Lecture 2: Income Accounting.
STEG Macro Development Course

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What is income accounting?

There are poorer and richer countries in the world.

... is it because richer countries...

1. employ more labor?
2. have better educated workers?
3. have more physical capital?
4. are doing better use of the same inputs?

What is income accounting?

There are poorer and richer countries in the world.

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1. employ more labor?
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- Income accounting refers to the approach to answering these questions.

  Measures of each ingredient,
  and their relative contributions (factor shares).

Income Accounting: current consensus.

Disparities in capital and labor account for at most 50% of the differences in income-per-capita.

Better use of inputs may feed-back into input accumulation. e.g. misallocation, frictions?

Heterogeneity: accounting at the aggregate, sector, firm level?

Input measurement?

Class Overview

1. Basics:
   - Framework.
   - Data.
2. Main findings.
3. Selected issues and open questions:
   - Factor-biased technical change.
   - Efficiency units and elasticities of substitution.
   - Relative prices and productivity differences.

Basics

Framework.

Income accounting: framework.

$$Y_t = A_t K_t^{\alpha} H_t^{1-\alpha}$$

Y_t output,
K_t physical capital,
H_t "quality-adjusted" labor force,
α capital share,
A_t TFP, Total Factor Productivity.

- Estimate?

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

Orthogonality between TFP and inputs,...VERY unlikely.

Income accounting: framework.

$$Y = AK^{\alpha}H^{1-\alpha}$$

- Important take-away from one-sector growth model:

  differences in TFP induce differences in K.

  but $\frac{K}{Y}$ is independent from TFP in steady state (s.s.)!

  Euler equation

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

Income accounting: framework.

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

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

In logs

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

How much of the variation in income per worker is accounted for variation in... ?

capital-output ratios,

human capital,

residual.

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

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

In logs

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

Basics

Data.

Income Accounting: data

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

- A dataset created to measure differences in living standards.

  Penn World Table

- Go-to measure for income accounting.

- Measuring living standards vs. productive capacity?

  Substantial changes since version 8.0.

  Remember to cite the data, and record the vintage you are using.

  Github repo to play with the data.

Income Accounting: data

Output per worker, $\ln\left(\frac{Y}{L}\right)$.

- Nominal output from National Accounts, $\tilde{Y}$.
- Real output

$$Y = \frac{\tilde{Y}}{P}$$

P? Purchasing Power Parities vs. Exchange Rates

Income Accounting: data

Output per worker, $\ln\left(\frac{Y}{L}\right)$.

- PPP from the International Comparison Program (ICP) benchmark surveys.
  - Compare similar quality goods: include
    - Consumption and Investment prices.
    - Tradable and non-tradable goods (but not imports and exports).
  - Same baskets of goods
- Issues comparing prices in poor and rich countries?

  Deaton & Heston, 2010

Income Accounting: data

Output per worker, $\ln\left(\frac{Y}{L}\right)$.

