Human Capital – Schooling

A. Two basic notions

1. There are mutable attributes of individuals that affect their labor market productivity
    a. General physical fitness and well-being – important for some types of manual labor; affected by nutrition, rest and exercise
    b. Manual skills (e.g., typing) – important for other types of manual labor; affected by practice and training
    c. Knowledge – affected by schooling and training
2. People choose the levels of these attributes rationally
    a. People recognize that changing these attributes involves near-term costs and long-term benefits
    b. People optimally choose the level of these attributes balancing these costs and benefits
    c. Becker's insight – this optimization problem is analogous to a firm's physical capital investment problem, hence the term human capital
    d. Though widely accepted now, this view was initially controversial

> It may seem odd now, but I hesitated a while before deciding to call my book Human Capital – and even hedged the risk by using a long subtitle. In the early days, many people were criticizing this term and the underlying analysis because they believed it treated people like slaves or machines.
>
> Gary Becker, *Human Capital* 3rd Edition, p. 16

B. Simple formal model of skill acquisition (schooling)

1. Assumptions and notation

a. will work in a continuous time framework

b. let S denote years of schooling

c. let $Y = f(S)$ denote per-period earnings; for simplicity, assume that labor supply is fixed and that earnings depend only on schooling

d. assume that lifetimes are infinite

e. assume that there are no direct costs of schooling but also that there are no earnings while in school

f. people seek to maximize their lifetime earnings, V

2. Wealth maximization problem

a. present discounted value of life-time earnings associated with a given level of schooling is

$$V = \int_S^{\infty} e^{-rt} f(S)\,\mathrm{d}t$$

$$= f(S) \int_S^{\infty} e^{-rt}\,\mathrm{d}t = f(S)\left(-\frac{e^{-rt}}{r} + C\right)\Bigg|_S^{\infty}$$

$$= f(S)\frac{e^{-rS}}{r}$$

b. individual's optimization problem is

$$\underset{S}{\text{Max}}\ V = f(S)\frac{e^{-rS}}{r}$$

c. first-order condition

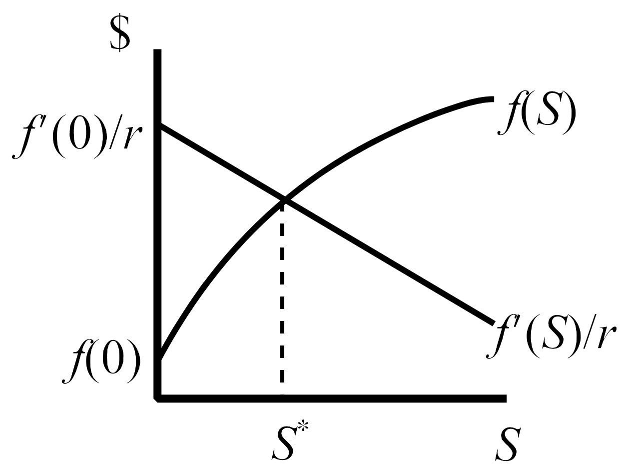
$$\frac{\mathrm{d}V}{\mathrm{d}S} = f'(S)\frac{e^{-rS}}{r} - f(S)e^{-rS} = 0$$

d. optimal level of schooling satisfies

$$\frac{f'(S)}{r} = f(S)$$

1) first term represents the marginal discounted lifetime return to an additional unit of schooling (recall that the present discounted value of an infinite, constant pay-off stream of B is B/r)
2) second term represents the earnings that are foregone while an addition unit of schooling is pursued, i.e., the marginal opportunity cost

e. assume $f''(S) < 0$, can depict the solution graphically



f. solution is an example of an optimal stopping rule (problem is analogous to the "when to sell the wine" and "when to cut the tree" problems)

g. example: let $f(S) = e^{\alpha + \beta S - \gamma S^2}$
1) $f'(S) = (\beta - 2\gamma S)\, e^{\alpha + \beta S - \gamma S^2}$
2) then the solution is $S^* = \beta / 2\gamma - r / 2\gamma$

