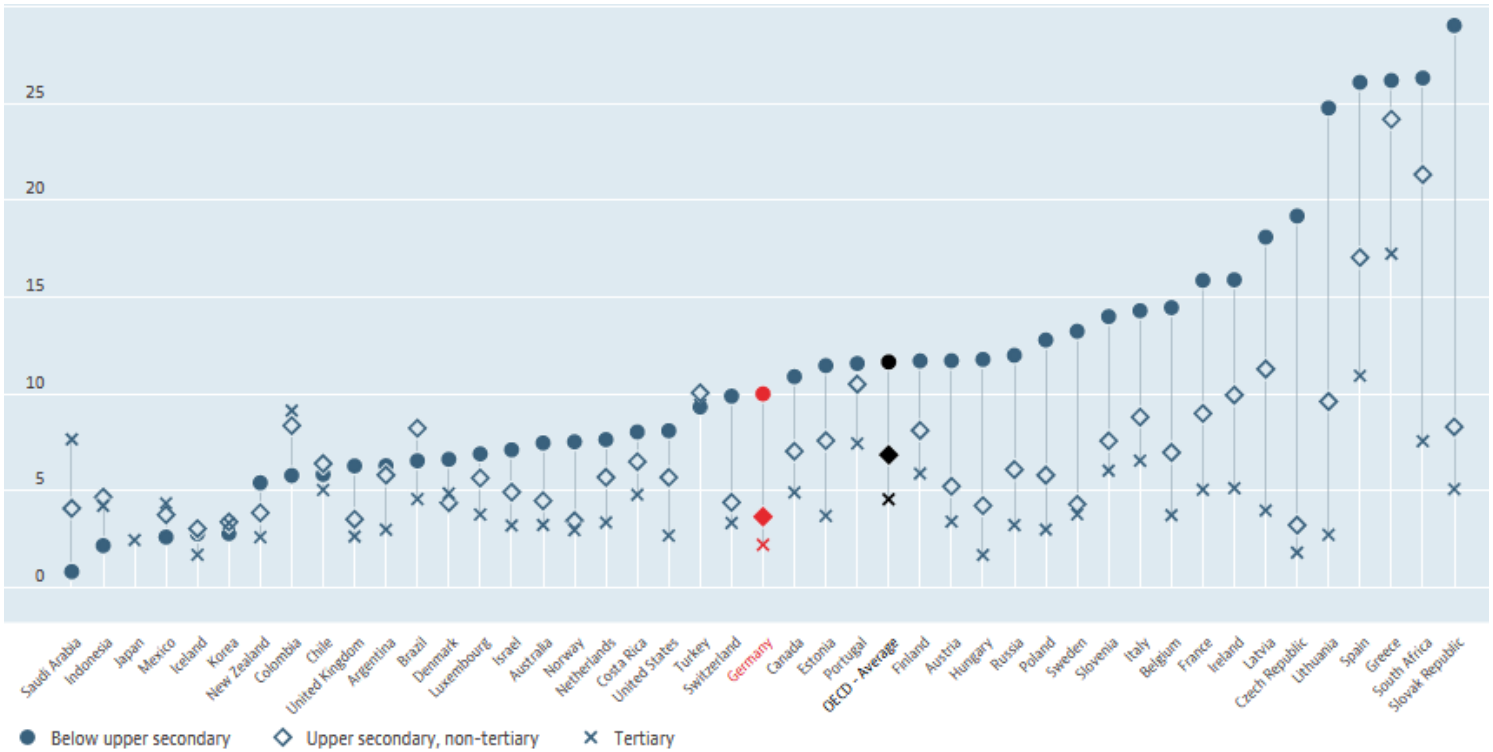
Expenditure on primary, secondary and post-secondary non-tertiary and on tertiary education by public or private source[b], as % of GDP



Motivation and Basic Facts

Negative correlation b/w educational attainment & unemployment rates:

- Relation particularly pronounced for, e.g., Spain & Greece
- Less pronounced for, e.g., Korea, Mexico or New Zealand



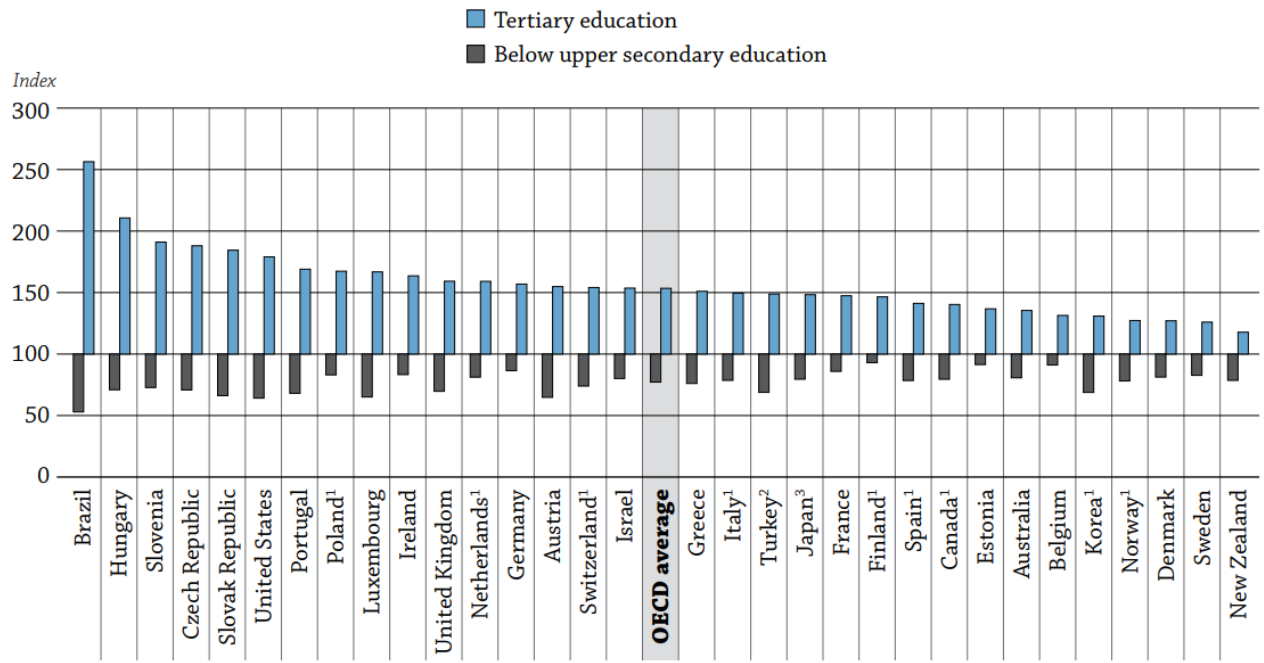
Motivation and Basic Facts

Substantial income differences across education groups:

- Large differentials by education groups for, e.g. Brazil & US
- Lower for, e.g., Denmark & New Zealand

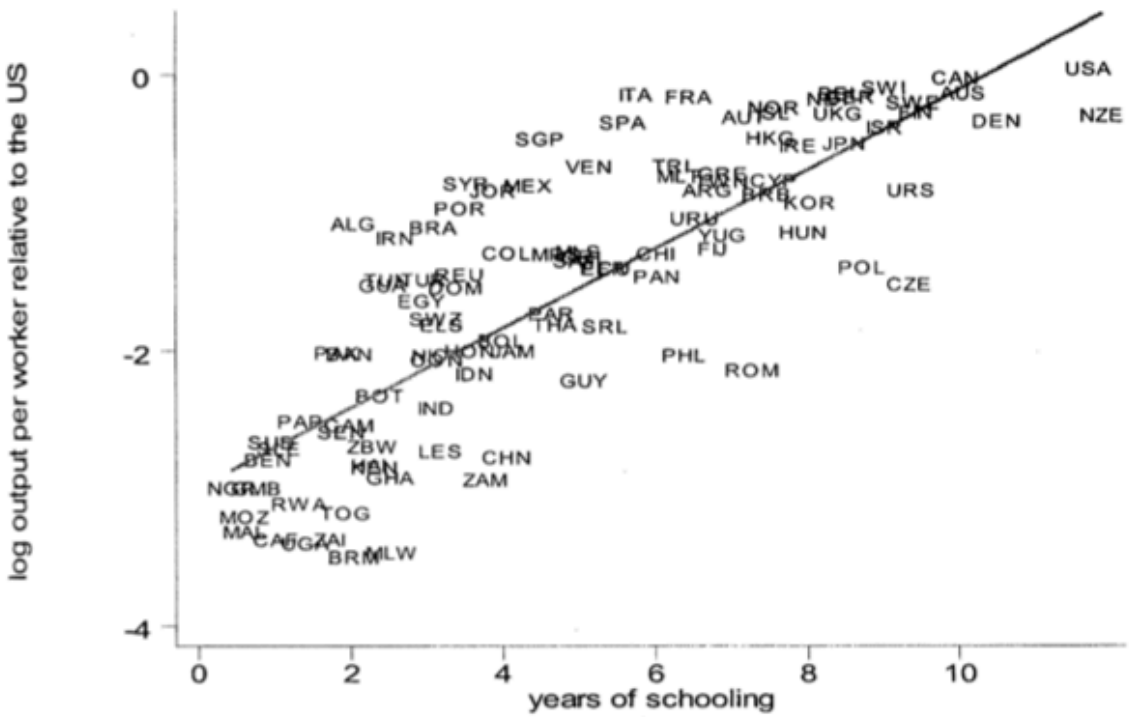
Chart A8.1. Relative earnings from employment by level of educational attainment for 25-64 year-olds (2009 or latest available year)