- PPP Price of consumption: Gheary-Khamis procedure

$$P_c = \sum_j \frac{P_c^j}{E^j} \overbrace{\frac{C^j}{C^w}}^{\text{shares}}$$

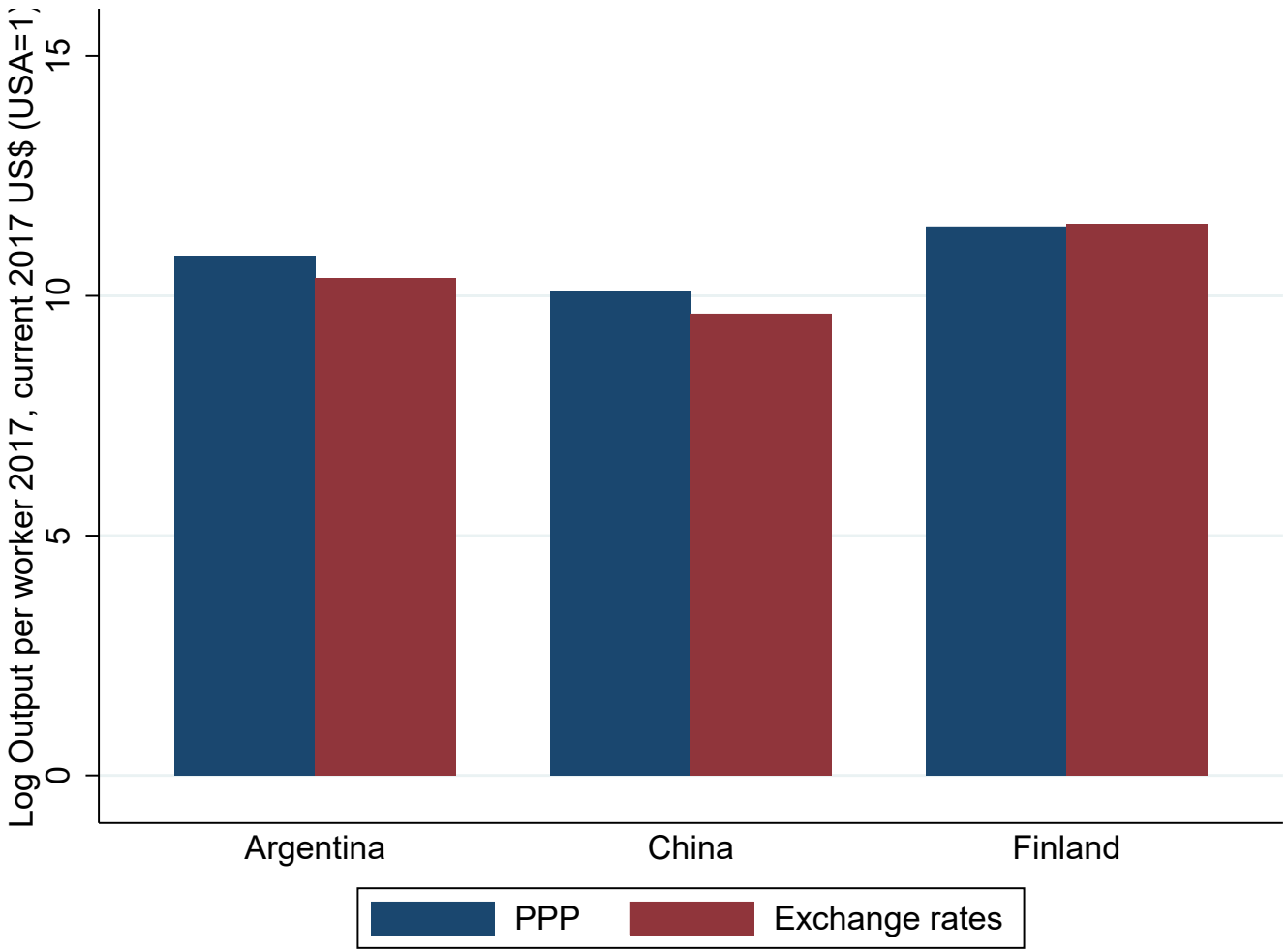
countries j
P_c^j domestic price of consumption.
C^j domestic consumption, $C^w \equiv \sum_j C^j$ world consumption
PPP exchange rate $E^j \equiv \frac{P_c^j C^j + P_I^j I^j}{P_c C^j + P_I I^j}$.

- Implication: prices from rich countries have more weight than prices from poor countries.

Income Accounting: data

Output per worker, $\ln\left(\frac{Y}{L}\right)$.

- Penn Effect/ Balassa-Samuelson effect



Income Accounting: data

Employment, *L*.

- Employment vs. hours worked.
- Hours worked decrease with development.

Bicks, Fuchs-Schundeln & Lagakos (2018).

