Lecture Note 16 - Education, Human Capital, and Labor Market Signaling

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Lecture Note 16
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Our prior discussion of the Full Disclosure Principle suggests that markets can efficiently solve information problems if information disclosure is credible and free. But the Full Disclosure Principle says nothing about whether this process will be efficient when disclosure is credible but *costly*. The Akerlof model, as well as the Rothschild-Stiglitz model that we will study next, show that there can be *too little* information disclosure. The signaling model of Spence (1973) demonstrates there can also be *too much* information disclosure. In general, disclosing information is not in itself harmful. But the social value of the information disclosed may not be worth the cost of conveying it. This is the insight of the Spence signaling model. The incentives for disclosure or non-disclosure are purely private. These private incentives may or may not generate desirable outcomes, judged by the standard of *social* efficiency.

1 Context: Educational investment

- Education is perhaps the most significant investment decision you (or your parents) will make.
- Most citizens of developed countries spend $12 - 20$ years of their lives in school. This involves two types of costs:
  - Direct costs: Buildings, teachers, textbooks, etc. (The U.S. spends 5 percent of Gross Domestic Product on direct costs of public education alone.)
  - Indirect costs: Opportunity costs of attending school instead of working or having fun. These costs surely swamp the direct costs of schooling.
- Is this enormous investment socially efficient?
- Economics has historically used one canonical model to think about educational investment, the Human Capital of Becker (1964). This model says the answer is likely to be yes.
- Spence suggested a second model: the signaling model. This model yields quite different conclusions.
- We'll compare and contrast these models.

2 A simplified human capital investment model: The 'equalizing differences' model of Jacob Mincer

- Define $w(s)$ as the wage of someone with s years of schooling.
- Assume $w'(s) > 0$: productivity and hence earnings rise with schooling.
- Assume that the direct costs of schooling, c, are zero for now.
- Define $r > 0$ as the interest rate.

- For simplicity, assume people are infinitely lived. (40 years is almost as good as infinity in models with time discounting.)

- What is the benefit from a year of schooling? It is $w(1)$ in perpetuity, or the Discounted Present Value (DPV) of receiving $w(1)$ annually in each subsequent year:

$$DPV\left[w(1)\right] = w(1) + \frac{w(1)}{1+r} + \frac{w(1)}{(1+r)^2} + ... + \frac{w(1)}{(1+r)^\infty},$$

  which can be simplified as follows:

$$\begin{aligned} DPV\ \ [w(1)] \cdot \left(\frac{1}{1+r}\right) &= \frac{w(1)}{1+r} + \frac{w(1)}{(1+r)^2} + \frac{w(1)}{(1+r)^3} + ... + \frac{w(1)}{(1+r)^\infty}, \\ DPV\ \ [w(1)] \cdot \left(1 - \frac{1}{1+r}\right) &= w(1), \\ DPV\ w(1) &= w(1)\left(\frac{1+r}{r}\right). \end{aligned}$$

- Note however that if you attend school for one year to obtain $w\,(1)$, you do not receive the first payment of $w(1)$ until after your first year of schooling is complete. So the benefit of one year of education is $w(1)\left(\frac{1+r}{r}\right)\left(\frac{1}{1+r}\right) = \frac{w(1)}{r}$.

- Conversely, a person who does not attend a year of schooling receives:

$$DPV\left[\ w(0)\right] = w(0) + \frac{w(0)}{1+r} + \frac{w(0)}{(1+r)^2} + ... + \frac{w(0)}{(1+r)^\infty} = w(0)\left(\frac{1+r}{r}\right).$$

- So, the net benefit of obtaining one additional year of schooling is:

$$w(1)\frac{1}{r} - w(0)\left(\frac{1+r}{r}\right)$$

- Now take as given:

  - A competitive market for labor.
  - Perfect capital markets (can always borrow the full cost of schooling).
  - Rational, identical individuals, each with same earnings potential.

- In equilibrium, it must be the case that the costs and benefits of an additional year of schooling are equated. (If the costs were lower than the benefits, everyone would get schooling. If the costs were greater, no one would get schooling. So, the equilibrium must have everyone indifferent.)

- This implies that

$$
\begin{aligned}
w(1)\frac{1}{r} &= w(0)\left(\frac{1+r}{r}\right), \\
\frac{w(1)}{w(0)} &= (1+r), \\
\ln w(1) - \ln w(0) &= \ln(1+r) \approx r.
\end{aligned}
$$

In other words, the wage increment for one more year of schooling must be approximately equal to the interest rate! (Note, this log approximation holds for small values of r, say $r < 0.2$. Above that, the approximation gets pretty approximate.)

