Introduction

Education is one of the largest sectors in the economy, and thus can be studied from a large amount of angles.

- Early Childhood Education (beyond just "being watched")
- Elementary/Secondary School
- Postsecondary Education

Education can be studied from a lot of angles:

Micro: Applying theories of labor economics and consumer theory to education.

Econometrics: Use data to analyze educational policies.

Macro: Investigate global demand for education-as-a-commodity.

Education System Basics

Returns to Education: There is a large return to education; those with a high school education tend to make far less than those with a bachelor's degree and up. Perceived value of being more education in private or public market.

Labor Market Outcomes: The more educated you are, the more likely to have a job; unemployment rates for high school graduates are higher than unemployment rates for college graduates.

Public Spending: Approximately 5–6% of GDP is spent on education in most OECD countries.

Funding Structure: Public schools are primarily funded through state and local governments — property taxes the largest source of funding for education, but federal government has started to fund more schools in recent years.

Growth of Education over Time: Claudia Goldin's 1993 paper "The Human-Capital Century and American Leadership" shows that the 20th century was really the century of greater and greater access and attainment in education.

Why Do We Get Educated?

Human Capital

What is human capital?

- Labor.
- Complexity or efficiency of work.

How does human capital differ from capital?

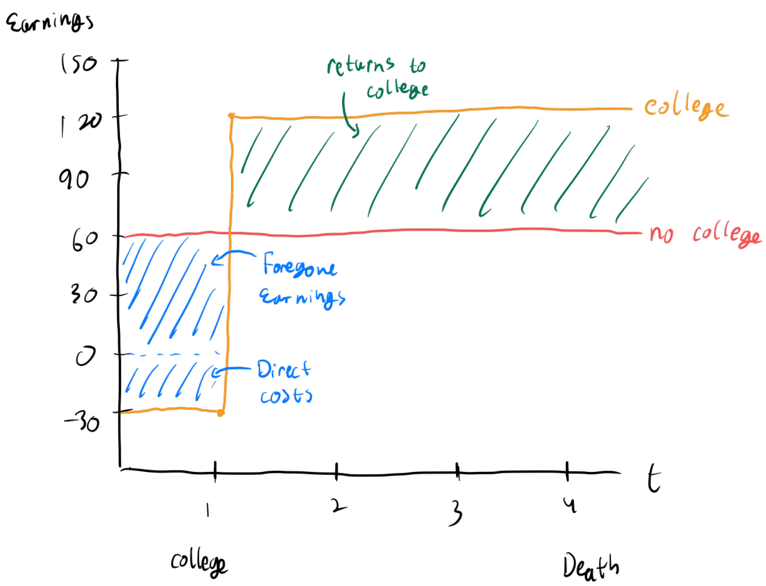
- Less static.
- Differential depreciation — potential for appreciation (people can skill up).
- Higher variance.
- Unionization/collective bargaining.
- Idea generation.
- Potentially greater mobility.
- Returns to human capital come in the form of wages — human capital is owned by the human that holds it.
- Cannot be collateralized.
- Divisibility (or lack thereof).

Education: how much?

Discrete Model: To college or not?

- Direct costs: tuition, room and board.
- Indirect costs: foregone earnings.
- Returns: expected future earnings (requires college degree or not).

We will assume that "college" is period 1, and college grads earn more post-college, and there is a discount rate r.



The discount rate of \$100 in $t > 0$ periods is worth $\frac{100}{(1+r)^t}$ in period 0 (aka today).

We generally think about r in terms of the interest rate — money today is worth more than money in the future due to the ability to invest.

The *present value* of a stream of money is found as follows:

$$\begin{aligned}
\text{PV} &= \frac{100}{(1+r)} + \frac{100}{(1+r)^2} + \cdots + \frac{100}{(1+r)^n} \\
&= \sum_{t=1}^{n} \frac{100}{(1+r)^t} && (1) \\
(1+r)\text{PV} &= 100 + \frac{100}{(1+r)} + \cdots + \frac{100}{(1+r)^{n-1}} \\
&= 100 + \sum_{t=1}^{n-1} \frac{100}{(1+r)^t} && (2) \\
(1+r)\text{PV} - \text{PV} &= 100 + \sum_{t=1}^{n-1} \frac{100}{(1+r)^t} - \sum_{t=1}^{n-1} \frac{100}{(1+r)^t} - \frac{100}{(1+r)^n} && (2)-(1) \\
r\text{PV} &= 100 - \frac{100}{(1+r)^n} \\
\text{PV} &= \frac{100}{r}\left(1 - \frac{100}{(1+r)^n}\right)
\end{aligned}$$

As n becomes larger, then the PV of the asset is larger. For example, if $n = 40$, $Y = 60,000$, and $r = 0.05$, then the PV of this revenue stream is approximately \$1 million.

