Economics 350: Two Interpretations of the Mincer Equation Learning-by-doing vs. On-the-job Training

Based in part on James Heckman, Lance Lochner, and Ricardo Cossa's "Learning-by-doing vs. on-the-job training: Using variation induced by the EITC to distinguish between models of skill formation," in Phelps, Edmund S. *Designing inclusion: tools to raise low-end pay and employment in private enterprise*. Cambridge Univ Press, 2003, pp. 74–130.

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1. Is learning rivalrous with or complementary with working? Rivalrous with or complementary with earning?
2. Do people pay for their learning? What is the form of the payment? Foregone earnings? Foregone leisure? Both?
3. What is the correct price of time to include in a labor supply equation? Is the measured average wage the correct price of time?
4. What is the correct interpretation of empirical Mincer earnings equations? What do we learn from cross-section estimates?
5. Should we correct our estimates of inequality in wage income for consequences of human capital investments?

Point of Departure:

- Two observationally equivalent interpretations of

$$\ln W = \alpha_0 + \alpha_1 S + \alpha_2 x + \alpha_3 x^2$$

- S = schooling
- x = work experience
- α_1 = "average rate of return" to schooling
- α_2, α_3 = "returns to experience"

Mincer's Justification

- OJT model: Becker-Ben Porath
- Learning comes at the expense of earning.
- $k(x)$: earnings forgone as % of potential earnings.
- Mincer assumes:
  1. Constant rates of return to post school investment r_p (If heterogeneous assumed to be independent of $k(x)$).
  2. $k(x) = 1 - \frac{x}{T}$
  3. T: maximum possible amount of experience.
  4. Effect of OJT on log earnings, additively separable from schooling.
  5. T functionally independent of S. (Each year of schooling adds one year to effective working life.)
  6. $r(x)$ same for all x.
- Then (1), (2), (3), (4) and (5) $\Rightarrow$ Mincer model. (See Mincer handout.)

- $\alpha_1 = r_s$; average "rate of return to schooling."
- $\alpha_2, \alpha_3 \Rightarrow r_p$; average rate of return to post school investment.
- Can show:

$$\left(\alpha_2 = \left(r_p + \frac{r_p}{2T}\right); \alpha_3 = -\frac{r_p}{2T}\right)$$

(see "Mincer" notes).

Second Model

- Empirically indistinguishable from first model.
- Work produces current wages and future wage growth.
- x =cumulated work experience.
- The only cost of x is forgone leisure.
- $\ln W = \alpha_1 + \alpha_2 S + \alpha_3 x + \alpha_4 x^2$.
- Keane and Wolpin (1997, 2001) and many successor models.
- Keane, 2016, *EJ*, on reading list.

Question: can we distinguish the two models?

General model and special cases: 2 period analysis: Worker Problem

- (C_0, L_0): Consumption and leisure in "0"
- (C_1, L_1): Consumption and leisure in "1"

$$\text{Preferences: } U(C_0, L_0) + \frac{1}{1+\rho} U(C_1, L_1) \tag{1}$$

- r is the borrowing rate; perfect certainty.

- H_0 = initial human capital; H_1 = final human capital
- Production function of human capital:
  $H_1 = H_0 + F(\theta_0, H_0, 1 - L_0)$
  $F_{\theta_0} \geq 0, F_{H_0} \geq 0, F_{1-L_0} \geq 0.$
- Depreciation implicit.
- θ_0 = learning "quality" of a job in period 0.
- As $\theta_0 \uparrow H_1 \uparrow (F_{\theta_0} > 0)$
- Learning quality irrelevant in period "1" because there is no period 2.
- Assume $\rho = r = 0$.
- θ_0 is valuable.
- It helps produce human capital.
- However, you have to be at a firm to realize its value.
- Does it have a price? Do people pay for learning opportunities?

