Session 2:

Why are Some Countries Richer than Others?

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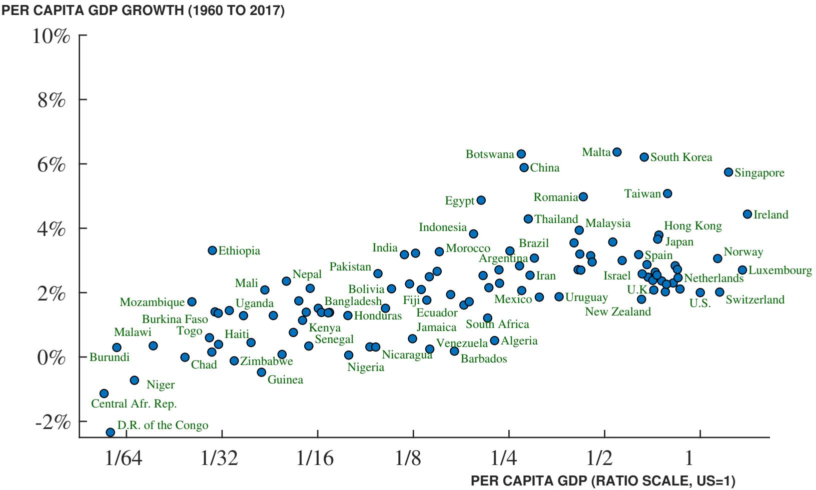
Levels and Growth Rates of Per Capita GDP



Outline of Today's Class

- Production functions
  - Returns to scale
  - The standard replication argument
- Income differences across countries through the lens of a production function
- Total factor productivity

The Role of Models

If we understand the process of economic growth — or of anything else — we ought to be capable of demonstrating this knowledge by creating it in these pen and paper (and computer-equipped) laboratories of ours. If we know what an economic miracle is, we ought to be able to make one.

— Robert E. Lucas, Jr.

What I cannot create, I do not understand.

— Richard P. Feynman

Production Functions

The Economy of Shangri La

- The people of Shangri La love to eat satsumas (a type of mandarin orange).
- Production of satsumas

$$Y = F(K, L) = \bar{A}K^{1/3}L^{2/3}$$

K = Number of satsuma trees (capital)

L = Number of workers

Y = Number of satsumas harvested during the year

$\bar{A}$ = A parameter of the production function

An Example

$$Y = F(K, L) = \bar{A}K^{1/3}L^{2/3}$$

K = 8 trees

L = 27 workers

$\bar{A}$ = 2000

Then

$Y = 2000 \times 2 \times 9$ = 36,000 satsumas.

What is the Name of this Production Function?

$$Y = \bar{A}K^{\alpha}L^{\beta}$$

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A Cobb-Douglas production function:

$$Y = \bar{A} K^{\alpha} L^{\beta}$$

Returns to Scale

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$$Y = F(K, L) = \bar{A}K^{\alpha}L^{\beta}$$

- Constant returns: Doubling inputs will double output ($\alpha + \beta = 1$)
- Increasing returns: Doubling inputs more than doubles output ($\alpha + \beta > 1$)
- Decreasing returns: Doubling inputs less than doubles output ($\alpha + \beta < 1$)

Returns to Scale

$$Y = F(K, L) = \bar{A}K^{1/3}L^{2/3}$$

Does this production function exhibit increasing, constant, or decreasing returns to scale?

$$F(2K, 2L) = \bar{A}(2K)^{1/3}(2L)^{2/3}$$
$$F(2K, 2L) = \bar{A}2^{1/3}K^{1/3}2^{2/3}L^{2/3}$$
$$F(2K, 2L) = 2^{1/3}2^{2/3}\bar{A}K^{1/3}L^{2/3}$$
$$F(2K, 2L) = 2\bar{A}K^{1/3}L^{2/3}$$
$$F(2K, 2L) = 2F(K, L)$$

What is the Standard Replication Argument?

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- How can a firm in Shangri La double its production of satsumas?
- One natural way is to double the number of satsuma trees and the number of workers
  - That is, we replicate the firm...
- The standard replication argument is a key argument that leads us to focus often on constant returns to scale.