Upper secondary and post-secondary non-tertiary education = 100



Motivation and Basic Facts

Figure 1 LOG OUTPUT PER WORKER AND YEARS OF SCHOOLING ACROSS COUNTRIES

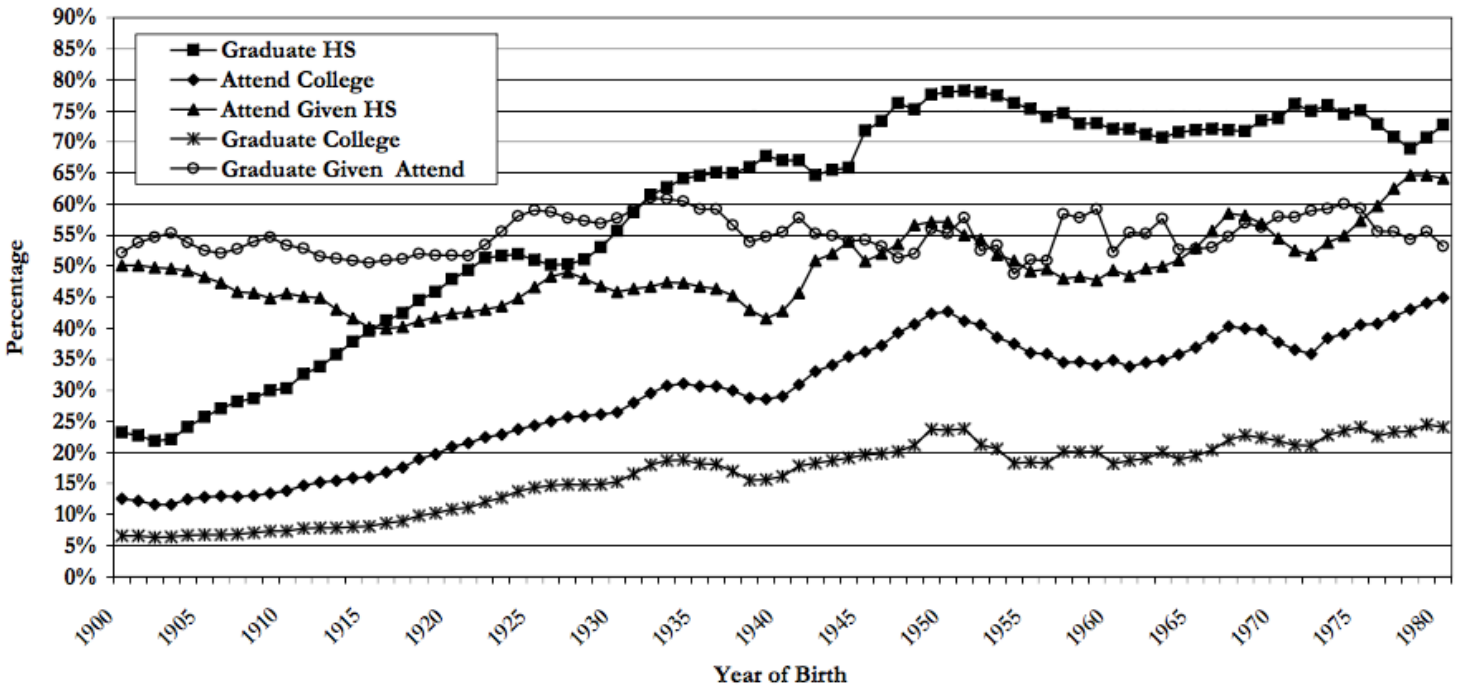


The line shows the fitted OLS relationship. The slope coefficient is 0.29, and the standard error is 0.02.

Motivation and Basic Facts

Source: Heckman and Lafontaine (2007)

Figure XIV. Educational Attainment Decompositions, Males 1900-1980 Birth Cohorts

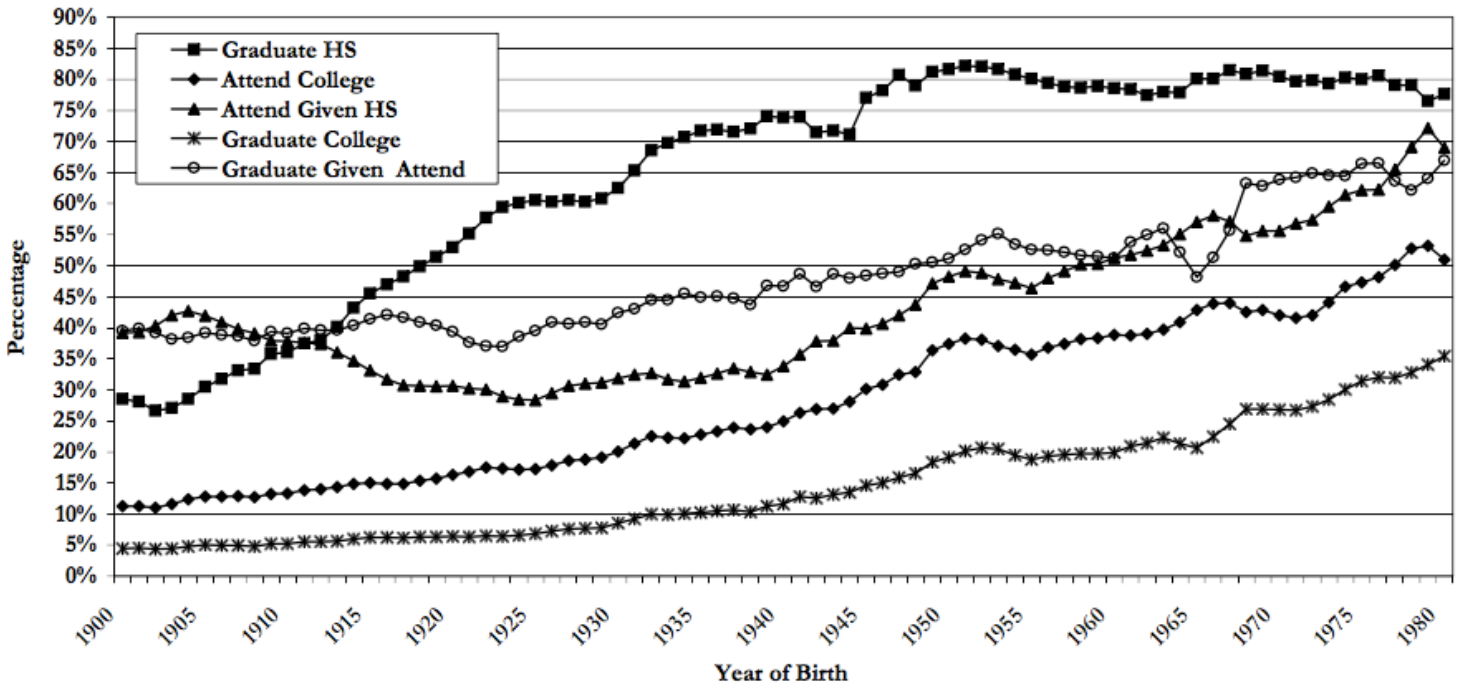


Notes: 3-year moving averages based on CPS October, Census, CPS March and NCES data. HS graduates are those who obtained a regular public or private HS diploma (excluding GEDs) from the NCES. "Graduate HS" is the fraction of 8th grade enrollments for a given cohort who report a regular HS diploma. "Attend Given HS" is the fraction of recent HS graduates who report being enrolled the fall of the year following graduation. "Attend College" is college enrollments of recent HS graduates as a fraction of 18 year old cohort size. College graduates are those who report a BA or higher by age 25. "Graduate Given Attend" is those who obtained a four year degree as a fraction of the college enrollment total for that cohort. Two-year degrees are not included. "Graduate College" is the number of college graduates as a fraction of the 18 year old cohort size. Population estimates are from the Census P-20 reports. HS diplomas issued by sex are estimated from CPS October data after 1982.

