Empirics: Human capital in Development

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Lecture notes

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BILLS AND KLENOW (2000): Some background

Suppose we have the C-D production function

$$y = Y/L = (K/Y)^{\frac{\alpha}{1-\alpha}} hA \Rightarrow g_y = \frac{\alpha}{1-\alpha} g_{K/Y} + g_h + g_A.$$

Next run a simple OLS regression

$$g_{y,1960-90} = \beta_0 + \beta_1(\text{Schoolenrollment, } 60) + \varepsilon$$

B&K find $\hat{\beta}_1 = 0.21$. So enrollment $\uparrow$ (give defintion: corresp. to 1 extra av. years of schooling in st st) –> $g_y \uparrow$ by .21%. Similar results if use $g_h + g_A$ is left hand side variable. Effect runs through $g_h + g_A$.

In theory: SE -> HC accumulation -> growth makes sense (Lucas, MRW).

But can we be sure the above reflect the causal impact from h on y?

BILLS AND KLENOW (2000): Some background

Of course not. A simple model:

– People live for two periods

– If they do *not* attend school: Income per 1 $= A(1)$, Income per 2 $=$ $A(2)$.

– If they do attend school: Income per 1: 0. Income per 2: $(1+\lambda_i R)A(2) > A(2)$. λ_i differ across individuals (ability), R is the return on schooling. Imagine a distribution for λ_i.

Attend school if

$$0 + \frac{(1+\lambda_i R)A(2)}{1+r} > A(1) + \frac{A(2)}{1+r} \Leftrightarrow \lambda_i \geq \bar{\lambda} \equiv \frac{1+r}{(1+g_A)R},$$

where $1+g_A \equiv A(2)/A(1)$.

So if *expect* $g_A \uparrow$ more will become educated (enrollment rates rise).

OLS not causal effect from $SE->$**growth.**

BILLS AND KLENOW (2000): Empirical strategy

Use theory to *generate* data on yrs of schooling (thus h). With those numbers in hand, ask:

1. Schooling –> growth. Can enrollment rate explain g_h? $g_h + g_A$?
2. Growth (expect.) –> Schooling. Could this account for the covariation observed empirically? E.g. can an increase in growth of about .21% imply an increase in average schooling of 1 year?

Generating data I

Define average human capital stock for a given country at time t

$$h(t) \equiv \frac{H(t)}{L(t)} \equiv \frac{\int_s^T h(a,t)\, L(a,t)\, da}{\int_s^T L(a,t)\, da},$$

where $L(t)$ is the labor force comprising agegroups from s to T.

BILLS AND KLENOW (2000):Generating data I

More specifically

$$h(a,t) \equiv E_t \cdot e^{f(s)+\gamma_1(a-s-6)+\gamma_2(a-s-6)^2}, \;\; f(s) \equiv \frac{\theta}{1-\psi} s^{1-\psi}$$

and E is an externality whereby $h(a,t)$ depends on lagged level of h (teachers), with an elasticity ϕ. If $\phi = 1$; Lucas. $\phi < 1$, s would need to rise so as to ensure growth in h.

If $\phi = 0$, and we know $\theta, \psi, \gamma_1, \gamma_2$ and years of schooling far back in time + age distribution back in time, its easy to get $h(a,t)$ thus, $H(t)$, from 1960-1990. If $\phi > 0$ you need to invoke the perpetual inventory method, requiring us to go further back when generating data (for h_{1960} to be sensible).

γ_1, γ_2, based on Mincer regressions can be obtained for a lot of countries. B&K use an average.

BILLS AND KLENOW (2000):Generating data I

What about θ, ψ?. B&K work out an ingenious method.

From the Mincer lit (Micro, seperate for each country) we know people have been estimating equations of the form

$$\ln w_{ji} = \lambda_0 + \lambda_1 s_{ij}$$

where i is individuals, j are countries (of course, from the perspective of Mincer reg. it always take place in some specific country). This equation holds for all workers. In particular a worker with average years of schooling in country j, $\bar{s}_j$.

