

# Lecture 3: Productivity and Human Capital in Developing Countries.

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# Human Capital and Productivity: A measurement Issue

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## Consensus that education and skills are essential for growth

- ▶ Output comes from a combination of capital and productive labor
- ▶ Human capital makes labor more productive
- ▶ Wages are equal to the marginal product of labor in an efficient market

## Measurement of human capital effects key for policy tradeoffs

- ▶ ROI on education realized in the long-term vs salient infrastructure projects more palatable to politicians.
- ▶ Bias for IO funding of education infrastructure (school) rather than educational capital (teachers)
- ▶ "More money in education not necessarily the answer"

# Human Capital

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## Stock of productivity-enhancing attributes embedded in people

- ▶ Multi-dimensional stock:
  - ▶ Knowledge, skills, habits, health, ...
- ▶ Produced by investments:
  - ▶ Education, training, practice, exercise, ...

## Brought to the forefront of economics in the late 1950s and early 1960s

- ▶ Especially Becker (1964), Mincer (1974), and Ben-Porath (1967).

# Two Goals for Today

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## Measure cross-country differences in stock of human capital

- ▶ Large relative to early consensus, cross-country income differences
- ▶ Note: only indirectly use the excellent literature on within-country human capital

## Illustrate key model mechanisms literature has used to think about these differences

- ▶ Build out from Becker (1964) and Ben-Porath (1967).
- ▶ Three mechanisms at work.

# Challenge

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**Thought experiment: what explains productivity differences among workers within a country?**

- ▶ Goal: enumerate and quantify the characteristics embedded in people
- ▶ Separate from environmental factors

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## **Thought experiment: what explains productivity differences among workers within a country?**

- ▶ Goal: enumerate and quantify the characteristics embedded in people
- ▶ Separate from environmental factors

## **Complications grow when investigating cross-country differences**

- ▶ Set of relevant characteristics is larger
- ▶ Greater differences in confounding, environmental factors

# Measurement of Human Capital Differences

# Production Function & Development Accounting

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## Assumption 1: Aggregate Production Function

$$Y_c = K_c^\alpha (A_c H_c)^{1-\alpha}$$
$$y_c = \underbrace{\left(\frac{K_c}{Y_c}\right)^{\frac{\alpha}{1-\alpha}} A_c}_{\equiv z_c} \underbrace{\frac{H_c}{L_c}}_{\equiv h_c}$$

## Development Accounting Equation

$$\underbrace{\log(y_c)}_{\text{PPP GDP p.w.}} = \underbrace{\log(z_c)}_{\text{capital-output \& TFP}} + \underbrace{\log(h_c)}_{\text{human capital p.w.}}$$

## Challenge: how to measure $h_c$ ?

- Probably not regressions (e.g., Mankiw, 1995)



# Key Assumptions

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Two assumptions allow substantial progress (Bils and Klenow, 2000)

- 1 Perfect substitution among labor types (efficiency units)
- 2 Competitive labor markets

Allow us to use firm's FOC to characterize demand for workers with  $h_i$  units of human capital:

$$\begin{aligned}w_{i,c} &= MPL_{i,c} \\w_{i,c} &= (1 - \alpha) \left( \frac{K_c}{Y_c} \right)^{\frac{\alpha}{1-\alpha}} A_c h_i \\ &= (1 - \alpha) z_c h_i\end{aligned}$$

# Connection to Micro-Labor Literature

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This first-order condition implies a log-linear wage equation:

$$\log(w_{i,c}) = \underbrace{\log([1 - \alpha]z_c)}_{\text{country effect}} + \underbrace{\log(h_i)}_{\text{worker human capital}}$$

Connects with a large micro-labor literature that estimates Mincer wage equations within a country:

$$\log(w_i) = \beta_0 + \beta_1 s_i + \beta_2 e_i + \beta_3 e_i^2 + \varepsilon_i$$

Connection between the two:

- ▶ The intercept  $\beta_0$  captures country-specific.
- ▶ Other variables such as  $s$  and  $e$  are dimensions/proxies of  $h$
- ▶  $\beta_1 - \beta_3$  capture the value of those dimensions

