14.03/003 Microeconomic Theory & Public Policy

Lecture 22. Education, Human Capital, and Labor Market Signaling

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Asymmetric Information: The Case of TMI

- 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*.

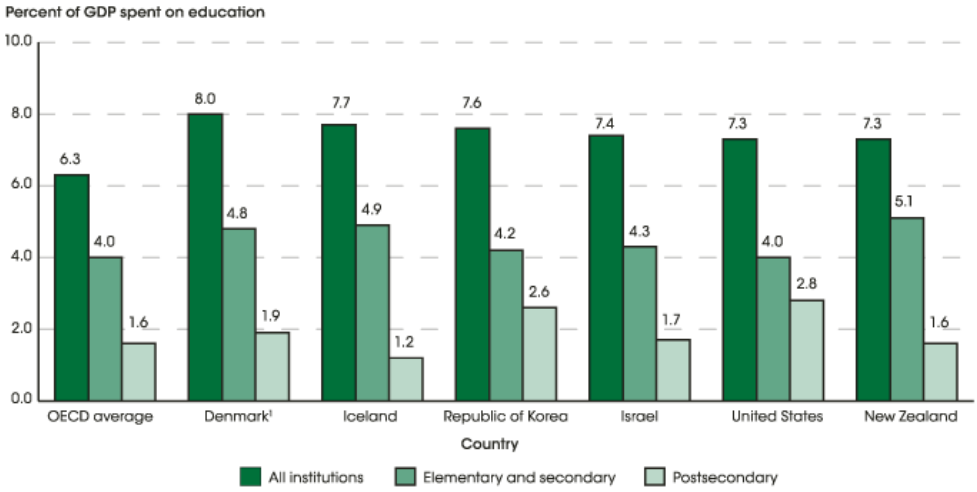
Asymmetric Information: The Case of TMI

- 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 Spence (1973) signaling model 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
- These private incentives may or may not generate desirable outcomes, judged by the standard of *social* efficiency

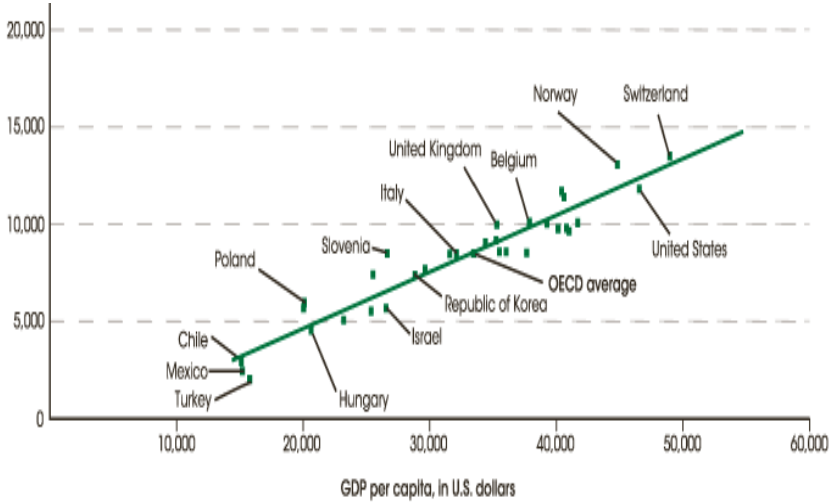
Context: Educational investment

- 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:
  - *Direct costs:* Buildings, teachers, textbooks, etc.
  - *Indirect costs*: Opportunity costs of attending school instead of working or having fun.
- Is this enormous investment socially efficient?
- Canonical model in economics: 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

Education Expenditures as a Share of GDP in OECD Countries in 2010



Annual Expenditures per Full-Time Elementary & Secondary Student 2010: OECD Countries by GDP



The Mincer Model of Educational Investment

Jacob Mincer, 1958

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

Mincer model

- **Discounted present value**

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

Mincer model

- **Discounted present value**

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

which can be simplified as follows:

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

- **Waiting cost**: If you attend school for 1 year, you don't receive 1st payment of $w(1)$ until after year of school complete
- **Gross benefit of one year of education:**

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

Net benefit of schooling

The **net benefit** of obtaining one additional year of schooling is:

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

Now assume the following:

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

Question: If the labor market is in equilibrium, what does NBE equal?