C. Extensions to the simple model

1. What accounts for the variation in schooling attainment?
   a. in the simple model, variation in schooling choices must reflect either
      1) differences in the returns to schooling or
      2) differences in borrowing costs (imperfect capital markets)
   b. can consider some extensions to the model that introduce other types of heterogeneity
2. Consumption value of schooling
   a. one criticism of the simple model is that it assumes that people attend school only to increase their wealth; schooling (knowledge) is not valued for its own sake
   b. assume that instead of being only concerned with lifetime wealth (consumption), people have preferences defined over both wealth and schooling such that $U = U(V, S)$
   c. optimization problem is

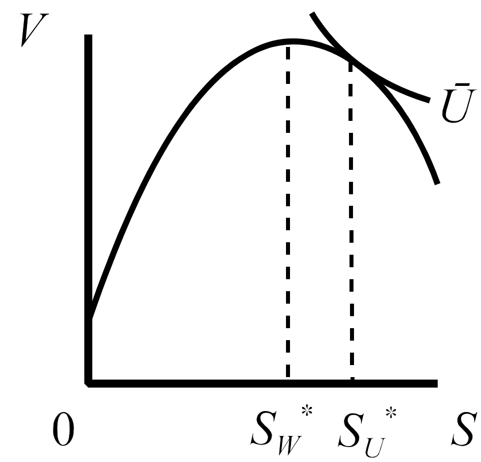
$$\underset{S}{\text{Max}}\ U(V,S)$$

   d. first-order condition

$$\frac{\partial U(V,S)}{\partial S} + \frac{\partial U(V,S)}{\partial V}\frac{\mathrm{d}V}{\mathrm{d}S} = 0$$

   differs from earlier solution in which we simply set $\mathrm{d}V/\mathrm{d}S = 0$

e. graphically, the solution is shown at the right



1) $S_W{}^*$ – wealth maximizing level of schooling
2) $S_U{}^*$ – utility maximizing level of schooling

f. assuming that wealth and schooling are goods (enter utility function positively), optimal schooling attainment is higher and optimal lifetime wealth is lower than in the simple model

what happens if there is disutility associated with schooling (e.g., disutility from boring professors)?

3. Direct costs of schooling
   a. assumptions
      1) return to the wealth maximization framework
      2) make the additional assumption that students must pay a per-period cost of K while they are in school
   b. the optimization problem now becomes

$$\underset{S}{\text{Max}}\ V = \int_S^\infty f(S)\, e^{-rt}\, \mathrm{d}t - \int_0^S K\, e^{-rt}\, \mathrm{d}t$$

   c. the first-order condition can be expressed

$$\frac{f'(S)}{r} = f(S) + K$$

indicates that people balance

1) marginal lifetime earnings benefit with
2) the opportunity costs and direct costs of an additional unit of schooling

d. education subsidies

1) elementary and secondary education is publicly provided; sources of funding in different years:

	1980-1	1999-0	2005-6
Federal	9.2 %	7.3 %	9.1 %
State	47.4 %	49.5 %	46.5 %
Local & other	43.4 %	43.2 %	44.4 %

total funding in 05-06 was $521 bil. (NCES 2008)

2) your tuition bills notwithstanding, higher education is highly subsidized; in 1980-1 and 1995-6 the sources of current revenues were

	1980-1	1995-6
Tuition	21.0 %	27.9 %
Federal	14.9 %	12.1 %
State	30.7 %	23.1 %
Local	2.7 %	2.8 %
Other	30.8 %	34.0 %

total funding was $66 billion in 1980-1 and $198 billion in 1995-6 (NCES 2008); public funding has decreased while private funding has increased

3) according to the model, subsidies should unambiguously increase schooling
4) what is the rationale for subsidizing education? at a societal level, doesn't subsidization lead to too much educational attainment? does this account for the fall in subsidies over time?