Motivation and Basic Facts

Source: Heckman and Lafontaine (2007)

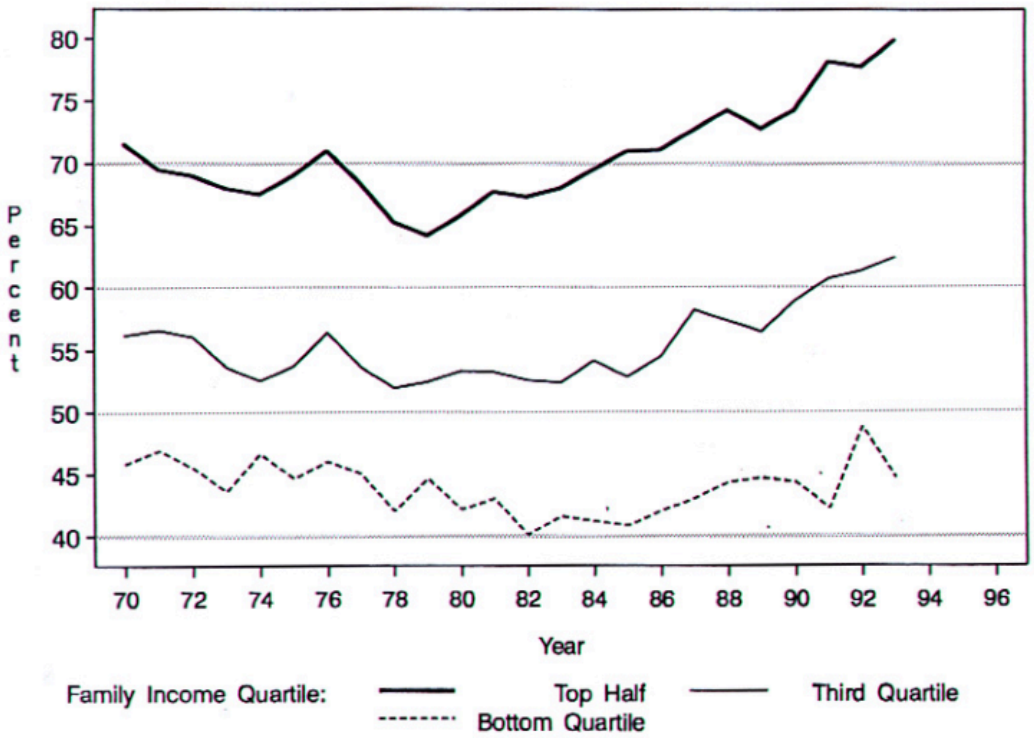
Figure XV. Educational Attainment Decompositions, Females 1900-1980 Birth Cohorts



Notes: 3-year moving averages based on CPS October, Census, CPS March and NCES data. HS graduates are those who obtained a regular public or private HS diploma (excluding GEDs) from the NCES. "Graduate HS" is the fraction of 8th grade enrollments for a given cohort who report a regular HS diploma. "Attend Given HS" is the fraction of recent HS graduates who report being enrolled the fall of the year following graduation. "Attend College" is college enrollments of recent HS graduates as a fraction of 18 year old cohort size. College graduates are those who report a BA or higher by age 25. "Graduate Given Attend" is those who obtained a four year degree as a fraction of the college enrollment total for that cohort. Two-year degrees are not included. "Graduate College" is the number of college graduates as a fraction of the 18 year old cohort size. Population estimates are from the Census P-20 reports. HS diplomas issued by sex are estimated from CPS October data after 1982.

Motivation and Basic Facts

Figure 2. College Participation by 18 to 24 Year Old High School Graduates and Equivalency Degree Holders



Note.— These numbers were computed from 1971 to 1989 CPS P-20 School Reports and the 1990-to 1993 October CPS data files. Racial-ethnic categories are mutually exclusive.
Source.—Cameron and Heckman(1998).

Human Capital Model

- With human capital theory, investments in human resources are considered similarly to other types of investments. Costs are incurred in expectation of future benefits and the investment in the last unit of human capital is made only if the benefits are expected to exceed the costs.
- On the supply side: additional schooling entails opportunity costs in the form of foregone earnings plus direct expenses such as tuition. To induce a worker to undertake additional schooling, he must be compensated by sufficiently higher lifetime earnings.

Human Capital Model

- On the demand side: to command higher earnings, more schooled workers must be sufficiently more productive than their less schooled fellow workers. In the perfect competition framework, the wage guides the allocation of workers across firms as to achieve an efficient allocation of resources by equating the wage to the value of the marginal product.
- In the long run equilibrium, the relationship between lifetime earnings and schooling must be such that *i*) the supply and demand for workers of each schooling level are equated and *ii*) no worker wishes to alter their schooling level.

Human Capital Model

- The study of the effects of investment in schooling and on-the-job training on the level, pattern and interpersonal distribution of life-cycle earnings have been pioneered by Becker (1964, 1975) and Mincer (1958, 1962, 1979).
- This lead to one of the most successful empirical equations called the “Mincer earnings function”

$$\ln(w_i) = \beta_0 + rS_i + \beta_1 E_i + \beta_2 E_i^2 + \varepsilon_i$$

where w_i is earnings (or the hourly wage when available) of person i, S_i is years of schooling, E_i is years of labor market experience, and ε_i is an error term.

Human Capital Model

- Years of schooling are a fairly direct measure of education human capital, while years of labour market experience is viewed as a proxy for on-the-job training.
- Mincer uses the transformation Experience equals Age minus Schooling minus 6, $E_i = A_i - S_i - 6$. This is not actual but "potential" experience, which the literature after Mincer adopted for the most part.
- Adding E_i to the regression captures the interaction between schooling and experience, but assumes multiplicative separability.

Human Capital Model

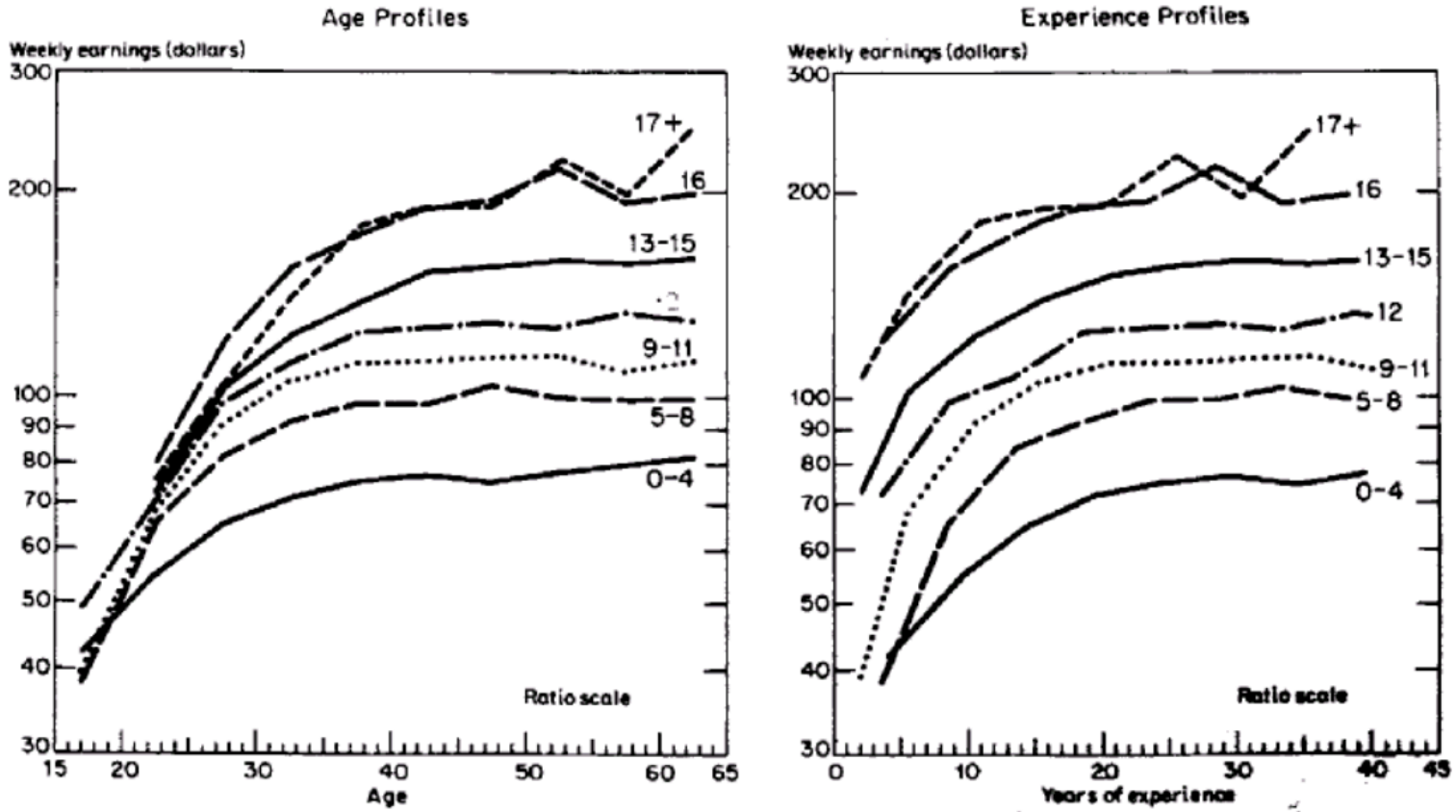
- The Mincer equation thus captures the important empirical regularities:
  1) increase in earnings with schooling,
  2) concavity of log earnings in experience,
  3) log earnings-experience profiles are parallel across different education groups (ratio of earnings for persons with education levels differing by a fixed number of years is roughly constant across schooling levels) $\Rightarrow$ no interaction between schooling and experience
  4) log earnings-age profiles diverge across different education groups.