- Assume all learning takes place at firms.
- Earnings in "0": $W(H_0, 1 - L_0, \theta_0)$
- Earnings in "1": $W(H_1, 1 - L_1)$
- Budget Constraint:

$$C_0 + C_1 = \underbrace{W(H_0, 1 - L_0, \theta_0)}_{\text{Earnings in period 0}} + \underbrace{W(H_1, 1 - L_1)}_{\text{Earnings in period 1}} \tag{2}$$

Pricing of human capital services in final output:

- R: rental rate on a unit of human capital: (efficiency units model).
- $$W(H_0, 1-L_0, \theta_0) = \underbrace{RH_0(1-L_0)}_{\text{potential earnings}} - \underbrace{P(\theta_0, 1-L_0, H_0)}_{\text{amount ``paid'' to the firm by agent to access } \theta_0}$$
- $W(H_1, 1-L_1) = RH_1(1-L_1)$
- $P(\theta_0, 1-L_0, H_0)$ is *the cost of learning quality* θ_0 with $1-L_0$ hours of work and with the agent having H_0 amount of human capital.

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Consider Becker-Ben Porath Model

- Leisure fixed: $L_0 = L_1 = \bar{L}$
- Jobs priced out in a special way
- Price of learning content θ_0 in a job: $P(\theta_0, 1 - \bar{L}, H_0) = P(\theta_0)$
- Production function: $H_1 = F(\theta_0, H_0) + H_0$
- $\theta_0 = I$ (time spent investing): In this model, "learning" is through investment time I_0 spent at work.
- $P(\theta_0) = RH_0 I$ (cost of investment)
- $W(H_0, 1 - L_0, \theta_0) = RH_0(1 - \bar{L}) - RH_0 I$
- Can add leisure (Blinder and Weiss, 1976; Heckman, 1976)

- The Ben-Porath (1967) model has a special functional form

$$\begin{aligned} H_1 &= G(H_0\theta_0) + H_0 \\ &= G(H_0 I_0) + H_0 \end{aligned} \tag{3}$$

- **Question: What are the first order conditions for the model (1), (2), and (3) with leisure fixed $L_0 = L_1 = \bar{L}$?**
- **How does investment depend on H_0 and R?**

Learning by Doing (LBD) Model in the Literature

- Cost of learning is foregone leisure.
- Ignored in Becker-Ben Porath models.
- Investment is a "free good."

$$\frac{\partial P}{\partial \theta_0} = 0$$

(Imai and Keane, 2004; Keane, 2016)

- Implicitly: θ_0 is the same at all jobs.
- *Free lunch. (No direct cost of learning.)*
- The only cost of learning is *foregone leisure*.
- Other intermediate cases are possible.

Firm Side of the Problem: Firm "'Sells" Investment Opportunities

- Firm has a valuable good: training possibilities.
- Firms may be heterogeneous in training opportunities **(but typically ignored)**.
- Two sector model of the firm.
- Firms: produce skills in one sector and then use skills for producing final output.
- Profits for a one-worker firm offering opportunity θ_0:

$$\underbrace{\Pi}_{\text{Profits}} = \underbrace{J((1-L_0), H_0, \theta_0)}_{\text{Final Goods Output}} + \underbrace{P(\theta_0, (1-L_0), H_0)}_{\substack{\text{Revenue from selling} \\ \text{training opportunities} \\ \text{to workers}}} - \underbrace{WRH_0(1-L_0)}_{\text{Labor Costs}}$$

- $J_{\theta_0} \leq 0$ (costly for firm to provide learning opportunities).

$P(\theta_0, (1 - L_0), H_0, R)$ is market clearing pricing function.

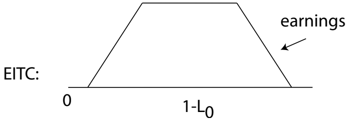
- Equates demand and supply across jobs, indexed by θ, L_0.
- **Question: What is the life cycle mobility of workers across firms?**

Can One Distinguish Between the Two Models?

- See Cossa, Heckman et al. (2003).

Consider taxes and subsidies in periods "0" and "1" in Two Models
Model 1: OJT (Becker-Ben Porath with Leisure)

- Motivated by analysis of EITC (Earned Income Tax Credit) program (Cossa et al., 2003).