- Simple as this model is, it does a pretty good job at capturing a remarkable empirical regularity. Over the last 95 years (which is as long as we can measure it for the U.S.), the estimated rate of return to a year of schooling has been about 5 to 10 percent—approximately equal to the real rate of interest plus inflation.

2.1 Mincer's equalizing differences model of human capital investment has four testable implications:

1. People who attend additional years of schooling are more productive.
2. People who attend additional years of schooling receive higher wages.
3. People will attend school while they are young, i.e., before they enter the workforce. [Why? Because the costs of school are the same whenever you attend it, but the benefits do not begin to accrue until you have completed it. You should therefore get your education before you start working.]
4. The rate of return to schooling should be roughly equal to the rate of interest.

3 The Spence signaling model of educational investment

- If education were unproductive, would any of the above still be true?
- Prior to Spence's 1973 paper, most economists would have said "no" reflexively. If education is unproductive, why would people spend time acquiring it? And why would employers pay higher wages to educated workers?
- The surprise of the Spence model is that even if education is unproductive, there may be employee and employer demand for it *in equilibrium.*
- Consider the following stylized model:

  1. People are of heterogeneous ability: H, L.

2. High ability people are inherently more productive than low ability people.
3. An individual's ability is known to him or her, but not to potential employers.
4. Education does not affect ability/productivity.
5. High ability people have lower cost of attending school than others. (Why would this be so? Lower psychic costs to a sitting in a chair for 4 years, subsidies to education are greater for high ability people, e.g., merit scholarships, or simply less time needed to do work for school).

- Let's use these parameter values:

Group	Productivity	Population Share	Cost of Education
L	$Y_L = 1$	λ	S
H	$Y_H = 2$	$1 - \lambda$	$\frac{1}{2}S$

- So average productivity of the population is $2(1 - \lambda) + 1\lambda = 2 - \lambda$.
- Notice that a worker's productivity does *not* depend on how much school she obtains.
- What are the possible equilibria of this model?

3.1 Separating equilibrium

- Assume that firms offer the following wage schedule:

$$w(S) = 1 + I[S \geq S^*], \tag{1}$$

where $I[\cdot]$ is the indicator function. A worker with $S_i \geq S^*$ years of education is paid 2 and otherwise 1.

- How much education will workers' obtain? The worker's problem is

$$\max_S w(S) - c(S).$$

- For a type H worker, the cost of S^* years of education is $0.5S^*$ and the wage benefit is 1. So type H workers will attend school for S^* years if: $2 - 0.5S^* > 1$.
- For a type L worker, the cost of S^* years of education is S^* and the wage benefit is 1 so L type workers will attend school if: $2 - S^* > 1$.
- Consider if the employer sets $S^* = 1 + \varepsilon$, where ε is a very small, positive number. Who will obtain education? Clearly H workers will strictly prefer obtaining S^* years of education whereas L workers will not find it worthwhile to obtain education S^* (since $2 - S^* < 1$).
- Is the employer's wage schedule, represented by (1), an equilibrium wage schedule?

- As we discussed in the Lemon's model, an equilibrium price/wage schedule needs to be internally consistent: employers find it worthwhile to pay the wages offered given the productivity of workers who claim these wages. Hence, in equilibrium, it must be the case that

$$E\left[Y\left(S\right)|w\left(S\right)\right] \geq w,$$

that is, the expected productivity of workers qualifying for a wage level based on their schooling must be at least equal to the wage. Here, the function $Y\left(S\right)$ gives the productivity of workers supplying labor with schooling level S. We are conditioning $Y\left(S\right)$ on the *function* $w\left(S\right)$ because employers offer a wage *schedule* not a single wage. The worker's choice of S_i therefore depends on the wage schedule $w\left(S\right)$.

- In our example, workers with $S = 0$ are type L. They have productivity 1 and wage 1 and so the employer's wage schedule is rational for these workers: $E\left[Y\left(0\right)|w\left(S\right)\right] = w\left(0\right) = 1$.