Human Capital Model

- Almost all empirical studies find that schooling has a positive and significant effect on earnings ($r > 0$) and that earnings are a concave function of labour market experience ($\beta_1 > 0$ and $\beta_2 < 0$).
- A simple regression model with a linear schooling term and a low-order polynomial in potential experience explains 20–35% of the variation in observed earnings data, with predictable and precisely-estimated coefficients in almost all applications.

Human Capital Model

AGE AND EXPERIENCE PROFILES OF RELATIVE WEEKLY 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*

Human Capital Model

Source: Krueger and Lindahl

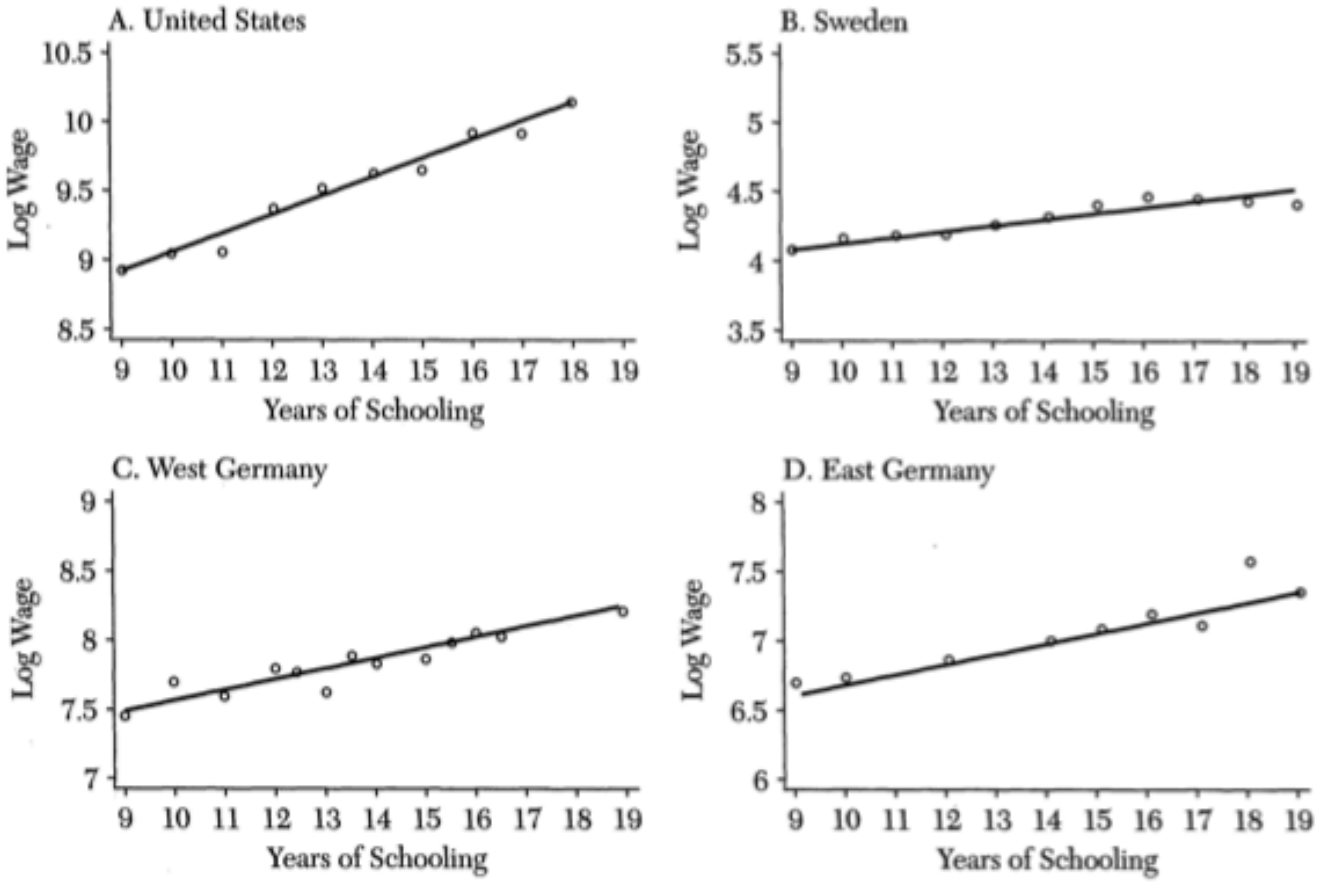


Figure 1. Unrestricted Schooling-Log Wage Relationship and Mincer Earnings Specification

Theoretical Foundations of the Mincer Model

- The theoretical foundations of Mincer specification can arise from two theoretical frameworks,
  i. compensating wage differentials (Mincer, 1958)
  ii. accounting identity framework (Mincer, 1974).

Compensating differentials framework:

- Let $w(s)$ represent the annual earnings of a representative individual with s years of education, and let r be the discount rate, both assumed to be constant over his lifetime, the present value of the stream of earnings (for infinitely lived individuals) is

Theoretical Foundations of the Mincer Model

$$
\begin{aligned}
PV(s) &= 0 + \frac{0}{1+r} + \cdots + \frac{0}{(1+r)^{s-1}} + \frac{w(s)}{(1+r)^{s}} \\
&\quad + \frac{w(s)}{(1+r)^{s+1}} + \cdots + \frac{w(s)}{(1+r)^{\infty}} \\
PV(s) &= \frac{w(s)}{(1+r)^{s}}\left[1 + \frac{1}{(1+r)} + \frac{1}{(1+r)^{2}}\right. \\
&\quad \left. + \frac{1}{(1+r)^{3}} + \cdots + \frac{1}{(1+r)^{\infty}}\right] \\
&= \frac{1}{(1+r)^{s}} w(s) \sum_{t=0}^{\infty} \frac{1}{(1+r)^{t}} = w(s)\left(\frac{1+r}{r}\right) \cdot \left(\frac{1}{(1+r)^{s}}\right)
\end{aligned}
\tag{1}
$$

Theoretical Foundations of the Mincer Model

- Assuming no direct costs of schooling and comparing an individual with 1 year of schooling, who has to wait that one year before earning a salary, to one with 0 year of schooling, and equalizing present values, we get

$$w(1)\left(\frac{1+r}{r}\right)\cdot\left(\frac{1}{1+r}\right)=\frac{w(1)}{r}=w(0)\left(\frac{1+r}{r}\right) \tag{2}$$

$$\frac{w(1)}{w(0)}=1+r$$

Theoretical Foundations of the Mincer Model

- Taking the logarithm on both side,

$$\ln(w(1)) - \ln(w(0)) = \ln(1+r) \approx r \quad \text{for } r < 0.2$$

  the wage increment for one more year of schooling must approximately be equal to the rate r.
- Or in continuous time, let $w(s)$ represent the annual earnings of a representative individual with s years of education,

$$\begin{aligned} V(s) &= \int_s^T e^{-rt} w(s) dt \\ &= \frac{w(s)}{r}(e^{-rs} - e^{-rT}) \end{aligned} \tag{3}$$

  where T is the end of working time.

