Development Accounting

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STEG Lecture

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Outline

1. Income differences across countries
2. The role of inputs (physical capital and human capital)
3. Sources of residual TFP differences
4. Welfare vs. GDP

Key citations

- Caselli (2005 Handbook of Economic Growth)
- Caselli and Feyrer (2007 Quarterly Journal of Economics)
- Restuccia and Rogerson (2008 Review of Economic Dynamics)
- Hsieh and Klenow (2009 Quarterly Journal of Economics)
- Hsieh and Klenow (2014 Quarterly Journal of Economics)
- Jones and Klenow (2016 American Economic Review)
- Jones (2016 Handbook of Macroeconomics)
- Boppart and Klenow (2024 Growth chapter in Grad Macro textbook)

PPP methodology

PPP GDP for country j based on the sum of expenditures across I goods:

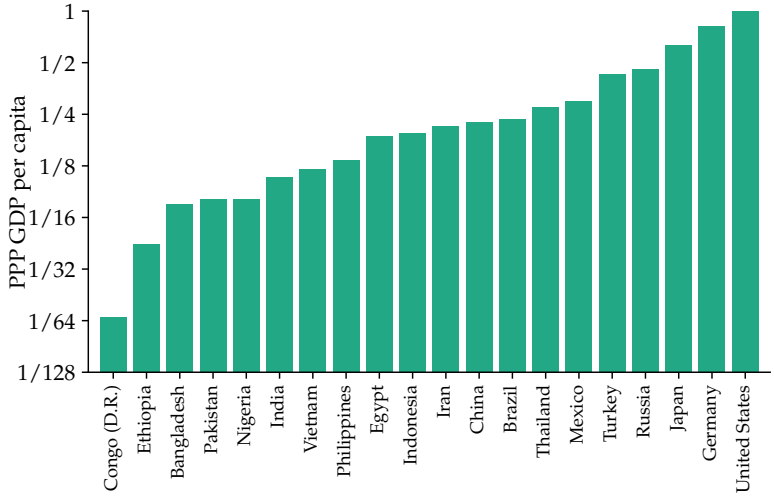
$$Y_j = \sum_{i}^{I} P_{i,\text{world}} \cdot Y_{i,j}$$

where $P_{i,\text{world}}$ is a weighted average of $P_{i,j}$ across all countries with weights $Y_{i,j}$.

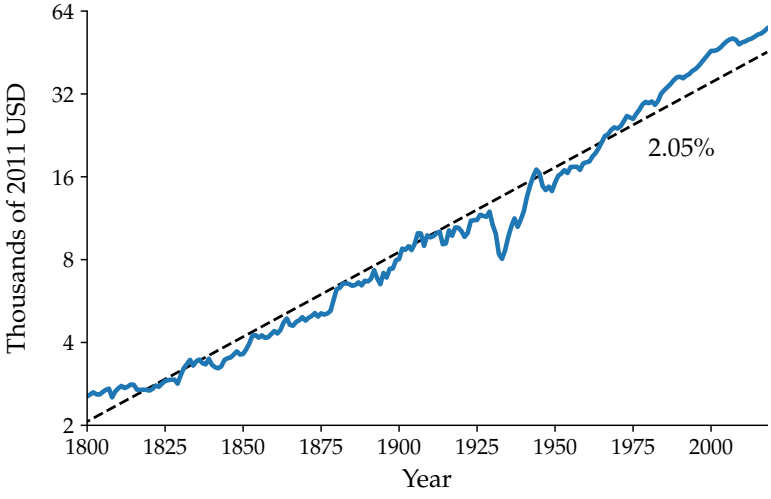
PPP prices tilt toward rich country prices, making poor countries appear richer.

All figures below are based on the latest version, Penn World Table (PWT) 10.01.

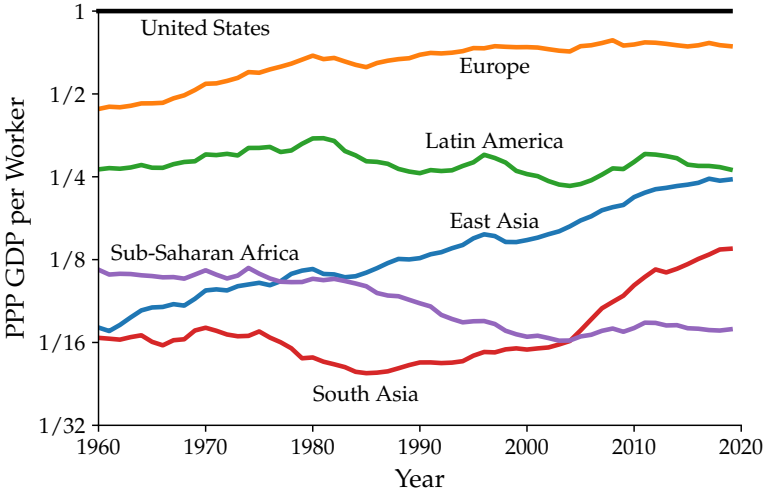
PPP GDP per capita in 2019 (USA=1)



