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?

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
- $\alpha_1 =$ "average rate of return" to schooling
- $\alpha_2, \alpha_3 =$ "returns to experience"

Mincer's Justification

- OJT model appeals to Becker-Ben Porath model of experience x.
- Learning comes at the expense of earning.
- $k(x)$ earnings forgone as % of potential earnings.
- Assume:
  1. Constant rates of return (or if heterogeneous assume independent of level of investment: r_p).
  2. $k(x) = 1 - \frac{x}{T}$ where T is the maximum possible amount of experience.
  3. Effect of OJT (in logs) additively separable from schooling.
  4. T functionally independent of S. (Each year of schooling adds one year to effective working life.)
  5. $r(x)$ 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).

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Second Model

- Empirically indistinguishable from first model.
- $x =$cumulated work experience.
- The only cost of x is forgone leisure.
- Work produces current and future wage growth.
- $\ln W = \alpha_1 + \alpha_2 S + \alpha_3 x + \alpha_4 x^2$.
- 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 ("technology of skill formation"):
  $H_1 = H_0 + F(\theta_0, H_0, 1 - L_0)$
  $F_{\theta_0} \geq 0, F_{H_0} \geq 0, F_{1-L_0} \geq 0.$
- Can add depreciation (assume no depreciation for simplicity).
- $\theta_0 =$ "quality" (investment content) of job in period 0.
- As $\theta_0 \uparrow H_1 \uparrow (F_{\theta_0} > 0)$
- $\theta_1 \equiv 0$; no investment in second period because no tomorrow.
- Assume $\rho = r = 0$.
- θ_0 is valuable.
- It helps produce human capital.
- However, you have to be at a firm to realize the investment opportunity.
- Does it have a price?

- Earnings in "0": $W(H_0, 1 - L_0, \theta_0)$
- Earnings in "1": $W(H_1, 1 - L_1, \theta_1)$
- 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 units of human capital (efficiency units model).
- $W(H_0, 1-L_0, \theta_0) = \underbrace{RH_0(1-L_0)}_{\text{potential earnings}} - \underbrace{P(\theta_0, 1-L_0, H_0)}_{\substack{\text{amount paid by agent to} \\ \text{acquire human capital} \\ \text{i.e., to access } \theta_0}}$
- $W(H_1, 1-L_1) = RH_1(1-L_1)$
- $P(\theta_0, 1-L_0, H_0)$ is *the cost of quality* θ_0 with $1-L_0$ hours of work and with the agent having H_0 amount of human capital with training content θ_0.

Becker-Ben Porath Model

- Leisure fixed: $L_0 = L_1 = \bar{L}$
- Jobs priced out in a special way
- Price of learning content θ in a job: $P(\theta_0, 1 - L_0, H_0) = P(\theta_0)$
- Production function: $H_1 = F(\theta_0, H_0) + H_0$
- $\theta_0 = I$ (time spent investing)
- $P(\theta_0) = RH_0 I$ (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

$$H_1 = G(H_0 \theta_0) + H_0 \tag{3}$$

- "Neutrality" (MC of investment = MR of investment)
- **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."

$$\frac{\partial P}{\partial(1-L_0)} = \frac{\partial P}{\partial \theta_0} = 0$$

$$\frac{\partial F}{\partial(1-L_0)} > 0 \qquad ; \qquad \frac{\partial F}{\partial \theta_0} = 0$$

(Imai and Keane, 2004; Keane, 2016)

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

Firm Side of the Problem

- Firm has a valuable good: training possibilities.
- Firms heterogeneous in training opportunities.
- Two sector model of the firm.
- Firms: can produce skills and use skills for producing final output, offer training opportunities, or both.
- Profits for a one-worker firm offering opportunity θ_0:

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

- $J_{\theta_0} \leq 0$.

- *Hedonic equilibrium* for firms and workers in skill production sector:

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

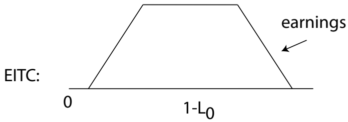
- (Will establish properties later.)
- Equates demand and supply across jobs, indexed by θ, L_0.
- **Question: What is the life cycle mobility of workers across firms?**

Can One Distinguish Between the Two Models?

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

Consider taxes and subsidies in periods "0" and "1". 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 subsidies: $\tau_0 > 0$, $\tau_1 > 0$.
- $R = 1$
- Individuals maximize (1): $U(C_0, L_0) + U(C_1, L_1)$ subject to

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

- Assume $H_1 = F(I_0) + H_0$ (abstract from self productivity).
- FOC for I_0: $(1+\tau_0)H_0 \leq (1+\tau_1)(1-L_1)F^{'}(I_0)$
- **Question: What is the FOC for the Ben Porath version of the model with labor supply?**
- $\boldsymbol{H_1 = F(I_0 H_0) + H_0}$
- $(1+\tau_0)H_0 \leq (1+\tau_1)(1-L_1)G^{'}(IH_0)H_0$
- Neutrality: H_0 raises productivity proportional to opportunity cost.

Consider the General Model

Compensate for income effects (λ constant or Frisch demands),

- $\tau_0 > \tau_1 = 0$: Period 0 subsidy raises MC of I_0: $H_1 \downarrow$
- $\tau_1 > \tau_0 = 0$: Period 1 subsidy raises MR of I_0: $H_1 \uparrow$
- $\tau_0 = \tau_1 > 0$: Flat subsidy increases $h_1 = 1 - L_1$ (time spent in market working) and raises MR of I_0: $(I_0, H_1)\uparrow$ (remember that wealth effects are neutralized).

Digression:

- Why? 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
- Assume $H_1 = F(I_0) + H_0$

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

λ is Held Constant

- Suppose initially that we have separability

$$U(C_0, L_0) = \phi(C_0) + \eta(L_0)$$
$$U(C_1, L_1) = \phi(C_1) + \eta(L_1)$$

- Then if $\tau_0 = \tau_1 \uparrow$, $L_0, L_1 \downarrow \therefore I_0 \uparrow$, $H_1 \uparrow$
- In the general case where $\tau_0 = \tau_1 = \tau$, as $\tau \uparrow$, price of leisure increases and agents substitute toward consumption
- $(1 - L_1) \uparrow \Rightarrow I_0 \uparrow \Rightarrow H_1 \uparrow$

- If we add back wealth and income effects discourage work and reduce investment in all cases.
- **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:

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

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

Compensate for income effects (λ constant)

- $\tau_0 = \tau_1 > 0$: Flat subsidy increases the current and future return to work $h_0 = 1 - L_0$ and $h_1 = 1 - L_1$.
- $\therefore H_1 \uparrow$.
- $\tau_0 > \tau_1 = 0$: Period 0 subsidy raises current return to h_0, $(H_1)\uparrow$
- $\tau_1 > \tau_0 = 0$: Period 1 subsidy raises future return to h_1, $(H_1)\uparrow$
- Wealth and income effects discourage work and reduce learning and investment in all cases.

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

- Suppose firms may 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:

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

- Consider taxes and subsidies in this model.
- As before, consider an income-compensated change from an initial position: $\tau_0 = \tau_1 = 0$.
- $\tau_0 = \tau_1 > 0$: 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 *).

- $\tau_0 > \tau_1 = 0$: Period 0 subsidy raises current return to h_0 and the MC of θ_0.
- **Ambiguous on** H_1 (everything else constant).
- $\tau_1 > \tau_0 = 0$: 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 off the job or not paid via earnings.

LBD (free lunch):

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