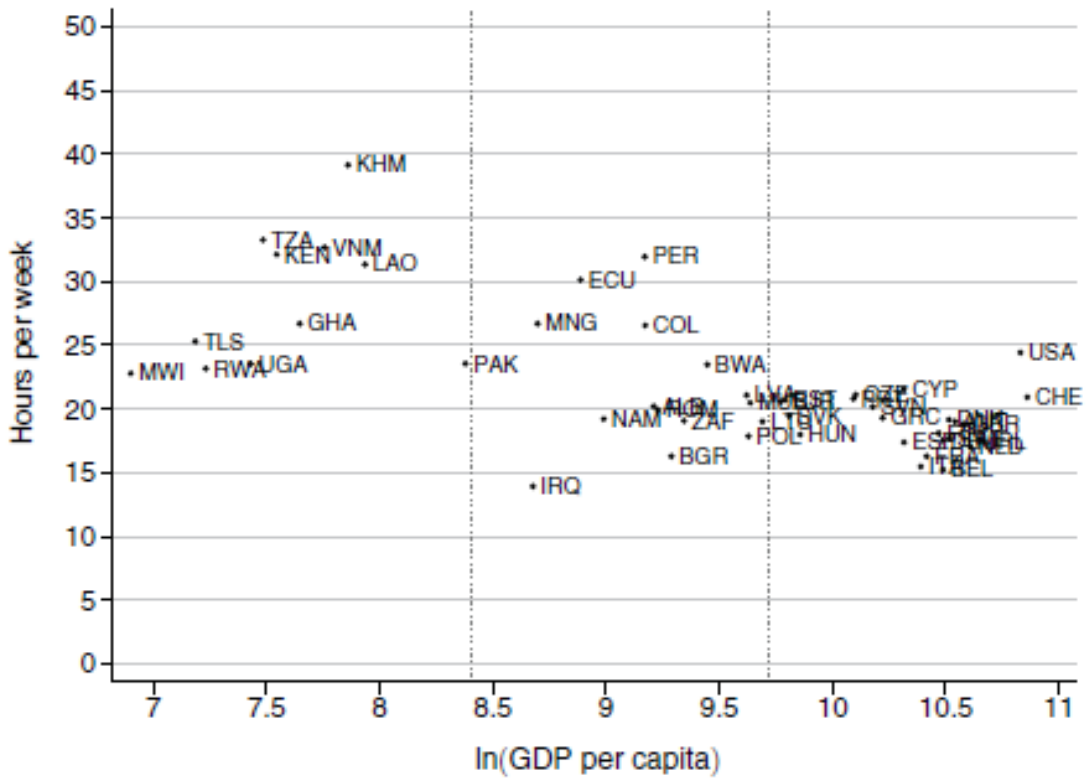


FIGURE 1. AVERAGE HOURS WORKED PER ADULT IN CORE COUNTRIES

Income Accounting: data

Capital-output ratio, $\frac{K}{Y}$.

- Current PWT considers different capital-types:
  - Machinery: computers, communication equipment.
  - Transportation.
  - Structures.
  - Other assets: IPP, Software.
- Productive Capital vs. Natural Resources Caselli & Feyrer, 2007
- crude adjustment to GDP: (-)rents from natural resources (WDI).

Income Accounting: data

Capital-output ratio, $\frac{K}{Y}$.

- Permanent inventory method
- Stock i, e.g. trucks

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

- Economy's stock

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

- Issues
  - δ Physical depreciation, measurement typically includes economic deprec.
  - K_0? Two options
    1. steady state of the Solow model, $K_{i,0} = \frac{I_{i,0}}{\delta_i + g}$.
    2. calibrate: $\frac{p^K K}{p^Y Y}$ stable across countries and time. Feenstra et.al. (2015).
       not really.. see here

Income Accounting: data

Capital-output ratio, $\frac{K}{Y}$.

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

- $\omega_{i,t}$? Two measures available from PWT 9.1+

  stocks: $\omega_{i,t} \equiv \frac{p_{i,t}K_{i,t}}{\sum_i p_i K_{i,t}}$.

  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.
- User cost of capital

$$r_{i,t} = \tilde{p}_{i,t}[R_t - (1-\delta) \overbrace{\frac{\tilde{p}_{i,t+1}}{\tilde{p}_{i,t}}}^{\text{gains/losses}}]$$

$\tilde{p}_{i,t}$ price relative to consumption.

Income Accounting: data

Capital share, α.

- Capital share estimated as a residual from labor income/output.
  - time-series suggest about a third (advanced economies)
  - cross-country data: massive differences.

  assume $\alpha = 1/3$ Hall & Jones, 1996.

- Consider self-employment: $1 - \alpha = .65 - .8$ Gollin(2002).

  key insight: self-employment treated as capital income.

- Current PWT provides country-specific factor shares.

  Lots' of variation!

Income Accounting: data

Human Capital, $\frac{H}{L}$.

- Human Capital

$$H = \overbrace{A^H e^{\phi(s,a)}}^{\text{efficiency units}} L$$

s schooling.
a age to proxy experience.
A^H quality of schooling. Bils & Klenow (2000)

- What is the return to human capital?
  - assume $A_H = 1$ identical across countries.
  - $\phi(s,a) = f(s) + g(a-s)$

    Mincer (1974)

$$\ln(w) = f(s) + g(a-s) = \theta s + \gamma_1 (a-s) + \gamma_2 (a-s)^2$$

Income Accounting: data

Human Capital, $\frac{H(t)}{L_t}$.