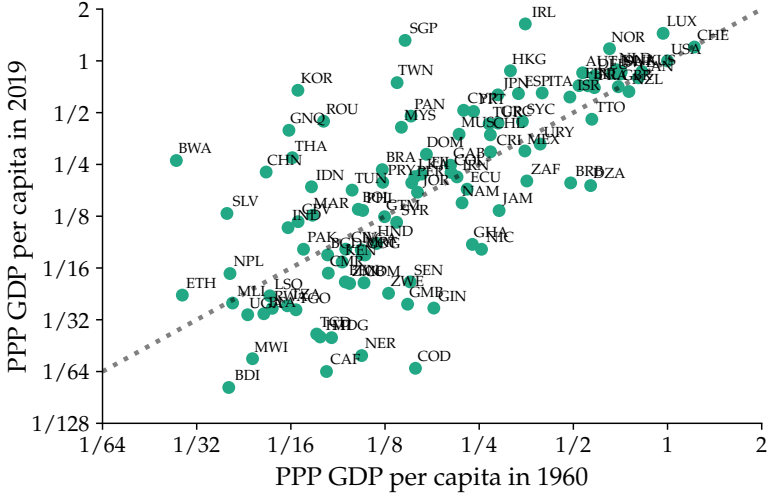
U.S. real GDP per capita, 1800-2023



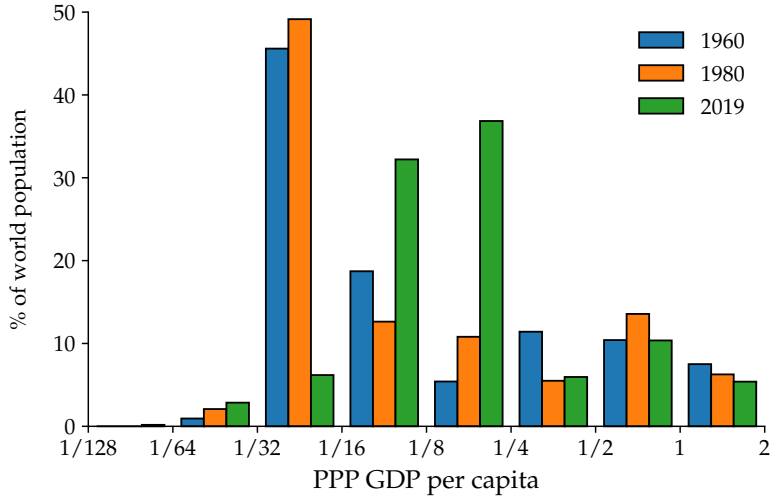
PPP GDP per worker (USA = 1)



PPP GDP per capita in 1960 and 2019 (USA=1 in each year)



PPP GDP per capita in 1960, 1980, and 2019 (USA=1 in each year)



A benchmark production function

$$Y = K^{\alpha}(AhL)^{1-\alpha}$$

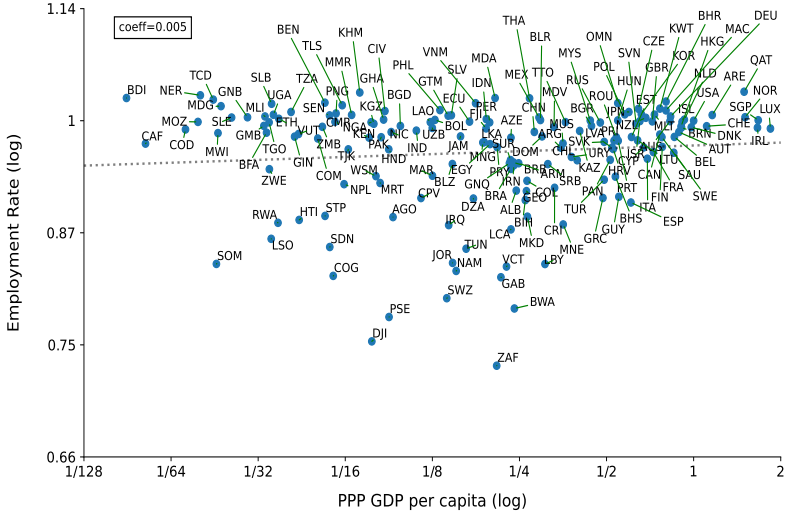
- $Y =$ PPP GDP
- $L =$ hours worked
- $K =$ PPP physical capital
- $h =$ human capital per worker
- $A =$ a residual
- $\alpha =$ elasticity of output wrt capital