4. Discrete time approach
   a. may be more realistic to think about discrete years of schooling; how does this change the model
   b. assuming there are no direct costs, the lifetime wealth associated with S years of schooling can be expressed

$$V(S) = \sum_{t=S+1}^{\infty} (1+r)^{1-t} f(S)$$

   c. change in lifetime wealth associated with an additional year of schooling is

$$V(S+1) - V(S) = -\frac{f(S)}{(1+r)^S} + \sum_{t=S+2}^{\infty} \frac{f(S+1) - f(S)}{(1+r)^{t-1}}$$

$$= (1+r)^{-S} \left[-f(S) + \sum_{t=S+2}^{\infty} \frac{f(S+1) - f(S)}{(1+r)^{t-S-1}} \right]$$

   d. optimal stopping rule
      1) continue in school while $V(S+1) - V(S)$ is positive
      2) examining the term in brackets, the condition is similar to that from the continuous time problem – continue in school while the current marginal foregone earnings are less than the present

discounted value of the marginal increment to lifetime earnings

3) complication with this approach (relative to continuous time) is that it requires multiple evaluations of the value function

D. Rates of return

1. Discrete time example: consider two earnings streams, $E_t(S)$ and $E_t(S+1)$, the rate of return on human capital is the interest rate r^* which causes the present discount value of the streams to be equal

$$\sum_{t=1}^{T}(1+r^*)^{1-t}E_t(S) = \sum_{t=1}^{T}(1+r^*)^{1-t}E_t(S+1)$$

2. Continuous time

a. let the present discounted value of earnings conditional on schooling be

$$V = \int_S^\infty f(S)e^{-rt}\,\mathrm{d}t$$

b. the rate of return on schooling is the interest rate, r^* which causes $\mathrm{d}V/\mathrm{d}S = 0$; thus, $r^* = f'(S) / f(S)$

c. solving the differential equation, $\ln f(S) = \alpha + r^*S$

d. regressing log earnings on schooling produces an estimate of the rate of return to schooling

e. this is essentially Mincer's earnings function (Mincer's actual function added a quadratic in work experience)

f. note that a true log-linear earnings function leads to a knife-edge solution for the optimal level of schooling

E. Empirical evidence

1. Willis'(1986) summary

a. Returns to education in the U.S. over time (Tab. 10.2)

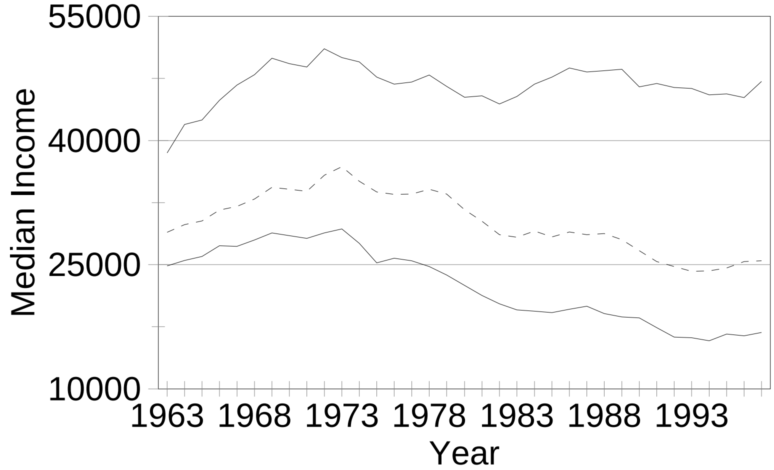
Year	Secondary	Higher (a)	Higher (b)
1939	18.2	10.7	-
1949	14.2	10.6	-
1959	10.1	11.3	-
1969	10.7	10.9	9.0
1976	11.0	5.3	8.3