# Constructive Approach to Measuring Human Capital Stocks

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## Four steps:

- ① Select dimensions (attributes, proxies) of human capital to be measured
- ② Measure each nation's stock along relevant dimensions
- ③ Evidence from Mincer wage equations is informative about value
- ④ Aggregate human capital



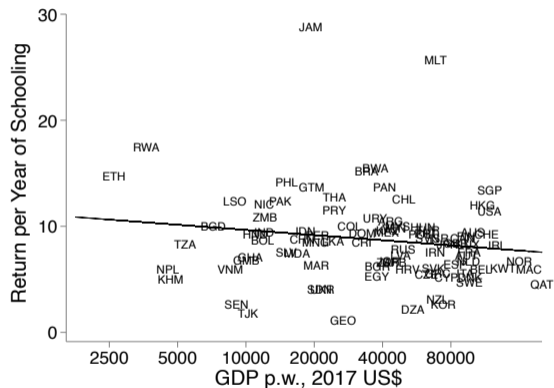
# Valuing Years of Schooling

## Literature: wages are log-linear in schooling

- ▷ U.S. return to schooling is 8–10%

## Some evidence this is breaking down

- ▷ Lemieux (2006)



(Caselli et al., 2016)

# Classic Estimate of Human Capital

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**Data description: large differences in years of schooling, common worldwide return of 8–10%.**

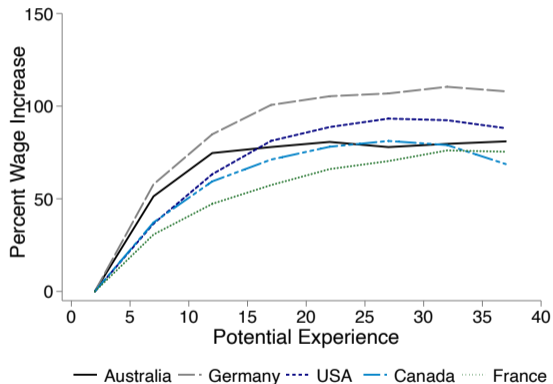
- ▶ Builds on earlier work of Psacharopoulos (1994), Psacharopoulos and Patrinos (2004)
- ▶ Weak or no evidence of diminishing returns (Banerjee and Duflo, 2005)
- ▶ See also new work with consistent, internal estimates (Jedwab et al., 2020; Rossi, 2020).

**Construct human capital as  $\log(h_c) = 0.1s_c$ .**

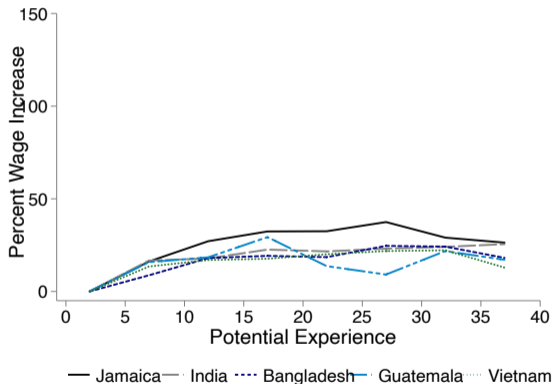
- ▶  $\frac{h_{90}}{h_{10}} = 2.1$ ;  $\frac{y_{90}}{y_{10}} = 18.9$ .
- ▶  $\frac{h_{90}/h_{10}}{y_{90}/y_{10}} = 10.9\%$ .
- ▶  $\frac{\text{cov}(\log(h), \log(y))}{\text{var}(\log(y))} = 18.6\%$

# Level of Experience is Similar, but Returns Vary

Potential experience = years since graduation =  $age - schooling - 6$ .



