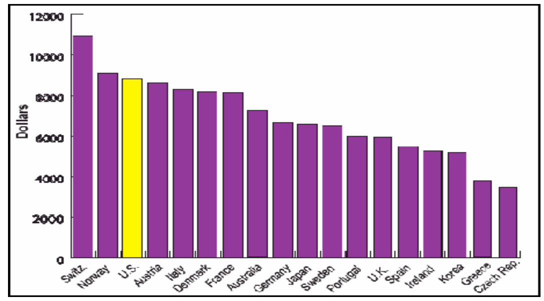
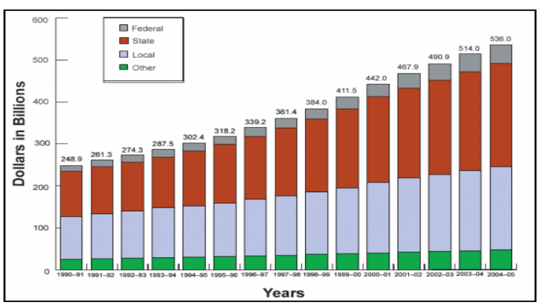
Why do economists care about education?

Annual Secondary Education Expenditures per Student



Source: Organisation for Economic Co-operation and Development, *Education at a Glance, 2004*.

U.S. Expenditures for Elementary and Secondary Education



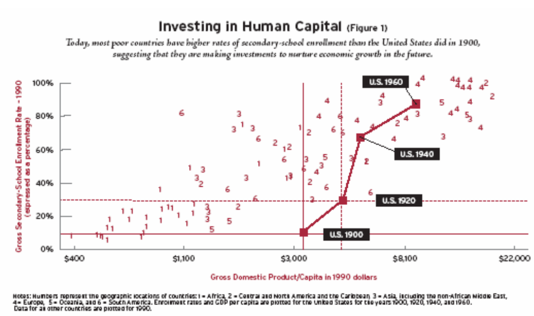
Sources: NCES, "Common Core of Data," surveys and unpublished data.

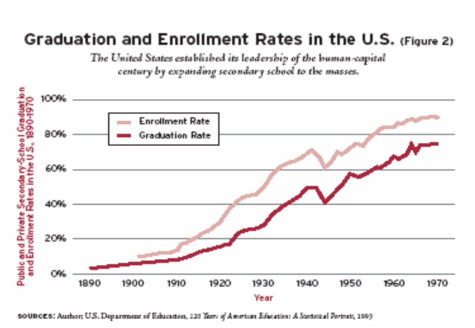
Why do economists care about education?

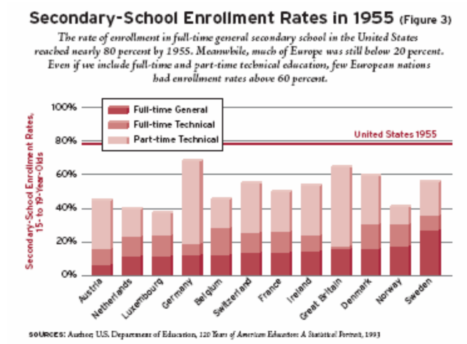
- Taylor, L. L. 1999. "Government's role in primary and secondary education."
- The fact that government currently spends a lot on education doesn't necessarily justify it.
- What does?
  - Imperfect capital markets may lead to under investment
  - Externalities may lead the social return to exceed the private return which leads to less than optimal investment
  - Society is altruistic towards children, and education is a way to redistribute resources towards children

The US educational system in perspective

- Goldin, Claudia. 2003. "The human capital century."
- The "virtues" of US mass education in the 20th century
  - Publicly funded
  - Managed by numerous, fiscally small independent districts
  - Open and forgiving
  - Academic yet practical in its curriculum
  - Secular in control
  - Gender neutral in its admission

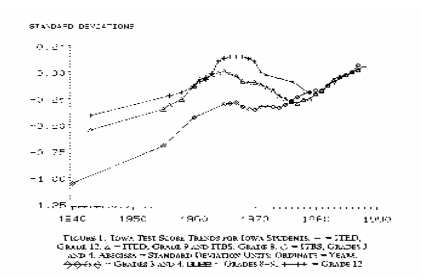






School Quality and Labor Force Productivity

- John Bishop. 1989. "Is the Test Score Decline Responsible for the Productivity Growth Decline?"



