Labor Economics, 14.661. Lecture 3: Education, Selection, and Signaling

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Introduction

- So far, no issues of imperfect information.
- But two workers with college degrees rarely have the same skills.
  - Are these differences observable to the econometrician?
  - Are these differences observable to the employer?
- The first of these leads to models with selection, which requires us to model selection of workers conditional on unobservables into jobs and different occupations.
- The second leads to models with asymmetric information.

Introduction (continued)

- We start with a simple model of selection.
- We then discuss the leading alternative to the human capital view, that education is purely or partly as a signal.
- Other models with asymmetric information will be discussed next week and thereafter.

Selection and Wages—The One-Factor Model

- Theoretical model of selection bias.
- Important for discussion of selection of workers into occupations and estimation biases from unobserved heterogeneity.
- Useful for migration and labor market equilibria.
- Contrast to signaling model.

Selection and Wages—The One-Factor Model (continued)

- Suppose that individuals are distinguished by an unobserved type, z.
- z is observed by the employer (no asymmetric information).
- Suppose z is distributed uniformly between 0 and 1.
- Individuals decide whether to obtain education, which costs c.
- The wage of an individual of type z when he has no education is

$$w_0(z) = z$$

- When he obtains education:

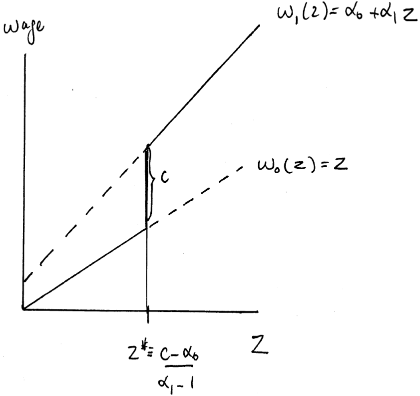
$$w_1(z) = \alpha_0 + \alpha_1 \cdot z, \tag{1}$$

  where $\alpha_0 > 0$ and $\alpha_1 > 1$.
- Therefore: α_0 is the *main effect of education* on earnings
- α_1 interacts with ability.
- The assumption that $\alpha_1 > 1$ implies that education is **complementary** to ability (is this reasonable?)

Selection and Wages—The One-Factor Model (continued)

- Optimal investment. Education if

$$z > z^* \equiv \frac{c - \alpha_0}{\alpha_1 - 1}.$$



Selection and Wages—The One-Factor Model (continued)

- Equilibrium *observed wages*

$$\bar{w}_0 = \frac{c - \alpha_0}{2(\alpha_1 - 1)}$$

$$\bar{w}_1 = \alpha_0 + \alpha_1 \frac{\alpha_1 - 1 + c - \alpha_0}{2(\alpha_1 - 1)}$$

- We have

$$\bar{w}_1 - \bar{w}_0 > \alpha_0,$$

so the wage gap between educated and uneducated groups is greater than the main effect of education.

Selection and Wages—The One-Factor Model (continued)

- This reflects two components.
  1. the return to education is not α_0, but it is $\alpha_0 + \alpha_1 \cdot z$ for individual z. Therefore, for a group of mean ability $\bar{z}$, the return to education is

     $$w_1(\bar{z}) - w_0(\bar{z}) = \alpha_0 + (\alpha_1 - 1) \cdot \bar{z},$$

     which we can simply think of as the return to education *evaluated at the mean ability of the group*.
  2. the average ability of the two groups is not the same, and the earning differences resulting from this ability gap are being counted as part of the returns to education→ high-ability individuals are selected into education increasing the wage differential.

Selection and Wages—The One-Factor Model (continued)

- To see this, rewrite the observed wage differential as follows

$$\bar{w}_1 - \bar{w}_0 = \alpha_0 + (\alpha_1 - 1)\left[\frac{c - \alpha_0}{2(\alpha_1 - 1)}\right] + \frac{\alpha_1}{2}$$

  - First two terms give the return to education evaluated at the mean ability of the uneducated group.
  - This would be the answer to the counter-factual question of how much the earnings of the uneducated group would increase if they were to obtain education.
  - The third term is the additional effect that results from the fact that the two groups *do not* have the same *ability* level.
  - This is "*the selection effect*".