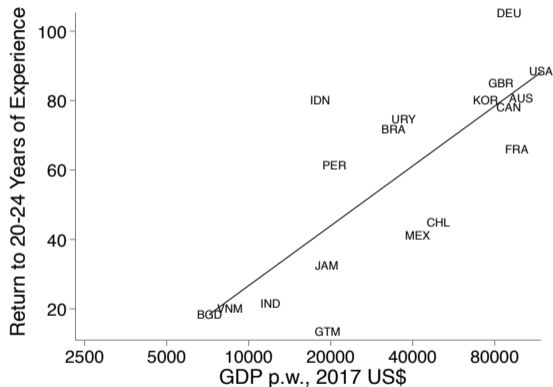
Profiles, Select Rich Countries



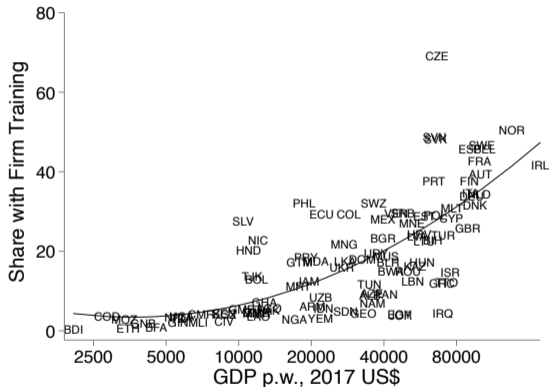
Profiles, Select Poor Countries

(Lagakos et al., 2018b)

# Returns to Experience, Training, and Development



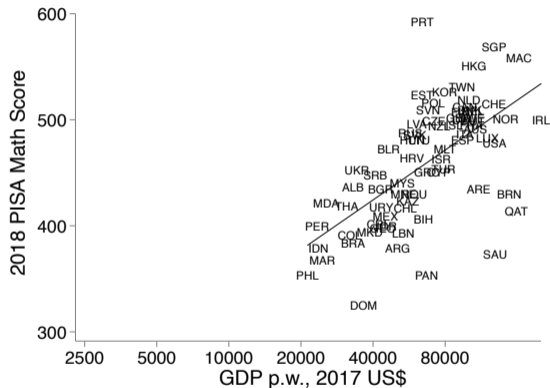
Returns to Experience and Development  
(Lagakos et al., 2018b)



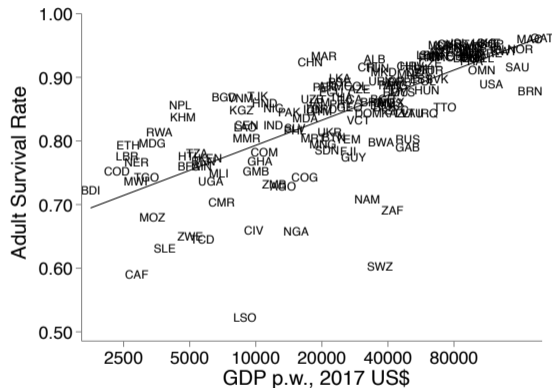
Training and Development  
(Ma et al., 2020)



# Education Quality & Health



2018 PISA Math Scores and Development  
(OECD PISA 2018 Database, 2018)



2018 Adult Survival Rate and Development  
(World Bank, 2020)

# Total Constructed Human Capital

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**Cumulating, one step at a time,  $\frac{\text{cov}(\log(h), \log(y))}{\text{var} \log(y)}$  metric:**

- ▷ Years of schooling: 19%
- ▷ Years + quality of schooling: 38%
- ▷ Total schooling + experience: 56%
- ▷ Total schooling + experience + health: 59%

## See also:

- ▷ Experience: Lagakos et al. (2018a); Jedwab et al. (2020)
- ▷ Education quality: Schoellman (2012); Hanushek and Woessmann (2012); Kaarsen (2014).
- ▷ Health: Weil (2007)

# Summary

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## **First approach to cross-country human capital differences is to construct it, piece by piece**

- ▶ Accounts for differences in stocks or (perhaps) returns
- ▶ Resulting estimates are large, account for perhaps 60 percent of income differences

## **Some concerns:**

- ▶ Necessary assumptions (see e.g. Jones, 2014).
- ▶ It is hard to be exhaustive
- ▶ May be double-counting