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- How can a firm in Shangri La double its production of satsumas?
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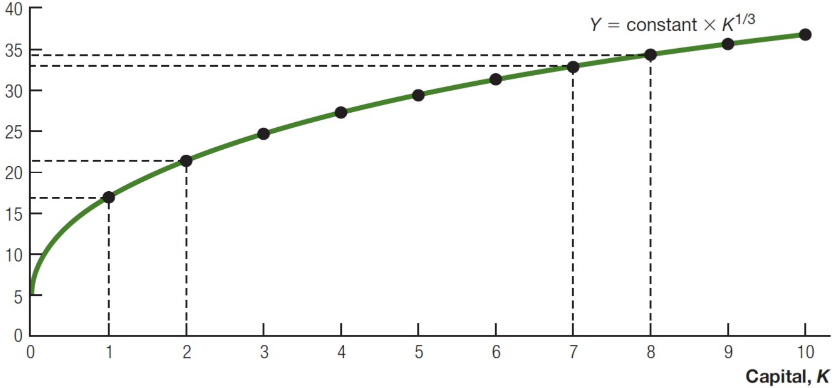
- The standard replication argument is a key argument that leads us to focus often on constant returns to scale.
- Why might returns to scale not be constant? Decreasing? Increasing?

The Diminishing Marginal Product of Capital



Very Important Distinction:

- Overall returns to scale
  - By the standard replication argument, we often argue that production functions exhibit constant returns to scale to all inputs.
- Diminishing returns to a particular input
  - If there are constant returns to all inputs together, then there are diminishing returns to each input by itself.
  - Holding labor constant, the production function exhibits diminishing returns to capital.
  - Adding more satsuma trees to Shangri La has a smaller and smaller effect on the total number of satsumas harvested (as there is a limit to how effectively the workers can farm and pick).

COVID-19 and the Production Function: A Decline in Employment

$$Y = F(K, L) = \bar{A}K^{1/3}L^{2/3}$$

- By April 2020, U.S. employment had fallen by 16% relative to January
  - With L workers at the start, employment fell to $0.84 \cdot L$
- Capital is still in place, so no change in K

$$Y_c = \bar{A}K^{1/3}\left(0.84 \cdot L\right)^{2/3}$$

$$Y_c = 0.89\bar{A}K^{1/3}L^{2/3}$$

$$Y_c = 89\% \cdot Y$$

- The drop in output is less than the drop in labor supply (why?)

In the first half of 2020, U.S. GDP fell by 10%, almost exactly what the PF predicts!

Factor Shares

- Factor shares: what fraction of GDP is paid to each factor?

- Recall from micro that under competitive markets, factors are paid their marginal products
  - Farm hires workers until MPL falls to equal wage
  - Farm rents trees until MPK falls to equal r

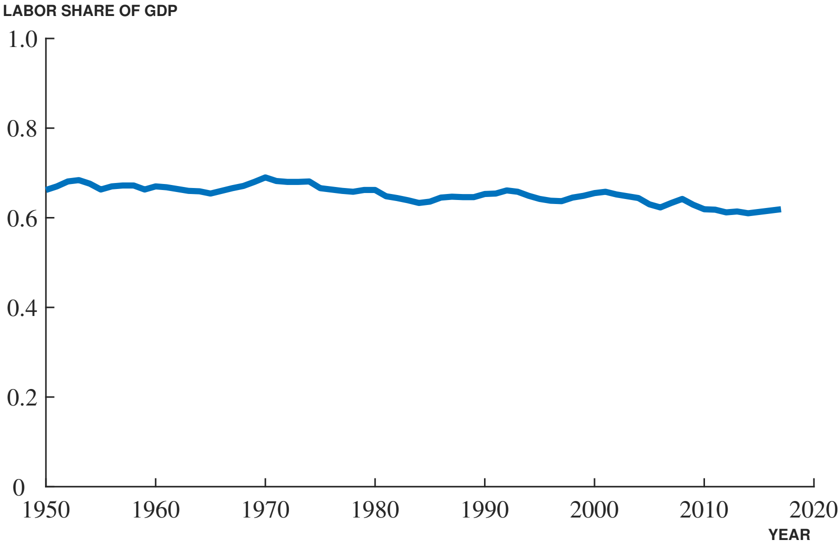
- With Cobb-Douglas production, factor shares equal the exponents:

$$\frac{wL}{Y} = \frac{2}{3} \quad \text{and} \quad \frac{rK}{Y} = \frac{1}{3}$$

(see pages 75–80)

- Notice that labor's share is predicted to be constant over time...

