Growth and Development:

Development Accounting

Jonathan Colmer

University of Virginia

Lecture Notes for PhD Growth and Development (EC8510)

Question

- Why are some countries rich and some countries poor?
- Is it because richer countries:
  - employ more labor?
  - have better educated workers?
  - have more physical capital?
  - do more with the same inputs?

Development Accounting: Recent Consensus

- Disparities in capital and labor account for at most 50-60% of the differences in income per capita
  - Better use of inputs may feedback into input accumulation, e.g., misallocation, frictions
  - Heterogeneity: accounting at the aggregate, sector, firm level?
  - Measurement error?

The Aggregate Production Function

- Production function

$$Y_t = A_t K_t^{\alpha} (L_t h_t)^{1-\alpha}$$

where Y_t = output, K_t = physical capital, L_t = number of workers, h_t = human capital per worker, α = capital share

- Estimate?

$$\ln(Y_t) = \underbrace{\alpha}_{\beta_k} \ln(K_t) + \underbrace{(1-\alpha)}_{\beta_H} \ln\underbrace{(H_t)}_{L_t h_t} + \underbrace{\ln(A_t)}_{\epsilon}$$

- What assumptions are we making?

Development Accounting Framework

- Important take-away from the one-sector growth model:
  - Differences in TFP induce differences in K
  - But $\frac{K}{Y}$ is independent from TFP in steady state.
- Euler equation:

$$1 = \beta[\underbrace{\alpha \frac{Y}{K}}_{\text{MPK}} + (1 - \delta)]$$

- Provides structure for looking at the data and doing the accounting.
  - Focusing on $\frac{Y}{K}$ kills the relationship between A and K.

Development Accounting Framework

$$\begin{aligned}
\frac{Y}{Y^{\alpha}} &= A\left(\frac{K}{Y}\right)^{\alpha} H^{1-\alpha} \\
Y &= A^{\frac{1}{1-\alpha}}\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} H \\
\frac{Y}{L} &= A^{\frac{1}{1-\alpha}}\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} \frac{H}{L}
\end{aligned}$$

In logs,

$$\ln\left(\frac{Y}{L}\right) = \ln(Z) + \frac{\alpha}{1-\alpha}\ln\left(\frac{K}{Y}\right) + \ln\left(\frac{H}{L}\right)$$

where $Z = A^{\frac{1}{1-\alpha}}$

Development Accounting Framework

- How much of the variation in income per worker is accounted for by variation in:
  - capital-output ratios?
  - human capital?
  - residual?

Data

- Penn World Tables!
- Go-to measure for income accounting.
- Measuring living standards vs. productive capacity?
- Substantial changes since version 8.0.
- Important to cite the data and record the vintage you are using.

Measurement is Complicated: Output, Y

- Nominal output comes from national accounts $\tilde{Y}$
- Real output: $Y = \tilde{Y}/P$
  - P? PPP vs. exchange rates.
  - Issues we discussed previously:
    - different baskets
    - different prices for the same goods
    - Balassa-Samuelson effect

Measurement is Complicated: Capital, K

- Current PWT considers different capital types
  - Machinery: computers, communication equipment
  - Transportation
  - Structures
  - Other assets: IPP, Software
- Productive capital vs. Natural Resources?
- Crude adjustment to GDP: subtract rents from natural resources (WDI)

Measurement is Complicated: Capital, K

- Physical Capital is constructed using the "perpetual inventory" method
- Stock i, e.g., trucks, computers, etc.

$$K_{i,t+1} = (1 - \delta)K_{i,t} + I_{i,t}$$

- The economy's stock,

$$K_t = \sum_i \omega_{i,t} K_{i,t}$$

- Need an initial value of K_0
  1) steady state of the Solow model, $K_{i,0} = \frac{I_{i,0}}{\delta_i + g}$
  2) calibrate: $\frac{p^k K}{p^Y Y}$ – Feenstra et al. (2015) argues it's stable across countries and time

Measurement is Complicated: Capital, K

$$K_t = \sum_i \omega_{i,t} K_{i,t}$$

- $\omega_{i,t}$? Two measures from PWT 9.1+
  - stocks: $\omega_{i,t} \equiv \frac{p_{i,t}K_{i,t}}{\sum_i p_{i,t}K_{i,t}}$
  - services: $\omega_{i,t} \equiv \frac{r_{i,t}K_{i,t}}{\sum_i r_{i,t}K_{i,t}}$ for r the rental rate.
- First approach overstates long-lived assets
- Rental rate comes from the "user cost of capital":

$$\begin{aligned} \tilde{p}_{it} R_t &= r_{it} + (1-\delta)\tilde{p}_{it+1} \\ r_{i,t} &= \tilde{p}_{i,t}[R_t - (1-\delta)\frac{\tilde{p}_{i,t+1}}{\tilde{p}_{i,t}} \end{aligned}$$