A useful decomposition

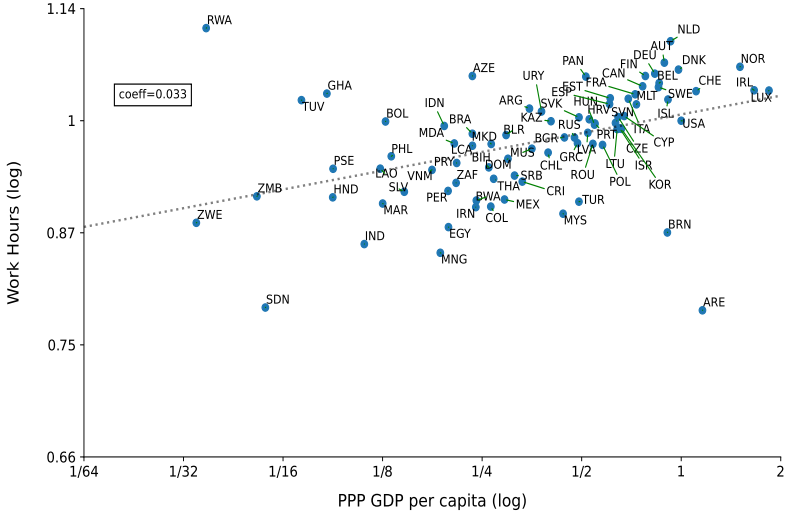
$$\frac{Y}{pop} = \frac{L}{pop} \cdot \left[\frac{K}{Y}\right]^{\frac{\alpha}{1-\alpha}} \cdot A \cdot h$$

- Respects that K/Y is invariant to the other terms in steady state
- Allows h production to be intensive in h

Employment/ Population



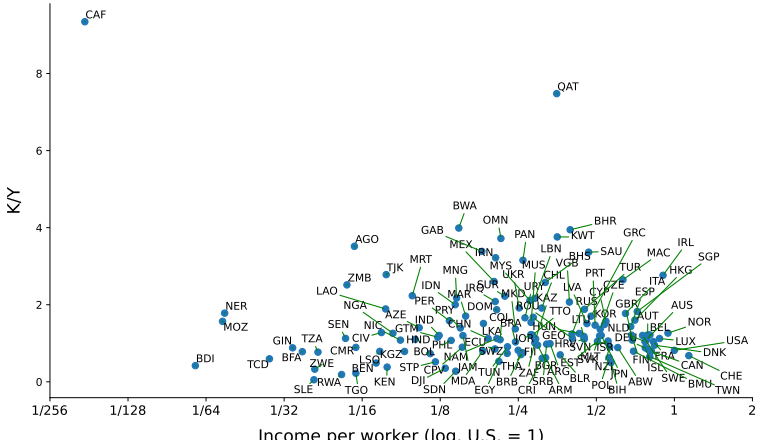
Hours worked per worker



90th/10th percentile country values in 2019:

$$\underbrace{\frac{Y}{pop}}_{12} = \underbrace{\frac{L}{pop}}_{1.1} \cdot \left[\frac{K}{Y}\right]^{\frac{\alpha}{1-\alpha}} \cdot h \cdot A$$

Capital/Output ratios



Development Accounting

$$\underbrace{\frac{Y}{pop}}_{12} = \underbrace{\frac{L}{pop}}_{1.1} \cdot \underbrace{\left[\frac{K}{Y}\right]^{\frac{\alpha}{1-\alpha}}}_{1.4} \cdot h \cdot A$$