Labor Income Share of GDP: wL/Y



The World through the Lens of a Production Function

Per Capita GDP

- With L workers (= population), per capita GDP in Shangri La is

$$y \equiv \frac{Y}{L} = \frac{\bar{A}K^{1/3}L^{2/3}}{L}$$

$$= \frac{\bar{A}K^{1/3}}{L^{1/3}}$$

$$= \bar{A}k^{1/3}$$

where y is per capita GDP and k is capital per person.

Per Capita GDP

$$y = \bar{A}\, k^{1/3}$$

- Output per person is the product of two terms:
  - $\bar{A}$: The productivity parameter — more productive economies are richer
  - $k^{1/3}$: Number of satsuma trees per person — subject to diminishing returns.

If we double the amount of capital per person in the economy, we less than double output per person.

Comparing Models with Data

- Toy model of satsumas in Shangri La
- Countries in the world are obviously much more complicated
  - A wide variety of goods, many different kinds of inputs
  - Interactions among economies
- Is it appropriate to use toy models to study the world?
  - All models make simplifying assumptions (e.g. studies of the demand for iPhones may omit a detailed model of macroeconomic conditions and the financial sector).
  - What makes a model successful is making the correct simplifying assumptions.
  - Healthy skepticism is warranted. Even when model gets it wrong, the errors may be informative...

Development Accounting

$$y = \bar{A}\, k^{1/3}$$

- Study various countries using the Production Function
  - Measure y as real GDP per person.
  - Measure k as capital per person — the economy's stock of factories, computers, machine tools, trucks, ships, tractors, highways, etc. (more later)

- Two approaches to the productivity parameter, $\bar{A}$
  1. Assume the same across countries: $\bar{A} = 1$
  2. Allow to be different...

The Model's Prediction for Per Capita GDP (U.S.=1)

Country	Observed capital per person, $\bar{k}$	Predicted per capita GDP $y = \bar{k}^{1/3}$	Observed per capita GDP
United States	1.000	1.000	1.000
Switzerland	1.309	1.094	1.151
Japan	0.930	0.976	0.734
U.K.	0.693	0.885	0.714
Italy	0.804	0.930	0.680
Spain	0.731	0.901	0.640
China	0.276	0.651	0.279
Brazil	0.202	0.587	0.252
South Africa	0.174	0.559	0.214
India	0.081	0.433	0.117
Burundi	0.005	0.173	0.015

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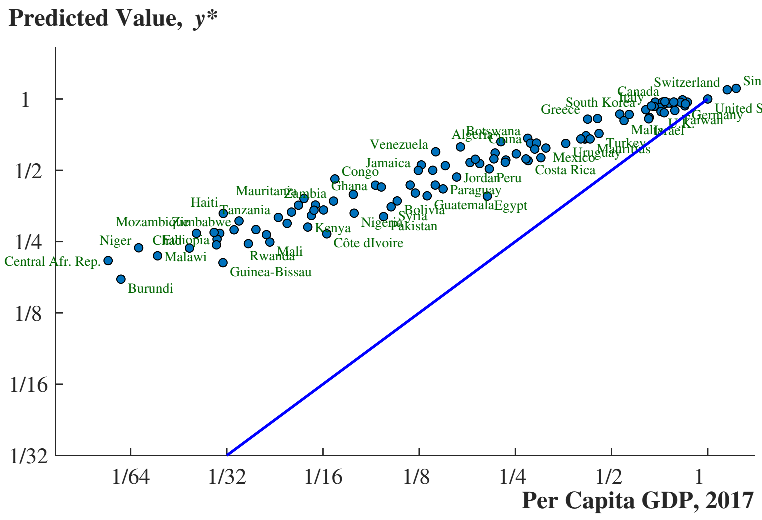
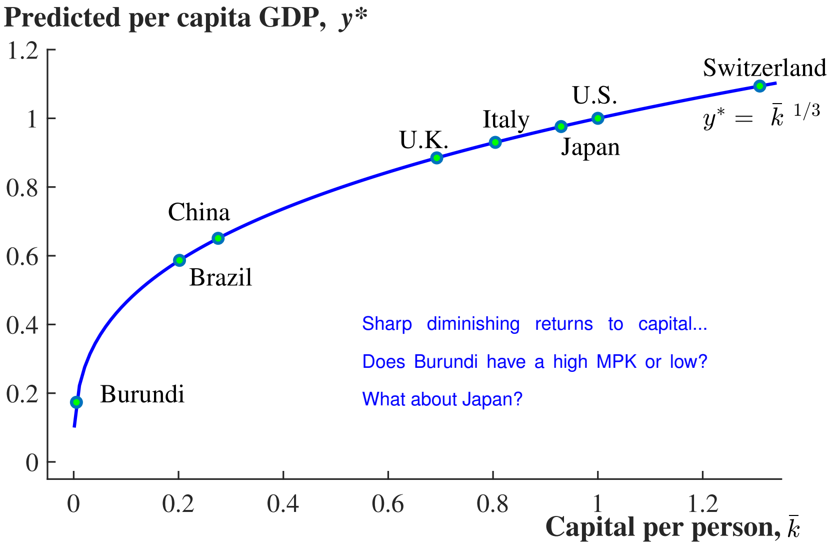


