How Important Is Capital?

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Outline

We start looking into the question:

Why are some countries rich and others poor?

We start with causes that are relatively easy to measure:

1. physical capital
2. human capital

Then we look at causes that are harder to quantify (institutions).

Objectives

At the end of this section you should be able to:

1. Calculate the effect of varying the capital stock on per capita GDP (for example economies).
2. Explain why this effect is not large.

The method generalizes to other factor inputs (such as human capital).

How important is capital?

- An old hypothesis: Poor countries lack capital.
  - Capital contains machines, equipment, structures, ...
- If capital is scarce, workers are unproductive.
  - Examples ...
- Questions:
  1. How well does this hypothesis line up with the data?
  2. What fraction of cross-country income gaps is due to capital?

Models as Measurement Tools

A key idea

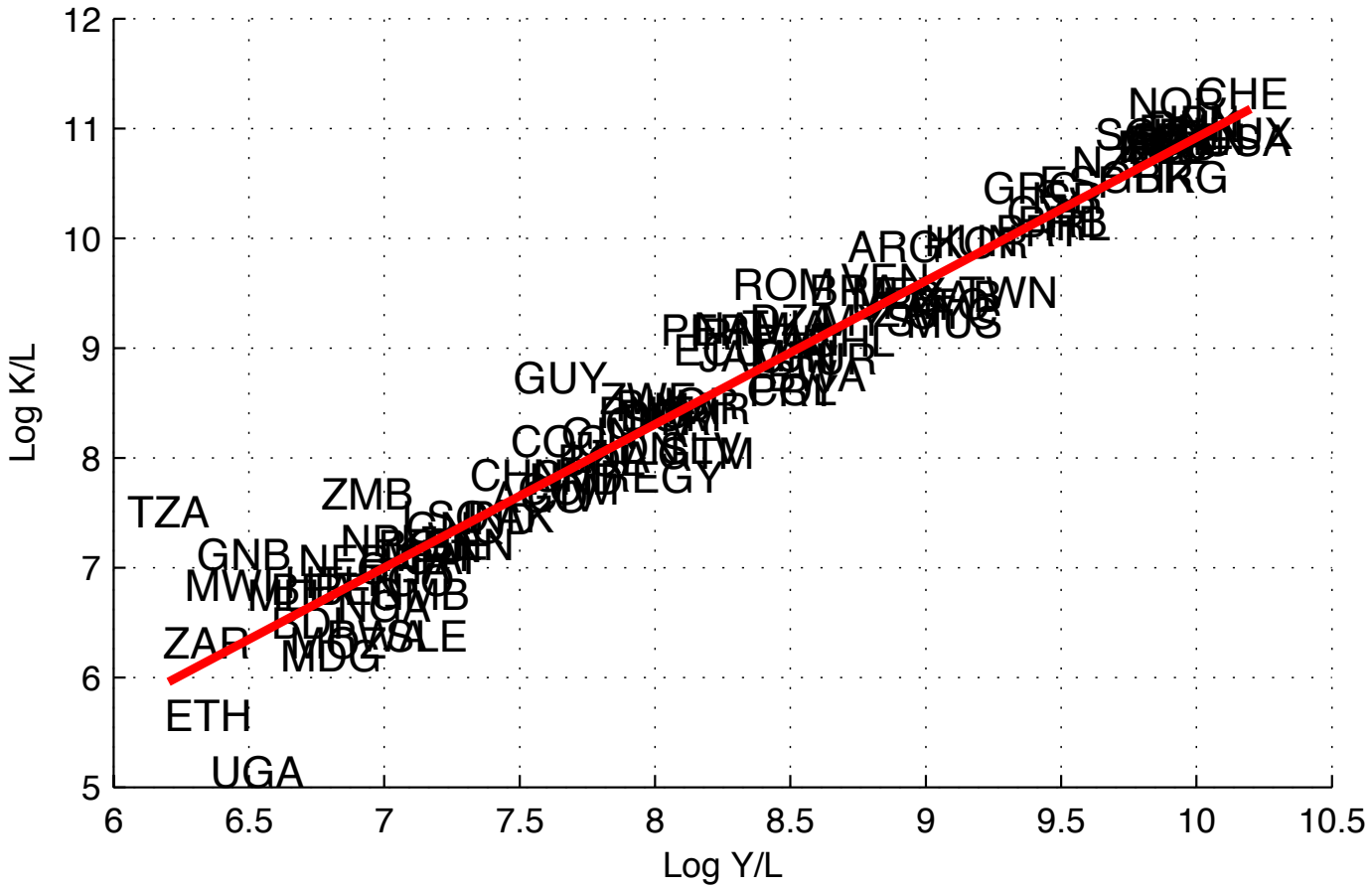
The model as a measurement tool.
To measure the effect of X on Y, we use the implications of a quantitative model

Later, we discuss the benefits and drawbacks of this method.

GDP and Capital Stock

- Let's measure income as real GDP per person: Y/L.
  - Real: using the same prices for all countries.
- Capital is measured as real capital stock per person: K/L.
- Do countries with high Y/L have high K/L?
- We can only answer that question for years since 1950 (data limitations).
- If the answer is yes, then we might look for models in which poor countries lack capital.

GDP and Capital Stock: 1990 data



How important is capital?

We want to quantify:

What fraction of cross-country GDP gaps is due to variation in K/L?

We don't have natural experiments.

- Or perhaps we do ...

Regressions don't work.

So we need a **quantitative model**.