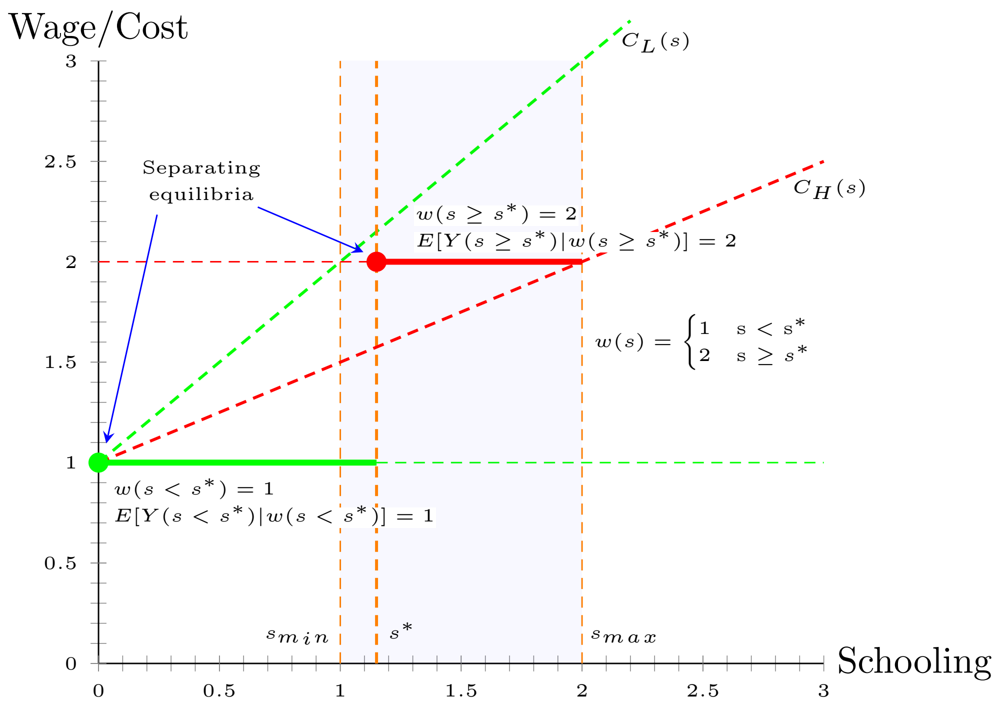
- Similarly, in this example, workers with $S = S^*$ are type H. They have productivity 2 and wage 2 and so the employer's wage schedule is also rational for these workers: $E\left[Y\left(1\right)|w\left(S\right)\right] = w\left(1\right) = 2$

- So, this is an equilibrium: high ability workers will obtain $S = S^*$ education, low worker will obtain $s = 0$ education, employers will break even, and neither H or L workers or employers will have incentive to deviate from the pay scheme.

- You may find it helpful to draw the indifference curves of both worker types in (w, S) space, as in Figure 1 below.[1] Observe that in these figures, the cost curves $C_L\left(S\right)$ and $C_H\left(S\right)$ serve as indifference curves. They originate from the initial wage offer for $w\left(S = 0\right)$, and they slope upward with the worker's cost of education. Along these cost curves, workers of each type are indifferent among all bundles on their respective cost curves offering higher wages and higher schooling relative to $w\left(S = 0\right)$. Workers strictly prefer to be *above* (northwest of) these curves relative to their default bundle of $w\left(S = 0\right)$. Workers strictly prefer to *not* be below (southeast of) these worse off relative to their default bundle of $w\left(S = 0\right)$.

[1] I thank Sergey Naumov for constructing the figures below.

Figure 1 : Potential Separating Equilibria with $\lambda = 0.5$



- Notice that the separating equilibrium requires that the wage schedule induce self-selection: high-productivity workers choose to obtain two years of schooling and low-productivity workers choose to obtain only one. In equilibrium, employers are happy to pay workers with S^* years of schooling a wage of 2 and workers with less than S^* year of schooling a wage of 1, and neither workers nor employers have an incentive to deviate from this equilibrium.

- The unfortunate aspect of this equilibrium is that education is completely unproductive, so these investments are socially wasteful. By obtaining education, H type workers 'signal' that they deserve a high wage—but this is a pure private benefit. From a social perspective, this signaling does nothing useful since it does not increase total output.

- Does it matter for this model whether employers believe that education is productive? Actually, it does not. So long as people who have schooling $S \geq S^*$ have productivity 2 and those who have schooling $S < S^*$ have productivity 1, employers have no incentive to deviate from the wage schedule. [Consider an experiment where employers were told that education is unproductive. Would they want to change their wage schedules?]

3.2 Pooling equilibria with positive education

- The example above is a *separating* equilibrium: L, H types obtain different levels of education. There are also a multiplicity of possible *pooling* equilibria, that is, cases where L and H types receive identical education.