In addition: There's data for estimated λ_1's for a lot of countries. Empirically, it seems that $\hat{\lambda}_1$ is smaller in countries with more average years of schooling, which is the motivation for the formulation $f(s) = \theta/(1-\psi)\, s^{1-\psi}, \psi < 1$.

BILLS AND KLENOW (2000):Generating data I

Consider the present model. We know (see slides for HC intro) that competitive markets and $h = e^{f(s)}$ implies:

$$\ln w_{ji} = \lambda_0 + f\left(s_{ij}\right)$$

(since $\ln h = f(s) + \exp$). Now, suppose we linearize $f\left(s_{ij}\right)$ around the average level (1 order) $f\left(s_{ij}\right) \approx f\left(\bar{s}_j\right) + f'\left(\bar{s}_j\right)\left(s_{ij} - \bar{s}\right)$.

Substituted back into the equation above

$$\ln w_{ji} = \lambda_0 + f\left(\bar{s}_j\right) + f'\left(\bar{s}_j\right)\bar{s} + f'\left(\bar{s}_j\right)s_{ij} \equiv \lambda_0 + \lambda_{1j}s_{ij}.$$

The neat thing is that, in theory we'll have $\lambda_{1j} = f'\left(\bar{s}_j\right) = \theta\bar{s}_j^{-\psi}$. Since we have data for λ_{1j} for a bunch of countries we may run the regression

$$\ln \lambda_{1j} = \ln\theta - \psi\ln\bar{s}_j,$$

and thus calibrate the human capital production function and get $h_j(t)$

BILLS AND KLENOW (2000):Results I, HC–>growth.

TABLE 2—GROWTH IN HUMAN CAPITAL REGRESSED ON SCHOOLING

		Schooling 1960 (Enrollment rates)	$\bar{R}^2$	Mean g_h
$\psi = 0.58$	$\phi = 0$	−0.100 percent (0.015)	0.35	1.39 percent
	$\phi = 0.19$	−0.091 (0.015)	0.29	1.60
$\psi = 0.28$	$\phi = 0$	−0.007 (0.011)	−0.01	1.11
	$\phi = ⅓$	0.029 (0.012)	0.06	1.43
	$\phi = 0.46$	0.054 (0.012)	0.19	1.60
$\psi = 0$	$\phi = 0$	0.048 (0.009)	0.23	0.94
	$\phi = ⅓$	0.087 (0.009)	0.50	1.18
	$\phi = 0.67$	0.171 (0.009)	0.80	1.60

Notes: The dependent variable is the average annual growth rate of human capital from 1960 to 1990. $1 - \psi$ and ϕ are the respective exponents on years of schooling and teacher human capital in the human-capital production function. The number of countries in the sample equals 85. For these 85 countries, the regression for growth in human capital plus technology [Table 1, col. (2)] is: $g_h + g_A = \underset{(0.054)}{0.238}\, S_{60}$, $\bar{R}^2 = 0.18$.

Figure 1:

BILLS AND KLENOW (2000):Generating data II

What about the other potential direction? Growth –> Schooling. Representative agent framework, to get calibrated levels of schooling, $\bar{s}_j$. Start by solving the optimal schooling decision. The problem is to:

$$\left(\{c\}_{t=0}^{T}, s\right) = \arg\max \int_0^T \ln c_t e^{-\rho t} dt - \underbrace{\frac{\xi}{\rho} e^{-\rho s}}_{\text{utility from attending school}}$$

Subject to:

$$\int_s^T e^{-rt} w(t)\, h(t)\, dt \geq \int_0^T e^{-rt} c(t)\, dt + \underbrace{\mu \int_0^s w(t)\, h(t)\, e^{-rt} dt}_{\text{tuition}}$$

and

$$h(t) = E_t e^{f(s)+g(t-s)} \text{ for all } t > s.$$

BILLS AND KLENOW (2000):Generating data II

You can show (download notes) the first order condition for s satisfies

$$(1+\mu) = \xi\left[\frac{c(s)}{w(s)\,h(s)}\right] + \int_s^T \left[f'(s) - g'(t-s)\right] e^{-r(t-s)} \frac{w(t)\,h(t)}{w(s)\,h(s)} dt$$

B&K describe how to operationalize this formular (i.e. back out a $\bar{s}_j$, using outside estimates for ξ,μ etc).