Theoretical Foundations of the Mincer Model

- Letting the compensating differentials take their time to equalize lifetime earnings:

$$V(s) = V(0) \Leftrightarrow \ln(V(s)) = \ln(V(0))$$

- The earnings difference between an individual with s years of schooling and 0 years will be given by

$$\begin{aligned} \ln w(s) &= \ln w(0) + r \cdot s + \ln\left((1 - e^{-rT})/(1 - e^{-r(T-s)})\right) \\ &= \ln w(0) + r \cdot s \end{aligned} \tag{4}$$

since the last term goes to zero as T gets large.

Theoretical Foundations of the Mincer Model

- This yields the nice interpretation of as an internal rate of return to schooling, that is, the discount rate equates the lifetime earnings streams from different educational choices.
- But this framework ignores the direct costs of schooling, assumes that earnings do not vary over the life-cycle, and that the age of retirement does not depend on years of schooling.
- An alternative framework used by Mincer (1974) builds on an accounting identity initially studied by Becker (1974) and Becker-Chiswick (1966).
- It allows earnings to vary over the life-cycle (for details, see slides in the Appendix).

Extensions to the Basic Mincer Model

- In most applications of the Mincer model, it is assumed that the intercept and slope coefficient are the same across persons and do not depend on the schooling level, however allowing β and r to differ across persons, as in Mincer (1974), produces a random coefficient model

$$\ln(w_i) = \beta_0 + rS_i + \beta_1 E_i + \beta_2 E_i^2 + \left[(\beta_{0i} - \beta_0) + (r_i - r)S_i + (\beta_{1i} - \beta_1)E_i + (\beta_{2i} - \beta_2)E_i^2\right]$$

- where the terms in bracket are part of the error term, expressed in deviations from the mean coefficients.

Extensions to the Basic Mincer Model

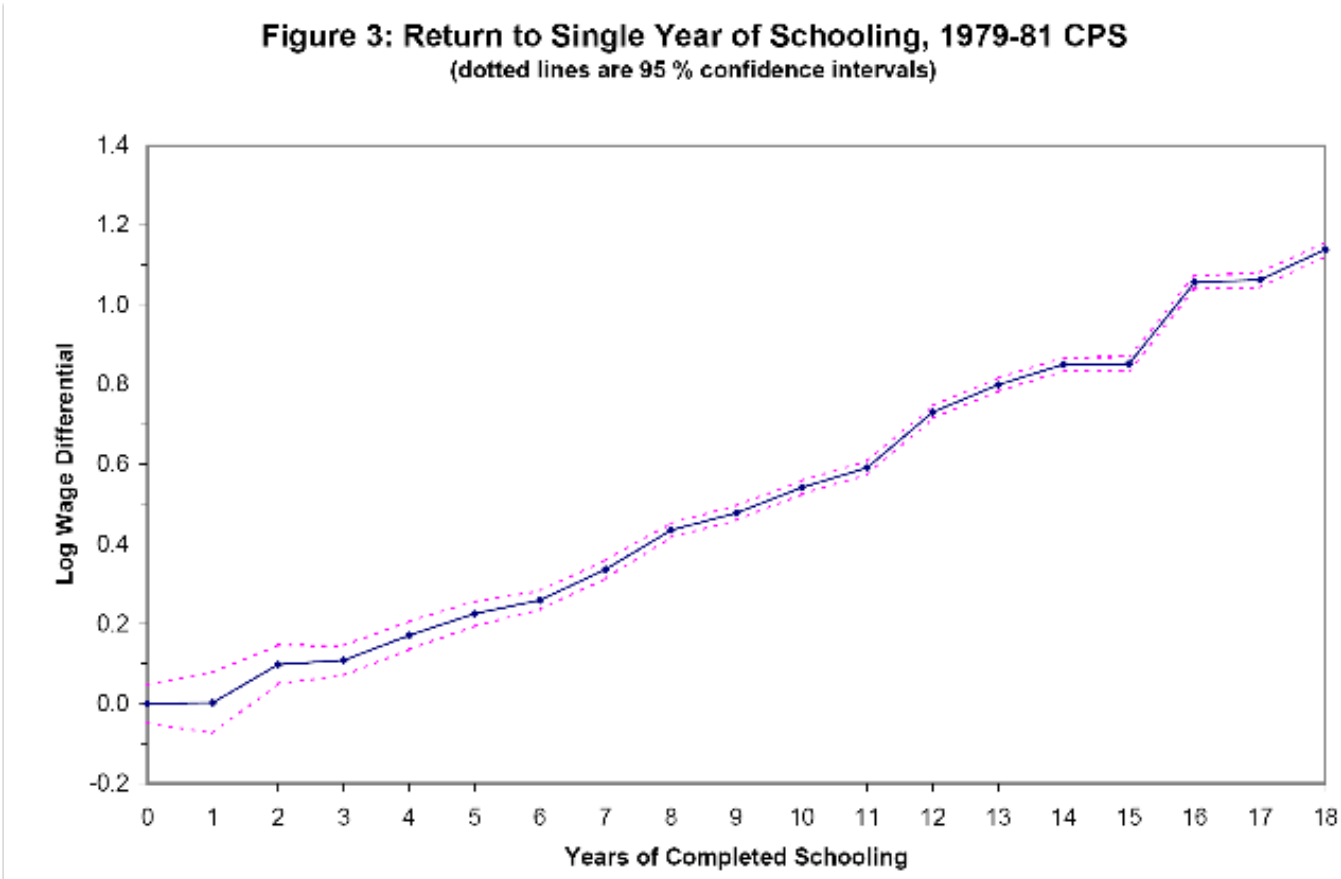
- It turns out that this is a crucial extension to the basic model. Since if individuals were identical, why should they choose different amounts of education?
- However, although heterogeneity explains why we observe different individuals having different schooling, an additional set of problems is introduced:
  - Schooling is endogeneous and, if this is not allowed for, estimated return may be biased.
  - Returns as well as schooling may vary across individuals.
- This will have important implications for the econometric estimation of the Mincer equation (see, Card, 1999).

Empirical Challenges to the Mincer Equation

The basic Mincer human capital earnings function does not appear to fit the data nearly as well in the 1980s and 1990s as it did in the 1960s and 1970s:

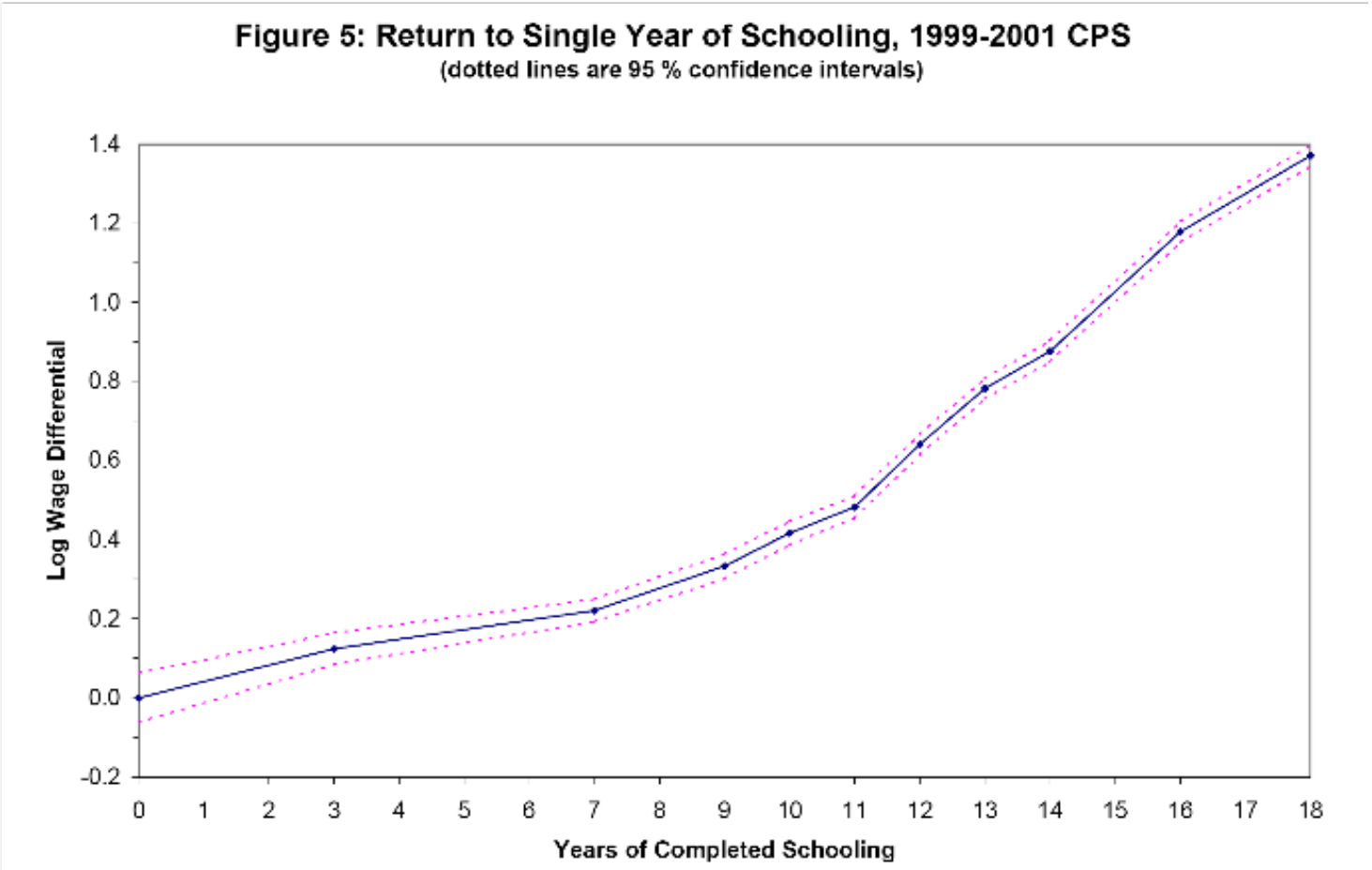
1) Log wages are an increasingly convex function of years of schooling: that is, the log-linearity in schooling no longer seems to hold.
2) The quadratic in experience tends to understate earnings growth at the beginning of the lifecycle and overstate the decline in earnings towards to the end of the lifecycle. Murphy and Welch (1990) find that a quartic fits the data better.