Bringing this to the model, where F denotes direct tuition cost, Y_0 denotes earnings with no schooling, and Y_S denotes earnings with schooling (where school occurs in period 1).

$$\begin{aligned}
\mathrm{PV}_0 &= \frac{Y_0}{(1+r)} + \frac{Y_0}{(1+r)^2} + \cdots + \frac{Y_0}{(1+r)^n}\\
\mathrm{PV}_S &= -F + \frac{Y_S}{(1+r)^2} + \cdots + \frac{Y_S}{(1+r)^n}\\
\mathrm{NPV}_S &= \mathrm{PV}_S - \mathrm{PV}_0\\
&= \underbrace{-F - \frac{Y_0}{(1+r)}}_{\text{Cost}} + \underbrace{\sum_{t=2}^{n} \frac{Y_S - Y_0}{(1+r)^t}}_{\text{Benefit}}\\
&= -F - \frac{Y_0}{1+r} + \frac{Y_S - Y_0}{r}\left(1 - \frac{1}{(1+r)}\right)\frac{1}{1+r}
\end{aligned}$$

To find if education is worth it, we calculate if $\mathrm{NPV}_S > 0$.

Continuous Model (or Mincer Model): To take an extra year of education or not?

- S is a discrete, integer choice (denoting a year of education).
- Y_S is salary after schooling for S years.
- There are zero direct costs of school.
- Years in labor force, K, are equivalent regardless of S.

We choose S where marginal benefit is equal to marginal cost.

$$\begin{aligned}
\mathrm{PV}_S &= \mathrm{PV}_{S+1}\\
\sum_{t=1}^{K} \frac{Y_S}{(1+r)^t} &= \sum_{t=2}^{K+1} \frac{Y_{S+1}}{(1+r)^t}\\
\frac{Y_S}{r}\left(1 - \frac{1}{(1+r)^K}\right) &= \frac{Y_{S+1}}{r}\left(1 - \frac{1}{(1+r)^K}\right)\frac{1}{1+r}\\
Y_S &= Y_{S+1}\frac{1}{1+r}\\
1 + r &= \frac{Y_{S+1}}{Y_S}
\end{aligned}$$

We choose school until the marginal rate of return is equal to the discount rate.

Housekeeping, January 30: Schedule for discussion and presentation is located at this link, and the guidelines for classroom activities are located at this link.

Educational Landscape

The human capital system consists of a number of components.

- Trade, technical, and vocational education (generally falls under post-secondary education)
- Early childhood education — Ages 6 weeks–5, includes day care and pre-K
- Primary education — Ages 5–12, Grades K–5/6

- Secondary education — Ages 12–18, Grades 6–12
- Post-secondary education — two year/community college, four year college
- Graduate education — profession-oriented (MBA, JD), research-oriented (master's, PhD), certification (CPA, CFA, actuarial credentialing)
- Adult education (GED, college)

In primary and secondary education, primary choice facing consumers of education is between public and private education.

Human Capital Model: Choice of Schooling Quantity

The human capital model indicates that consumers of education choose their amount of schooling, S, based on the following factors:

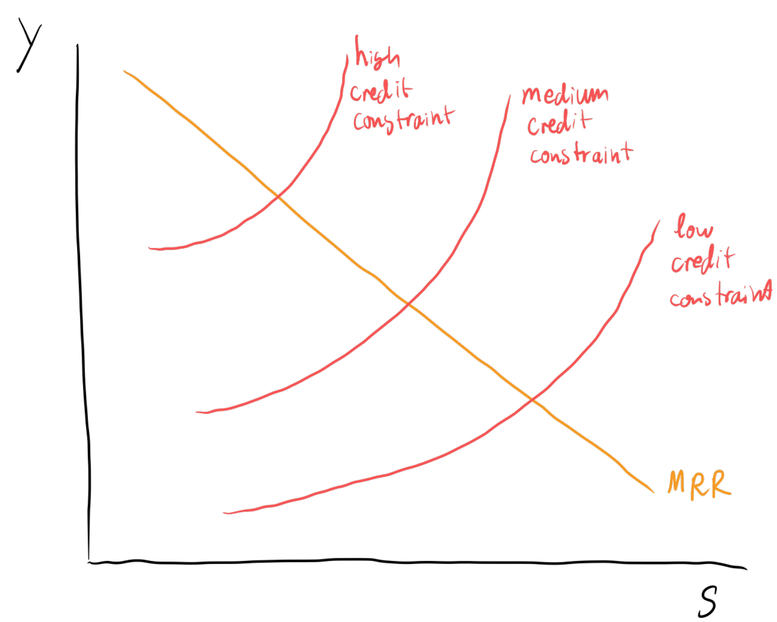
- Discrete: Y_S (income from having been schooled) vs Y_0 (income without schooling)
- Continuous: $\frac{Y_{S+1}}{Y_S}$ (marginal rate of return from schooling)
- F (the cost of schooling)
- r (discount rate)

However, this leads us to ask an important question — why might S differ?

- Differing (marginal) rates of return — job-specific factors, overqualification, ability, quality of education
- Different cost of education — borrowing, aid, credit constraints

  Comment: Credit constraints increase exponentially as quantity of schooling increases.

A model of credit constraints' effects on choices of education can be seen as follows:



Broadly speaking, if S differs because of marginal rate of return, then subsidies may be inefficient — subsidies will cause inefficient excess schooling.

However, if S differs because of cost, then subsidies improve overall output and efficiency.

Signaling

The basic idea behind the human capital model is that by getting more educated, you become smarter and have a higher rate of return — regardless of whether or not you get a degree. Now, we will discuss a model where schooling does not indicate one's level of smartness.

Assumptions:

(1) No human capital accrued at school.

(2) Two types of workers: low ability (L) of proportion p with productivity 1 and high ability (H) of $1-p$ with productivity 2.

(3) Cost of education is lower for type H. For type L, the cost of education is c, and for type H the cost of education is $c/2$.

(4) Generic employer who, if they distinguish H and L, pay marginal benefit — wage to L is 1, wage to H is 2.

(5) If the employer cannot distinguish between H and L, then they pay the expected marginal benefit, $(1-p)(2)+(p)(1)=2-p$.

Game Play:

- Employer forms belief $w(S)$ about the worker productivity
- Employer sets $w(S)$
- Workers observe $w(S)$ and decide on S
- Workers are hired and firms observe their productivity

Types of Equilibria:

- Separating equilibrium: a situation where H chooses education and L does not choose education. In this case, education serves as a pure signal of high productivity — there is no separating equilibrium where H chooses no education and L chooses education.
- Pooling equilibrium: all workers choose education, and the employer cannot differentiate, meaning the employer pays $2-p$ to all workers.

Finding a Separating Equilibrium: We assume that there is a separating equilibrium — H chooses $S=1$ and L chooses $S=0$. Then, the employer forms beliefs to set a wage structure as follows:

$$w(S)=\begin{cases}2 & S=1\\ 1 & S=0\end{cases}.$$

In order to be an equilibrium, both H and L types need to have an incentive not to deviate.

- H Type Equilibrium Condition: Return to education is higher than return to non-education.

$$\begin{aligned}2-\frac{c}{2} &> 1\\ c &< 2\end{aligned}$$

- L Type Equilibrium Condition: Return to non-education is higher than return to education.

$$\begin{aligned}1 &> 2-c\\ c &> 1\end{aligned}$$

Therefore, if $c\in(1,2)$, we can find a separating equilibrium.

Finding a Pooling Equilibrium: We assume that there is a pooling equilibrium where all players are educated — H chooses $S = 1$ and L chooses $S = 1$. Then, the employer forms beliefs to set a wage structure as follows:

$$w(S) = \begin{cases} 2 - p & S = 1 \\ 1 & S = 0 \end{cases}$$

In order to be an equilibrium, both H and L types need to have an incentive not to deviate.