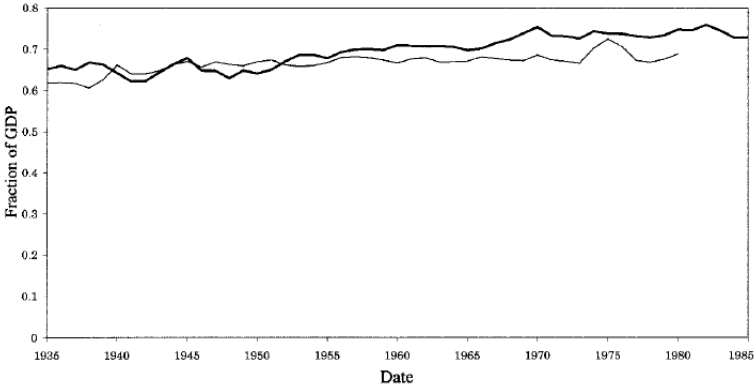
Measurement is Complicated: Capital Share α

- Capital share estimated as a residual from labor income/output
  - time-series: about a third (advanced economies)
  - cross-country data: massive differences.
- We tend to assume $\alpha = 1/3$ (Hall and Jones, 1996)
- Gollin (2002) need to account for self-employment.
  - Self-employment tends to be treated as capital income.

$$1 - \alpha = 0.65 - 0.8$$

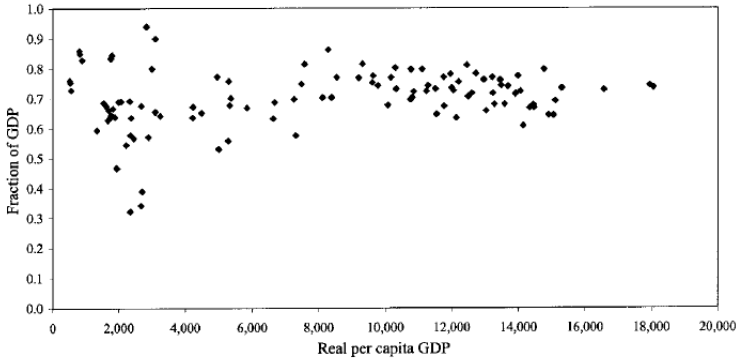
- Current PWT provides country-specific factor shares.
- Lots of variation!

Measurement is Complicated: Capital Share α



Source: Gollin (2002)

Measurement is Complicated: Capital Share α



Source: Gollin (2002)

Measurement is Complicated: Employment, L

- Employment vs. hours worked.
- Hours worked decrease with development (Bicks et al., 2018)

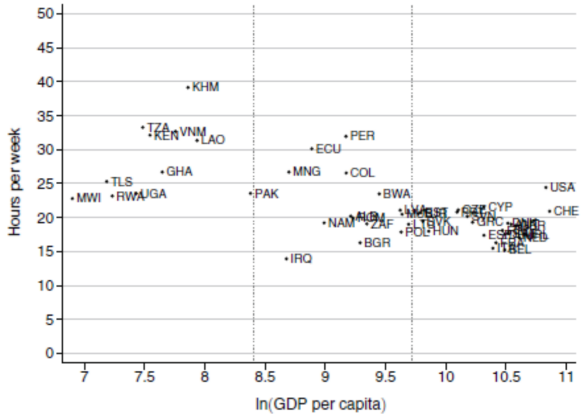


FIGURE 1. AVERAGE HOURS WORKED PER ADULT IN CORE COUNTRIES

Measurement is Complicated: Human Capital, h

- Human capital: "The knowledge, skills, health or values embodied in people that make them productive." – Gary Becker.

$$h_i = A^H \exp(\phi(s, a)$$

  - s is years of schooling
  - a is age (proxy for experience)
  - A^h quality of schooling (Bils & Klenow, 2009)

- What is the return to human capital?
  - assume $A^H = 1$
  - $\phi(s, a) = f(s) + g(a - s)$
  - Mincer (1974): $ln(w) = f(s) + g(a - s) = \theta_s + \gamma_1(a - s) + \gamma_2(a - s)^2$

Measurement is Complicated: Human Capital, h

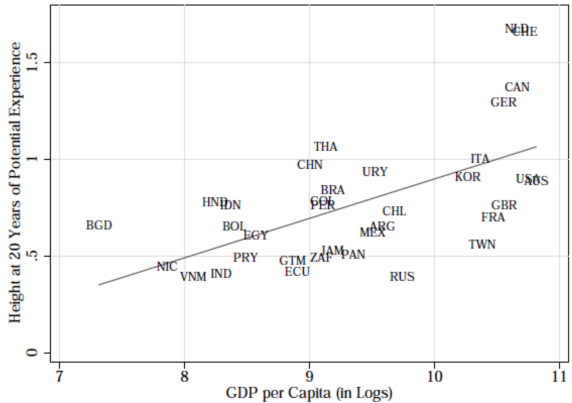
- PWT human capital measures are based on:
  - Educational attainment (Barro & Lee v2.2 and Cohen et al. (2014))
  - Piece-wise linear returns to education (Psacharopoulos,1994)

$$\phi(s) = \begin{array}{cc} 0.134s & \text{if } s \leq 4 \\ 0.134(4) + 0.101(s-4) & \text{if } 4 < s \leq 8 \\ 0.134(4) + 0.1014 + 0.068(s-8) & \text{if } s > 8 \end{array}$$

Measurement is Complicated: Human Capital, h

- Experience? (Lagakos et al., 2018
  - Experience profile is steeper for workers with higher s
  - Experience-wage profiles are twice as steep in rich countries than in poor countries.