# Deductive Approach

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**Human capital is, by definition, embedded in people.**

- ▶ Migrants carry their human capital to new countries
- ▶ Their outcomes allow us to deduce the importance of human capital

**Recall that under the maintained assumptions, wages are given by:**

$$\log(w_{i,c}) = \log([1 - \alpha]z_c) + \log(h_i)$$

**Trade-off: two additional concerns that need to be addressed**

- ▶ Migrants are not randomly chosen (selection)
- ▶ Migrants' human capital may not be the same (skill loss, discrimination)

# Wage Gains at Migration

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Wage gains for worker who migrates from  $c$  to  $c'$  is:

$$\log(w_{i,c'}) - \log(w_{i,c}) = \log(z_{c'}) - \log(z_c)$$

Change in  $z_c$  is one part of development accounting puzzle

$$\log(y_c) = \log(z_c) + \log(h_c)$$

**Intuition: suppose worker migrates from poor to 10× richer country**

- ▶ Wages increase 10×? Country ( $z_c$ ) explains low wages
- ▶ Wages don't change? Low human capital explains low wages
- ▶ Selection, skill loss?
- ▶ Alternatives: Hendricks (2002); Schoellman (2012); De Philippis and Rossi (forthcoming)

# Implementation

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**Needed: data on pre- and post-migration wages. Two sources (Hendricks and Schoellman, 2018).**

- ① New Immigrant Survey: sample of adult LPR recipients to the US, May–November 2003
- ② Migration Projects: sample of communities in Mexico and Latin America with high migration rates

## **Wages converted to PPP**

- Compare real wage gains to gap in real GDP per worker

## **Large set of covariates**

- Demographics, education, occupation, industry, visa status

# Human Capital and Development Accounting

Group	Hourly Wage		Development Accounting			
	Pre-Mig.	Post-Mig.	Wage Gain	GDP Gap	<i>h</i> share	95% C.I.
<b>Panel A: NIS Sample by GDP per worker category</b>						
< 1/16	\$2.82	\$8.91	3.2	31.8	0.66	(0.60, 0.73)
1/16 – 1/8	\$4.19	\$11.83	2.8	11.9	0.58	(0.54, 0.62)
1/8 – 1/4	\$4.95	\$9.48	1.9	5.6	0.63	(0.55, 0.71)
1/4 – 1/2	\$5.05	\$9.11	1.8	3.0	0.48	(0.34, 0.62)
1/2 – 1	\$12.64	\$15.18	1.2	1.3	0.48	(-0.23, 1.19)
<b>Panel B: MP Sample by Subsample</b>						
Latin Am. MP	\$4.84	\$7.05	1.5	7.0	0.79	(0.71, 0.87)
Mexican MP	\$2.96	\$6.04	2.0	2.9	0.33	(0.29, 0.37)

**Pool poor countries (<1/4 US GDP p.w.) in NIS: 62%**

- ▶ Range of adjustments for skill loss: 50–60%

# Summary of Measurement

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## Deductive approach: strengths and weaknesses

- ▶ Exhaustive, but not constructive
- ▶ Avoids double counting
- ▶ Requires additional assumptions about migrants

## Quantitatively similar results

- ▶ Human capital accounts for 50–60% of income differences

## Still room to explore

- ▶ Parenting & early childhood (Schoellman, 2016; De Philippis and Rossi, forthcoming)
- ▶ Culture (Ek, 2020)
- ▶ Specific skills (Hjort et al., 2021)



# Models of Human Capital Differences

# Goal for Model Section

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## **Illustrate mechanisms that can help explain large human capital differences**

- ▶ Why do people in some countries invest much more?
- ▶ Benchmark model that delivers no differences (Becker, 1964; Ben-Porath, 1967)
- ▶ Three mechanisms that deliver differences

## **Quantitative modeling as a measurement device**

- ▶ Models can be calibrated or estimated using cross-country, cross-sectional data
- ▶ Ask: how important are mechanisms, human capital?