- H type equilibrium Condition: Return to education is higher than return to non-education.

$$\begin{aligned} (2 - p) - \frac{c}{2} &> 1 \\ c &< 2 - 2p \end{aligned}$$

- L type equilibrium condition: Return to education is higher than return to non-education.

$$\begin{aligned} (2 - p) - c &> 1 \\ c &< 1 - p \end{aligned}$$

Therefore, so long as $c < 1 - p$, both types of employees will choose education over non-education. Essentially, if the cost of education is very low, then everyone will choose education.

Working through a similar set of logic, we can also find a sufficient c such that everyone chooses no education.

$$w(S) = \begin{cases} 2 - p & S = 0 \\ 2 & S = 1 \end{cases},$$

if $c > 2p$. Notice that both of these pooling equilibria are more likely to exist the higher proportion of H types.

Signal vs Index

- Signal: implicit assurance of skill or quality, chosen by worker, not readily apparent. Examples include education levels.
- Index: worker cannot control said assurance of skill or quality, but predetermined, generally a source of discrimination. Examples include disability, race, gender, and age.

The signaling model starts with employers offering different wages based on a signal — the signal is something a worker has some level of control.

However, the signaling model could also be thought of as an indexing model (by varying parameters p and c while equalizing productivity). Essentially, the signaling model is about a legal form of discrimination (education-based discrimination), but we can apply it to illegal forms of discrimination.

Human Capital and Signaling Model: Features

Human Capital	Both Models	Signaling Model
positive externalities	inequality	pure private returns
education is efficient		education is inefficient

Claudia Goldin: The Human-Capital Century

- The 20th century was the century where people became educated — early on, few people even had a primary education, but now, the vast majority of people obtain secondary school.
- Education is democratic.
  - Democracy is a government by the people, for the people.
  - Power is not vested by God or inherent in blood, but governance comes from the consent of the governed.
  - Public demand for education leads to more education being delivered.
  - Education provides both skills and time to create better citizens.
- Virtues: egalitarianism, forgiveness (possibly changing), separation of church and state.
- Primary education was very common across the rich world, but secondary education was far more common in the United States than other countries.
- Specifically, American secondary education was about *general* education (algebra, writing, reading comprehension, etc.), not merely vocational or technical training. The European system is much more heavily tracked.
- Idea that one would spend years 10–18 in education began in the United States. Adults were better able to establish themselves in the new economy, and the underlying structures were exported to the rest of the United States.
- European systems developed out of monarchy/aristocracy, leading to deterministic ideas of the demands of the economy.
- Decentralized American education system — curriculum followed the economy, rather than determined for the economy.
- The standards for general education developed around a pure method of approach towards problems.
- Rise of large corporations generated large need for management, idea generation, communication — had to do HR, accounting, etc. at a scale never seen before. Skills were meant to be portable and transferable, which the decentralized American education system satisfied the demand for.

Understanding Causality

When discussing questions in economics, there are two basic approaches:

- Theory: models (as discussed in our model of human capital and the signaling model).
- Empirics: using data to understand the dynamics of the world.

For example, we may want to understand the impact of a good teacher in the role of educational success through different measures:

- Pass rates or graduation rates.
- College entrance rates.
- Test scores.
- Earnings.

We can think of each of these as our Y_i, our outcome variable of interest. At the same time, we have to measure the quality of a teacher, X_i, through different mechanisms:

- Education
- Course Evaluations (with adequate controls for race and gender)
- Subject

Defining Causality

The impact of variable A *causally* affects variable B as the change in B if A, and only A, is altered. Causality is usually defined using a counterfactual.

In the case of education, for Y_i, student i's outcome, with Y_{1i} for an outcome for a student with a good teacher and Y_{0i} for a student with a bad teacher. We define D_i, our dummy variable, as 1 if the teacher is good and 0 if the teacher is bad.