Mincer in equilibrium

In equilibrium, it must be the case that the *costs and benefits of an additional year of schooling are equated.* **This implies that:**

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

- Wage increment for year of schooling must approx equal the interest rate!
- Model captures a remarkable empirical regularity
- Over the last 95 years, estimated rate of return to year of schooling in the U.S. has been about 5 to 10 % —approx equal to the real interest rate (interest to an investor or lender after allowing for inflation).

Average return to a year of schooling and average years of schooling worldwide, 1982 – 2012

Montenegro and Patrinos, 2014

The Spence Job Market Signaling Model

Michael Spence , 1973

The Spence signaling Model

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).

The Spence signaling model

Let's use these **parameter values:**

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

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

Separating equilibrium

- Assume that firms offer the following **wage schedule**:

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

  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

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

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

- Consider if the employer sets $S^* = 1 + \varepsilon$, where ε is a very small, positive number.
- **Question:** Is this an equilibrium wage schedule? How do we approach this problem?

Separating equilibrium

- Workers choose the optimal level of education given wage schedule.
- Employers must find it worth their while to pay the wages offered given the productivity of workers who claim these wages.
- (Note: necessary under any equilibrium, not just separating eqm.)

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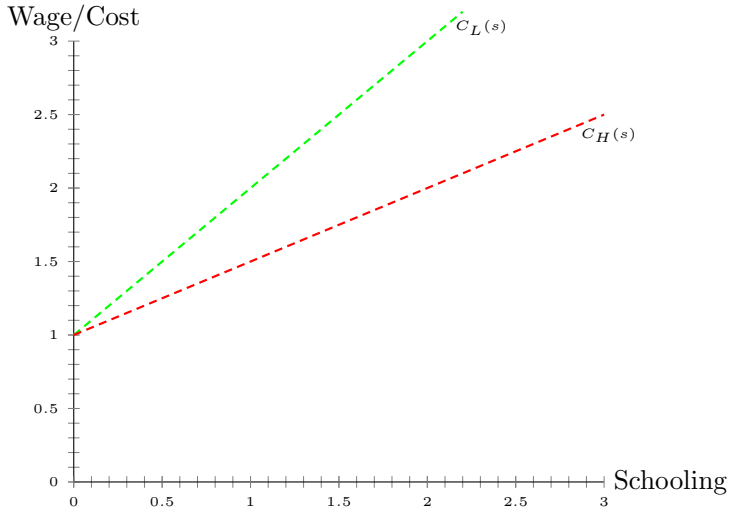
  - Type H workers will attend school for S^* years if: $2 - 0.5 \cdot S^* > 1$.
  - L type workers will attend school if: $2 - S^* > 1$.
  - For employers it must be the case that $E\left[Y\left(S\right)|w\left(S\right)\right] \geq w(S)$, where $Y\left(S\right)$ gives the productivity of workers supplying labor with schooling level S.

Separating Equilibrium

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



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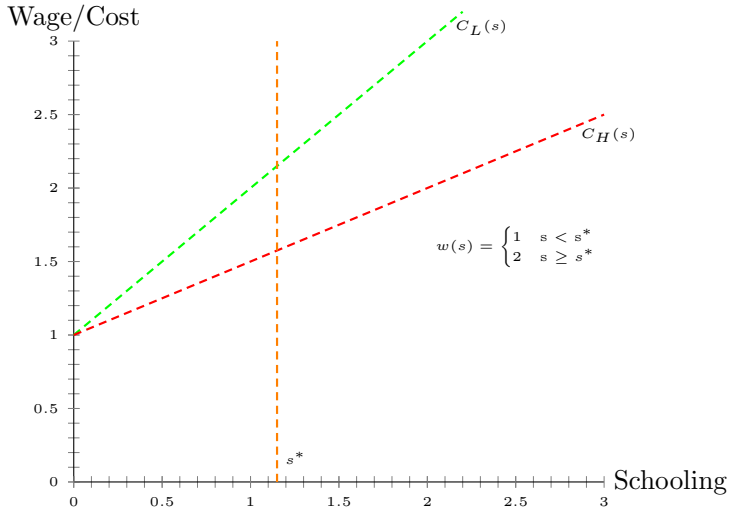