Empirical Challenges to the Mincer Equation



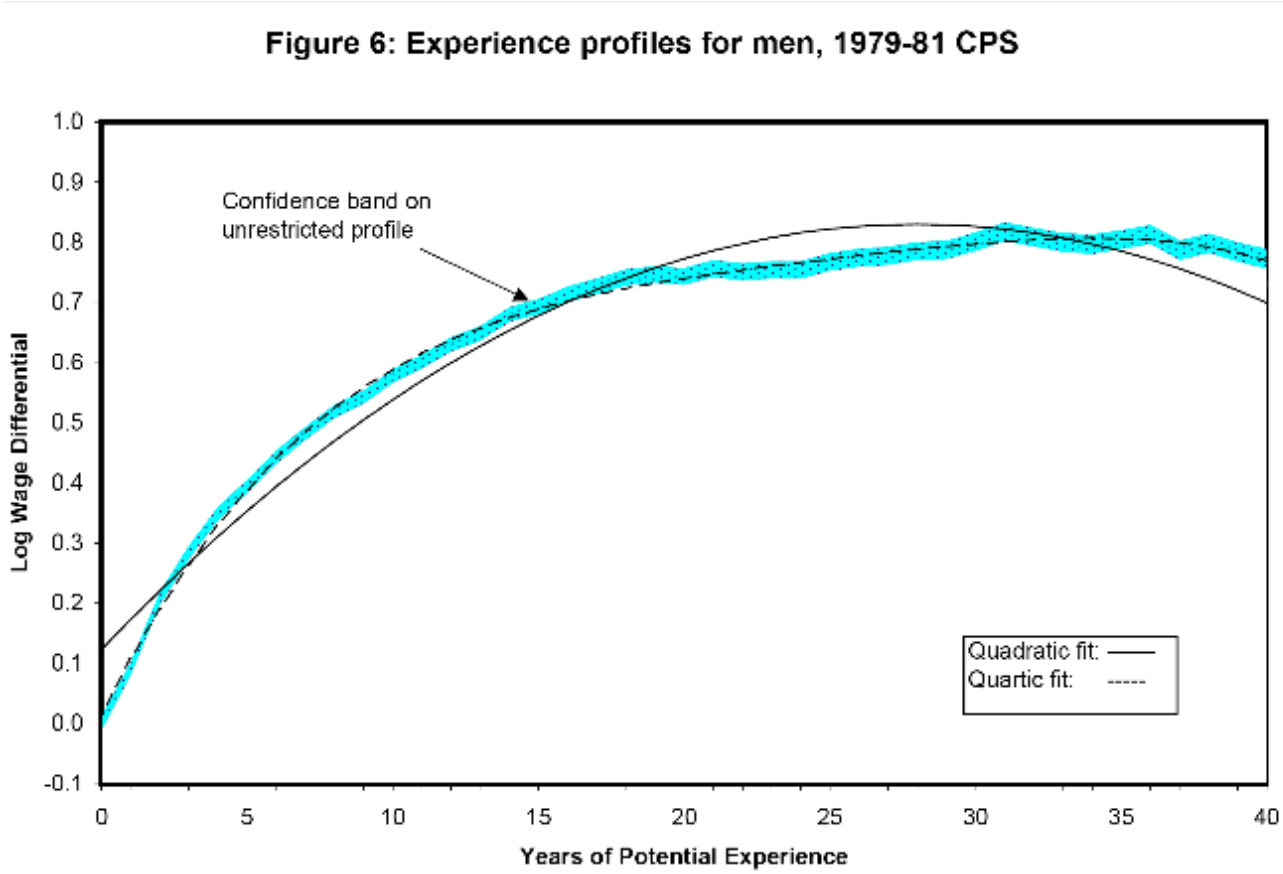
Source: Lemieux (2001)

Empirical Challenges to the Mincer Equation



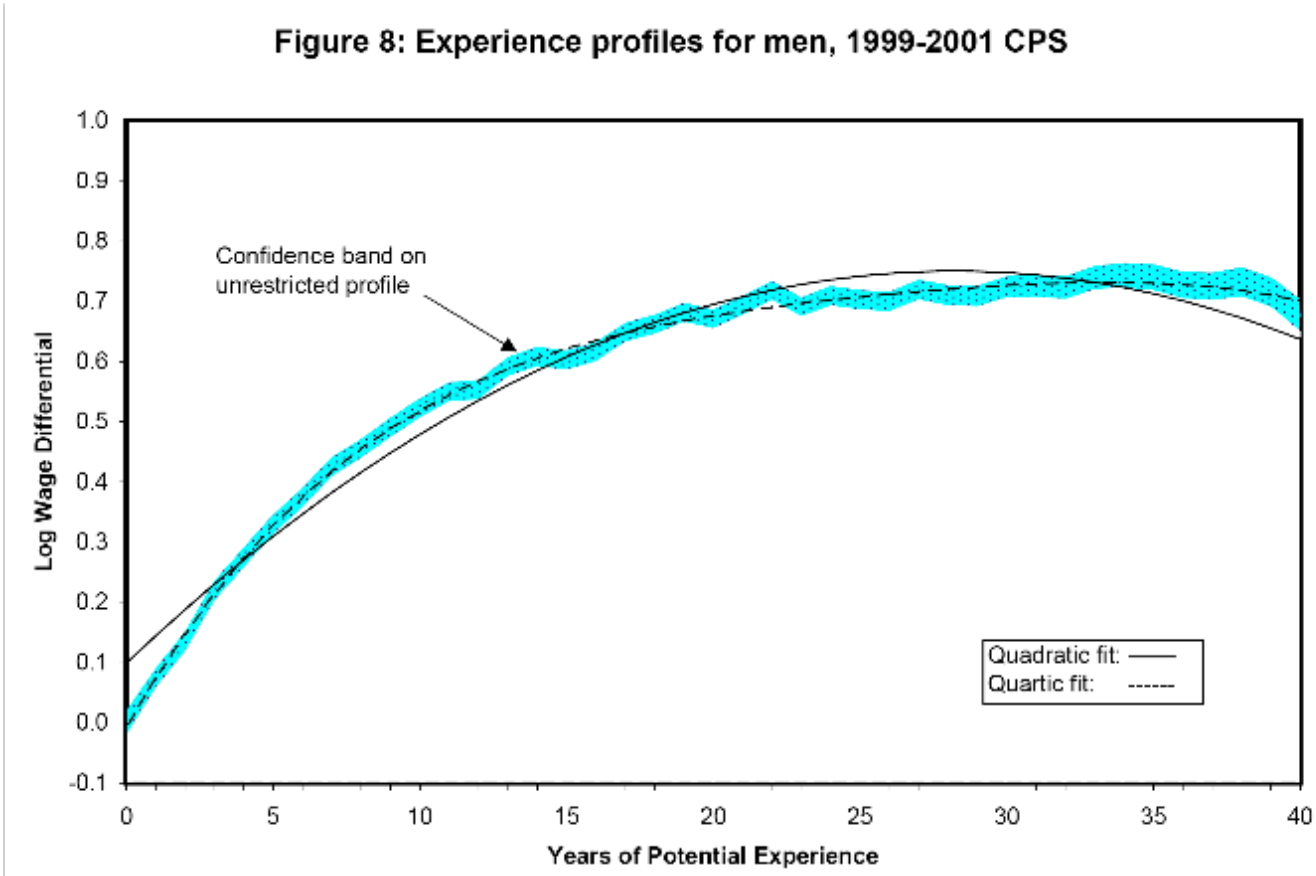
Source: Lemieux (2001)