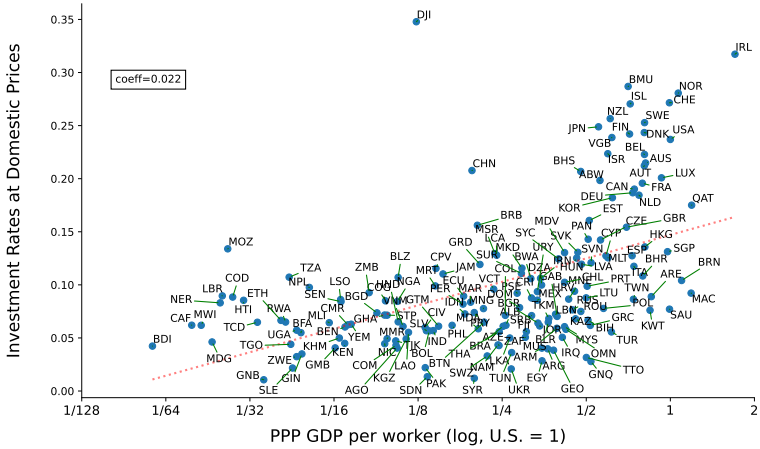
Forces driving K/Y variation

Saving rates? YES

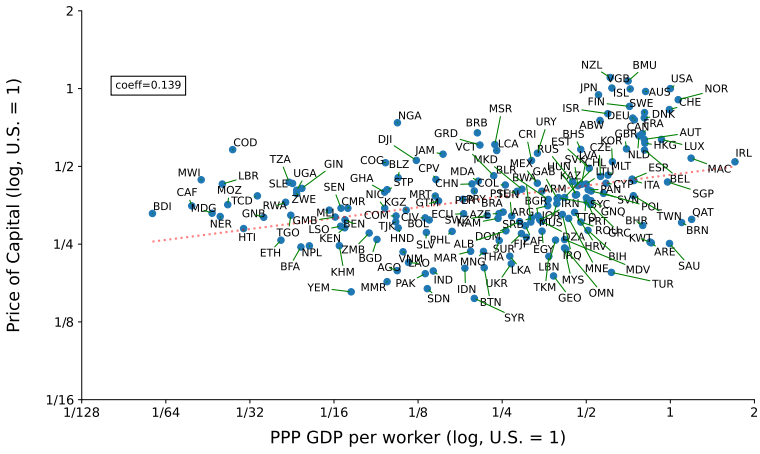
Investment prices? NO

Consumption prices? YES

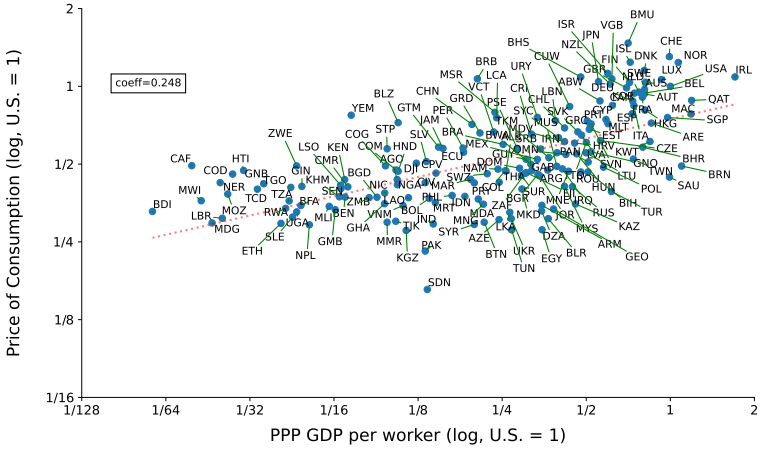
Investment rates at domestic prices



Price of equipment relative to that in the U.S.



Price of consumption relative to that in the U.S.