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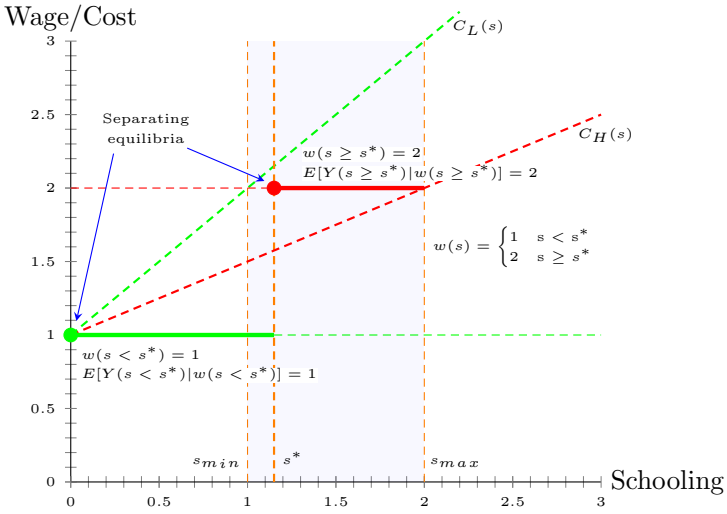

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  - Workers with $S = 0$ are type L. They have productivity 1 and wage 1 and so the employer's wage schedule is rational for these workers.
  - Workers with $S = S^*$ are type H and have productivity 2 and wage 2.
- $\rightarrow$ This is an **equilibrium**: 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.

Separating equilibrium

- Notice that the separating equilibrium requires that the wage schedule induce **self-selection**
- High-productivity workers choose to obtain more schooling than low-productivity workers.

Separating equilibrium

- Notice that the separating equilibrium requires that the wage schedule induce **self-selection**
- High-productivity workers choose to obtain more schooling than low-productivity workers.
- The unfortunate aspect of this equilibrium is that education is completely unproductive, so these investments are socially wasteful.
- From a social perspective, the signal does **nothing useful** since it does not increase total output

Pooling equilibrium with positive education

- Example above is a **separating** equilibrium: L, H types obtain different levels of education.
- There may be **pooling** equilibria where L and H receive identical education

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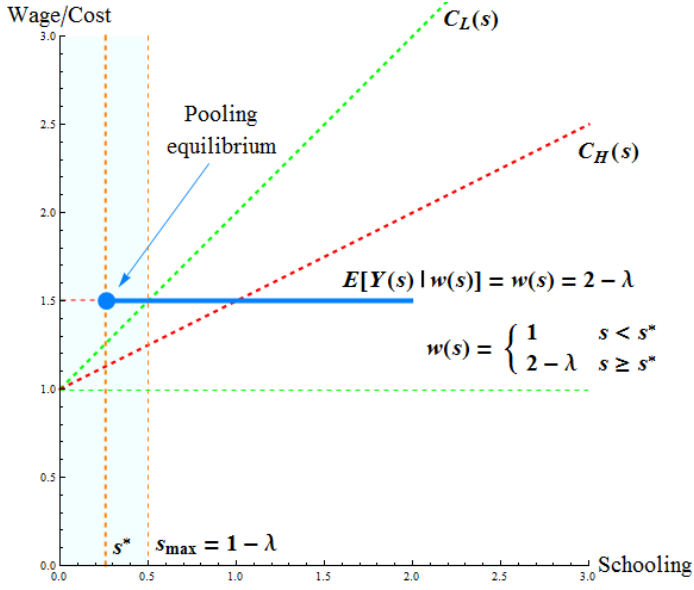
- There may be **pooling** equilibria where L and H receive identical education
- Imagine that employers offered a wage schedule of

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

so workers with $S < 0.5$ are paid $w = 1$ and otherwise $w = 2 - \lambda$. Who invests in schooling?

Pooling Equilibrium with Universal Education



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  so workers with $S < 0.5$ are paid $w = 1$ and otherwise $w = 2 - \lambda$
  - 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 get schooling $S = 0.5$.
- Are employers' wages rational given this fact? Yes:

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

Another pooling equilibrium

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

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

Question: Who will obtain schooling in this case?

