Growth accounting: what explains changes in output

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Introduction

- So far, we have looked at cross-country differences in output per capita.
- We are now going to look at what explains growth within a country over time. We follow here the framework proposed by Solow (1957).
- This allows us to further test predictions of the Solow model:
  - Countries in steady state should grow at a constant rate.
  - Countries growing fast should do so temporarily because of rapid capital accumulation.
  - Countries growing negatively should do so temporarily because of rapid capital decumulation.
  - Countries with the same steady state should converge in output per worker.

Growth accounting framework

Output over time

Similar to development accounting, we start again with the aggregate production function:

$$Y(t) = K(t)^{\alpha(t)} \left(A(t)H(t)\right)^{1-\alpha(t)} \tag{1}$$

$$H(t) = L(t) \exp(\psi\, u(t)). \tag{2}$$

Note, we now allow education and α to be time-varying. Now take logs and take the derivative with respect to time:

$$\frac{\dot{Y}(t)}{Y(t)} = \alpha(t)\frac{\dot{K}(t)}{K(t)} + (1-\alpha(t))\left[\frac{\dot{A}(t)}{A(t)} + \frac{\dot{L}(t)}{L(t)} + \psi\frac{\partial u(t)}{\partial t}\right]. \tag{3}$$

Output per capita over time

Instead of total output, we can also look at output per capita:

$$y(t) = \frac{Y(t)}{L(t)} = \left(\frac{K(t)}{L(t)}\right)^{\alpha(t)} \left(A(t)\exp(\psi\, u(t))\right)^{1-\alpha(t)} \tag{4}$$

$$\frac{\dot{y}(t)}{y(t)} = \alpha(t)\frac{\dot{k}(t)}{k(t)} + (1-\alpha(t))\left[\frac{\dot{A}(t)}{A(t)} + \psi\frac{\partial u(t)}{\partial t}\right]. \tag{5}$$

The intuition is very simple. Output per worker growth either because capital per worker is growing (capital deepening), the quality of the workforce is growing, or technology is growing.

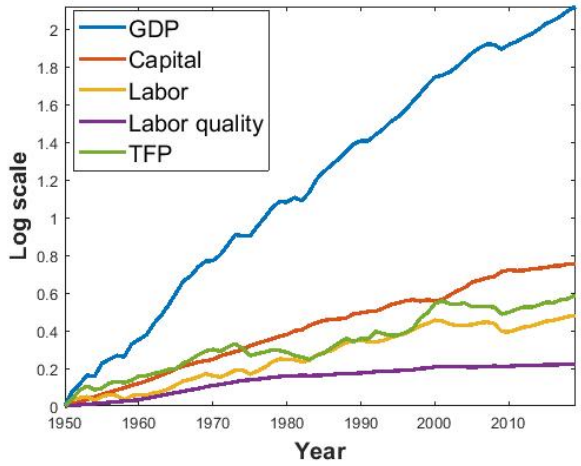
Measurement

I am going to use data from the Penn World Tables.

To measure the time-varying $1-\alpha$, I use the time-varying labor share.

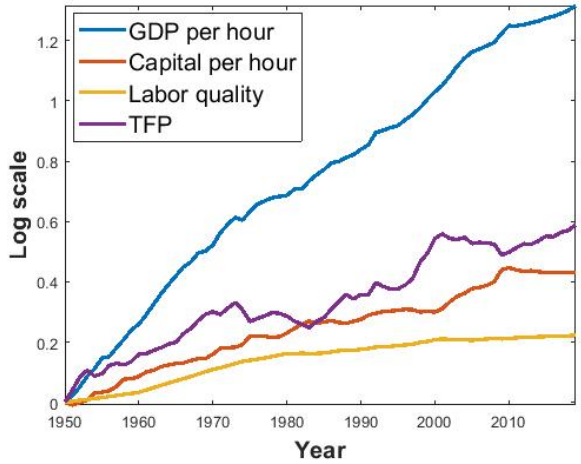
To measure the labor input, I multiply the number of working people by the average hour worked. This allows countries to differ in the numbers of hours worked by person which I take as exogenous.

Output growth in the U.S.



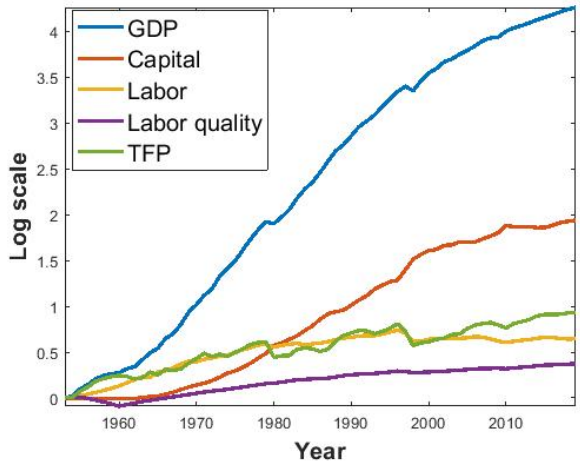
- Capital accumulation is the number one contribution for output growth in the U.S.
- A better educated workforce is relatively unimportant.
- The growth slowdown since 1970 is mostly due to low TFP growth. We observe the some gain since 2010.