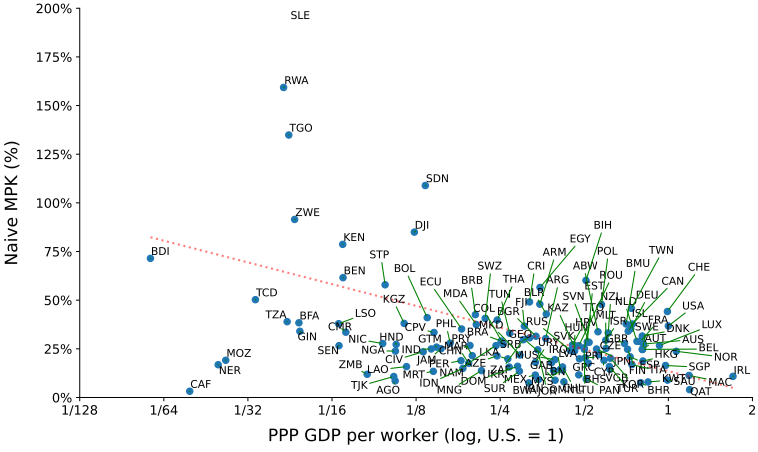


Caselli and Feyrer MPK's

$$\text{Naive MPK} \equiv \frac{\alpha Y}{K}$$

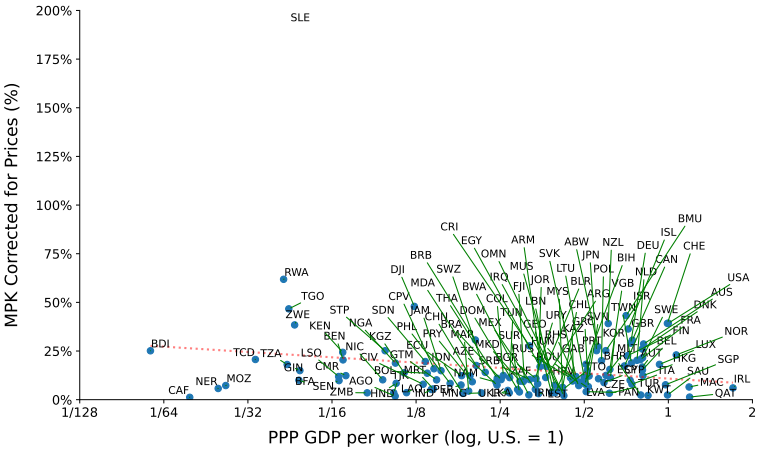
$$\text{Corrected for prices MPK} \equiv \frac{\alpha P_Y Y}{P_K K}$$

Naive MPK



PPP GDP per worker (log, U.S. = 1)

MPK corrected for prices



Schooling and human capital

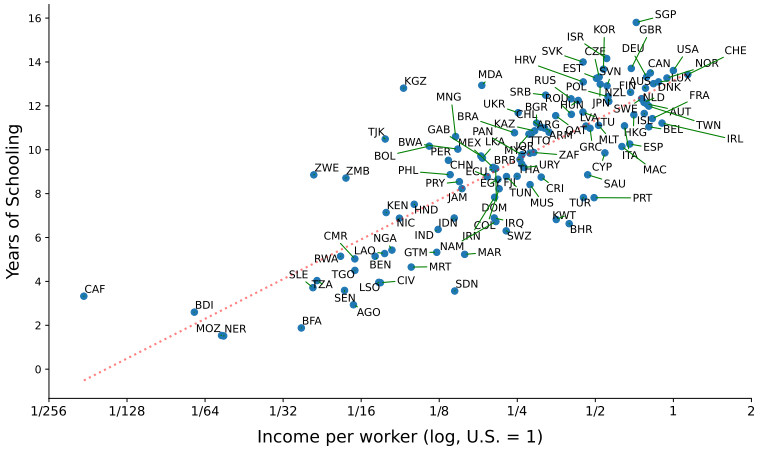
PWT estimates human capital per worker h based on coefficients from regressing log wages on years of schooling across workers within countries (i.e., Mincer regressions):

$$h = e^{\phi(s)}$$

where

$$\phi(s) = \begin{cases} 0.134 \cdot s \text{ if } s \leq 4 \\ 0.134 \cdot 4 + .101 \cdot (s-4) \text{ if } 4 \leq s \leq 8 \\ 0.134 \cdot 4 + .101 \cdot 4 + 0.068 \cdot (s-8) \text{ if } s > 8 \end{cases}$$

Years of schooling



Development Accounting

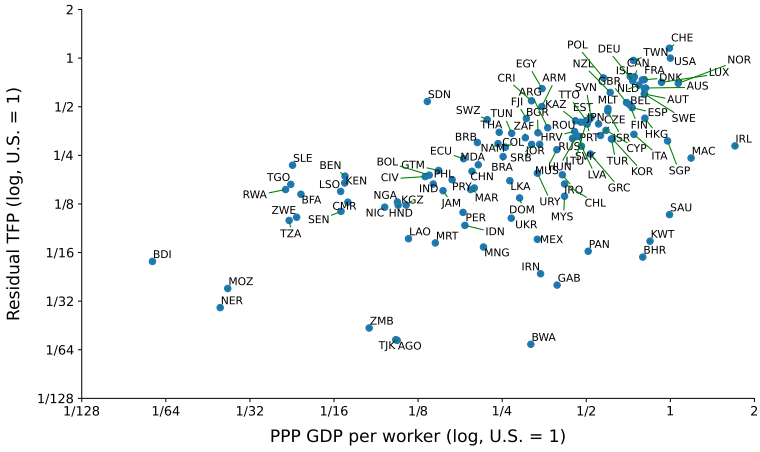
$$\underbrace{\frac{Y}{pop}}_{12} = \underbrace{\frac{L}{pop}}_{1.1} \cdot \underbrace{\left[\frac{K}{Y}\right]^{\frac{\alpha}{1-\alpha}}}_{1.4} \cdot \underbrace{h}_{1.7} \cdot \underbrace{A}_{4.9}$$