Empirical Challenges to the Mincer Equation



Source: Lemieux (2001)

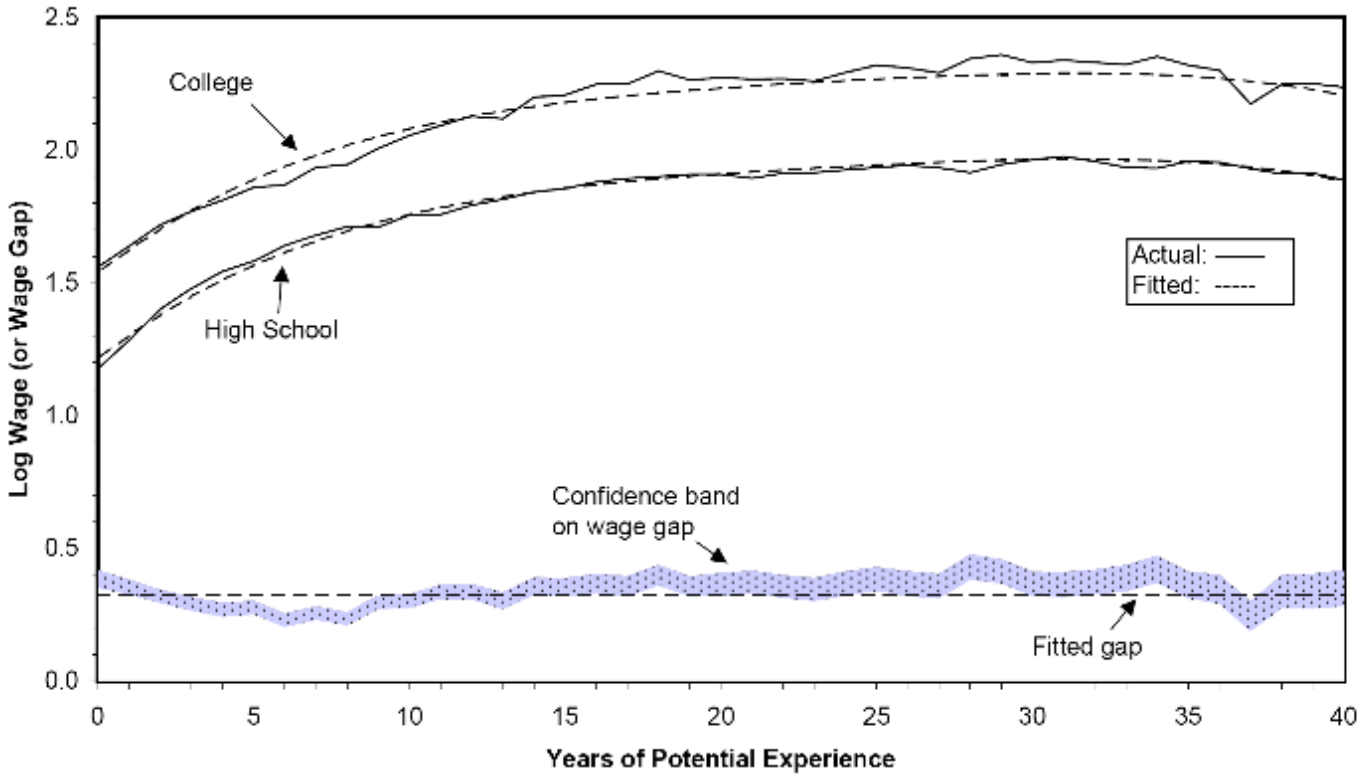
Empirical Challenges to the Mincer Equation



Source: Lemieux (2001)

Empirical Challenges to the Mincer Equation

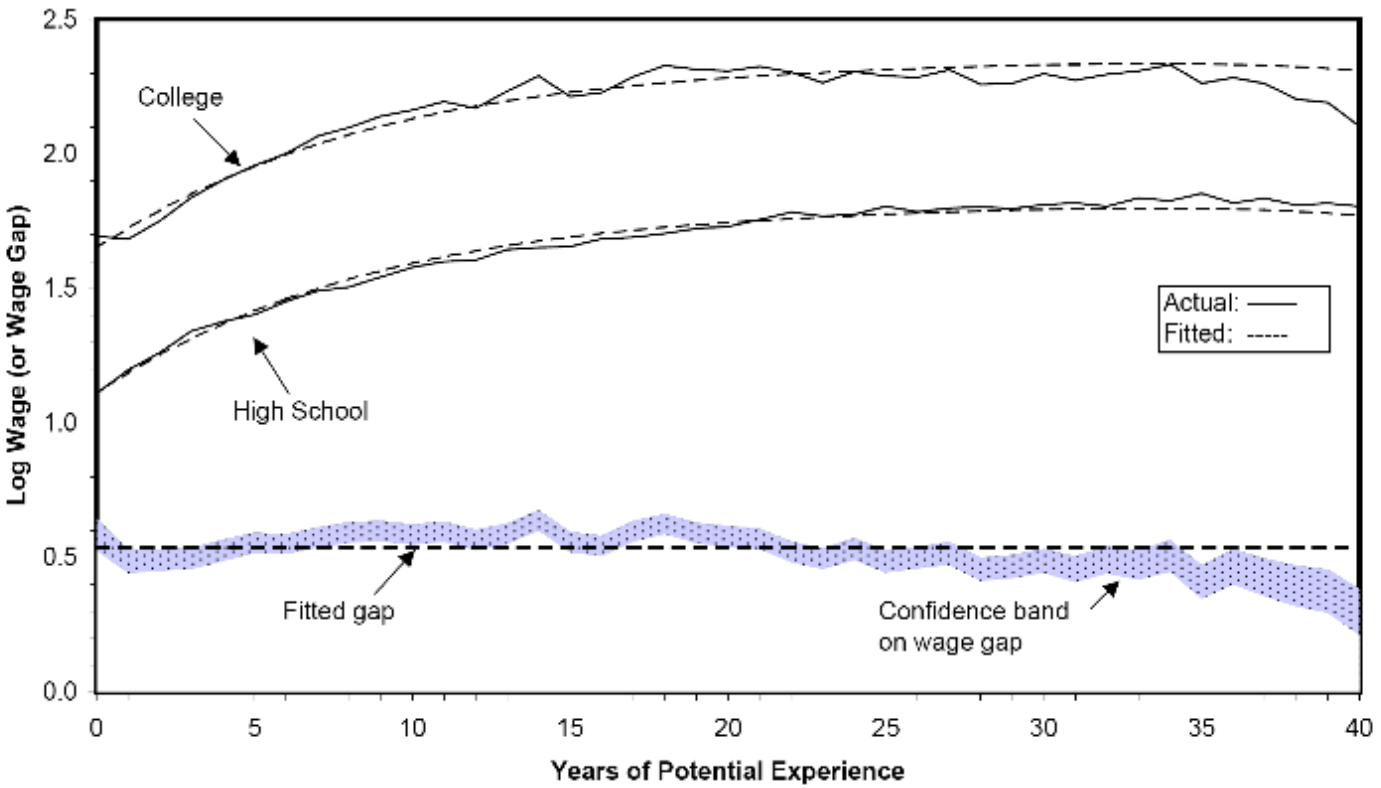
Figure 9: Experience profiles and Wage Gap for College and High School Graduates, 1979-1981 CPS



Source: Lemieux (2001)

Empirical Challenges to the Mincer Equation

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



Source: Lemieux (2001)

Empirical Challenges to the Mincer Equation

3) Experience-wage profiles are no longer parallel for different education groups: that is, the multiplicative separability between experience and schooling no longer holds. For example, the college-high school wage gap is now much larger for less experienced than for more experienced workers.

- The Mincer model is for individuals tracked over school and working ages, and should be estimated by tracking single cohorts through education and the labour market.
- But it is usually estimated from a cross-section of individuals, which is actually only legitimate if the economy is in a long run steady state.

Empirical Challenges to the Mincer Equation

4) Rapid technical change or secular improvement in the quality of education would violate this assumption and invalidate the use of cross-sectional data for estimation: cross-section and cohort based estimates of returns to education would not be expected to be the same.