- Assume learning takes place on the job.
- τ_0, τ_1 are proportional taxes or subsidies.
- $R = 1$
- Individuals maximize (1): $U(C_0, L_0) + U(C_1, L_1)$ subject to

$$C_0 + C_1 = \underbrace{(1+\tau_0)H_0(\overbrace{1 - I_0 - L_0}^{\text{work time}})}_{\text{Measured after tax/subsidy earnings in period 0}} + \underbrace{(1+\tau_1)H_1(1 - L_1)}_{\text{Measured after tax/subsidy earnings in period 1}}$$

- This formulation abstracts from the basic problem of where on the budget set should agents locate.
- $V(L_0, A_0)$ is period zero value fn. $L_0 = \operatorname{argmax} V(L_0, A_0)$.
- **Question: What is the FOC for the Ben Porath version of the model with labor supply?**
- $\boldsymbol{H_1 = F(I_0 H_0) + H_0}$
- $(1+\tau_0)H_0 \leq (1+\tau_1)(1-L_1)G'(I_0 H_0)H_0$
- Neutrality: H_0 raises productivity proportional to opportunity cost.
- If instead, $H_1 = F(I_0) + H_0$ (abstract from self productivity of H_0).
- FOC for I_0: $\quad (1+\tau_0)H_0 \leq (1+\tau_1)(1-L_1)F'(I_0)$
- Higher H_0 raises the opportunity cost of investment.
- Feature missing in Becker-Ben Porath model with neutrality.

Consider the Impact of Taxes and Subsidies

Compensate for income effects (λ constant or Frisch demands, not Hicks-Slutsky) (see Frisch Demands handout for background),

- $\tau_0 > \tau_1 = 0$: Period 0 subsidy raises MC of I_0: $I_0 \downarrow \therefore H_1 \downarrow$
- $\tau_1 > \tau_0 = 0$: Period 1 subsidy raises MR of I_0: $I_0 \uparrow H_1 \uparrow$
- $\tau_0 = \tau_1 > 0$: FOC unchanged.

Digression for Non-Ben Porath Case

Consider an interior solution (local)

- Consider the following Lagrangian:

$$\mathcal{L} = U(C_0, L_0) + U(C_1, L_1) \\ - \lambda \left[C_0 + C_1 - (1+\tau_0) H_0 (1 - I_0 - L_0) - (1+\tau_1) H_1 (1 - L_1) \right]$$

- FOC: C_0, C_1

$$U_1(C_0, L_0) = \lambda$$
$$U_1(C_1, L_1) = \lambda$$

- FOC: L_0, L_1

$$U_2(C_0, L_0) = \lambda(1+\tau_0)H_0$$
$$U_2(C_1, L_1) = \lambda(1+\tau_1)H_1$$

- FOC: I_0 for the case where
- For $H_1 = F(I_0) + H_0$

$$(1+\tau_0)H_0 = (1+\tau_1)F'(I_0)(1-L_1)$$

λ is Held Constant: Suppose We Relax this Condition?

- Assume (C_0, C_1) and (L_0, L_1) are normal goods.
- If $\tau_0 = \tau_1 \uparrow$, so agent gets a subsidy (or pays less tax) per period $L_0, L_1 \uparrow \therefore I_0 \downarrow$, $H_1 \downarrow$
- In the general case where $\tau_0 = \tau_1 = \tau$, as $\tau \uparrow$, value of time (price of leisure) increases, agents substitute toward consumption effects reinforced by income effects.
- $(1 - L_1) \downarrow \Rightarrow I_0 \downarrow \Rightarrow H_1 \downarrow$. (Pure wealth effects, more consumption, more leisure, and less work and investment.)
- **Problem:** Verify these claims.