- Imagine that employers offered a wage schedule of

$$w(S) = 1 + I[S \geq 0.5] \cdot (1 - \lambda),$$

so workers who have S less than 0.5 receive a wage of 1 and otherwise a wage of $2 - \lambda$. Who would invest in education?

- H types will acquire $S = 0.5$ at cost 0.25 if

$$2 - \lambda - 0.25 > 1 \Rightarrow \lambda < 0.75$$

- And L types will acquire $s = 0.5$ at cost 0.5 if

$$2 - \lambda - 0.5 > 1 \Rightarrow \lambda < 0.5$$

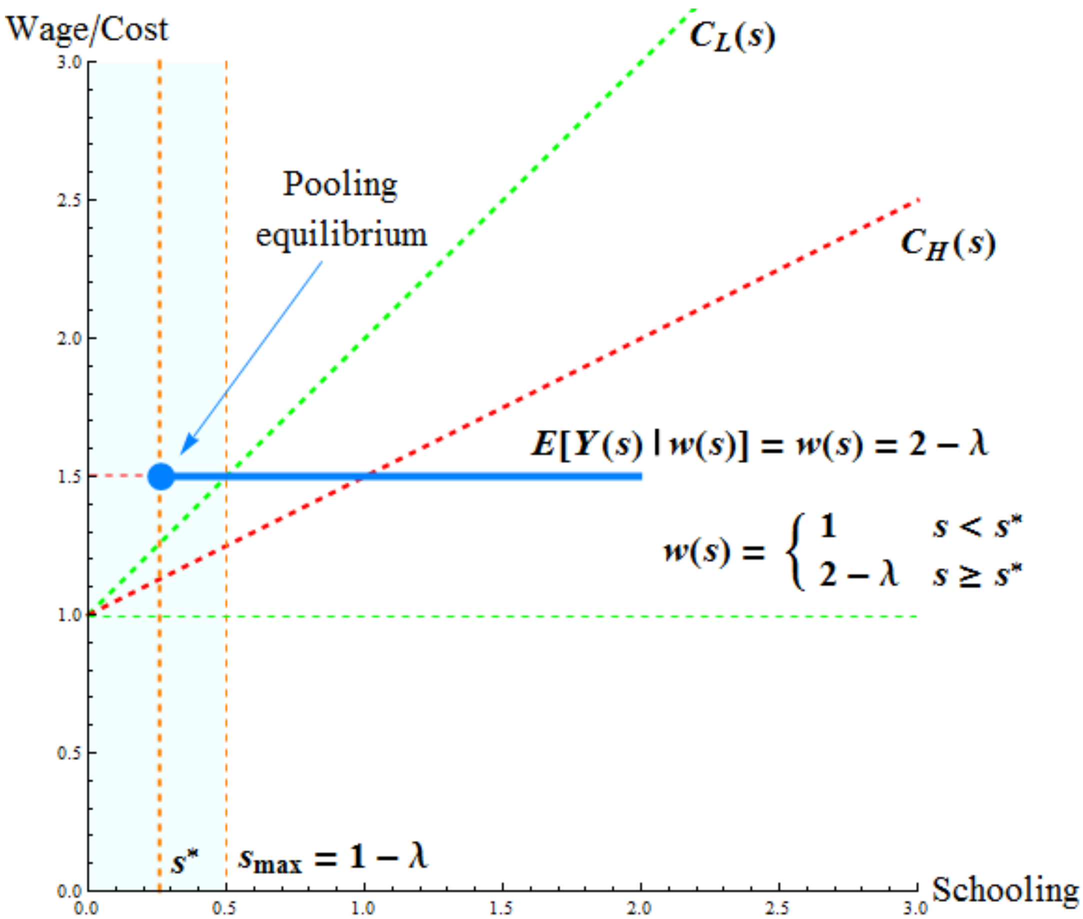
- So, if $\lambda < 0.50$, all workers acquire education $s = 0.5$.

- Are employers' wages rational given this fact? Yes. Because expected productivity of the working population is

$$E\left[Y\left(0.5\right)|w\left(S\right)\right] = 2 - \lambda = w\left(0.5\right)$$

- So, this is a feasible pooling equilibrium, as depicted below

Figure 2: Potential Pooling Equilibria with $\lambda = 0.5$



- [Note: it's a little bit of a strange equilibrium because it does not specify what would happen if employers ever met a group of workers with $s = 0$ and found their productivity was also $2 - \lambda$. This model was written when game theory was still quite primitive, and so it does not do a tidy job of considering how 'off equilibrium' beliefs affect the model.]
- [Note: What would happen if, for example, $\lambda = 0.51$? This wage schedule could not be a feasible equilibrium. High but not low productivity workers would acquire education, yet the wage paid to high productivity workers would only be 1.5 whereas their productivity is 2. Employers would have an incentive to deviate from this wage schedule to bid up wages of high productivity workers.]