Output per hour growth in the U.S.



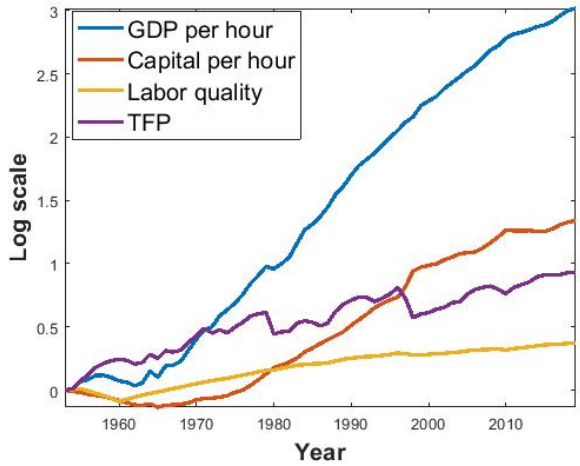
Also quantitatively, the model does a good job. As education is no longer constant, we should have $g_k > g$. This is the case (Log point changes 1.07 vs. 0.99).

A growth miracle: output growth in Korea



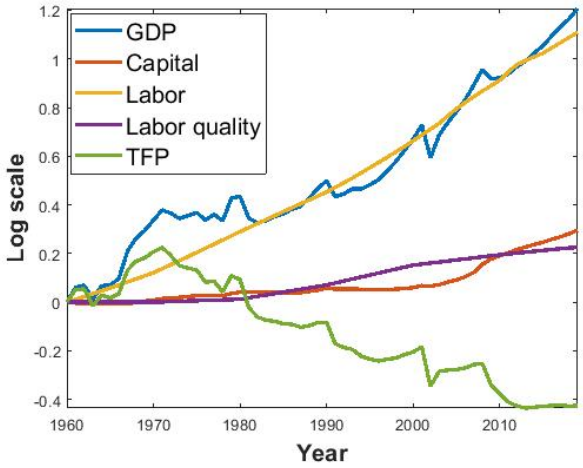
- Korea grew much quicker than the U.S. (Log scale 4.3 vs. 2.1).
- As predicted by the Solow model, what stands out is the relatively rapid capital growth (Log scale 4 vs. 1.9).
- Yet, TFP growth was also quicker (Log scale 1.8 vs. 1.0).

Output per hour growth in Korea



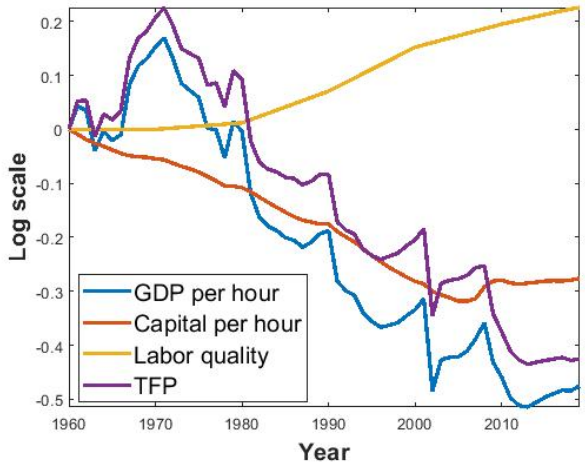
Again, consistent with the Solow model, we have $g_k > g$. In fact, consistent with the idea that Korea started out below its steady state in 1953, we have $g_k >> g$ (Log scale 2.8 vs. 1.8). The result is even starker when taking 1965 as the starting point. Also consistent with the Solow model, g_y and g_k are falling over time.

A growth disaster: output growth in Madagascar



- Madagascar was one of the poorest countries in 1960. Despite that, almost all output growth is due to labor growth.
- Capital growth is slow.
- TFP growth has been negative since 1970.

Output per hour growth in Madagascar



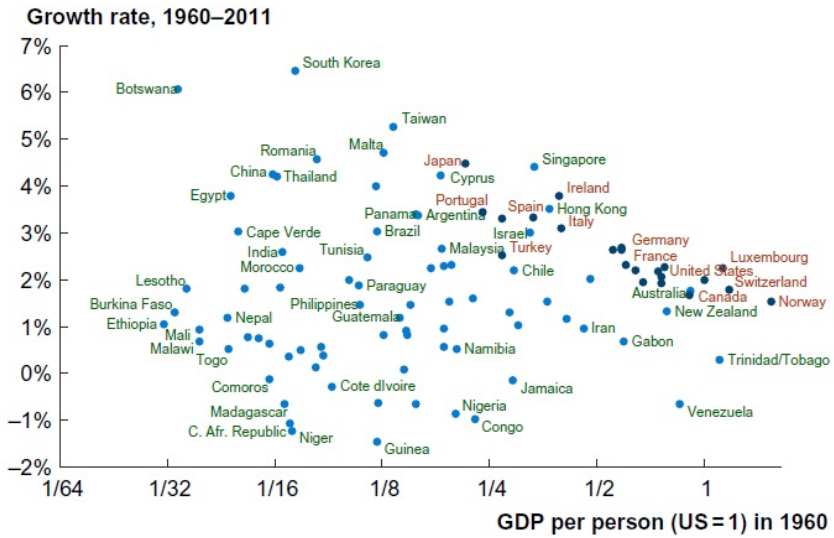
- A constant (positive) TFP growth rate is a poor assumption for Madagascar.
- In fact, *declining* TFP is key to understand declining output per hour.