Selection and Wages—The One-Factor Model (continued)

- Alternatively, we could have written

$$\bar{w}_1 - \bar{w}_0 = \alpha_0 + (\alpha_1 - 1)\left[\frac{\alpha_1 - 1 + c - \alpha_0}{2(\alpha_1 - 1)}\right] + \frac{1}{2},$$

  - Now the first two terms give the return to education evaluated at the mean ability of the educated group, which is greater than the return to education evaluated at the mean ability level of the uneducated group.
  - So the selection effect is somewhat smaller, but still positive.

Baseline Signaling Model

- Consider the following simple model to illustrate the issues.
- There are two types of workers, high ability and low ability.
- The fraction of high ability workers in the population is λ.
- Workers know their own ability, but employers do not observe this directly.
- High ability workers always produce y_H, low ability workers produce y_L.

Baseline Signaling Model (continued)

- Workers can invest in education, $e \in \{0, 1\}$.
- The cost of obtaining education is c_H for high ability workers and c_L for low ability workers.
- **Crucial assumption** ("single crossing")

$$c_L > c_H$$

- That is, education is more costly for low ability workers. This is often referred to as the "single-crossing" assumption, since it makes sure that in the space of education and wages, the indifference curves of high and low types intersect only once. For future reference, I denote the decision to obtain education by $e = 1$.
- To start with, suppose that education does not increase the productivity of either type of worker.
- Once workers obtain their education, there is competition among a large number of risk-neutral firms, so workers will be paid their *expected productivity*.

Baseline Signaling Model (continued)

- Game of incomplete information $\rightarrow$ Perfect Bayesian Equilibrium
- Two (extreme) types of equilibria in this game.

1. Separating, where high and low ability workers choose different levels of schooling.
2. Pooling, where high and low ability workers choose the same level of education.

Separating Equilibrium

- Suppose that we have

$$y_H - c_H > \ y_L > y_H - c_L \tag{2}$$

- This is clearly possible since $c_H < c_L$.
- Then the following is an equilibrium: all high ability workers obtain education, and all low ability workers choose no education.
- Wages (conditional on education) are:

$$w\left(e=1\right) = y_H \text{ and } w\left(e=0\right) = y_L$$

- Notice that these wages are conditioned on education, and *not directly on ability*, since ability is not observed by employers.

Separating Equilibrium (continued)

- Let us now check that all parties are playing best responses.
- Given the strategies of workers, a worker with education has productivity y_H while a worker with no education has productivity y_L. So no firm can change its behavior and increase its profits.
- What about workers?
- If a high ability worker deviates to no education, he will obtain $w(e=0) = y_L$, but

$$w(e=1) - c_H = y_H - c_H > y_L.$$

Separating Equilibrium (continued)

- If a low ability worker deviates to obtaining education, the market will perceive him as a high ability worker, and pay him the higher wage $w(e=1) = y_H$. But from (2), we have that

$$y_H - c_L < y_L.$$

- Therefore, we have indeed an equilibrium.
- In this equilibrium, education is valued simply because it is a signal about ability.
- Is "single crossing important"?

Pooling Equilibrium

- The separating equilibrium is not the only one.
- Consider the following allocation: both low and high ability workers do not obtain education, and the wage structure is

$$w(e=1) = (1-\lambda) y_L + \lambda y_H \text{ and } w(e=0) = (1-\lambda) y_L + \lambda y_H$$

- Let us strengthen the condition (2) to

$$y_H - c_H > (1-\lambda) y_L + \lambda y_H \text{ and } y_L > y_H - c_L \tag{3}$$

- Again no incentive to deviate by either workers or firms.
- Is this Perfect Bayesian Equilibrium reasonable?

Pooling Equilibrium (continued)

- The answer is no.
- This equilibrium is being supported by the belief that the worker who gets education is no better than a worker who doesn't.
- But education is more costly for low ability workers, so they should be less likely to deviate to obtaining education.
- This can be ruled out by various different refinements of equilibria.