A Model of Production

A Model of Production

Steps:

1. Develop a model that links the cause (K/L) to the outcome of interest (Y/L).
2. Estimate its parameters.
3. Plug the observed values of K/L into the model; one for each country in the data.
   Compute the model predicted Y/L for each country.

Then we say: the model's predicted variation in Y/L is the share of the observed variation that is due to capital.

We cannot run controlled experiments in reality, so we run them in the model.

A general method

The method is very general.

It can be used to measure the effect of any cause (here: K/L) on any outcome (here: Y/L).

But this is not magic.

The answer is only as good as the model.

Therefore: models need to be **validated** somehow.

A Model of Production

We are looking for a model that accurately describes how aggregate output varies with inputs (capital, labor, ...).

This is an **aggregate production function.**

- Production function?
- Aggregate?

The production function is largely a description of technology.

But not entirely: there is no reason to think that output is produced efficiently.

Aggregate production function

We start very simple.

Then we think about how making things more complicated affects the results.

The economy produces one good (Y) from two inputs (capital and labor).

The functional form is Cobb-Douglas:

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

$A > 0$ is a parameter.

α is a parameter between 0 and 1.

Measurement

Y: Gross Domestic Product (**GDP**).

- from National Income and Product Accounts
- in PPP prices

L: Labor input is measured as **total hours worked**.

- Or, if we don't have data, we use the number of people working (labor force) or the total population of working age (15-64).

K: the stock of machines, equipment and structures used in production

- How is capital measured?

Complications:

- quality adjustments
- multiple labor inputs (education) or capital inputs (types of equipment)

An aggregate production function?

- We have made some really strong assumptions in writing down

$$Y = K^{\alpha}(AL)^{1-\alpha} \tag{2}$$

- Does this make sense?

What about the functional form?

This is called a Cobb-Douglas production function

$$Y = K^{\alpha}(AL)^{1-\alpha} \tag{3}$$

It has certain properties that fit the data well for quite a few countries.

1. Constant returns to scale.
2. The capital share is constant (α) (see below).

What happens if we relax the functional form?

- See Practice Problems and Caselli (2005).

Constant returns to scale

Doubling K and L doubles Y.

Returns to scale could be increasing or decreasing.

Why do **decreasing** returns to scale seem unlikely?

What would happen with **increasing** returns?

Capital share

To find the capital share, we solve for the marginal product of capital.

It is the derivative

$$dY/dK = \alpha K^{\alpha-1}(AL)^{1-\alpha} \tag{4}$$

$$= \alpha A^{1-\alpha}(K/L)^{\alpha-1} \tag{5}$$

$$= \alpha Y/K \tag{6}$$

Assume that capital is paid its marginal product (why?).

Then capital income =

$$dY/dK \times K = \alpha(Y/K) \times K = \alpha \tag{7}$$

Capital share

Fact

With a Cobb-Douglas production function, capital receives the constant share α of income.

Why does this result matter?

- Because it allows us to estimate α easily:
  all we need to do is look up the breakdown of GDP into capital and labor income.

Capital share

Important fact

The share of GDP that goes to capital is near 1/3.
This is true in rich and poor countries and in early and late time periods.

Therefore, $\alpha = 1/3$.

Exercise: Show that labor receives share $1 - \alpha$.

Digression: The prices of capital and labor

Why does it make sense to assume that capital is paid dY/dK?

Consider a firm that maximizes profits.

It hires capital at price r and labor at price w.

Revenue is $p\ F(K,L)$.

It maximizes

$$\max_{K,L} pF(K,L) - rK - wL \tag{8}$$

The firm is a price taker in all markets.

How much capital and labor should the firm hire?

The prices of capital and labor

Take the first order condition to find

$$\begin{aligned} p\ dF(K,L)/dK - r &= 0 \\ p\ dY/dK &= r \\ r/p &= dY/dK \end{aligned} \tag{9}$$

The firm hires capital until the price of capital (r/p) equals the marginal product.

But what happened to p when I said that capital is paid dY/dK?

Summary

The model postulates an aggregate production function: $Y = K^{\alpha}(AL)^{1-\alpha}$.

Key features of the data that motivate this:

1. Constant returns to scale.
2. Constant shares of GDP earned by capital (1/3) and labor (2/3).

The capital share is a constant α

This is how we estimate $\alpha = 1/3$: in NIPA, capital earns 1/3 of GDP.

Robustness

If this seems simple, many assumptions can be relaxed:

- more general production functions
- many types of capital and labor
- many goods produced

The results don't change too much.

Caselli (2005) contains a lot of robustness checks.

The Model as Measurement Device

We can now run counterfactual experiments in the model.

- For example, we can give poor countries additional capital.

What are benefits / drawbacks of this method?

Why do we use it?

What can go wrong?

But there are **many possible models** that I could write down.

How to choose?

Economics vs. Sociology

Perhaps the defining feature of economics:

We use "one" model to understand many questions.

Benefits:

- discipline
- the model can be tested against lots of data

Drawbacks:

Reading

- Jones (2013b), ch. 1

Additional reading:

- Jones (2013a), ch. 3
- Caselli (2005)

References I

Caselli, F. (2005): "Accounting for Cross-Country Income Differences," in *Handbook of Economic Growth*, ed. by P. Aghion and S. N. Durlauf, Elsevier, vol. 1B, chap. 9.

Jones, C. I. (2013a): *Macroeconomics*, W W Norton, 3rd ed.

Jones, Charles; Vollrath, D. (2013b): *Introduction To Economic Growth*, W W Norton, 3rd ed.