- PWT Human capital measures based off of
  - Educational Attainment.

    Barro & Lee version 2.2 and Cohen, Soto & Leker (2014).
  - Piece-wise linear returns to education.

    Psacharopoulos(1994).

- Human Capital Index (PWT): schooling

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

marginal return to a year of schooling $\frac{\partial \phi(s)}{\partial s}$.

Income Accounting: data.

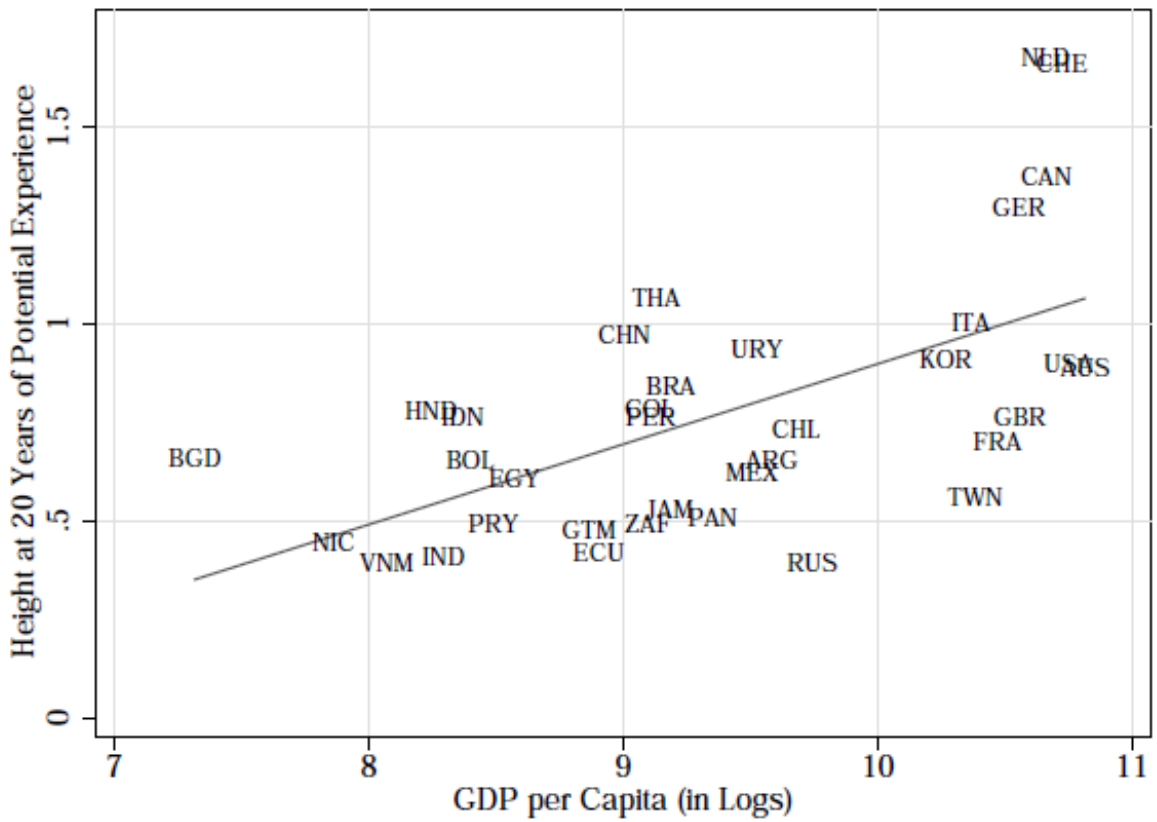
Human Capital, $\frac{H}{L}$.

- Experience? Lagakos, Moll, Porzio, Qian, Schoellman (2018).

  experience profile steeper for workers with higher s.

  experience-wage profiles are twice as steep in rich than in poor countries.

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



Main Results

How much variation in income per worker is accounted for variation in **factors of production** vs. **efficiency** in using those factors?