# Model: Firm(s)

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**Firm(s): same as above. Operates the aggregate technology:**

$$Y_c = K_c^\alpha (A_c H_c)^{1-\alpha}$$

**Maintain same two key assumptions:**

- ① Perfect substitution among labor types (efficiency units)
- ② Competitive labor markets (workers paid marginal product)

**Yields simple expression for wages:**

$$w_{i,c} = (1 - \alpha) z_c h_i$$

# Benchmark Model: Simple School Choice

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Consumer lives for one unit of time. They maximize utility:

$$\int_0^1 \log(c(t)) dt$$

They divide their unit of time between school and work

- ▶ Attend school for length of time  $s$
- ▶ Schooling yields human capital  $h(s)$
- ▶ Work with  $h(s)$  for the remaining  $1 - s$

Budget constraint:

$$\int_0^1 c(t) dt = \mathbb{I} = (1 - \alpha)z_c h(s)(1 - s)$$

# Two Results for Benchmark Model

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Workers smooth consumption throughout the period

$$c(t) = c = \bar{c}$$

Optimal school choice maximizes income. FOC:

$$\underbrace{(1 - \alpha)z_c(1 - s)h'(s)}_{\text{marginal benefit of extra } s} = \underbrace{(1 - \alpha)z_c h(s)}_{\text{marginal cost of extra } s}$$

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Simplify to find that optimal school choice is independent of  $z_c$  (Becker neutrality)

$$h'(s)(1 - s) = h(s)$$

# Mechanism 1: Borrowing Constraints

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## Model assumes worker consumes while in school, before earning

- ▷  $s\bar{I}$  units of consumption, in total
- ▷ Possibly direct costs of education as well

## Limits on ability of children and families to finance this investment (Becker and Tomes, 1986):

- 1 Credit markets are imperfect
- 2 Children cannot enter binding contracts
- 3 Altruism may not be perfect
- 4 Parents cannot pass on debt to their children

Variation in mechanisms to address these limits may help explain human capital investment

## Mechanism 2: Goods Inputs to Human Capital Production

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Use time and goods to invest in human capital (Manuelli and Seshadri, 2014). New budget constraint:

$$\int_0^1 c(t)dt + e = \mathbb{I} = (1 - \alpha)z_c h(s, e)(1 - s)$$

Specialize to the power human capital production function:

$$h(s, e) = s^\eta e^\gamma$$

Solve for the elasticities (Erosa et al., 2010):

$$\varepsilon_{s,z} = 0$$

$$\varepsilon_{e,z} = \frac{1}{1 - \gamma}$$

$$\varepsilon_{h,z} = \frac{\gamma}{1 - \gamma}$$



# Mechanism 3: Complementary Role for Government

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Allow for government expenditures into education  $g$ . Three channels:

- ①  $h(s, e + g) = s^\eta(e + g)^\gamma$ : matters if  $g$  exceeds privately optimal level of  $e$ .
- ②  $h(s, e, g)$ : raises the marginal product of schooling and/or expenditures
  - ▷ E.g.,  $h(s, e, g) = gs^\eta e^\gamma$  implies that  $e$  (but not  $s$ ) responds to  $g$
- ③ Alleviates borrowing constraints

# Putting the Features to Work

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## Three papers put variations of these ideas to work

- ▷ (Plus some extra features..)
- ▷ Discipline the model to fit facts shown in the constructive method section
  - ▷ Time spent in school, return to schooling, life-cycle wage growth..

## These models generate differences in school attainment and human capital quality:

- ▷ Córdoba and Ripoll (2013): human capital quality varies by a factor  $\approx 2.5\times$
- ▷ Manuelli and Seshadri (2014): human capital quality varies by a factor of  $\approx 5\times$ .
- ▷ Erosa et al. (2010): human capital, TFP approximately equally important

# Other Model Ideas

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## Other mechanisms

- ① Quantity-quality tradeoff (Córdoba and Ripoll, 2013; Manuelli and Seshadri, 2014)
- ② Life expectancy (Córdoba and Ripoll, 2013; Manuelli and Seshadri, 2014)
- ③ Skill-biased technical change (Goldin and Katz, 2008)
- ④ Structural change (Buera et al., 2018)
- ⑤ ...