With data on s_j's in hand they examine the impact of expected g_{60-90} on schooling!

Expectation is a weigtned average of own *ex post* growth, and the world average.

BILLS AND KLENOW (2000):Results II.

TABLE 5—CALIBRATED REVERSE CAUSALITY CHANNEL

		(1) Expected growth $= \frac{1}{4} g_{Aj} + \frac{3}{4} g_{A\text{avg}}$	(2) Expected growth $= \frac{1}{3} g_{Aj} + \frac{2}{3} g_{A\text{avg}}$	(3) Expected growth $= \frac{1}{2} g_{Aj} + \frac{1}{2} g_{A\text{avg}}$
$\psi = 0.58$	No wealth effect ($\zeta = 0$)	0.101 percent	0.135 percent	0.201 percent
	With a wealth effect ($\zeta > 0$)	0.119	0.151	0.214
$\psi = 0.28$	No wealth effect ($\zeta = 0$)	0.208	0.276	0.406
	With a wealth effect ($\zeta > 0$)	0.227	0.293	0.420

Notes: Dependent variable: Average annual 1960–1990 growth rate of A.

Right-hand-side variables: 1960 schooling predicted by the model. Schooling s predicted by the model solves $1 + \mu = \zeta(\text{annuity}) + \int_s^T e^{(g_A + \gamma_1 + \gamma_2(a-s) - r)(a-s)}[\theta s^{-\psi} - \gamma_1 - 2\gamma_2(a - s)]\, da$.

$1 - \psi$ = the exponent on years of schooling in human-capital production.

Other parameter values: $\theta = 0.323$ or 0.176, depending on ψ (so that Mincerian return averages 9.9 percent average across 56 countries).

$\gamma_1 = 0.0512$, $\gamma_2 = -0.00071$ (average coefficients in Mincerian returns to experience across 52 countries).

$\mu = 0.5$ (student-paid instruction costs relative to the opportunity cost of student time).

$r = 0.093$ to 0.105 (ensures predicted 1960 schooling matches the actual average of 6.2 for 93 countries).

$T = 54.5$ (average life expectancy 60.5 from Barro and Lee [1993] minus the six years before school).

ζ = (value which generates an income elasticity of schooling of 0.20 as in Haveman and Wolfe, 1995).

$g_{A\text{avg}} = 0.0151$ = the average growth rate across the 93 countries from 1960–1990.

Coefficients are scaled by the variance of predicted schooling relative to the variance of 1960 schooling.

Figure 2:

BILLS AND KLENOW (2000): Bottom Line

Schooling does seem to matter for growth.

But **the bulk** of the observed correlation between enrollment rates and growth is likely due to reverse causality! Policy implications?

A few remarks

Very forward looking agents (representative). Creditmarket imperfections? Uncertainty?

Quality? Lucas' framwork is explicitly build on a "quality" notion of human capital. How much does quality matter?

HENDRICKS (2002)

The basic idea. Suppose you have the following production function in country c: $Y_c = F(K_c, A_c N_c) = K_c^{\theta} (A_c H_c)^{1-\theta}$. The human capital stock is given by

$$H_c = e^{f(s)+g(a-s)} \eta_c N_c$$

where s is (average) schooling, a is age, η_c is efficiency units of human capital in country c (or, its quality), while N_c is the number of workers in country c. Observe the new part: η_c, and that it likely distorts our TFP (/A) estimates, since

$$TFP_c = \frac{Y_c}{K_c^{\theta} \left[e^{f(s)+g(a-s)} N_c \right]^{1-\theta}} = A_c^{1-\theta} \eta_c.$$

So getting at η_c would be very useful. Potentially, A_c differences are not needed at all! Problem: seems indistinguishable from A_c

HENDRICKS (2002)

Second thought .. maybe not indistinguishable. If people of very different "quality" participate in the same labor market (work with same K, A and with the same experience), then η_c could be determined as a residual.

Data on Immigrants in US labor market.