Development Accounting with all countries

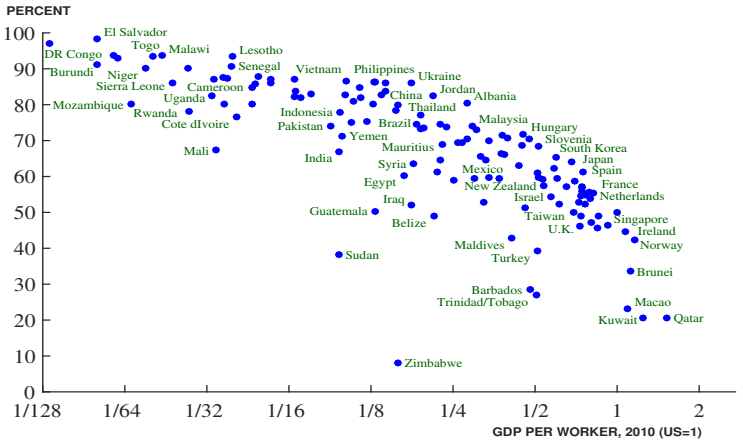
		Contributions from		
Statistic	Y/L	K/Y	h	A
Variance	1.00	0.14	0.08	0.57
Elasticity		0.14	0.22	0.64
90/10 ratio	12.0	1.40	1.70	4.92

Notes: The sample is 117 countries in 2019. The variances are for each variable in logs. The elasticity entries are from separate regressions of each variable on log GDP per capita.

Residual TFP



The Share of TFP in Development Accounting



The Facts of Growth – p. 28

Limits to the Mincerian schooling approach

- Erosa, Koreshkova and Restuccia (2010 Review of Economic Studies)
- Schoellman (2012 Review of Economic Studies)
- Hendricks and Schoellmann (2018 Quarterly Journal of Economics)
- Lagakos, Moll, Porzio, Qian and Schoellman (2018 Journal of Political Economy)

Development Accounting revisited

$$\underbrace{\frac{Y}{pop}}_{12} = \underbrace{\frac{L}{pop}}_{1.1} \cdot \underbrace{\left[\frac{K}{Y}\right]^{\frac{\alpha}{1-\alpha}}}_{1.4} \cdot \underbrace{h}_{1.7-5.1} \cdot \underbrace{A}_{1.6-4.9}$$

Potential sources of TFP differences

- Technology
- Misallocation
- Natural resources
- Measurement error

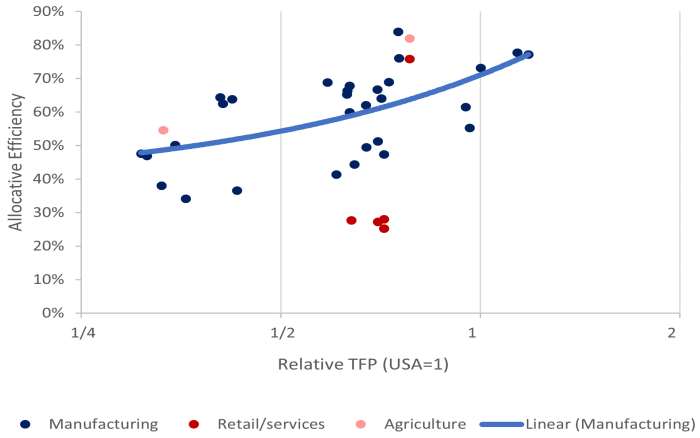
Misallocation

- TFPR $\equiv$ revenue/inputs
- Big TFPR gaps exist across firms, even within narrow industries.
- TFPR gaps imply VMPK and VMPL gaps.
- If so, potential aggregate TFP gains from reallocating K and L across firms.

TFPR dispersion within 4-digit industries

	$90^{th}/10^{th}$	$75^{th}/25^{th}$
U.S.	1.9	1.3
China	5.6	2.5
India	5.7	2.4

Allocative Efficiency vs. TFP across 30 countries



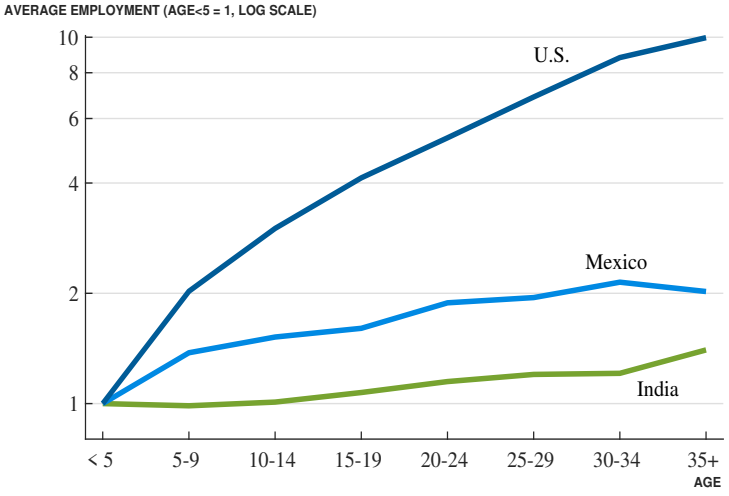
Higher allocative efficiency in high TFP countries

Elasticity of 0.40 (s.e. 0.11) so 40% of TFP differences?