- Eric Hanushek and Dennis Kimko. 2000. "Schooling, Labor-Force Quality, and the Growth of Nations."

	(Column 4)	(Column 5)
Initial per capita income (1960)	-0.745	-0.481
	(0.181)	(0.093)
Quantity of schooling	0.519	0.106
	(0.195)	(0.119)
Annual population growth	-0.713	-0.038
	(0.224)	(0.215)
Labor force quality (QL1)		0.133
		(0.024)
Constant	4.092	-1.756
	(0.974)	(1.346)
R-Squared	0.41	0.73

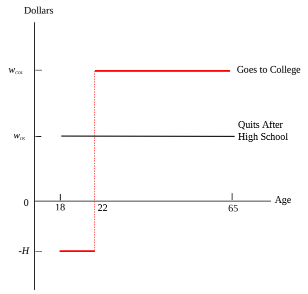
Investing in education

- People bring into the labor market a unique set of abilities and acquired skills known as human capital
- Workers add to their stock of human capital throughout their lives, especially via job experience and education
- Education is strongly correlated with:
  - Labor force participation rates
  - Unemployment rates
  - Earnings

Present Value: Borrowing a technique from finance

- Present value allows you to compare of dollar amounts spent and received in different time periods
- $PV = \frac{y}{(1+r)^t}$
- y is the dollar amount
- r is the discount rate

Potential Earnings Streams Faced by a High School Graduate



A person who quits school after getting his high school diploma can earn w_{HS} from age 18 until the age of retirement. If he decides to go to college, he foregoes these earnings and incurs a cost of *H* dollars for 4 years and then earns w_{COL} until retirement age.

Potential Earnings Streams Faced by a High School Graduate

- The present value of entering the labor force as a high school graduate is:

$$PV_{HS} = w_{HS} + \frac{w_{HS}}{1+r} + \frac{w_{HS}}{(1+r)^2} + \frac{w_{HS}}{(1+r)^3} + \ldots + \frac{w_{HS}}{(1+r)^{46}}$$

- The present value of entering the labor force after college is:

$$PV_{COL} = -H - \frac{H}{1+r} - \frac{H}{(1+r)^2} - \frac{H}{(1+r)^3} + \frac{w_{COL}}{(1+r)^4} + \frac{w_{COL}}{(1+r)^5} + \ldots + \frac{w_{COL}}{(1+r)^{46}}$$

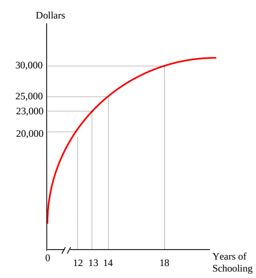
$$= \text{Direct cost of college} + \text{Post - College earnings}$$

- You should go to college if: $PV_{COL} > PV_{HS}$

Generalizing to multiple school level choices: The wage-schooling locus

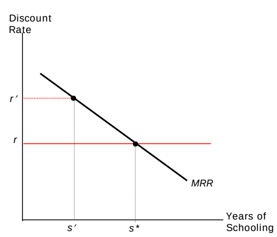
- What salary will firms be willing to pay workers for given levels of schooling
- Three properties:
  - The wage-schooling locus is upward sloping
  - The slope of the wage-schooling locus indicates the increase in earnings associated with an additional year of education
  - The wage-schooling locus in concave

The wage-schooling locus



The wage-schooling locus gives the salary that a particular worker would earn if he completed a particular level of schooling. If the worker graduates from high school, he earns $20,000 annually. If he goes to college for 1 year, he earns $23,000.

The schooling stopping decision



The *MRR* schedule gives the marginal rate of return to schooling, or the percentage increase in earnings resulting from an additional year of school. A worker maximizes the present value of lifetime earnings by going to school until the marginal rate of return to schooling equals the rate of discount. A worker with discount rate *r* goes to school for *s** years.

Estimating the Rate of Return to Education

- A typical study estimates a regression of the form:

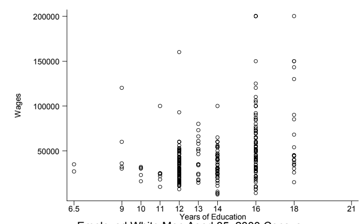
$$\ln(W_i) = \beta_0 + \beta_1 S_i + \beta_2 Exp_i + \beta_3 Exp_i^2 + \ldots + \beta_x X_i + \varepsilon_i$$

- W is the wage rate
- S is years of schooling
- Exp is years of work experience
- X is other exogenous variables
- β_1 is the coefficient that estimates the rate of return to one added year of schooling

Quick OLS Review

- Imagine that we want to estimate the impact of education on wages. While we cannot observe the wages and education levels for the entire population, we can obtain this information for a random sample of the population.