- Mincer was well aware that this may be a problem in his early work (Mincer, 1958), and conjectured that the cross-sectional age-earnings profiles were probably understating life-cycle earnings growth since, in those days, there was substantial secular growth in average earnings.
- In fact it turned out the opposite (Beaudry & Green, CJE 2000, on the next slide).

Empirical Challenges to the Mincer Equation

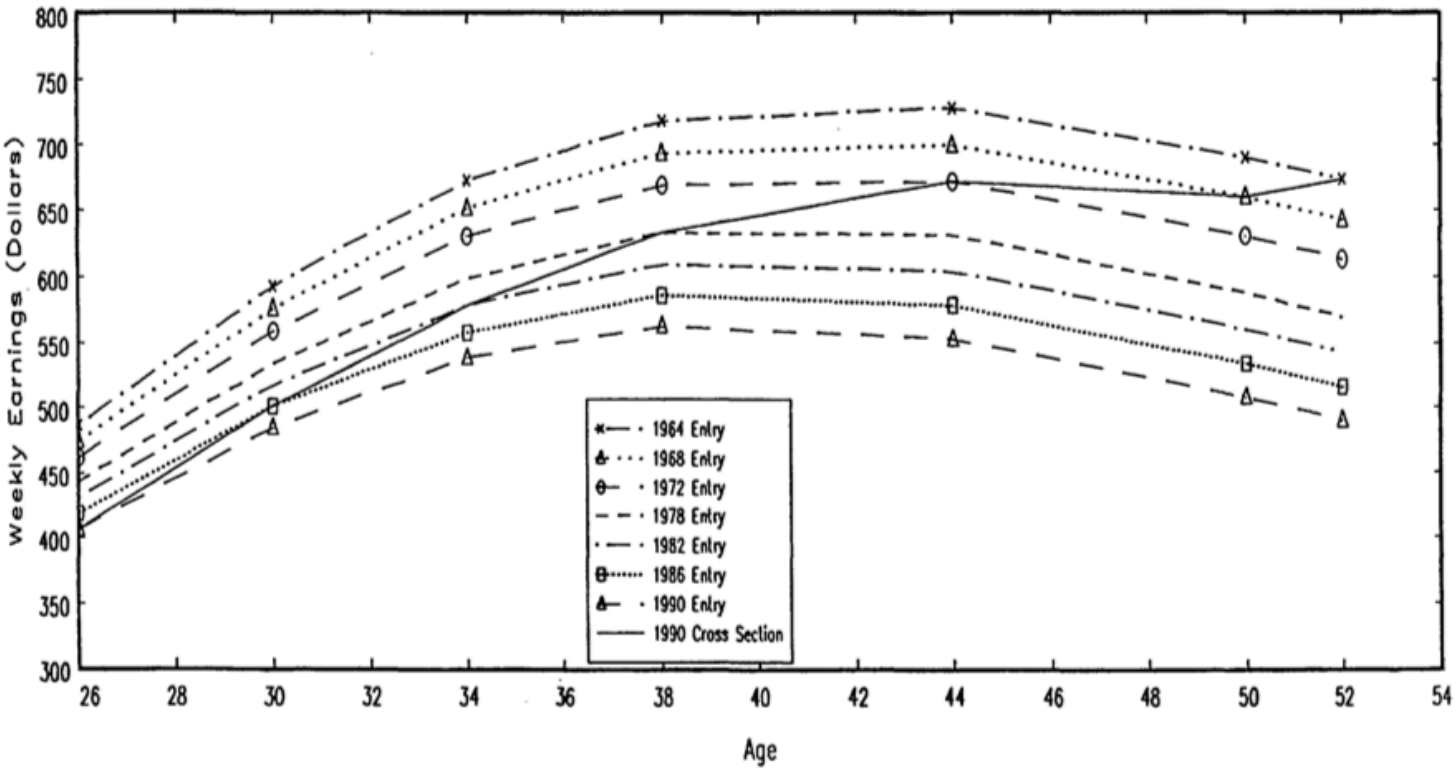


FIGURE 3b Age-earnings profiles allowing differing slopes by cohort: males, university education

Note: Includes forward-projections for the youngest cohorts.

Take-Away on the Mincer Equation

- In summary, recent evidence suggests that the basic Mincer human capital earnings model remains a parsimonious and accurate model in a stable environment where educational achievement grows smoothly across cohorts, as it did in the time period originally studied by Mincer (1974).
- In a less stable environment, however, major shifts in the relative supply of different age-education groups can induce important changes in the structure of wages that have to be taken into account when estimating a standard Mincer equation.

Take-Away on the Mincer Equation

Issue to be discussed: How to interpret the coefficient on schooling?

- Ability bias: Upward "bias"
- Heterogeneity in effects: ???
- Measurement Error: Downward “bias”
- Signalling vs. Human Capital

$\Rightarrow$ Problem set estimates the “causal effect” of education.

Challenges to human capital theory as an explanation for education decisions

- One of the clearest implications of HK theory is that education decisions should be highly responsive to pecuniary factors such as rate of return to education, tuition fees, etc.
- But this is generally not supported by the empirical evidence
- Rates of returns to college/postgraduate educations almost doubled in the United States since about 1980, but enrollments did not increase much, especially for men
- Most studies also suggest that enrollment elasticities with respect to tuition are modest

Possibly behavioral economics explanation.

Basic Readings

- Borjas, George. *Labor Economics*. Chapter 6.
- Mincer, Jacob. *Schooling, Experience and Earnings*, Columbia University Press for NBER, 1974.

Appdx: Theoretical Foundations of Mincer Model

An alternative theoretical foundation of the Mincer model is framework used by Mincer (1974):

- Builds on an accounting identity initially studied by Becker (1974) and Becker-Chiswick (1966).
- Allows earnings to vary over the life-cycle.

Appdx: Theoretical Foundations of Mincer Model

- Let E_t be potential earnings at time t. Investments in training are expressed as a fraction of potential earnings invested, $C_t = k_t E_t$, where k_t is the fraction invested at time t and let ρ_t be the return to training investments made at time t. Then

$$E_{t+1} = E_t + C_t \rho_t = E_t(1 + k_t \rho_t)$$

- Repeated substitution yields $E_t = \Pi_{j=0}^{t-1}(1 + \rho_j k_j) E_0$.

Appdx: Theoretical Foundations of Mincer Model

- Formal schooling is defined as years spent in full-time investments ($k_t = 1$). Assume that the rate of return on formal schooling is constant ($\rho_t = \rho_s$) and that formal schooling takes place at the beginning of life.
- Also assume that the rate of return to post-school investment, ρ_t, is constant over time and equals ρ_0. Then, we can write (in logs)

$$\ln E_t = \ln E_0 + S \ln(1 + \rho_s) + \sum_{j=s}^{t-1} \ln(1 + \rho_0 k_j)$$

Appdx: Theoretical Foundations of Mincer Model

- Which yields the approximate relationship (for small ρ_s and ρ_0) using the fact that, $\ln(1+\rho) \approx \rho$, if $\rho < 0.2$,

$$\ln E_t \approx \ln E_0 + \rho_s S + \rho_0 \sum_{j=s}^{t-1} k_j$$

- To establish a relationship between potential earnings and years of labour market experience, Mincer (1974) further assumes a linearly declining rate of post-school investment:

$$k_{s+x} = \kappa(1 - \frac{x}{T})$$

where $x = t - s \geq 0$ is the amount of work experience as of age t and T is the length of working life.

Appdx: Theoretical Foundations of Mincer Model

- Under these assumptions, and using the fact that $\sum_{j=0}^{x-1}(j/T) = [x(x-1)]/(2T)$, the relationship between potential earnings, schooling and experience is given by:

$$\ln E_{x+s} \approx [\ln E_0 - \kappa\rho_0] + \rho_s S + \left(\rho_0\kappa + \frac{\rho_0\kappa}{2T}\right)x - \frac{\rho_0\kappa}{2T}x^2$$

Appdx: Theoretical Foundations of Mincer Model

- Observed earnings equal potential earnings less investment costs, producing the following relationship for observed earnings:

$$
\begin{aligned}
\ln w(s,x) &\approx \ln E_{s+t} - \kappa\left(1 - \frac{x}{T}\right) \\
\ln w(s,x) &\approx \left[\ln E_0 - \kappa\rho_0 - \kappa\right] + \rho_s s \\
&\quad + \left(\rho_0\kappa + \frac{\rho_0\kappa}{2T} + \frac{\kappa}{T}\right)x - \frac{\rho_0\kappa}{2T}x^2 \\
&\approx \alpha_0 + \rho_s s + \beta_0 x + \beta_1 x^2
\end{aligned}
\tag{5}
$$