

Introduction to economic growth (3)

EKN 325

Manoel Bittencourt

University of Pretoria

Introduction

- Neoclassical growth models are descendants of the Solow model. The one we are going to see is a model that incorporates human capital
- then we examine the fit of the model, can neoclassical models explain why there is so much heterogeneity in the world today? Or, why there are rich and poor countries in the world today?
- finally, we discuss the presence, or the lack of, convergence in cross-sections of countries, is income inequality amongst countries decreasing, or converging to a particular level?

The Solow model with human capital

- In an influential paper, Mankiw, Romer and Weil (1992), assess the empirical implications of the Solow model. They conclude that the model fits the data well, particularly if human capital is incorporated in the model
- the above means that labour in different countries possess different levels of education and skills. The Cobb-Douglas production function incorporates capital K and skilled labour H (and it is augmented with technology A just as before),

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

- this model assumes that in this economy people spend time learning new skills (or accumulating human capital), instead of doing other things

The Solow model with human capital

- Let's assume that u is the fraction of time that a particular individual spends on learning new skills, and L is the total amount of labour in the production function,

$$H = e^{\psi u} L, \quad (2)$$

- where ψ is a positive constant. Bear in mind that if $u = 0$, then all labour is unskilled, or $H = L$ (as in the original Solow model). On the other hand, increasing u has a positive effect on H . Furthermore, if u increases by 1 unit, say, an additional year of schooling, and $\psi = .10$, the interpretation is that H increases by 10 percent
- the above comes from Labour Economics, which predicts that an additional year of schooling increases wages by 10 percent, on average

The Solow model with human capital

- Capital accumulation is given, just like before, by,

$$\dot{K} = s_k Y - dK$$

- to solve this model we use the same techniques as before, we rewrite the augmented production function (1) in terms of per (unskilled) worker L ,

$$y = k^\alpha (Ah)^{1-\alpha}, \quad (3)$$

- where $h = e^{\psi u}$, by definition. Moreover, the model assumes that u (or how the individuals decide how much time to spend on accumulating skills) is exogenously given

The Solow model with human capital

- Equation (3) above can be divided by Ah , which gives,

$$\tilde{y} = \tilde{k}^\alpha$$

- the capital accumulation equation is given by,

$$\tilde{k}' = s_k \tilde{y} - (n + g + d)\tilde{k} \equiv s_k \tilde{k}^\alpha - (n + g + d)\tilde{k} \quad (4)$$

- recall, the steady-state of \tilde{k} is found by $\tilde{k}' = 0$, which gives,

$$\tilde{k} = \left(\frac{s_k}{n + g + d} \right)^{\frac{1}{1-\alpha}} \quad (5)$$

The Solow model with human capital

- Substituting the above, equation (5), into the production function gives the steady-state of the output-technology ratio \tilde{y} ,

$$\tilde{y}^* = \left(\frac{s_k}{n + g + d} \right)^{\frac{\alpha}{1-\alpha}} \quad (6)$$

- lastly, rewriting the above in terms of output per worker gives,

$$y^*(t) = \left(\frac{s_k}{n + g + d} \right)^{\frac{\alpha}{1-\alpha}} hA(t) \quad (7)$$

- the interpretation of (7) is important: some countries are richer than others because they invest in physical capital, have low population growth rates (just as in the original Solow model), and also because they spend time accumulating skills h plus have high levels of technology A (it is more than just education and technology, it is the combination of both, or efficiency)

The Solow model with human capital

- The question now is: how well does this model fit the data? To answer that, bear in mind that incomes grow over time, therefore it is important to use the concept of relative incomes, or how particular countries are evolving w.r.t. the USA (the benchmark country), which (by definition) is given by $\hat{y}^* = \frac{y^*}{y_{US}^*}$
- then we have to substitute equation (7), the steady-state of output, into the \hat{y}^* above to get,

$$\hat{y}^* = \left(\frac{\hat{s}k}{n + g + d} \right)^{\frac{\alpha}{1-\alpha}} \hat{h}\hat{A},$$

- where the hat (^) denotes a variable in relative, to the USA, terms

The Solow model with human capital

- Figure 3.1 illustrates that relative income is positively correlated to the levels predicted by the above equation
- recall that workers in rich countries spend on average 11 years on training, in poor countries workers spend less than 3 years on training, the differences in ability to operate particular technologies are staggering!
- furthermore, bear in mind that we are not taking into account differences in the quality of educational systems here

The Solow model with human capital

- Differences in productivity are large amongst countries, therefore a model of growth and development must explain them
- what about technology A ? Well, we can solve for technology by using our production function, which gives,

$$A = \left(\frac{y}{k}\right)^{\alpha/1-\alpha} y/h$$

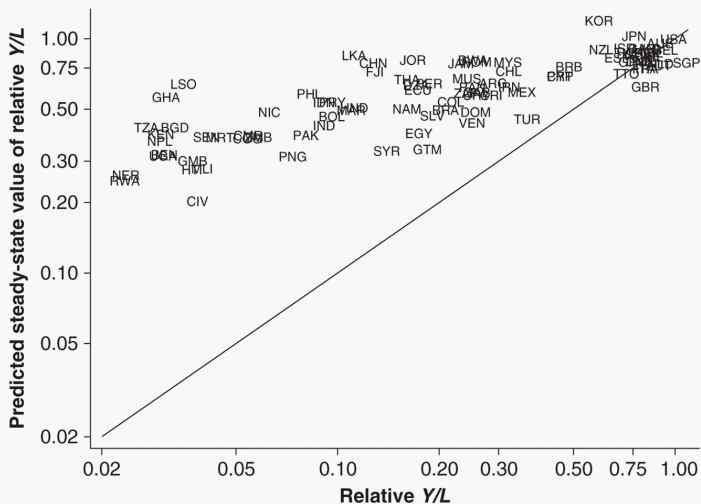
- figure 3.2 illustrates the fact that rich countries also have high levels of technology. Rich countries not only have high levels of physical capital, but also use the stock of capital more efficiently