3.3 Pooling equilibrium with no education

- Consider a different pooling equilibrium in which employers offer the wage schedule:

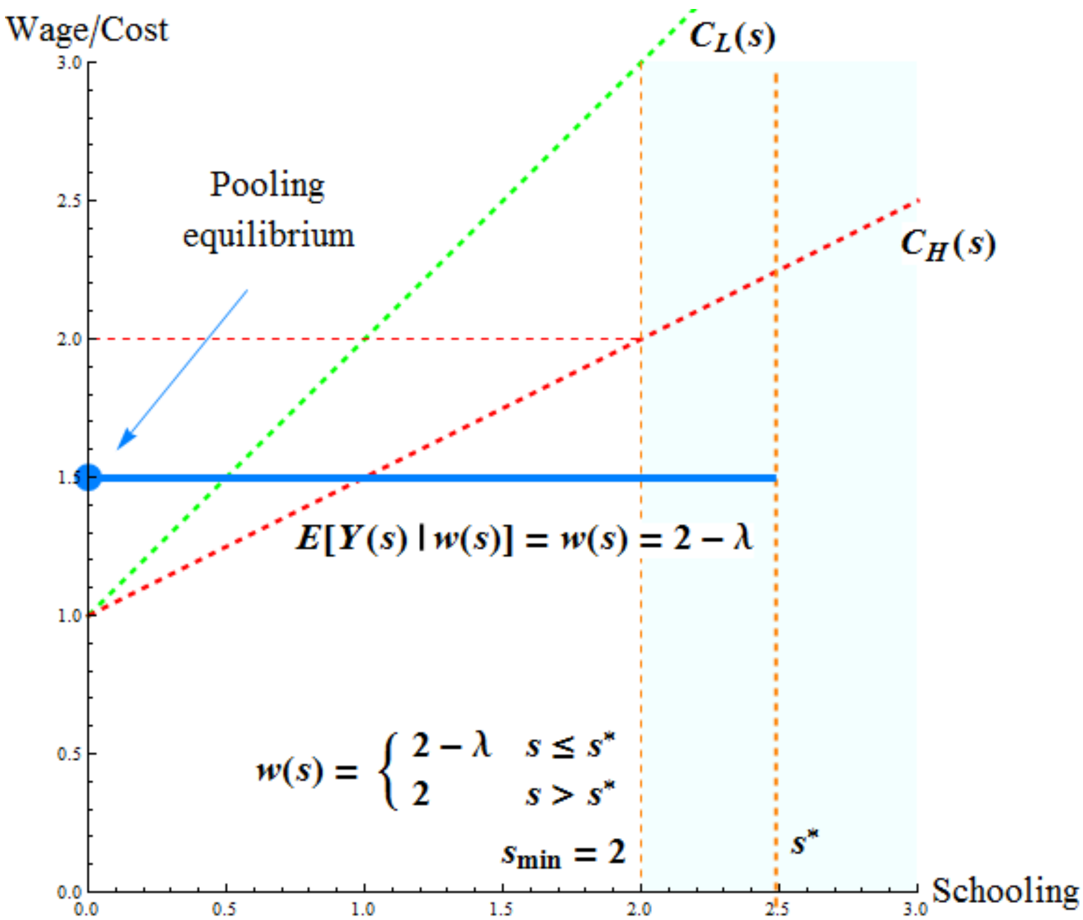
$$w(S) = (2 - \lambda) + I[S^* \geq 2.5].$$

- Who will obtain schooling in this case? The answer is no one, since the cost of obtaining 2.5 units of schooling for both H and L exceeds the wage benefit of 1.

- But again employer's beliefs are self-confirming since the pool of uneducated workers does have productivity $2 - \lambda$, which is equal to the wage:

$$E[Y(0)|w(S)] = 2 - \lambda = w(0)$$

Figure 3: Potential Pooling Equilibria with $\lambda = 0.5$



- Can these two pooling equilibria be Pareto ranked? Yes. The latter one is better: productivity and wages are identical in both cases, but in the latter case there are no wasteful expenditures on schooling (which are a DWL in the signaling model).