Predicted Per Capita GDP, Production View (U.S.=1)



Do Poor Countries have High MPK?

- The previous figure suggests a puzzle: poor countries should have very high MPK.
  - If that were true, how would businesses and entrepreneurs respond?
  - What do capital flows look like around the world? U.S.? China?

- Caselli and Feyrer (2007 QJE) use measures of GDP, capital, and the shape of production functions to calculate MPK for many countries:
  - Rich countries: 8.4 percent
  - Poor countries: 6.9 percent

Successes and Failures with $\bar{A} = 1$

- Success: Countries are rich or poor according to how much capital per person they have

- Failures:
    - Countries are generally much poorer than model suggests
    - Returns to capital are not higher in poor countries

Total Factor Productivity

Development Accounting II: Allowing TFP Differences

- $\bar{A}$ is often called Total Factor Productivity or TFP. Why?

$$Y = \bar{A}\,K^{1/3}L^{2/3}$$

- In per capita terms, recall

$$y = \bar{A}\,k^{1/3}$$

One way to explain why poor countries are not as rich as their capital would suggest is by having $\bar{A} < 1$.

  - Maybe, for some reason, poor countries are just not very efficient at using their capital and labor (and other inputs).

Measuring TFP

- Difficulty: We can measure GDP, capital, and labor, but there is no independent measure of TFP.

- Solution: We measure TFP as a residual. That is, we observe every quantity in the production function *other than* TFP:

$$\bar{A} = \frac{y}{k^{1/3}}$$

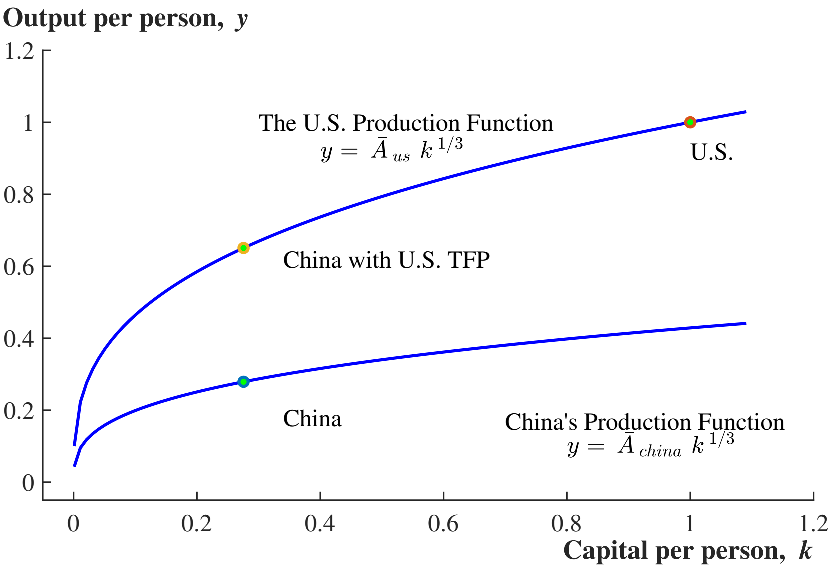
- TFP as a “measure of our ignorance”
  - Any omitted inputs or measurement problems will be included in TFP