Consider competitive markets. We know then, given the production function above that

$$w_c = (1-\theta)\,\kappa_c^{\frac{\theta}{1-\theta}} A_c e^{f(s_c)+g(a_c-s_c)} \eta_c$$

Since $Y = K^{\theta}(AH)^{1-\theta} \Leftrightarrow Y/N = \left(\frac{K}{Y}\right)^{\frac{\theta}{1-\theta}} A\left(\frac{H}{N}\right), F_N' = (1-\theta)\,Y/N$

, and where we have defined $\kappa \equiv K/Y$.

HENDRICKS (2002)

Now, suppose we normalize $\eta_c = 1$ in some reference country, the US. Then observed differences in wage income between country c and the US decomposes into

$$\frac{w_c}{w_{us}} = \left(\frac{\kappa_c}{\kappa_{us}}\right)^{\frac{\theta}{1-\theta}} \frac{A_c}{A_{us}} e^{f(s_c)-f(s_{us})+g(a_c-s_c)-g(a_{us}-s_c)} \eta_c$$

Consider the wage of an individual from country c, *who is working in the US*, relative to the wage of a US worker with similar years of schooling and experience. The difference:

$$\frac{\text{wage of immigrant from country c}}{\text{wage of native born US citizen}} = \frac{\kappa_{US}^{\frac{\theta}{1-\theta}} A_{US} e^{f(s)+g(a-s)} \eta_c}{\kappa_{US}^{\frac{\theta}{1-\theta}} A_{US} e^{f(s)+g(a-s)}} = \eta_c$$

i.e. relative quality!

HENDRICKS (2002)

With estimates of η_c in hand, we may proceed to examine whether these differences are important in accounting for difference in income per capita/wages.

First calculate US A level, and use that for all countries (so "H_0" is that η_c is all that matters). We also put $\eta_{US} = 1$, so all η_c is measured *relative* to US. Hence use

$$TFP_{US} = \frac{Y_{US}}{K_{US}^{\theta}\left[e^{f(s_{US})+g(a_{US}-s_{US})}N_{US}\right]^{1-\theta}} = A_{US}^{1-\theta}.$$

"As usual", $\theta = 0.3$.

HENDRICKS (2002)

Next, calculate the counterfactual wage in source country using calculated η_c and observed values for κ_c etc, *but* US A :

$$w_c^{\eta} = (1-\theta)\,\kappa_c^{\frac{\theta}{1-\theta}} e^{f(s_c)+g(a_c-s_c)} A_{US}\eta_c$$

Now, ideally the ratio

$$\frac{w_c^{\eta}}{w_{US}} \approx \frac{w_c^{\text{observed}}}{w_{US}}.$$

Unfortunately its not. It turns out there is a large residual. Looking at table 1, $\frac{w_c^{\eta}}{w_{US}}$ is typically *much* larger than $\frac{w_c^{\text{observed}}}{w_{US}}$ (assuming same A, but allowing different η leads you to overestimating wages in source countries), implying that *quality* differences can only account for a relatively small part of the observed wage differences, it seems.

HENDRICKS (2002)

Problem: Self selection (only the smart and pretty people go to the States). Suppose the observed quality of an immigrant is

$$\eta_c = \sigma_c \tilde{\eta}_c$$

where $\tilde{\eta}_c$ is the "typical" quality of citizens. σ_c is a self selection paramter. Average source country wages are theoretically (assuming A is the same)

$$w_c \equiv (1-\theta)\, \kappa_c^{\frac{\theta}{1-\theta}} A_{US} e^{f(s_c)+g(a_c-s_c)} \tilde{\eta}_c$$

while the *calcuated* source country wage, assuming US technology (where quality is calculated using US labor market data – so identifying $\eta_c = s_c \tilde{\eta}_c$)

$$w_c^{\eta} \equiv (1-\theta)\, \kappa_c^{\frac{\theta}{1-\theta}} A_{US} e^{f(s_c)+g(a_c-s_c)} s_c \tilde{\eta}_c.$$

HENDRICKS (2002)

The ratio

$$\frac{w_c^\eta}{w_c} \equiv \frac{(1-\theta)\,\kappa_c^{\frac{\theta}{1-\theta}} A_c e^{f(s_c)+g(a_c-s_c)} s_c \tilde{\eta}_c}{(1-\theta)\,\kappa_c^{\frac{\theta}{1-\theta}} A_c e^{f(s_c)+g(a_c-s_c)} \tilde{\eta}_c} = s_c$$

s_c represents *the amount of self selection needed to fully account for productivity difference.*

Interpreted as the wage of the immigrant, relative to the mean, in the *source* country. How big is this thing?