# Conclusion: Two Main Ideas

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## **Measurement: human capital varies substantially across countries**

- ▶ Constructive & deductive approaches: 50–60% of income differences

## **Model: we have mechanisms to help generate such differences**

- ▶ Deviate from classic, simple school choice model
- ▶ Borrowing constraints, goods investments, public education, ..

# Extra Slides

# Wage Equation (Derivation #1)

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Firm hires  $H_c$  units of human capital at a wage per unit of human capital  $\omega_c$

$$\max_{K_c, H_c} K_c^\alpha (A_c H_c)^{1-\alpha} - r_c K_c - \omega_c H_c$$

FOC for human capital sets the price per unit of human capital:

$$\begin{aligned}\omega_c &= (1 - \alpha) \frac{K_c (A_c H_c)^{1-\alpha}}{H_c} \\ &= (1 - \alpha) \frac{K_c (A_c H_c)^{1-\alpha}}{L_c} \frac{1}{h_c} \\ &= (1 - \alpha) \left( \frac{K_c}{Y_c} \right)^{\frac{\alpha}{1-\alpha}} A_c \\ &= (1 - \alpha) z_c\end{aligned}$$

Worker who supplies  $h_{i,c}$  units of human capital earns observed wage  $w_{i,c}$ :

$$\begin{aligned}w_{i,c} &= \omega_c h_{i,c} \\ &= (1 - \alpha) z_c h_{i,c}\end{aligned}$$

## Wage Equation (Derivation #2)

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Firm chooses quantity  $N_{i,c}$  of workers with human capital  $h_{i,c}$  to hire at wage  $w_{i,c}$ :

$$\max_{K_c, N_{i,c}} K_c^\alpha \left( A_c \sum_i N_{i,c} h_{i,c} \right)^{1-\alpha} - r_c K_c - \sum_i w_{i,c} N_{i,c}$$

FOC for type  $i$  labor sets the wage:

$$\begin{aligned} w_{i,c} &= (1 - \alpha) K_c^\alpha \left( A_c \sum_i N_{i,c} h_{i,c} \right)^{-\alpha} A_c h_{i,c} \\ &= (1 - \alpha) \frac{K_c^\alpha (A_c \sum_i N_{i,c} h_{i,c})^{1-\alpha}}{L_c} \frac{L_c}{H_c} h_{i,c} \\ &= (1 - \alpha) \left( \frac{K_c}{Y_c} \right)^{\frac{\alpha}{1-\alpha}} A_c h_{i,c} \\ &= (1 - \alpha) z_c h_{i,c} \end{aligned}$$

# Elasticity Derivation

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Worker chooses schooling and expenditures to maximize income net of expenditures:

$$\max_{e,s} \quad \mathbb{I} - e = (1 - \alpha)z_c s^\eta e^\gamma (1 - s)$$

First-order conditions:

$$s : (1 - \alpha)z_c \eta s^{\eta-1} e^\gamma (1 - s) = (1 - \alpha)z_c s^\eta e^\gamma$$

$$e : (1 - \alpha)z_c s^\eta \gamma e^{\gamma-1} (1 - s) = 1$$

Re-arrange to yield expressions for  $s$ , then  $e$ , then  $h$  in turn:

$$s^* = \frac{\eta}{1 + \eta}$$

$$e^* = \left[ (1 - \alpha) \frac{\eta^\eta}{(1 + \eta)^{1+\eta}} \right]^{\frac{1}{1-\gamma}} z_c^{\frac{1}{1-\gamma}}$$

$$h^* = \left[ (1 - \alpha) \frac{\eta^\eta}{(1 + \eta)^{1+\eta}} \right]^{\frac{\gamma}{1-\gamma}} z_c^{\frac{\gamma}{1-\gamma}} \left( \frac{\eta}{1 + \eta} \right)^\eta$$



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