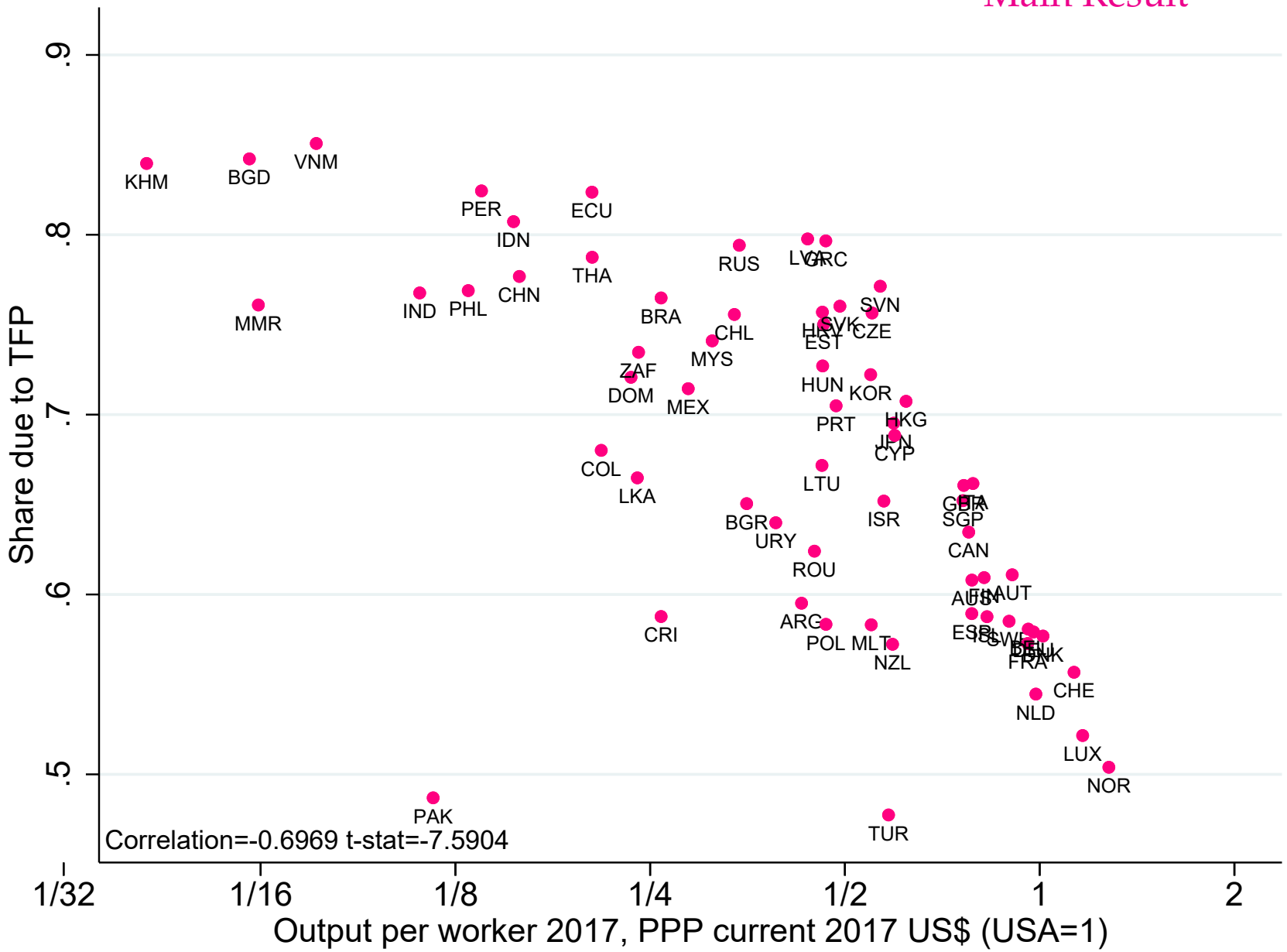
Income Accounting

Main Result, Income 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

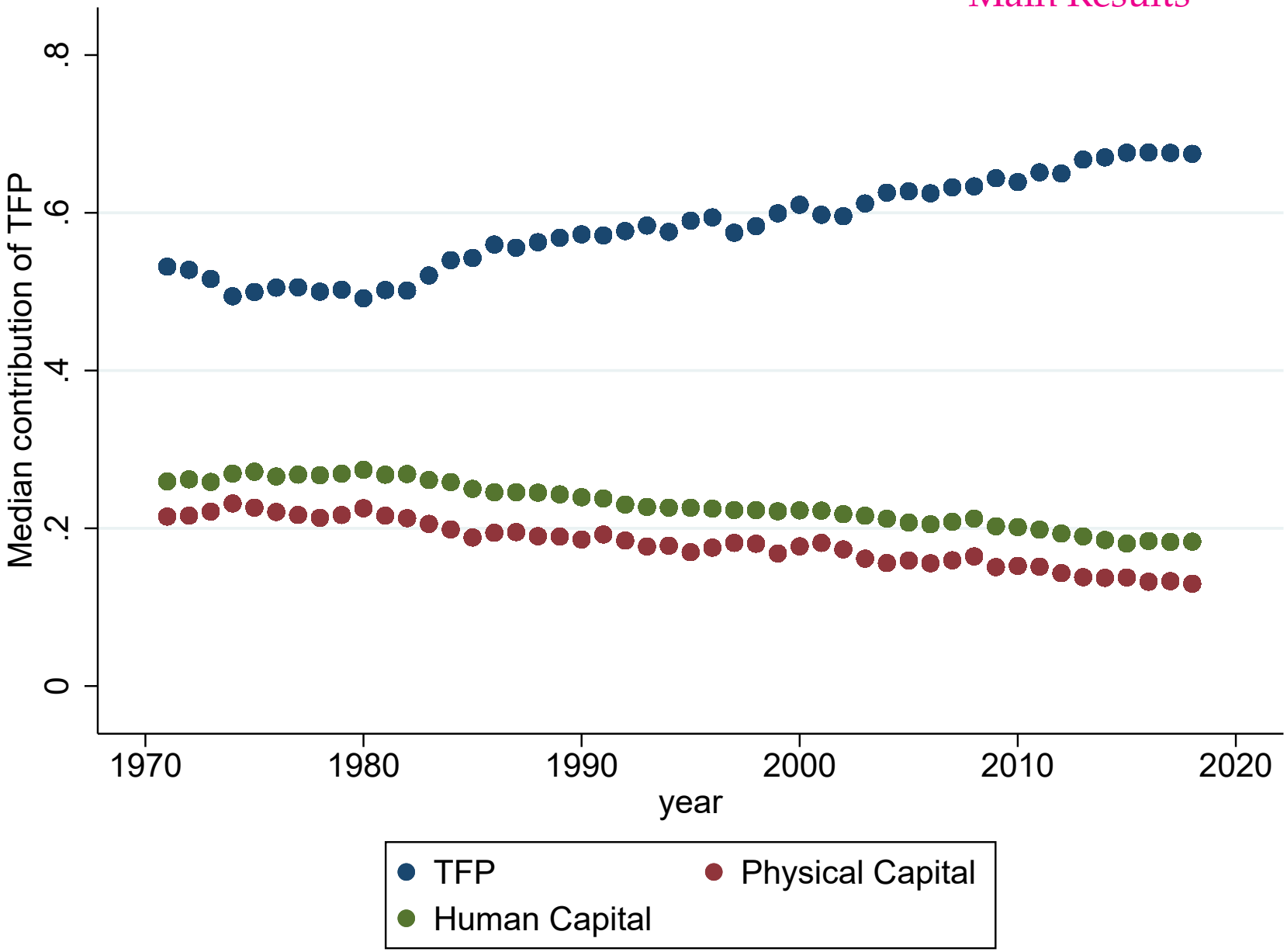
Income Accounting

Main Result



Income Accounting

Main Results



Income Accounting

Main Results

- A variance-decomposition-inspired measure: Caselli 2005

  Factor-only component of output-per-worker y:

$$y^{\mathrm{KH}} \equiv \left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}} \frac{H}{L}$$

- Output-per-worker

$$y = Z y^{\mathrm{KH}}$$

- Variance-decomposition

$$var(\ln y) = var(\ln Z) + var(\ln y^{\mathrm{KH}}) + 2cov(\ln Z, \ln y^{\mathrm{KH}})$$

Income Accounting

Main Results

$$var(\ln y) = var(\ln Z) + var(\ln y^{KH}) + 2cov(\ln Z, \ln y^{KH})$$

- How much of the income variation is accounted for variation in factors of production?

  Equivalent to variation when $Z = 1$, $cov(\ln Z, \ln y^{KH}) = 0$
- Key measure

$$\text{Success} = \frac{var(\ln y^{KH})}{var(\ln y)}$$

- Alternatively, assign covariance equally Klenow Rodriguez-Clare, 2005.

$$\text{Success} = \frac{var(\ln y^{KH}) + cov(\ln Z, \ln y^{KH})}{var(\ln y)}$$

Income Accounting

Main Results, 2017.

$$\text{Success} = \frac{var(\ln y^{\text{KH}})}{var(\ln y)}$$

- Variance of output-per-worker: .65
- Variance of output-per-worker KH: .18

$$\text{Success} = 0.27$$

Income Accounting

Main Results: sectorial disparities.