- **Question: For a Ben Porath Technology with labor supply, what is the answer to these questions for these subsidy changes?**

Model 2: Learning By Doing (LBD): Cost of Learning is Same as Cost of Work–Foregone Leisure

- $R = 1$
- Individuals maximize $U(C_0, L_0) + U(C_1, L_1)$ subject to

$$C_0 + C_1 = (1+\tau_0)H_0(1-L_0) + (1+\tau_1)H_1(1-L_1).$$

and

$$H_1 = H_0 + \phi(1-L_0) \qquad \text{(Period "1" earnings)}$$

FOC:

$$U_2(C_0, L_0) = \lambda[\overbrace{H_0(1+\tau_0)}^{\substack{\text{Marginal effect of}\\ \text{a unit of work}\\ \text{on current}\\ \text{earnings}}} + \overbrace{\phi'(1-L_0)(1-L_1)(1+\tau_1)}^{\substack{\text{Effect of}\\ \text{current hour of work}\\ \text{on future earnings}}}]$$

$$U_2(C_1, L_1) = \lambda[\underbrace{H_0 + \phi(1-L_0)](1+\tau_1)}_{\substack{\text{Measured effect of an extra}\\ \text{hour of work on after subsidy on earnings}}}$$

Compensate for income effects (λ constant)

- Start from $\tau_0 = 0, \tau_1 = 0$.
- $\tau_0 = \tau_1$: Flat subsidy increases the current and future return to work $h_0 = 1 - L_0$ and $h_1 = 1 - L_1$.
- $\therefore H_1 \uparrow$.
- $\tau_0 > \tau_1$: Period 0 subsidy raises current return to h_0, $(H_1)\uparrow$
- $\tau_1 > \tau_0$: Period 1 subsidy raises future return to h_1, $(H_1)\uparrow$
- Positive wealth and income effects discourage work and reduce learning and investment in all cases.
- $\therefore \lambda$ vary, impacts ambiguous on it.

Model 2′: LBD with a Market for Learning Opportunities (No Free Lunch and Heterogeneous Firms)

- Suppose firms offer different learning opportunities indexed by $\theta \in (\underline{\theta_0}, \bar{\theta_0})$.
- So $H_1 = H_0 + \phi(1 - L_0, \theta_0)$ where $\frac{\partial^2 \phi}{\partial(1-L_0)\partial\theta_0} > 0$.
- With a distribution of firm types, a market for learning will emerge.
- All old workers and young workers who expect high L_1 (low h_1) place little value on learning, θ_0.
- Pricing function $P(\theta_0)$ may arise with $P'(\theta_0) > 0$. (Worker pays for learning opportunities)
- This adds a new wrinkle to the LBD model.
- Wage earnings:
  - In the first period: $W(H_0, \theta_0) = H_0(1 - L_0) - P(\theta_0)$.
  - In the second period, it is $H_1(1 - L_1)$

- We acquire a new first order condition in the LBD model.
- Individuals choose firm type or learning opportunity (θ) according to:

$$(1+\tau_0)P'(\theta_0) = (1+\tau_1)(1-L_1)\frac{\partial\phi(1-L_0,\theta_0)}{\partial\theta_0} \qquad (*)$$

- **Problem:** Verify this condition.

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- Consider an income-compensated change from an initial position: $\tau_0 = \tau_1 = 0$.
- $\uparrow \tau_0 = \tau_1 > 0$: Flat subsidy increases current and future return to h_0 (= period zero hours of work) and raises return to θ_0 by increasing h_0 and h_1 (period 1 hours of work).
- $\therefore$ This is a force for $H_1 \uparrow$.
- But it raises the cost of buying θ_0, a force for $H_1 \downarrow$ (see *).
- **Problem:** Verify.

- $\tau_0 > \tau_1$: Period 0 subsidy raises current return to h_0 and the MC of θ_0.
- **Ambiguous on** H_1 (everything else constant).
- $\tau_1 > \tau_0$: Period 1 subsidy raises future return to h_0 and return to θ_0.
- $\therefore H_1 \uparrow$.
- Test of model not clear anymore.
- **Note:** Can equate this model with OJT model if θ_0 equated to I_0 in Ben Porath. Then the two models are indistinguishable.

- Implicit is a theory of life cycle mobility (stepping stone mobility).

Implications for Measured Wages

OJT:

a. First period earnings $<$ potential earnings if investment is paid by foregone earnings (wage rates understated).
b. First period earnings $=$ potential earnings if investment occurs off the job or not paid via earnings.

LBD (free lunch):

- First period earnings $<$ potential earnings. Wage rates understated (true price of time is greater that measured wage).