For example, consider a random sample of 271 employed white 35-year old men from the 2000 Census.



Employed White Men Aged 35, 2000 Census

To analyze the relationship between education and wages we need a model.

The LINEAR model is the simplest model:

$$y_i = \beta_0 + \beta_1 x_i + u_i$$

where:
- y_i is the dependent variable
- x_i is the independent
- β_0 is the intercept
- β_1 is the slope
- u_i is the error term
- i = 1,…,n

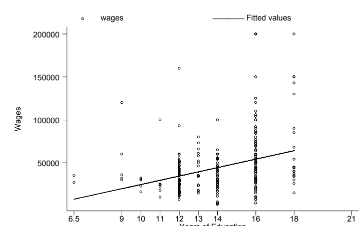
The error term captures all of the factors affecting y_i other than x_i

- We would like to obtain estimates for β_0 and β_1

How do we estimate β_0 and β_1 ?

- The error term associated with the ith observation is called the RESIDUAL

$$\hat{u}_i = y_i - \hat{\beta}_0 - \hat{\beta}_1 x_i$$



Employed White Men Aged 35, 2000 Census

- The least squares (OLS) coefficients are the values of $\hat{\beta}_0$ and $\hat{\beta}_1$ that minimize the sum of squared residuals:

$$\sum_{i=1}^{n} \hat{u}_i^2 = \sum_{i=1}^{n} (y_i - \hat{\beta}_0 - \hat{\beta}_1 x_i)^2$$

- To solve for $\hat{\beta}_0$ and $\hat{\beta}_1$:

$$\underset{\hat{\beta}_0, \hat{\beta}_1}{Min} \sum \hat{u}_i^2 = \sum (y_i^2 - 2\hat{\beta}_0 y_i - 2\hat{\beta}_1 x_i y_i + \hat{\beta}_0^2 + 2\hat{\beta}_0 \hat{\beta}_1 x_i + \hat{\beta}_1^2 x_i^2)$$

- First order conditions:

$\hat{\beta}_0$:

$$\sum (-2y_i + 2\hat{\beta}_0 + 2\hat{\beta}_1 x_i) = 0$$

$$\sum (-y_i + \hat{\beta}_0 + \hat{\beta}_1 x_i) = 0 \qquad \text{or, equivalently,} \quad \sum \hat{u}_i = 0$$

$$n\hat{\beta}_0 = \sum y_i - \hat{\beta}_1 \sum x_i$$

$$\hat{\beta}_0 = \frac{\sum y_i}{n} - \hat{\beta}_1 \frac{\sum x_i}{n}$$

$$\hat{\beta}_0 = \bar{y} - \hat{\beta}_1 \bar{x}$$

$\hat{\beta}_1$:

$$\sum (-2x_i y_i + 2\hat{\beta}_0 x_i + 2\hat{\beta}_1 x_i^2) = 0$$

$$\sum (-x_i y_i + \hat{\beta}_0 x_i + \hat{\beta}_1 x_i^2) = 0 \qquad \text{or, equivalently,} \quad \sum x_i(-y_i + \hat{\beta}_0 + \hat{\beta}_1 x_i) = 0$$

$$\sum x_i y_i = \hat{\beta}_0 \sum x_i + \hat{\beta}_1 \sum x_i^2 \qquad \sum x_i \hat{u}_i = 0$$

$$\sum x_i y_i = \hat{\beta}_0 n\bar{x} + \hat{\beta}_1 \sum x_i^2$$

- substituting in for $\hat{\beta}_0$:

$$\sum x_i y_i = (\bar{y} - \hat{\beta}_1 \bar{x}) n\bar{x} + \hat{\beta}_1 \sum x_i^2$$
$$\sum x_i y_i - n\bar{x}\bar{y} = -\hat{\beta}_1 n\bar{x}^2 + \hat{\beta}_1 \sum x_i^2$$
$$\sum x_i y_i - n\bar{x}\bar{y} = \hat{\beta}_1 (\sum x_i^2 - n\bar{x}^2)$$
$$\hat{\beta}_1 = \frac{\sum x_i y_i - n\bar{x}\bar{y}}{\sum x_i^2 - n\bar{x}^2} \quad \Rightarrow \quad \hat{\beta}_0 = \bar{y} - \left(\frac{\sum x_i y_i - n\bar{x}\bar{y}}{\sum x_i^2 - n\bar{x}^2} \right) \bar{x}$$

or

$$\hat{\beta}_1 = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2} \quad \Rightarrow \quad \hat{\beta}_0 = \bar{y} - \left(\frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sum (x_i - \bar{x})^2} \right) \bar{x}$$