Pooling Equilibrium (continued)

- Simplest refinement: *Intuitive Criterion* by Cho and Kreps.
- The underlying idea: if there exists a type who will never benefit from taking a particular deviation, then the uninformed parties (here the firms) should deduce that this deviation is very unlikely to come from this type.
- This falls within the category of "forward induction" where rather than solving the game simply backwards, we think about what type of inferences will others derive from a deviation.

Pooling Equilibrium (continued)

- Take the pooling equilibrium above. Consider a deviation to $e = 1$.
- There is no circumstance under which the low type would benefit from this deviation, since

$$y_L > y_H - c_L,$$

and the low ability worker is now getting

$$(1 - \lambda) y_L + \lambda y_H.$$

- Therefore, firms can deduce that the deviation to $e = 1$ must be coming from the high type, and offer him a wage of y_H.
- Then (2) ensures that this deviation is profitable for the high types, breaking the pooling equilibrium.

Pooling Equilibrium (continued)

- The reason why this refinement is called The Intuitive Criterion is that it can be supported by a relatively intuitive "speech" by the deviator along the following lines:

  you have to deduce that I must be the high type deviating to $e = 1$, *since low types would never ever consider such a deviation, whereas I would find it profitable if I could convince you that I am indeed the high type). Of course, this is only very loose, since such speeches are not part of the game, but it gives the basic idea.*

- The overall conclusion: separating equilibria, where education is a valuable signal, may be more likely than pooling equilibria.
- When would this not be the case?

Generalizations

- Suppose education is continuous $e \in [0, \infty)$.
- Cost functions for the high and low types are $c_H(e)$ and $c_L(e)$, which are both strictly increasing and convex, with $c_H(0) = c_L(0) = 0$.
- The single crossing property is that

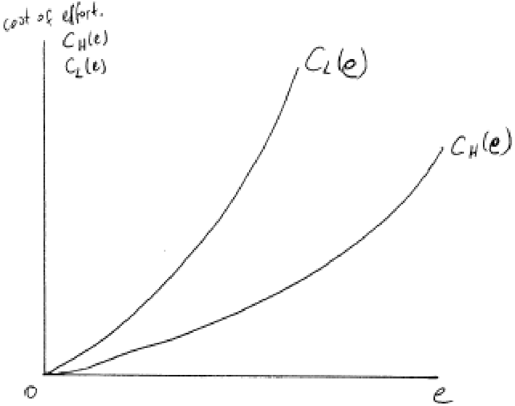
$$c'_H(e) < c'_L(e) \text{ for all } e \in [0, \infty),$$

  that is, the marginal cost of investing in a given unit of education is always higher for the low type (why is this the right condition?).
- Suppose that the output of the two types as a function of their educations are $y_H(e)$ and $y_L(e)$, with

$$y_H(e) > y_L(e) \text{ for all } e.$$

Generalizations (continued)

- The single crossing property:



Generalizations (continued)

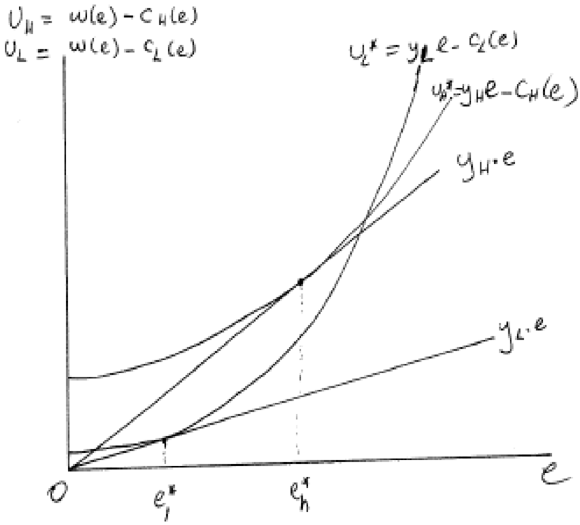
- Again there are many Perfect Bayesian Equilibria, some separating, some pooling and some semi-separating.
- But applying a stronger form of the Intuitive Criterion reasoning, we will pick the *Riley equilibrium* of this game, which is a particular separating equilibrium.

