technische universität
dortmund

Lecture 5b: Signaling

Michael J. Böhm

Empirical Economics

Wintersemester 2025/26

Signaling

In contrast to human capital, in signaling theory education investments have no productivity effects but act as signal of ability.

- Basic signaling model:
  Spence (1973): Observable measures of human capital as signal of (innate) ability but limited productivity effects of schooling.
- Empirical evidence on the importance of signaling:
  Tyler/Murane/Willett (2000): Estimating the Labor Market Signaling Value of the GED, Quarterly Journal of Economics.

The basic signaling model

The model's set-up:

- High & low-ability workers ($y_h > y_l$); λ: share of high-ability workers
- Workers know their own ability, employers don't observe it before hiring
- Workers can invest in education ($e = [0, 1]$) at differing costs ($c_l > c_h$)
  $\rightarrow$ *education acts as signal but has no productivity effect*
- Workers remunerated according to their *expected* productivity

The basic signaling model

The timing of the decision process:

- Each worker chooses whether to invest in education
- Firms observe *education decision* of worker and compete for her/him

Dynamic game with incomplete information and two potential equilibria

- Separating equilibrium:
  Low and high-ability workers choose different levels of education
- Pooling equilibrium:
  Both types choose same level of education

The basic signaling model - Equilibria

Two potential equilibria: separating and pooling equilibrium

I. The separating equilibrium:

Suppose costs and productivity are given such that

$$y_h - c_h > y_l > y_h - c_l$$

In this set up, equilibrium solution is reached where (i) all high-ability individuals invest in education, and (ii) all low-ability workers don't invest

Realized wages equal

$$w(e = 1) = y_h \text{ and } w(e = 0) = y_l$$

The basic signaling model - Equilibria

Outcomes as best responses for workers and employers

a. Employers:

- Given workers' behavior, a worker with education has productivity y_h, one without education y_l. No firm can change its behavior and increase profits.

b. Workers:

- If a high-ability worker deviates from equilibrium, the wage adjusts to $w(e = 0) = y_l$, the current wage being $w(e = 1) - c_h = y_h - c_h > y_l$.
- If a low-ability worker deviates, the wage adjusts to $w(e = 1) = y_h$. However, $y_h - c_l < y_l$ such that a deviation is not profitable.

The basic signaling model - Equilibria

II. Pooling equilibrium:

Suppose all workers obtain no education and wage is given by:

$$w(e[0,1]) = (1-\lambda)y_l + \lambda y_h$$

Best responses

[a] No incentives for workers to invest in education

- Given costs of education and zero returns on investment

[b] Firms: Universal education, expected productivity $(1-\lambda)y_l + \lambda y_h$

The basic signaling model - Equilibria

Is the pooling equilibrium reasonable? No.

- Due to belief that workers with education no better than workers without
- Yet, education more expensive for low than high-ability workers: $c_l > c_h$
- Low ability workers should be less likely to deviate

Intuitive criterion rules out unreasonable beliefs

- If there is a type of worker that never gains from deviating, uninformed parties should recognize that a deviation from this type is unlikely.

The basic signaling model - Equilibria

Separating Equilibrium: Key message that education valued because serves as a signal of ability

- Education may only serve as signal as long as $c_l > c_h$
- No education investments in the presence of perfect information

Overall conclusion:

- As long as $y_h - c_h > y_l > y_h - c_l$
  $\rightarrow$ separating equilibrium where education will be valued as a signal

Empirical evidence - The importance of signaling

Estimating the signaling value of education: Tyler/Murnane/Willett (2000)

Threshold for passing the GED test varies across U.S. states

- GED credential as secondary schooling certificate for high-school dropouts
- Out of roughly 1 million dropouts per year, around 1/3 acquire GED

Keeping GED score constant, derivation of signaling value of education

- Differential passing standards across states allow authors to net out effect of human capital on earnings & isolate signaling value of GED certificate

Tyler et al. - Signaling value of GED

GED comprises five single tests:

- maths, writing, social studies, science and “interpreting arts & literature”

GED test as important pathway towards gaining a secondary degree:

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
Total	(percent)											
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

Preparation for GED tests involves (substantial) studying
$\rightarrow$ Test participation might raise human capital level
$\rightarrow$ Learning as explanation for higher wages for GED certificate holders

Tyler et al. - Signaling value of GED

Correlations between GED acquisition and wages

$$y_i = \alpha + \beta GED_i + \gamma HS_i + \epsilon_i$$

GED holder earn slightly more than workers without any degree
$\rightarrow$ significant correlation weakens when ability is controlled for

Correlation...

- ...picks up human capital and signaling effects
- ...compares GED holders to those who never tried and those who failed test

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

Tyler et al. - Signaling value of GED

Identification strategy exploits differences in passing thresholds across US:

Suppose there are two individuals with the same GED test score. Individual A in a tough state fails, while individual B in a lenient state just passes. Holding human capital constant (test score), the authors may derive the effect of GED certificates on earnings by comparing individuals A and B accounting for differences in state labor markets.