1) returns decrease with level of schooling
2) returns decrease over time
3) more recent data indicate that the returns have increased

b. consider also the following graph

Median Income for Males

by Educational Attainment, 1963-97



top line is earnings for college-educated men, middle line is earnings for high school graduates, bottom line is for men with some high school

F. Econometric Issues

1. Consider the following two equation system consisting of empirical representations of an earnings equation and its associated optimal schooling equation

$$\ln y_i = \alpha + \beta S_i + \gamma S_i^2 + \varepsilon_i$$

$$S_i = \beta/2\gamma - 1/2\gamma \, r_i + \nu_i$$

2. This is a recursive simultaneous system; OLS estimation of the first equation is biased if $E(\varepsilon_i \, \nu_i) \neq 0$

3. Unobserved differences in "ability" could account for a positive correlation between ε_i and ν_i

a. independent of the level of schooling, higher ability people might be more productive and therefore earn more
b. higher ability people may also face lower effective costs of schooling (e.g., can obtain the same schooling as lower ability people with less effort) and therefore obtain more schooling
c. a positive correlation between ε_i and ν_i would bias the estimated rate of return to schooling upward
d. could parameterize this correlation by specifying $\varepsilon_i = \varphi A_i + \varepsilon_i^*$ and $\nu_i = \eta A_i + \nu_i^*$ where $E(\varepsilon_i^* \nu_i^*) = 0$; here $E(\varepsilon_i \nu_i) = \varphi \eta \sigma_A^2 \neq 0$
e. how to account for this correlation?

4. Direct measures and proxies for A_i
   a. most obvious way to account for A_i is to include a direct measure
      1. some surveys do include things like IQ scores
      2. the NLSY includes a general ability measure, the Armed Forces Qualification Test
   b. alternatively, could use proxy (indirect measures)
   c. is this the only omitted variable? Bias could remain from other omitted variables
   d. is the omitted variable perfectly measured? Mismeasurement will also lead to bias
   e. are these measures affected by schooling? If so, how do we account for the total affect of schooling?
5. Siblings controls for A_i

a. intuition here is that siblings may be alike in their ability
b. specifically, assume that

$$\ln y_{ij} = \alpha + \beta S_{ij} + \gamma S_{ij}^{2} + \varphi A_i + \varepsilon_{ij}^*$$

where i denotes the individual and j denotes the family; here ability is assumed to be the same across siblings
c. could use fixed effects techniques (e.g., differencing across siblings within a family to remove A_i)
d. disadvantages (see Griliches 1979)
    1. requires siblings data
    2. if assumption on A_i is incorrect, bias will remain and might even be exacerbated
    3. bias from measurement error will be exacerbated

6. Instruments for schooling
    a. can use two-stage least squares or some other instrumental variable technique
    b. require a suitable instrument
        1. must find a variable that is a good predictor for schooling
        2. but that is not directly related to earnings (i.e., is only related to earnings through schooling)
    c. tough to find variables that meet both criteria
    d. example: Angrist and Krueger (1991) used quarter of birth and compulsory attendance laws

7. Variation in the returns to schooling
   a. suppose our model is

$$\ln y_i = \alpha + \beta_i S_i + \gamma S_i^2 + \varepsilon_i$$

$$S_i = \frac{\beta_i}{2\gamma} - \frac{1}{2\gamma} r_i + \nu_i$$

   where now the returns to schooling (β_i) vary across people
   b. suppose further that we are interested in just the average return to schooling $\bar{\beta}$
   c. much more difficult to estimate the average return to schooling
   d. instruments would need to satisfy stronger conditions
      1. terms ν_i, ε_i and $\beta_i - \bar{\beta}$ would need to be mean independent of instrument
      2. second moment of $\beta_i - \bar{\beta}$ would also have to be fixed and independent of instruments
      3. additional restrictions on ν_i
      4. without these assumptions, even exogenous instruments can lead to biased estimates of the average returns to schooling
   e. more thorough discussion in Card (1999)

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