Caveats:

- TFP is for the whole economy
- Varying sample frames (typically broader coverage in rich countries)
- These all use EoS across firms of 3, which is conservatively low
- Measurement error could be worse in poorer countries
- Too few studies for agriculture, services, retail trade

One aspect of technology: firms over their life cycle



Welfare vs. GDP per capita

$$U_0 = E_0 \left[\sum_{a=1}^{100} S(a) \cdot u(c_a, l_a) \right]$$

- U_0 is expected discounted utility
- $S(a)$ is the survival rate through age a and let $e \equiv \sum_{a=1}^{100} S(a)$
- $u(c_a, l_a)$ is flow utility
- c_a is consumption at age a
- l_a is leisure at age a

Flow utility

$$u(c, \ell) = \overline{u} + \log(c) + v(\ell)$$

$$\text{where} \quad v(\ell) = -\frac{\theta\epsilon}{1+\epsilon} \cdot (1-\ell)^{\frac{1+\epsilon}{\epsilon}}$$

- Death is normalized to zero
- ϵ is the constant Frisch elasticity of labor supply
- Assume $\log(c_a) \sim N(\mu, \sigma^2)$ and let $\bar{c} \equiv E(c)$

A decomposition of consumption-equivalent welfare

$$U(e_{us}, \lambda_i \cdot \bar{c}_{us}, \bar{l}_{us}, \sigma_{us}) = U(e_i, \bar{c}_i, \bar{l}_i, \sigma_i)$$

$\Rightarrow$

$$\begin{aligned}
\log \lambda_i \;=\; & \tfrac{e_i - e_{us}}{e_{us}} \left(\bar{u} + \log \bar{c}_i + v(\bar{\ell}_i) - \tfrac{1}{2}\sigma_i^2\right) && \text{Life expectancy} \\
& + \log \bar{c}_i - \log \bar{c}_{us} && \text{Consumption} \\
& + v(\bar{\ell}_i) - v(\bar{\ell}_{us}) && \text{Leisure} \\
& - \tfrac{1}{2}(\sigma_i^2 - \sigma_{us}^2) && \text{Inequality}
\end{aligned}$$

Parameter values and data inputs

Parameter values:

- $\ln c$ so $\gamma = 1$
- Frisch elasticity of $\epsilon = 1$
- Weight on leisure θ to fit l_{us}, incorporating marginal tax rates
- $\bar{u}$ to fit estimates of the value of a life year (!)

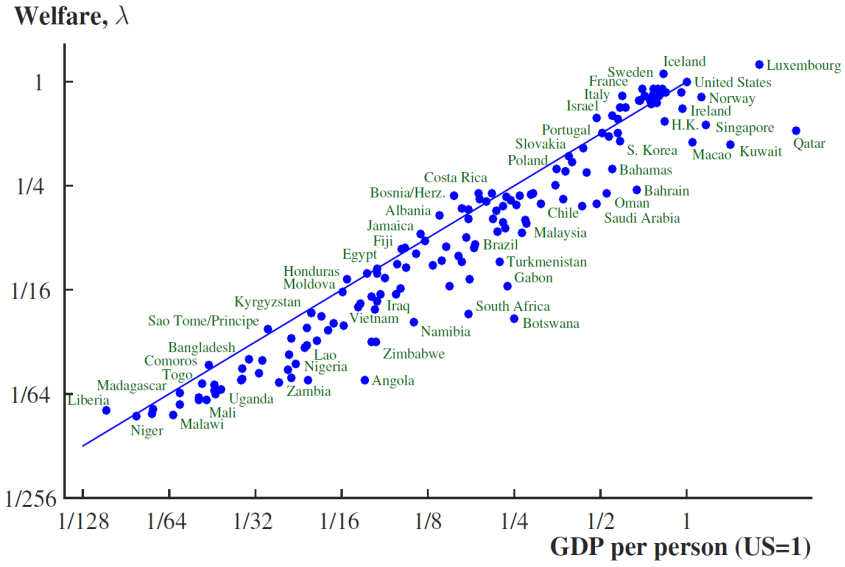
Data for each country on:

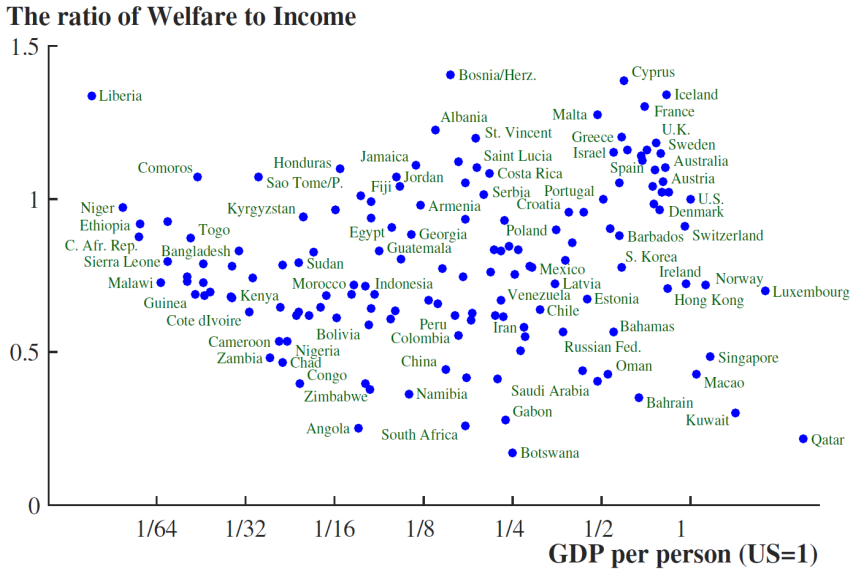
- Life expectancy e
- Mean consumption $\bar{c}$
- Mean leisure $\bar{l}$
- Consumption inequality σ

Findings on welfare vs. GDP

- corr($\ln \lambda_i$, $\ln y_i/y_{us}$) > 0.9
- Mean absolute deviation $\sim$ 35% is economically significant
- Europe is closer to the U.S. — higher life expectancy and leisure and lower inequality
- Developing countries are farther behind (life expectancy, inequality)
- Rising life expectancy boosts growth from 2% to 3%

These facts generalize to using household micro data for 13 countries.


Welfare, λ
1
1/4
1/16
1/64
1/256
1/128
1/64
1/32
1/16
1/8
1/4
1/2
1
GDP per person (US=1)
Iceland
Luxembourg
Sweden
France
United States
Italy
Norway
Israel
Ireland
H.K.
Singapore
Portugal
Qatar
Slovakia
S. Korea
Macao
Kuwait
Poland
Bahamas
Costa Rica
Bosnia/Herz.
Bahrain
Albania
Oman
Chile
Saudi Arabia
Jamaica
Malaysia
Fiji
Brazil
Egypt
Turkmenistan
Honduras
Gabon
Moldova
Kyrgyzstan
Iraq
South Africa
Sao Tome/Principe
Vietnam
Botswana
Namibia
Bangladesh
Zimbabwe
Comoros
Lao
Nigeria
Togo
Angola
Madagascar
Zambia
Liberia
Uganda
Mali
Niger
Malawi


The ratio of Welfare to Income
1.5
1
0.5
0
1/64
1/32
1/16
1/8
1/4
1/2
1
GDP per person (US=1)
Liberia
Bosnia/Herz.
Cyprus
Iceland
France
Albania
Malta
U.K.
St. Vincent
Greece
Sweden
Saint Lucia
Israel
Australia
Comoros
Honduras
Jamaica
Spain
Sao Tome/P.
Jordan
Costa Rica
Austria
Fiji
Serbia
Portugal
U.S.
Niger
Kyrgyzstan
Armenia
Croatia
Denmark
Ethiopia
Togo
Egypt
Georgia
Poland
Barbados
Switzerland
C. Afr. Rep.
Guatemala
Bangladesh
S. Korea
Sierra Leone
Sudan
Mexico
Ireland
Norway
Malawi
Morocco
Indonesia
Latvia
Luxembourg
Kenya
Venezuela
Estonia
Hong Kong
Guinea
Chile
Cote dIvoire
Peru
Iran
Bahamas
Bolivia
Colombia
Cameroon
Russian Fed.
Nigeria
Singapore
Zambia
Chad
China
Oman
Congo
Macao
Zimbabwe
Namibia
Saudi Arabia
Bahrain
Gabon
Kuwait
Angola
South Africa
Qatar
Botswana