- These estimates of the intercept ($\hat{\beta}_0$) and slope ($\hat{\beta}_1$) are based on a sample of x_i and y_i , $i = 1,\ldots,n$. These are estimates of the unknown true population intercept (β_0) and slope (β_1).

Hypothesis Tests – with one regressor

- We can determine whether or not there is a significant LINEAR relationship between *x* and *y* by testing whether the slope coefficient (β_1) is equal to zero or not.

$$H_0: \quad \beta_1 = 0$$
$$H_1: \quad \beta_1 \neq 0$$

- The t-statistic, as always, is the estimate minus the parameter under the null hypothesis divided by the standard error of the estimator.

$$t = \frac{\hat{\beta}_1 - \beta_1}{\hat{\sigma}_{\hat{\beta}_1}}$$

- Which you then compare to the two-sided critical value with n–2 degrees of freedom.

Returning to estimating the rate of return to education

- A typical study estimates a regression of the form:

$$\ln(W_i) = \beta_0 + \beta_1 S_i + \beta_2 Exp_i + \beta_3 Exp_i^2 + \ldots + \beta_x X_i + \varepsilon_i$$

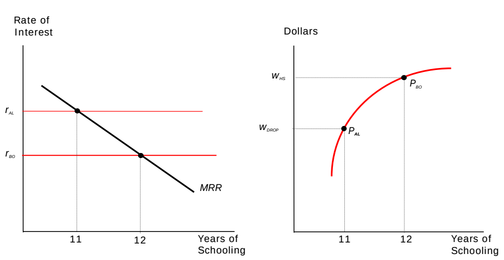
- *W* is the wage rate
- *S* is years of schooling
- *Exp* is years of work experience
- *X* is other exogenous variables
- β_1 is the coefficient that estimates the rate of return to one added year of schooling

Table 2
OLS estimates

Country	Males		Females	
USA	0.074	*0.004*	0.096	*0.005*
Great Britain	0.127	*0.006*	0.130	*0.006*
West Germany	0.036	*0.002*	0.043	*0.004*
Russia	0.044	*0.004*	0.053	*0.004*
Norway	0.023	*0.002*	0.025	*0.003*
Australia	0.051	*0.004*	0.052	*0.006*
Netherlands	0.031	*0.002*	0.019	*0.004*
Austria	0.038	*0.004*	0.064	*0.006*
Poland	0.073	*0.005*	0.100	*0.005*
East Germany	0.026	*0.003*	0.045	*0.004*
New Zealand	0.033	*0.004*	0.029	*0.005*
Italy	0.037	*0.003*	0.053	*0.005*
Ireland	0.085	*0.006*	0.090	*0.008*
Japan	0.075	*0.007*	0.094	*0.014*
Hungary	0.075	*0.007*	0.077	*0.006*
N. Ireland	0.174	*0.011*	0.146	*0.011*
Sweden	0.024	*0.004*	0.033	*0.005*
Slovenia	0.080	*0.007*	0.101	*0.007*
Israel	0.053	*0.007*	0.061	*0.008*
Czech Rep.	0.035	*0.007*	0.043	*0.007*
Bulgaria	0.040	*0.009*	0.057	*0.010*
Slovak Rep.	0.052	*0.012*	0.064	*0.009*
Canada	0.038	*0.008*	0.045	*0.008*
Czechoslovakia	0.031	*0.010*	0.036	*0.007*
Spain	0.046	*0.005*	0.038	*0.010*
Switzerland	0.045	*0.007*	0.048	*0.012*
Latvia	0.067	*0.020*	0.078	*0.014*
Philippines	0.113	*0.015*	0.192	*0.030*
Pooled	0.048	*0.001*	0.057	*0.001*

Robust standard errors are in italics. The estimating equations include year dummies, union status, marital status, age and age squared and, in the case of the aggregate equation, country-year dummies.