HENDRICKS (2002)

Well ... big.

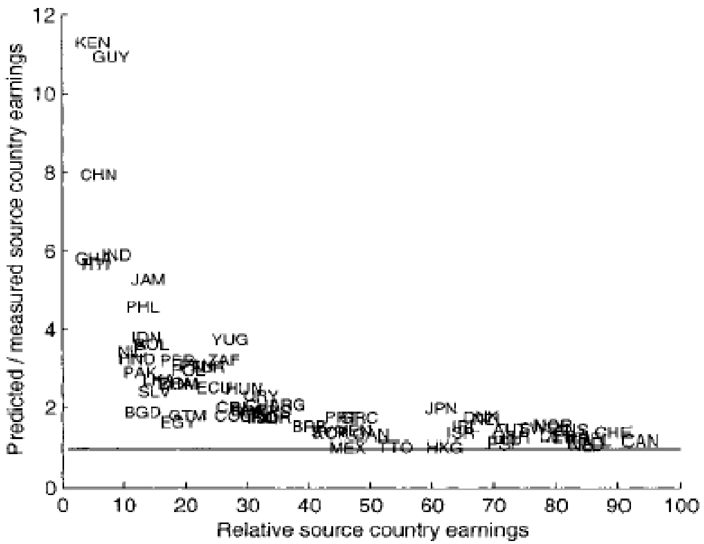

FIGURE 2. RATIO OF PREDICTED TO MEASURED SOURCE COUNTRY EARNINGS

Figure 3:

Shows w_c^η / w_c vs w_c / w_{US}.

HENDRICKS (2002)

Another perspective

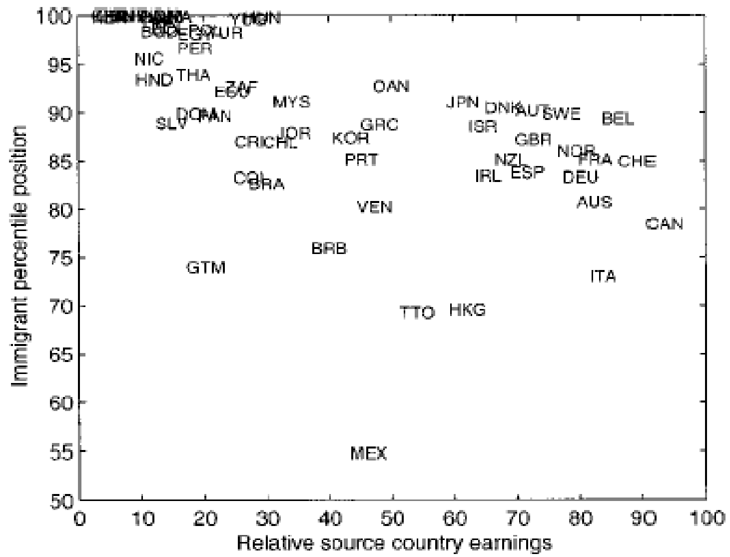

Figure 4:

In some cases they would belong to top 0.001 of the source country wage distribution. He cites evidence that suggest that return migrants do not earn that much more (if anything) compated to people who never migrated.

HENDRICKS (2002): Bottom line

From previous levels-accounting exercises, we know that human capital *quantity* does not account for the lions share of observed differences in Y/L (Caselli, 2004). This is not causality (which may be only – in a relative sense – weakly running from HC to growth anyway).

This paper attacks a weak spot; *Quality*. However, in the end the basic proposition that “A" accounts for the bulk of observed variation in Y/L is sustained.