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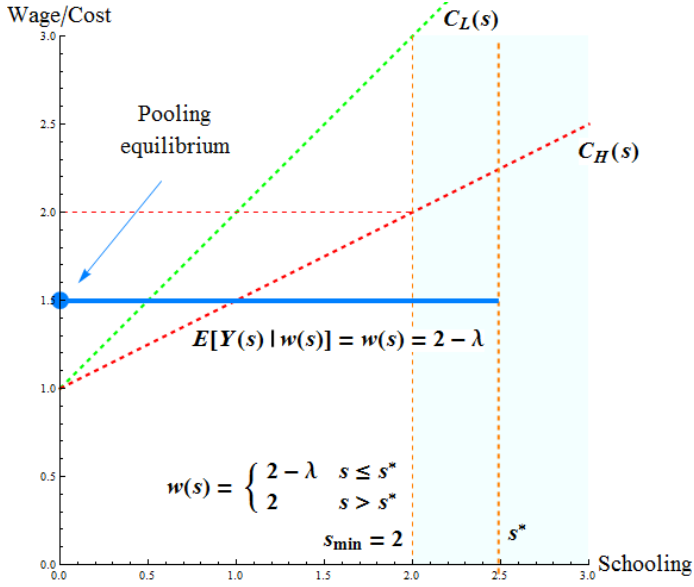
Pooling Equilibrium with No Education



Another pooling equilibrium

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

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

Question: Who will obtain schooling in this case?

- **A: 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:

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

Another pooling equilibrium

- **Can these two pooling equilibria be Pareto ranked?**

Another pooling equilibrium

- **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

Summary of signaling

- Signaling model is closely related to models of adverse selection from last week
- Wage offers must 'call forth' workers whose productivity given their education is consistent with the wages they're paid (Nash eq'm)
- The market failure/inefficiency stems from asymmetric information
- In models with asymmetric information, prices/wages serve two functions
  1. Remunerate the seller for goods or services rendered *(standard)*
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  1. Remunerate the seller for goods or services rendered *(standard)*
  2. Determine set (or qualities) of goods and services offered *(non-standard)*
- In the equilibrium of these models, prices do not merely reflect social costs as they should, but rather strategic equilibria among buyers and sellers
- If you have one instrument (price) to solve two economic problems, you will generally get suboptimal results

Empirical Implications of Mincer and Signaling Model

1. People who attend additional years of schooling are more productive
   - *Mincer:* ✓
   - *Signaling:* ✓

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3. People will attend school while they are young, i.e., before they enter the workforce
   - *Mincer:* ✓
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4. The rate of return to schooling should be roughly equal to the rate of interest
   - *Mincer:* ✓
   - *Signaling:* No prediction

Empirical Implications of Mincer and Signaling Model

- **How do you empirically distinguish human capital from signaling model?**

Empirical Implications of Mincer and Signaling Model

- **How do you empirically distinguish human capital from signaling model?**
- Ideally: Find people of identical ability and randomly assign them a diploma.
  - Spence model implies the ones with diploma earn more.
  - Mincer model implies having a diploma makes no difference on earnings.

Empirical Implications of Mincer and Spence Model

- **Is it plausible that education serves as a signal of ability rather than a means to enhance productivity?**

Empirical Implications of Mincer and Spence Model

- **Is it plausible that education serves as a signal of ability rather than a means to enhance productivity?**
  - Many MIT students will be hired by consulting firms that have no use for physics, biology, chemistry, calculus, or HASS-D classes
  - Why did you choose MIT over your state university that is probably less expensive and may have offered you a better scholarship?
  - Is this all due to educational quality, or is some of it credentialism?

Estimating the Labor Market Signaling Value of the GED

Tyler, Murnane, and Willett , 2000

The Tyler, Murnane and Willett study

- The General Educational Development certificate **(GED)**
  - By 1996, 9.8% of those ages $18-24$ had completed High School via the the GED versus 76.5% via a HS diploma.
  - Between 1990 and 1996 HS Diploma rates actually fell dramatically for Black, Non-Hispanics
  - The rise in the GED just offset this frop
  - 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.