- Two sectors, Agriculture, A and Non-agriculture, $\bar{A}$:

$$y = P_A y_A l_A + P_{\bar{A}} y_{\bar{A}} l_{\bar{A}}$$

P_j PPP prices
l_j labor shares.

- Main challenge: PPP deflators by sector P_j ?

calibrated model, Duarte & Restuccia, 2010.

agriculture, Restuccia, Yang & Zhu, 2008. manufacturing and services, Baily & Solow, 2001.

Income Accounting

Main Results: sectorial disparities.

- How important is agriculture? Caselli 2005

	log-variance
real output-per-worker	1.1
US y_A	0.04
US $y_{\bar{A}}$	0.58
US l_A	0.3

$$y = P_A y_A l_A + P_{\bar{A}} y_{\bar{A}} l_{\bar{A}}$$

Selected Issues

Selected Issues

"2-pager Ads" of issues to think about.

- Factor-biased technical change.
- Efficiency units and elasticities of substitution.
- Relative prices, sectors and income differences.

Selected Issues

Factor Biased Technology

- Assumption throughout: "different" Labor (and Capital) perfect substitutes in production.
- Focus on skill and unskilled work Caselli & Coleman, 2006.

  ... Huge empirical literature suggest otherwise.

$$y_t = k^{\alpha}\left[(A_u L_u)^{\sigma} + (A_s L_s)^{\sigma}\right]^{\frac{1-\alpha}{\sigma}}$$

Selected Issues

Factor Biased Technology

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$$y_t = k^{\alpha}\left[(A_u L_u)^{\sigma} + (A_s L_s)^{\sigma}\right]^{\frac{1-\alpha}{\sigma}}$$

- Main findings:
  1. $\frac{A_s}{A_u}$ increases with development.
  2. A_s tends to be higher in rich economies.
  3. A_u tends to be **higher** in poor economies.

Selected Issues

Factor Biased Technology, ctnd

- Link between endowments, factor accumulation and technology.
- Has the direction of technical change shifted?
- Is skill the main relevant dimension for the bias in technology?
- What about capital and labor?
- Either way, what are the "correct" elasticities of substitution?

Selected Issues

Efficiency units in measuring inputs

- Systematic differences in the vintages of capital and human capital.
- Working assumption: additive productive efficiency

  2 low-productivity workers = 1 high-productivity worker.
  consistent with macro-Mincer equation.
- If workers are complementary... Jones (2014)

  amplified role of human capital in income disparities!

Selected Issues

Efficiency units in measuring inputs

- Do wage differentials reflect productivity gains from schooling/experience?

  likely not.
  role of human capital can be large or small. Caselli & Ciccone, 2018

- If wage differentials for high skill workers are so large, why they don't move across countries?

  how big are these differentials? Hjort, Malmberg & Schoellman, (...).

Selected Issues

Efficiency units in measuring inputs

- Poor countries use capital with lower "embodied technology"/ older vintages of capital.
- Speed of adoption is also slower.

  Detailed used and new equipment data to clean-out composition effects. Caunedo & Keller, 2021

- What are the underlying complementarities with labor that rationalize those differences?
- Are they consistent with barriers to adoption?
- Is technology in investment sectors different than in consumption sectors?

Lot's of information in Relative Prices!

Selected Issues

Relative Prices

- Trade economists:
  - tradable,
  - non-tradable.
- Growth economists:
  - Consumption,
  - Investment.
- Macro-Development economists:
  - Agriculture,
  - Manufacturing,
  - Services.