3.4 A slightly more ambitious example [For self-study]

- Consider a model with a continuous distribution of productivity and a single type of education: the "diploma."

- Productivity η is distributed uniformly between 0 and 100.
- The cost of obtaining a diploma is $80 - 0.50\eta$: that is, diploma's 'cost less' for more productive workers.
- Obtaining a diploma does not affect productivity.
- Employers cannot distinguish worker productivity and so pay expected productivity. Hence, without further information, the wage would be $w = E[\eta] = 50$.

- Question: What are equilibrium education and wages in this model?
- The solution concept looks much like the art appraisal example in our discussion of the adverse selection model.
  - First, we solve for workers' optimal education choice taking wages as given.
  - Next, we solve for the employer wages given workers' education choice.
  - Find the equilibrium wages that satisfy both choices simultaneously (so that they are mutually consistent): $E\left[\eta\left(w\right)\right] = w$.
- Define w_1 as the wage of someone with a diploma and w_0 as the wage of someone without.
- A worker will get a diploma if the wage gain $(w_1 - w_0)$ exceeds the cost:

$$
\begin{aligned}
w_1 - w_0 &\geq (80 - 0.50\eta), \\
\text{so } \eta^* &= 2 \cdot (w_0 - w_1 + 80).
\end{aligned}
$$

A person with $\eta \geq \eta^*$, will obtain a diploma, otherwise not.

- Now, we need to solve for the wages given η^*. Employers will pay expected wages given diploma/no diploma. Using the uniform distribution of η, this gives:

$$
\begin{aligned}
w_1 &= E(\eta|\eta \geq \eta^*) = \frac{\eta^* + 100}{2}, \\
w_0 &= E(\eta|\eta < \eta^*) = \frac{\eta^*}{2}
\end{aligned}
$$

- So plugging back into the above:

$$
\begin{aligned}
\eta^* &= 2 \cdot (w_0 - w_1 + 80) \\
&= 2 \cdot \left(\frac{\eta^*}{2} - \frac{\eta^* + 100}{2} + 80\right) \\
&= 2 \cdot 30 \\
\eta^* &= 60, \\
&\Rightarrow w_0 = 30, w_1 = 80.
\end{aligned}
$$

- Let's check this solution. At the equilibrium, a person with $\eta = 60$ must be indifferent between getting a diploma or not. Without a diploma, she gets a wage of 30. With a diploma, her net wage is $80 - (80 - 0.5\eta) = 30$. So she is indifferent. And clearly for $\eta > 60$, workers will get a diploma, otherwise not.

- As above, obtaining a diploma is privately optimal but socially unproductive. One way to see this is to check average wages in the economy:

$$E(w) = 0.6 \cdot 30 + 0.4 \cdot 80 = 50,$$

  which is exactly the wage that would prevail if *no one* got a diploma. Diplomas do not affect total societal output.

- But in the separating equilibrium, 40 percent of workers have bought an education at average cost of $80 - 0.5 \cdot 80 = 40$. And this is pure deadweight loss: total output and the sum of wages paid are identical whether or not workers obtain education. It is privately beneficial, however, for more productive workers to obtain an education to raise their wages (in the process, lowering the wages of less productive workers).

[End of self-study section]

3.5 Summary of signaling

- Signaling is quite closely related to the Lemons and Full Disclosure models that we have already seen. In all models, an equilibrium requires a price schedule that is self-confirming. Wage offers must 'call forth' workers whose productivity given their education is consistent with the wages they are paid.

- The fundamental market failure in all of these models stems from asymmetric information. In models with asymmetric information, prices/wages serve two functions. One is to remunerate the seller for goods or services rendered. This is the *standard* purpose. The second function is to determine the entire range of goods and services that will be offered by other sellers. (So, in the painting example, the price I'm willing to pay must take account of the qualities of all sellers who will offer paintings at my price—not just the seller with whom I'm transacting.) It is a truism in economics that if you are using one instrument (here, the price) to solve two separate economic problems, you will obtain suboptimal results. In the equilibrium of these models, prices do not merely reflect social costs as they should (as we proved in General Equilibrium). Instead, they reflect strategic equilibria among buyers and sellers.

3.6 Empirical implications of signaling

Does the signaling model share any implications with the Becker/Mincer Human Capital model?