Large fraction of U.S. 'High School Graduates' actually have a GED

TABLE I

HIGH SCHOOL COMPLETION RATES OF 18–24 YEAR-OLDS FROM 1975–1996, AND BY METHOD OF COMPLETION FROM 1988–1996

Completion method	Year[a,b]											
	1975	1980	1985	1988	1989	1990	1991	1992	1993	1994	1995	1996
	(percent)											
Total												
Completed	83.6	83.9	85.4	84.5	84.7	85.6	84.9	86.4	86.2	85.8	85.3	86.2
Diploma				80.3	80.5	80.6	80.7	81.2	81.2	78.8	77.5	76.5
Alternative[c]				4.2	4.2	4.9	4.2	5.2	4.9	7.0	7.7	9.8
White, non-Hispanic												
Completed	87.2	87.5	88.2	88.7	89.0	89.6	89.4	90.7	90.1	90.7	89.8	91.5
Diploma				84.4	85.1	84.8	85.2	85.7	85.5	84.2	82.6	81.0
Alternative				4.2	3.9	4.8	4.2	5.0	4.7	6.4	7.2	10.5
Black, non-Hispanic												
Completed	70.2	75.2	81.0	80.9	81.9	83.2	82.5	82.0	81.9	83.3	84.5	83.0
Diploma				76.1	76.9	77.9	77.3	75.9	76.1	75.2	75.4	73.0
Alternative				4.8	5.0	5.3	5.2	6.1	5.8	8.1	9.0	10.0
Hispanic												
Completed	62.2	57.1	66.6	58.2	59.4	59.1	56.5	62.1	64.4	61.8	62.8	61.9
Diploma				54.4	54.8	54.8	53.4	56.6	58.2	54.2	54.0	55.2
Alternative				3.8	4.7	4.2	3.1	5.5	6.1	7.6	8.8	6.7

High school graduates earn substantially more than GED holders

TABLE II

EARNINGS REGRESSIONS FOR INDIVIDUALS IN THE HIGH SCHOOL AND BEYOND SURVEY (DEPENDENT VARIABLE IS THE LOG OF THE AVERAGE OF 1990–1991 ANNUAL EARNINGS AND STANDARD ERRORS ARE IN PARENTHESES.)

	Whites[a]	Minorities[b]	Whites	Minorities
Intercept	9.518**	9.320**	9.455**	9.199**
	(0.057)	(0.079)	(0.059)	(0.081)
Female	−0.397**	−0.306**	−0.40**	−0.298**
	(0.019)	(0.030)	(0.022)	(0.032)
GED	0.162*	0.164	0.094	0.083
	(0.072)	(0.109)	(0.072)	(0.109)
High school graduate	0.536**	0.581**	0.380**	0.400**
	(0.057)	(0.073)	(0.059)	(0.075)
Math test score			0.012**	0.008**
			(0.002)	(0.002)
Reading test score			0.0002	0.002
			(0.003)	(0.005)
Writing test score			0.002	0.008*
			(0.003)	(0.005)
Science test score			−0.008*	0.003
			(0.004)	(0.005)
Vocabulary test score			0.007*	0.009*
			(0.003)	(0.004)
Region dummies[c]	Yes	Yes	Yes	Yes
R^2	0.11	0.087	0.133	0.131
N[d]	5,403	2,810	5,403	2,810

The Tyler, Murnane and Willett study

Question: What is the labor market signaling value of the GED?

- Can we compare wages of GED versus non-GED holders to measure the signaling effect of the GED?

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Question: What is the labor market signaling value of the GED?

- Can we 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.
  - 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.
- 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

The Tyler-Murnane-Willett empirical 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.

What does the signaling model predict

- Some dropouts obtain the GED and some do not
- Plausible that the market is at some type of *separating equilibrium*
- For the GED to perform as a signal, must be that the cost of obtaining it is lower for more productive workers
- This seems plausible: You cannot pass the GED without some education and study

What does the signaling model predict

- For the GED to perform as a signal, must be that the cost of obtaining it is lower for more productive workers.
- 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:

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

What does the signaling model predict in this case?