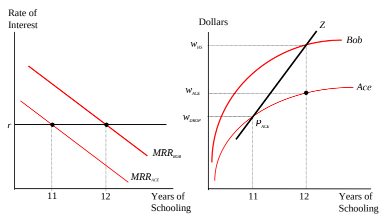
Schooling and earnings with different discount rates



Estimating the Rate of Return to Education

- As long as workers differ only in their discount rates we can calculate the MRR to education from the wage differential between two workers who differ in their educational attainment, because they have the same wage-school locus. In other words, we can estimate it using the simple OLS model we already discussed.

Schooling and earnings when workers have different abilities



Ace and Bob have the same discount rate (r) but each worker faces a different wage-schooling locus. Ace drops out of high school and Bob gets a high school diploma. The wage differential between Bob and Ace (or w_{HS} - w_{DROP}) arises both because Bob goes to school for one more year and because Bob is more able. As a result, this wage differential does not tells us by how much Ace's earnings would increase if he were to complete high school (or w_{ACE} - w_{DROP}).

Estimating the Rate of Return to Education

- If there are unobserved ability differences in the population, earnings differentials do not estimate the returns to education. The correlation between education and ability differentials bias (contaminate) the estimate.
- Possible solutions:
  - Include all available information about ability as control variables
  - Compare people with identical ability levels: identical twins
  - Instrumental variables
    - Compulsory schooling laws and month of birth
    - College proximity
    - Veteran status

Education as a Signal

- Education reveals a level of attainment which signals a worker's qualifications to potential employers
- Information that is used to allocate a workers in the labor market is called a signal
- There could be a "separating equilibrium"
  - Low-productivity workers choose not to obtain X years of education, voluntarily signaling their low productivity
  - High-productivity workers choose to get at least X years of schooling and separate themselves from the pack

A simple example

- Assume there are two types of workers: high and low ability

Type of worker	Proportion of population	PV of lifetime productivity
Low ability	0.5	$1 million
High ability	0.5	$1.2 million

- If firms cannot observe productivity, and there is no education "signal", all workers will be paid average productivity.

$$w = 1{,}000{,}000 \times 0.5 + 1{,}200{,}000 \times 0.5$$
$$= \$1{,}100{,}000$$

- If firms cannot observe productivity, but and education signal is available, it is possible to have a separating equilibrium.
- Assume the following:
  - Education has no human capital component
  - The education signal is a four year diploma
  - Each year of education costs low types C and high types C/2
- In order for there to be a separating equilibrium it must be profitable for high types to obtain the diploma and not profitable for the low types
- Low types: $$1{,}200{,}000 - C \times 4 < 1{,}000{,}000$$ $$C > 50{,}000$$
- High types $$1{,}200{,}000 - \frac{C}{2} \times 4 \geq 1{,}000{,}000$$ $$C \leq 100{,}000$$

- What happens if:
  - C = 75,000?
  - C = 40,000?
  - C = 110,000?
  - Y = 2?
  - Y = 6?
  - The high productivity rises to $1,400,000 PV lifetime?

In general

- Assume there are two types of workers: high and low ability

Type of worker	Proportion of population	PV of lifetime productivity
Low ability	p	X_L
High ability	1-p	X_H

  - The education signal is a Y year diploma
  - Each year of education costs low types C_L and high types C_H where $C_L > C_H$

- In order for there to be a separating equilibrium it must be profitable for high types to obtain the diploma and not profitable for the low types
- Low types: $X_H - C_L \times Y < X_L$

$$C_L > \frac{X_H - X_L}{Y}$$

- High types: $X_H - C_H \times Y \geq X_L$

$$C_H \leq \frac{X_H - X_L}{Y}$$

$$\Rightarrow \text{Separating Equilibrium if}: \quad C_H \leq \frac{X_H - X_L}{Y} < C_L$$

$$\Rightarrow \text{Pooling Equilibrium if}: \quad C_H > \frac{X_H - X_L}{Y} \quad or \quad C_L < \frac{X_H - X_L}{Y}$$

Private versus Social Returns

- The private rate of return is the increase in earnings of a worker due to an additional year of education.
- The social rate of return is the increase in national income due to an additional year of education.
- These are not necessarily equal.
  - For example, signaling may benefit an individual worker without any net benefit to society, only redistribution between workers.
  - There are also more indirect routes that may constitute social gains such as increased civic engagement in addition to direct increases in national income or higher rates of GDP growth/