1. People who attend additional years of schooling are more productive. YES.

2. People who attend additional years of schooling receive higher wages. YES.

3. People will attend school while they are young, i.e., before they enter the workforce. YES.

4. The rate of return to schooling should be roughly equal to the rate of interest. NO PREDICTION.

Because the empirical implications of the Human Capital and Signaling models appear so similar, many economists had concluded that these models could not be empirically distinguished. The paper published in the *Quarterly Journal of Economics* in 2000 by Tyler, Murnane and Willett demonstrates that this conclusion was premature.

4 Testing signaling versus human capital models of education

Does it seem plausible that education serves (in whole or part) as a signal of ability rather than simply a means to enhance productivity?

- You obviously learn some valuable skills in school (e.g., engineering, computer science, signaling models).
- Many MIT students will be hired by consulting firms that have no use for any of these skills.
- Why do these consulting firms recruit at MIT, not at Hampshire College, which produces many students with no engineering or computer science skills (let alone, knowledge of signaling models)?
- Why did you choose MIT over your state university that probably costs one-third as much? Is this all due to educational quality, or is some of it credentialism?

Harder question: How do you go about empirically distinguishing the human capital from the signaling model?

1. Measure whether more educated people are more productive? (Would be true for either model.)

2. Test whether higher ability people go to school? (Could be true in either case—certainly true in the signaling case.)

3. Find people of identical ability and randomly assign some of them to go to college. Check if the college educated ones earn more? (Both models say they would.)

4. Measure people's productivity before and after they receive education—see if it improves. (Conceptually okay, very difficult to do.)

5. Find people of identical ability and randomly assign them a diploma. See if the ones with diplomas earn more. (A pure test of signaling.)

5 The Tyler, Murnane and Willett study

- TMW are interested in knowing whether the General Educational Development certificate (GED) raises the subsequent earnings of recipients.
- This question is quite important for educational policy:
  - By 1996, 9.8% of those ages $18-24$ had completed High School via the the GED versus 76.5% via a HS diploma.
  - See Table I. Notice that between 1990 and 1996, HS Diploma rates actually fell dramatically for Black, Non-Hispanics. The rise in the GED just offset this. We ought to hope that these GED-holders are doing somewhat better than HS dropouts.
- In 1996, $759,000$ HS Dropouts attempted the GED and some $500,000$ passed.
- The monetary cost of taking the GED is $50 and the exam lasts a full day.
- The average person spends 20 hours studying for the GED (though some spend much more and some spend zero).
- See Table II. GED holders earn substantially less than HS graduates, but somewhat more than HS Dropouts.
- Why can't we simply compare wages of GED versus non-GED holders to measure the signaling effect of the GED?
- Self-selection (endogenous choice):
  - GED holders probably would have earned less than HS Diploma holders regardless. These are not typically the cream of your HS class.
  - GED holders probably would have earned more than other HS dropouts regardless. Relative to other dropouts, GED holders have:
    - More years of schooling prior to dropout.
    - Higher measured levels of cognitive skills.
    - Their parents have more education.
- So, simple comparisons of earnings among dropouts/ GED holders/ HS diploma holders tell us little about the causal effect of a GED for a person who obtains it.

5.1 The TMW strategy

- GED passing standards differ by U.S. state. Some test takers who would receive a GED in Texas with a passing score of $40-44$ would not receive a GED in New York, Florida, Oregon or Connecticut with the identical scores.

- But if GED score is a good measure of a person's ability/productivity, then people with same 'ability' ($40 - 44$) are assigned a GED in Texas but not in New York.
- This quasi-experiment effectively randomly assigns the GED 'signal' to people with the same GED scores across different U.S. states.
- If we could determine who these marginal people are, we could identify the pure signaling effect of the GED, holding ability constant.

5.2 What does the signaling model predict in this case?

- Since some dropouts obtain the GED and some do not, it's plausible that the market is at some type of 'separating' equilibrium (i.e., not everyone gets the signal).
- For the GED to perform as a signal, it needs to be the case that the cost of obtaining it is lower for more productive workers (otherwise everyone or no one would get it). This seems quite plausible: you cannot pass the GED without some education and study.
- In equilibrium, the following must be true for individuals:

$$\begin{aligned} w_{GED} - w_{NO-GED} &\geq C_{GED} \Rightarrow \text{obtain,} \\ w_{GED} - w_{NO-GED} &< C_{GED} \Rightarrow \text{don't obtain,} \end{aligned}$$

  where C_{GED} is the direct and indirect costs of obtaining the GED.
- And the following must be true for employers:

$$\begin{aligned} w_{GED} &= E(\text{Productivity}|C_{GED} \leq w_{GED} - w_{NO-GED}), \\ w_{NO-GED} &= E(\text{Productivity}|C_{GED} > w_{GED} - w_{NO-GED}). \end{aligned}$$