Measuring TFP so the Model Fits Exactly

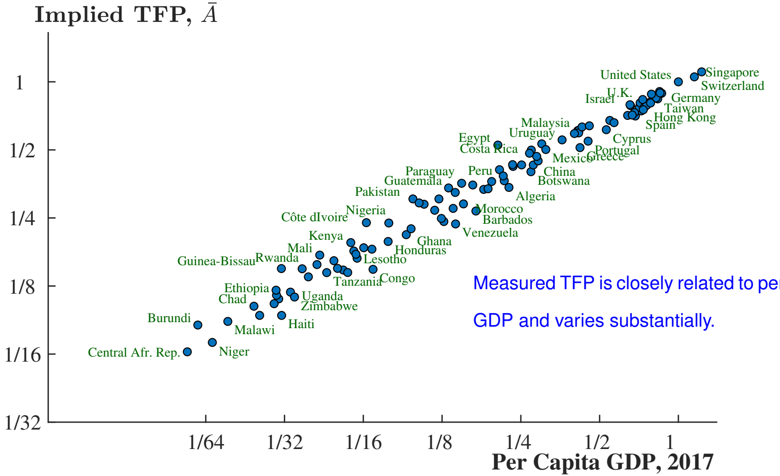
Country	Per capita GDP (y)	$\bar{k}^{1/3}$	Implied TFP ($\bar{A}$)
United States	1.000	1.000	1.000
Switzerland	1.151	1.094	1.052
U.K.	0.714	0.885	0.807
Japan	0.734	0.976	0.752
Italy	0.680	0.930	0.731
Spain	0.640	0.901	0.710
China	0.279	0.651	0.429
Brazil	0.252	0.587	0.429
South Africa	0.214	0.559	0.383
India	0.117	0.433	0.270
Burundi	0.015	0.173	0.084

To match the data, poor countries must be very inefficient in production — low TFP.

The U.S. and Chinese Production Functions



Measuring TFP so the Model Fits Exactly



Measured TFP is closely related to per capita GDP and varies substantially.

The Importance of Capital versus TFP

- Which is more important in explaining income differences across countries?

- Compare the five richest and five poorest economies:

$$\underbrace{\frac{y_{rich}}{y_{poor}}}_{65} \simeq \underbrace{\frac{\bar{A}_{rich}}{\bar{A}_{poor}}}_{13} \cdot \underbrace{\left(\frac{k_{rich}}{k_{poor}}\right)^{1/3}}_{5}$$

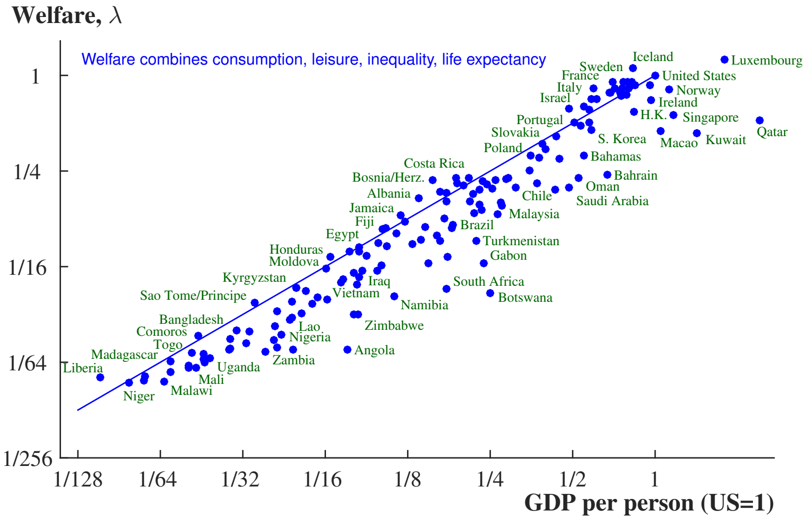
- TFP is about three times as important as capital.
    - So TFP accounts for 3/4 of cross-country income differences and capital accounts for 1/4.

      Poor countries are poor mainly because they are so inefficient at using their inputs.

Reading: Beyond GDP?

- Amartya Sen, “Quality of Life: India vs. China”
- Questions:
  - Who is Amartya Sen?
  - What is the main point of the reading?

Welfare vs. GDP (Jones and Klenow, 2016)



Questions for Review

- What is a Cobb-Douglas production function?
- What are increasing returns, constant returns, and decreasing returns, and how are the last two relevant in this lecture?
- What is the standard replication argument and how is it used?
- Why are profits equal to zero under perfect competition?
- Explain the equation $y = \bar{A}k^{1/3}$.
- How does a production function approach account for income differences across countries?
- What are the limitations of the production function approach?
- What other explanations for income differences are important?