- 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.
- 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.
- **What does the Human Capital model predict?**

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- **What does the Human Capital model predict?**
- The Human Capital model predicts that since ability is comparable among these groups, their wages will also be comparable

Estimation

- We want to estimate:

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

  Y_1, Y_0 are earnings with/without GED for those with a GED

- Location randomizes assignment of GED: Texas vs. New York. Need it to be the case that for those in the relevant score range $S \in [40, 44]$:

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

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

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

- Compare GED-holders from TX to GED non-holders from NY w/scores $40 - 44$

Estimation

- Concern: possible a **direct effect** of being in NY vs. TX that operates independently of the GED at any level of ability. For example

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

- If so, $\hat{T}$ from previous equation would estimate $T+\delta$, i.e., the treatment effect plus the location effect
- Use control group: GED test-takers who score just above cutoff for NY and TX
- 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

Estimation

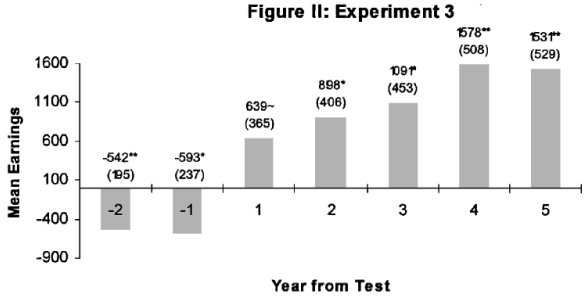
- The outcome variable will be earnings for each of these four groups:

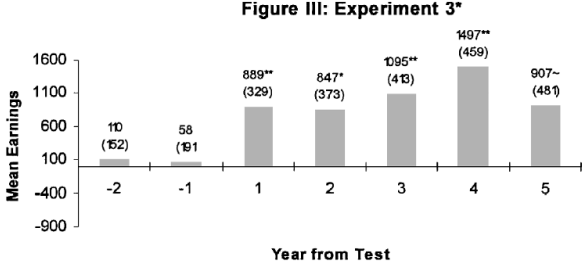
	Low Passing Standard	High Passing Standard
Low Score (treatment group)	$E[Y_1 \mid TX, S = Low]$	$E[Y_0 \mid NY, S = Low]$
High Score (control group)	$E[Y_1 \mid TX, S = High]$	$E[Y_1 \mid NY, S = High]$

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

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

Contrasting earnings of GED and non-GED holders with scores 40-44





GED signaling benefits are large for whites, insignificant for minorities

TABLE V

DIFFERENCE-IN-DIFFERENCES ESTIMATES OF THE IMPACT OF THE GED ON 1995 EARNINGS OF DROPOUTS WHO TESTED IN 1990 (STANDARD ERRORS ARE IN PARENTHESES.)

	Experiment 4			Experiment 3			Experiment 3*		
	State passing standard is		Low-High standard contrast	State passing standard is		Low-High standard contrast	State passing standard is		Low-High standard contrast
	Low	High		Low	High		Low	High	
Panel A: Whites									
Test score is									
Low	9628	7849	1779	9362	7843	1509	9362	8616	746
	(361)	(565)	(670)	(400)	(312)	(507)	(400)	(219)	(456)
High	9981	9676	305	9143	9165	−23	9143	9304	−162
	(80)	(65)	(103)	(135)	(63)	(149)	(135)	(135)	(150)
Difference-in-differences for whites			1473*			1531**			907*
			(678)			(529)			(481)
Panel B: Minorities									
Test score is									
Low	6436	8687	−2252	7005	7367	−363	7005	6858	147
	(549)	(690)	(882)	(347)	(347)	(495)	(347)	(290)	(452)
High	7560	8454	−894	7782	8375	−593	7782	7568	214
	(184)	(96)	(207)	(214)	(93)	(233)	(214)	(133)	(252)
Difference-in-differences for minorities			−1357			231			−67
			(906)			(548)			(518)

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  - No, 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.
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  - No, 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.
- **Study shows that GED is taken as a positive signal by employers. Requires that:**
  1. GED holders are on average more productive than non-GED holders
  2. The GED is 'more expensive' for less productive than more productive workers
  3. Employers unable to perfectly distinguish productivity directly, hence use GED status as a signal of expected productivity