Riley equilibrium: first find the most preferred (*first-best*) education level for the low type in the perfect information case

$$y_L'\left(e_l^*\right) = c_L'\left(e_l^*\right).$$

Generalizations (continued)

- First best diagrammatically:



Generalizations (continued)

- Then we can write the *incentive compatibility constraint* for the low type, such that when the market expects low types to obtain education e_l, the low type does not try to mimic the high type.

$$y_L\left(e_l^*\right) - c_L\left(e_l^*\right) \geq w\left(e\right) - c_L\left(e\right) \text{ for all } e, \tag{4}$$

- Let e_h be the level of education for high type such that this constraint holds as an equality :

$$y_L\left(e_l^*\right) - c_L\left(e_l^*\right) = y_H\left(e_h\right) - c_L\left(e_h\right).$$

- Question: why did rewrite $w\left(e_h\right) = y_H\left(e_h\right)$?
- Then the Riley equilibrium is such that low types choose e_l and obtain the wage

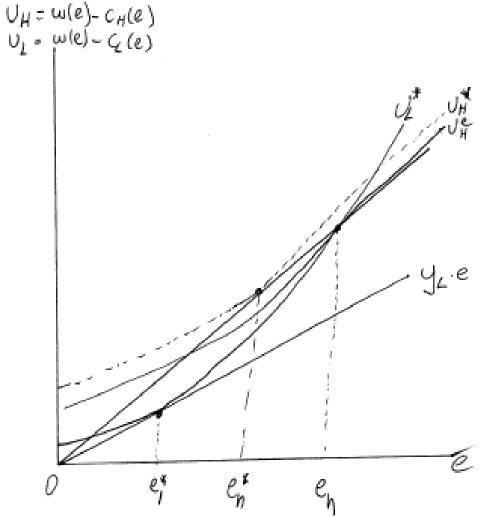
$$w\left(e_L^*\right) = y_L\left(e_l^*\right),$$

and high types choose e_h and obtain the wage

$$w\left(e_h\right) = y_H\left(e_h\right).$$

Generalizations (continued)

- *Riley equilibrium* diagrammatically:



Generalizations (continued)

- Why are high types are happy to do this? From the single-crossing property:

$$\begin{aligned} y_H(e_h) - c_H(e_h) &= y_H(e_h) - c_L(e_h) - (c_H(e_h) - c_L(e_h)) \\ &> y_H(e_h) - c_L(e_h) - (c_H(e_l^*) - c_L(e_l^*)) \\ &= y_L(e_l^*) - c_L(e_l^*) - (c_H(e_l^*) - c_L(e_l^*)) \\ &= y_L(e_l^*) - c_H(e_l^*), \end{aligned}$$

- High ability workers investing in schooling more than they would have done in the perfect information case, in the sense that e_h characterized here is greater than the education level that high ability individuals chosen with perfect information, given by $y'_H(e_h^*) = c'_H(e_h^*)$.

Evidence on Labor Market Signaling

- For different types of evidence:
  1. Do degrees matter?
  2. Do compulsory schooling laws affect schooling levels for higher grades?
  3. Returns to GED?
  4. Investigation of *negative externalities*
- Why are these informative about signaling?
- Which ones are more convincing?

Evidence on Labor Market Signaling (continued)

- Third approach: Tyler, Murnane and Willett.
- Passing grades in the Graduate Equivalent Degree (GED) differ by state.
- So an individual with the same grade in the GED exam will get a GED in one state, but not in another.
- If the score in the exam is an unbiased measure of human capital, and there is no signaling, these two individuals should get the same wages.
- If the GED is a signal, and employers do not know where the individual took the GED exam, these two individuals should get different wages.

Evidence on Labor Market Signaling (continued)

- Using this methodology, the authors estimate that there is a 10-19 percent return to a GED signal.
- An interesting result that Tyler, Murnane and Willett find is that there are no GED returns to minorities.
- This is also consistent with the signaling view, since it turns out that many minorities prepare for and take the GED exam in prison. Therefore, GED would be not only a positive signal, but also likely a signal that the individual was at some point incarcerated. Hence not a good signal at all.