$$Y_i = Y_{0i} + D_i \underbrace{(Y_{1i} - Y_{0i})}_{\text{treatment effect}}.$$

Potential Outcomes Framework

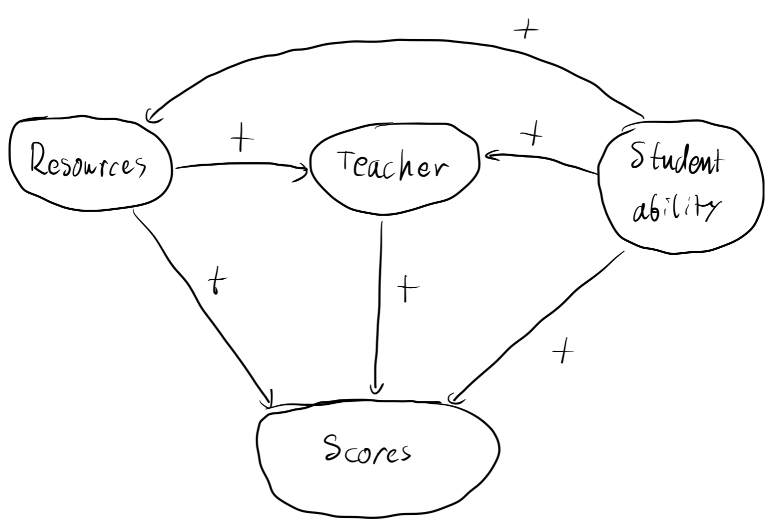
- What does a researcher observe? We assume $N > 1$. In this case,

$$\begin{aligned} E(Y_{1i}|D_i = 1) - E(Y_{0i}|D_i = 0) &= \text{ observed difference of } D_i = 1 \\ &= \overbrace{E(Y_{1i}|D_i = 1) - \underbrace{E(Y_{0i}|D_i = 1)}_{\text{counterfactual}}}^{\text{Average Treatment Effect (impact of good teacher)}} \\ &+ \overbrace{\underbrace{E(Y_{0i}|D_i = 1)}_{\text{counterfactual}} - E(Y_{0i}|D_i = 0)}^{\text{selection bias}} \end{aligned}$$

Therefore, we can see that the observed difference is a function of treatment and selection bias. The most difficult part of empirical research is finding situations where selection bias is as close to zero as possible.

In regression analysis, we might have the model that states

$$\text{score}_i = \beta_0 + \beta_1 \text{TeacherQuality}_i + \varepsilon_i.$$



Suppose that teachers matter — even then, there are other variables, such as resources or intrinsic ability. The diagram depicts the various ways that selection bias can create positive correlation.

In this case, $\hat{\beta_1}$ will be biased by selection. This is known as omitted variable bias, and violates the principle that $\text{Cov}(X, \varepsilon) = 0$.

To resolve this, we may update our regression model to control for the omitted variable of resources, denoted Z.

$$\text{score}_i = \beta_0 + \beta_1 \text{TeacherQuality}_i + \beta_2 \text{Resources}_i + \varepsilon_i$$
$$\text{observed effect} = E(Y_{1i}|D_i = 1, Z) - E(Y_{0i}|D_i = 1, Z) + \underbrace{E(Y_{0i}|D_i = 1, Z) - E(Y_{0i}|D_i = 0, Z)}_{\text{selection bias}}.$$

However this still leaves out other omitted variables (such as parental involvement). As we add more control variables, selection bias should reduce. All these control variables exist to mitigate selection bias and make a non-experimental setting as close to an experiment as possible.

There are a few major ways to identify causality:

(1) Experiments
(2) Instrumental Variables
(3) Difference-in-difference
(4) Regression discontinuity
(5) Panel data

Experiments

The "cleanest" way to

- Identify a Target Population.
- Randomize Population.
  - Treatment group experiences condition.
  - Control group does not experience condition.
- Experiments have the following desirable properties:
  - Internal Validity: $E(\varepsilon|X) = 0$ (error is uncorrelated with independent variable)
  - Randomness
- However, true randomness is difficult to attain. The ABCs of experiments also threaten internal validity.
  - Attrition: individuals drop out of experiments.
  - Balance: distribution of covariates may not be the same across groups.
  - Compliance: not everyone assigned to a treatment may experience it.
- There are also other limits:
  - Feasibility: expense, time, or even full impossibility.
  - Ethics: some experiments may pose ethical issues
  - External validity: experiments may only provide insights to specific situations.

- Threats to internal validity:
  - Poor randomization
  - Experimental contamination
  - Response rate, compliance
  - Attrition
- Threats to external validity:
  - Non-representative sample
  - Treatment depends on experiment
  - Excessive controls, Hawthorne effect
  - Scalability