States may set passing standards above country-wide minimum:

Tyler et al. - Signaling value of GED

Combination of minimum score in each test & minimum average test score over all tests

$\rightarrow$ yielding different passing standards across the US; Authors use the following:

- a minimum score of at least 40 *or* a mean score of at least 45,
- a minimum score of at least 35 *and* a mean score of at least 45, and
- a minimum score of at least 40 *and* a mean score of at least 45.

Data:

- Individual-level data on GED test scores, demographics and income history
- Data aggregated to state$\times$GED score group$\times$gender$\times$ethnic group cells

Tyler et al. - Signaling value of GED

Set-up generates three natural experiments

- Score groups 1 & 2 never receive GED, irrespective of state of residence
- Score groups 5-10 always receive GED, irrespective of state of residence

TABLE III
GED SCORE GROUPS FORMED BY COMBINING MINIMUM AND MEAN SCORES
(OUTLINED CELLS = VARIATION IN GED-STATUS BY STATE, DARK SHADING = ALL POSSESS GED, NO SHADING = NONE HAVE GED.)

	Mean score	
Minimum score	<45	$>=45$
20–34	Score group 1	
35–39	Score group 2	Score group 4
40–44	Score group 3	Score group 5
45–46		Score group 6
47–48		Score group 7
49–50		Score group 8
51–52		Score group 9
53+		Score group 10

Tyler et al. - Signaling value of GED

Treatment vs. control groups:

i. Some states award the GED from score group 4 onwards, others from score group 5
ii. Some states award the GED from score group 3 onwards, others from score group 5
iii. Some states award the GED from score group 3 onwards, others from score group 4

Tyler et al. - Signaling value of GED

Empirical specification:

$$y_i = \beta_0 + \beta_1 ST_i + \beta_2 SG_i + \alpha(T_i \times ASG_i) + \beta_3 Female_i + \epsilon_i$$

- y_i: individual i's annual earnings after GED; ST_i: U.S. state dummy variables
- SG_i: GED test score group
- T_i: Dummy turning one if individual in more lenient state
- ASG_i: Dummy turning one if individual in affected score group

Given aggregate data, specification boils down to difference-in-differences design:

$$\hat{\alpha} = (\bar{Y}_T - \bar{Y}_C) - (\bar{Y}_{THi} - \bar{Y}_{CHi})$$

- $\bar{Y}_T$: individuals in score group 3 or 4 living in lenient state (with GED)
- $\bar{Y}_C$: individuals in score group 3 or 4 living in though state (no GED)
- $\bar{Y}_{THi}/\bar{Y}_{CHi}$: high scoring groups $>$4 in lenient/though state (all with GED)

Tyler et al. - Baseline results

- Positive earnings effect of GED certificate for whites
- Insignificant effect 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* (678)			1531** (529)			907-- (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 (906)			231 (548)			−67 (518)

Tyler et al. - Signaling value of GED

Why should treatment effects differ between whites and minorities?

I. Different selection into GED test

- 17% of minority males participated in GED while being in prison
- Share of white males incarcerated during time of test: 4%
- Having been in prison may depress the positive signal of the GED

II. Different reasons for participation in GED

- Majority / minority may participate in GED for different reasons: 'value of credential for employment' vs. 'compulsory for benefit receipt'
- GED only a signal of productivity for those actively pursuing program
- If minority group participate for compulsory reasons more often, GED may not be considered as a signal for minorities

Conclusions

[I.] Differences in human capital (education, experience) explain huge share of variation in wages

[II.] Different perceptions of human capital

- Human capital investments (e.g. schooling) increase productivity
- Schooling investments as signal of (innate) ability

[III.] Empirical evidence for both explanations

- Ability and selection biases need to be taken care of

Conclusions 2: if we had more time

Jespen et al (2016) use Regression Discontinuity Design (RDD) of individuals who just pass or fail the degree threshold. Argue that Tyler et al's DD here does not work (should not allow for retaking GED).

Graetz (2021) argues that Diploma DD or RDDs can

- Identify information frictions in degrees.
- Help estimate speed of employer learning (e.g. Altonji & Pierret 2002)

But cannot distinguish signaling from human capital (premium is average of innate and acquired HK of *all* GED vs HS graduates in the market). Instead:

- Estimate causal effect of schooling on productivity.
- Work harder to get distinct predictions signaling vs HK.
- Realize speed of learning upper bound on role of signaling.

Readings

- Borjas, George. *Labor Economics*. Chapter 6.9.
- Altonji, J. G., & Pierret, C. R. (2001). Employer learning and statistical discrimination. QJE.
- Graetz, G. (2021). On the interpretation of diploma wage effects estimated by regression discontinuity designs. CJE.
- Jepsen, C., Mueser, P., & Troske, K. (2016): Labor market returns to the GED using regression discontinuity analysis. JPE.
- Tyler et al. (2000):
  Estimating the Labor Market Signaling Value of the GED, QJE.