Do we observe convergence in living standards?

Does the world become more equal?

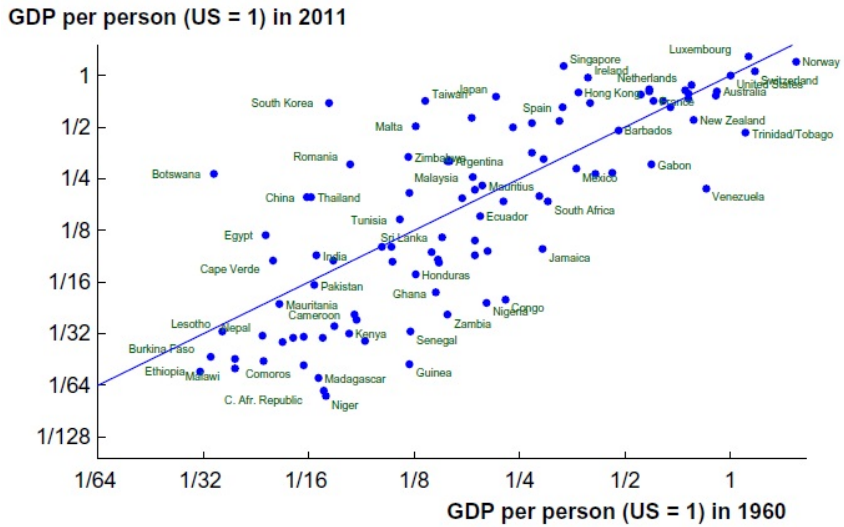
- We have seen that at any point in time, countries vary vastly in their income per capita.
- We may be interested in the question whether countries converge in their living standards over time.
- For convergence, we need that those countries who are relatively poor grow relatively quickly.

Convergence between countries



Looking at the world as a whole, we observe no general convergence between countries. It is not true that those countries which were poor in 1960 grew on average quicker than those countries who were rich in 1960. It is worth, however, to remember, that the picture would look different when looking at population weighted measures.

Convergence between countries II



As a result, those countries which were relatively rich in 1960 tend to be also relatively rich in 2011.

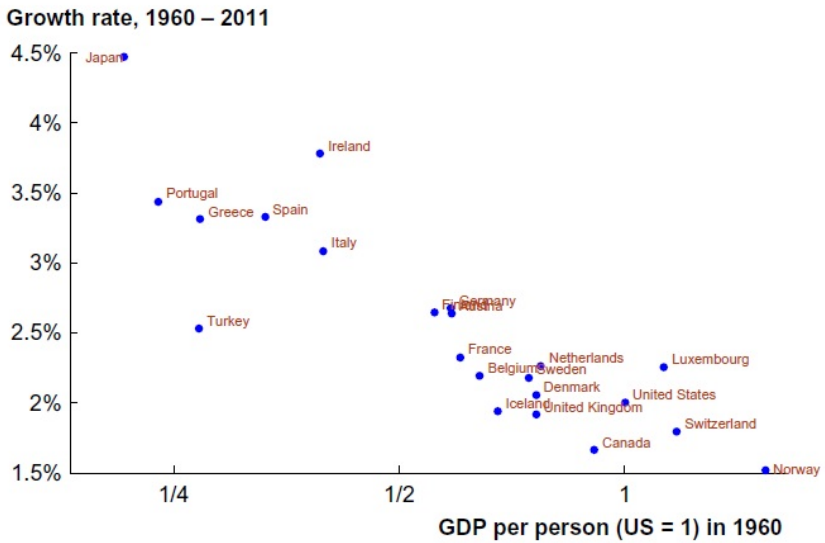
Is this inconsistent with the Solow model?

The world as a whole becoming more equal is referred to as *absolute convergence*.

It is important to recognize that the Solow model does not predict absolute convergence. Instead it predicts *conditional convergence*. Two countries with the same steady state should converge over time in GDP per capita.

As we have seen, countries do not have all the same steady state. They differ in their savings rates, population growth rates, technology growth rates, and technology levels.

Is there conditional convergence?



The countries forming the OECD have relatively similar socio-economic structures and, hence, may be thought to have similar steady states. Baumol (1986) was the first to show that conditioning on this group of countries, we indeed observe convergence in living standards.

References

Baumol, W. J. (1986): "Productivity growth, convergence, and welfare: what the long-run data show," *The american economic review*, 1072–1085.

Solow, R. M. (1957): "Technical change and the aggregate production function," *The review of Economics and Statistics*, 312–320.