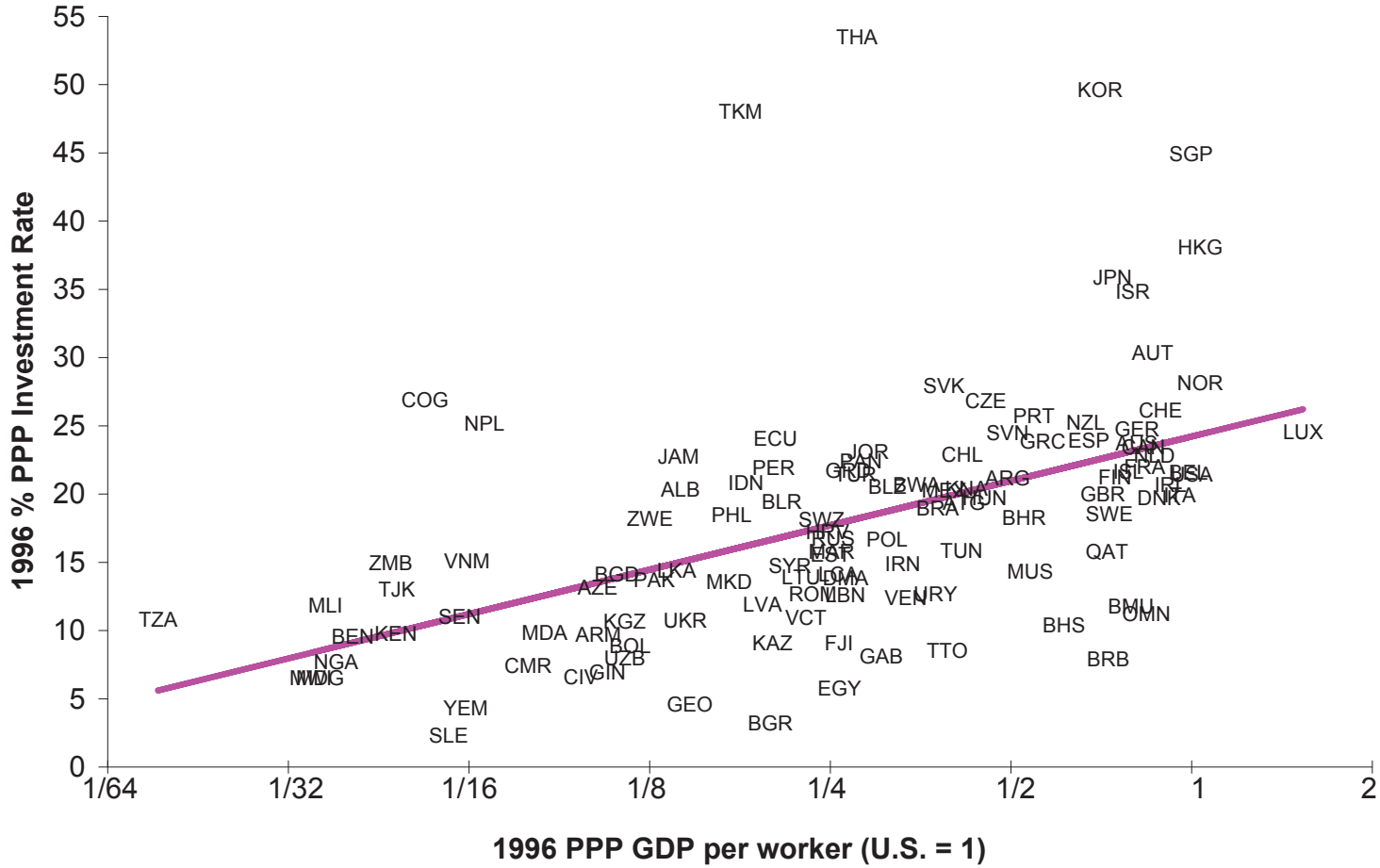
Relative prices can be mapped to Relative TFP

Selected Issues

Relative Prices: Investment and Consumption

- Lower investment rates in poor countries. Barro, 1991.

Figure 1: Investment Rates at International Prices



Selected Issues

Relative Prices: Investment and Consumption

- Not at domestic prices...

Figure 2: Investment Rates at Domestic Prices

Selected Issues

Relative Prices

- Lower investment rates in poor countries. Barro, '91

- .. accounted for the low price of consumption! Hsieh & Klenow, 2007.

  poor countries are "relatively bad" at
  - producing capital
  - producing tradable goods in exchange for capital.

Selected Issues

Relative Prices: Agriculture, Manufacturing, and Services.

- Service sector increasingly important in GDP!
- Re/Deindustrialization patterns (?)
- Relative price of services raises with development.

  Implication: Productivity differences in services are services lower than in manufacturing. Herrendorf & Valentinyi, 2012.

  Elasticity of the price of services to income is heterogeneous across categories. Duarte & Restuccia, 2020

Questions?