- If these conditions are satisfied, firms will be willing to pay the wages w_{GED}, w_{NO-GED} to GED and non-GED holders respectively, and workers will self-select to obtain the GED accordingly.
- Notice an additional hidden assumption: firms cannot perfectly observe worker ability independent of the GED. If they could, the GED would not have any intrinsic signaling value since employers could judge productivity without needing this signal. It seems quite reasonable to assume that firms cannot observe ability perfectly.
- Given the quasi-experimental setup, the signaling model predicts that workers with GED scores of $40 - 44$ will earn more if they receive the GED certificate than if they do not.
- By contrast, the Human Capital model implies that since ability is comparable among these groups, their wages will also be comparable.

5.3 Estimation

- The econometric strategy should be quite familiar now. We want to estimate:

$$T = E\left[Y_1 - Y_0 | GED = 1\right]$$

  where Y_1, Y_0 are earnings with and without the GED *for the people who obtained the GED*—that is, we want to estimate the effect of 'treatment on the treated.'

- The variable that randomizes assignment of the GED is location: Texas vs. New York. So, we need to assume the following *for those in the relevant score range, S, (where $S \in [40, 44]$)*:

$$\begin{aligned} E\left[Y_1 | NY, S\right] &= E\left[Y_1 | TX, S\right], \\ E\left[Y_0 | NY, S\right] &= E\left[Y_0 | TX, S\right] \end{aligned}$$

- If these assumptions are correct, a valid estimate of the treatment effect is:

$$\hat{T} = E\left[Y_1 | TX, S\right] - E\left[Y_0 | NY, S\right].$$

  That is, we would compare GED holders from Texas (in score range $40 - 44$) to GED non-holders from NY in score range $40 - 44$ to get an estimate of T.

- However, we might be concerned that there is also a direct effect of being in NY vs. TX that operates independently of the GED at any level of ability. For example

$$E\left[Y_1 | NY, S\right] - E\left[Y_1 | TX, S\right] = E\left[Y_0 | NY, S\right] - E\left[Y_0 | TX, S\right] = \delta.$$

  In this case, $\hat{T}$ from our previous equation would estimate $T + \delta$, i.e., the treatment effect plus the location effect.

- To surmount this problem, TMW select a control group of GED test takers with scores just above the cutoff for both groups of states. Hence, the GED treatment works as follows:

	Low Passing Standard	High Passing Standard
Low Score (treatment group)	GED	NO GED
High Score (control group)	GED	GED

- The outcome variable will be earnings for each of these four groups:

	Low Passing Standard	High Passing Standard
Low Score (treatment group)	$E\left[Y_1 \| TX, S = Low\right]$	$E\left[Y_0 \| NY, S = Low\right]$
High Score (control group)	$E\left[Y_1 \| TX, S = High\right]$	$E\left[Y_1 \| NY, S = High\right]$

- Hence, the Diff-in-Diff estimate is:

$$\begin{aligned}
E\left[\hat{T}\right] &= E\left[Y_0|TX, S = Low\right] - E\left[Y_1|NY, S = Low\right] \\
&\quad - \left(E\left[Y_1|TX, S = High\right] - E\left[Y_1 NY, S = High\right]\right) \\
&= T + \delta - \delta \\
&= T
\end{aligned}$$

- Results:
  - See Table V.
  - See Figures I-III.

5.4 Conclusions from TMW study

- Large signaling effects for whites, estimated at 20% earnings gain after 5 years.
- Does this prove that GED holders are *not* more productive than non-GED holders?
  - No. Just the opposite.
  - For there to be a signaling equilibrium, it must be the case that GED holders *are* on average more productive than otherwise similar HS dropouts who do not hold a GED.
- Do these results prove that education is unproductive?
  - No, they also have nothing to say on this question because education/skill is effectively hold constant by this quasi-experiment.
- What the study shows unambiguously is that the GED is taken as a positive signal by employers. And this can only be true if:
  1. GED holders are on average more productive than non-GED holders.
  2. The GED is in some sense more expensive for less productive than more productive workers to obtain. This probably has to do with maturity, intellect, etc.
  3. Employers are unable to perfectly distinguish productivity directly and hence use GED status as one signal of expected productivity.