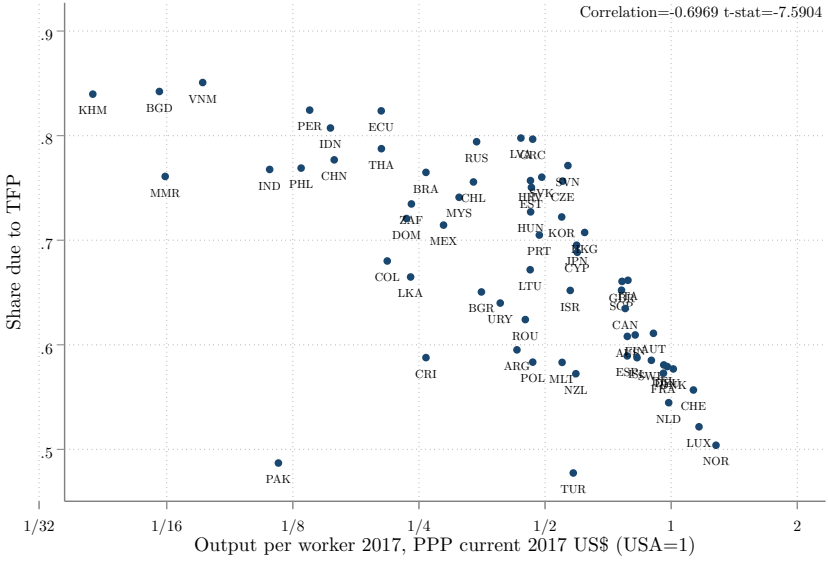
Figure 2: Returns to Experience vs. GDP per Capita – All Countries



Main Result, Development Accounting 2017

Country	$\frac{Y}{L}$	$\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}}$	$\frac{H}{L}$	Z	share due to TFP
Singapore	1.01	1.12	1.06	0.84	0.59
United States	1.00	1.00	1.00	1.00	
France	0.82	1.33	0.85	0.72	0.61
Germany	0.77	1.18	0.98	0.67	0.64
China, Hong Kong SAR	0.76	1.41	0.87	0.62	0.67
United Kingdom	0.72	1.21	1.01	0.59	0.67
Republic of Korea	0.63	1.21	0.99	0.52	0.69
Japan	0.59	1.22	0.96	0.50	0.70
Argentina	0.40	0.98	0.81	0.50	0.61
Mexico	0.35	1.16	0.73	0.41	0.67
Botswana	0.32	1.17	0.77	0.35	0.72
South Africa	0.30	1.08	0.75	0.37	0.69
Brazil	0.25	1.17	0.79	0.27	0.77
Thailand	0.24	1.18	0.73	0.28	0.76
China	0.19	1.04	0.71	0.26	0.74
Indonesia	0.18	1.30	0.62	0.22	0.79
India	0.13	1.06	0.57	0.22	0.73
Kenya	0.07	0.85	0.62	0.13	0.80
Malawi	0.02	0.61	0.52	0.06	0.84
Average	0.35	1.14	0.71	0.40	
1/Average	2.88	0.88	1.40	2.48	0.67

Main Result, Development Accounting 2017



Caselli (2005): Measuring the Variance of Cross-Country Income

- Goal: explain variance of income per capita across countries
  - Define $y_i^{KH} \equiv \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} \frac{H}{L}$
  - Caselli calls this the "factor-only model"
  - Output per-worker

$$y = Zy^{KH}$$

  - Variance-decomposition

$$var(lny) = var(lnZ) + var(lny^{KH}) + 2cov(lnZ, lny^{KH})$$

Caselli (2005): Measuring the Variance of Cross-Country Income

- How much of the variation in output per worker is accounted for by variation in factors of production?
  - Equivalent to variation when $Z = 1$ and $cov(lnZ, lny^{KH}) = 0$
  - Key measures of success from factor-only model,

$$success = \frac{Var[\log(y^{KH})]}{Var[\log(y)]}$$

  - Using 2017 data, success $= \frac{0.18}{0.65} = 0.27$

Sidebar: Sectoral Disparities

- Two sectors: agriculture, A, and non-agriculture, M.

$$y = P_A y_A l_A + P_M y_M l_M$$

- Main challenge: Need PPP deflators by sector (Duarte and Restuccia, 2010; Restuccia et al., 2008; Baily and Solow, 2001)

- How important is agriculture? (Caselli, 2005)

	log-variance
real output-per-worker	1.1
US y_A	0.04
US y_M	0.58
US l_A	0.3

Conclusions

- Differences in factors of production explain at most 50-60% of income differences across countries.
- Both differences in the accumulation of physical and human capital are important.
- However, the data suggests that inefficiencies may be more important.
  - Suggests we need theories of TFP differences across countries.
- Many caveats and room for future work.
  - Factor-biased technical change
  - Efficiency units and elasticities of substitution
  - Relative prices, sectors, and income differences