The Solow model with human capital

- A word of caution here is therefore in place: these models do not tell us why some countries invest more in physical and human capital than others, this will be discussed later on in the course, however it can be anticipated that (good) government policies and (good) institutions (or good incentives) are the answer behind this 'miracle'

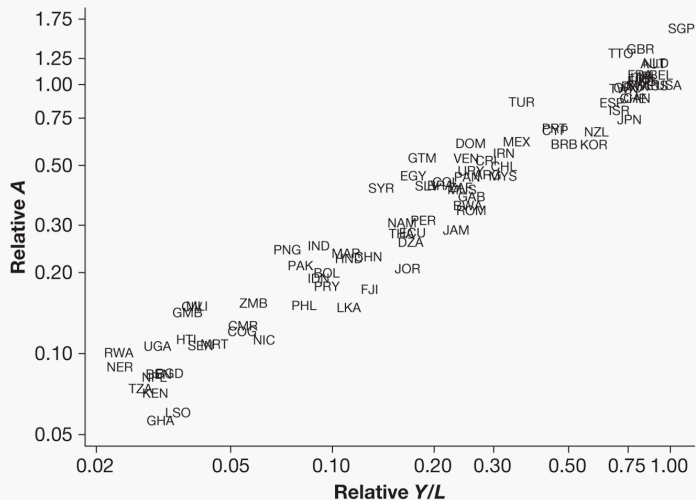
The Solow model with human capital

FIGURE 3.1 THE “FIT” OF THE NEOCLASSICAL GROWTH MODEL, 2008



The Solow model with human capital

FIGURE 3.2 PRODUCTIVITY LEVELS, 2008



Convergence and explaining differences in growth rates

- Now, the question is: how well does the neoclassical model explain differences in growth rates?
- Aleksander Gerschenkron (1952) and Moses Abramovitz (1986) suggest that 'backward' countries tend to grow faster than rich countries, or to converge to higher levels of capital
- however, we have also seen how much heterogeneity exists in the world today, the typical USA worker earns in less than 10 days what a similar worker earns in one year in Ethiopia. So, is there convergence or not?, or are poor countries somehow converging to higher levels of income?

Convergence and explaining differences in growth rates

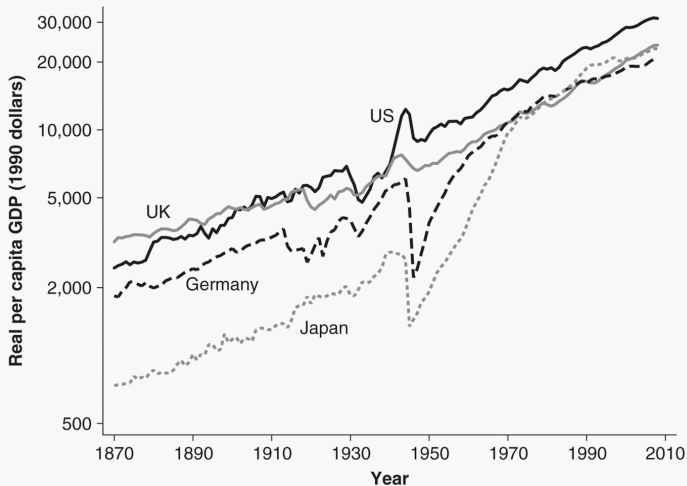
- Bear in mind that an important source of convergence would be technological transfer, by international trade, scientific journals and newspapers, immigration of scientists and engineers, lecturers, *etc.* However, the neoclassical model provides another answer
- Baumol (1986) provides some empirical evidence of convergence amongst some groups of countries. Figure 3.3 illustrates that by plotting per capita GDP for several now industrialised countries between 1870 and 2008
- it can be seen that countries which were lagging behind the UK (the benchmark at the time) in 1880 have now surpassed the British, they converged to, and even overtook, the UK over time

Convergence and explaining differences in growth rates

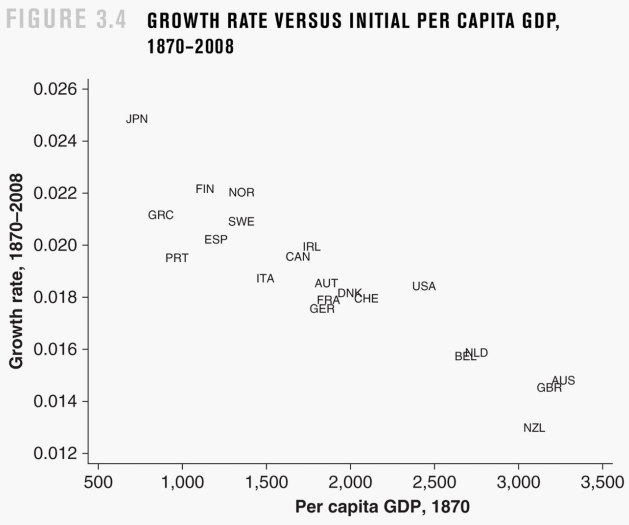
- Figure 3.4 plots the growth rate between 1870 and 2008 against per capita GDP in 1870. Those countries with lower GDP per capita in 1870 have been growing faster over time, Japan, Finland and Norway, and those with higher GDP per capita in 1870, the UK and Australia, have been growing, but slowly

Convergence and explaining differences in growth rates

FIGURE 3.3 PER CAPITA GDP, 1870-2008



Convergence and explaining differences in growth rates

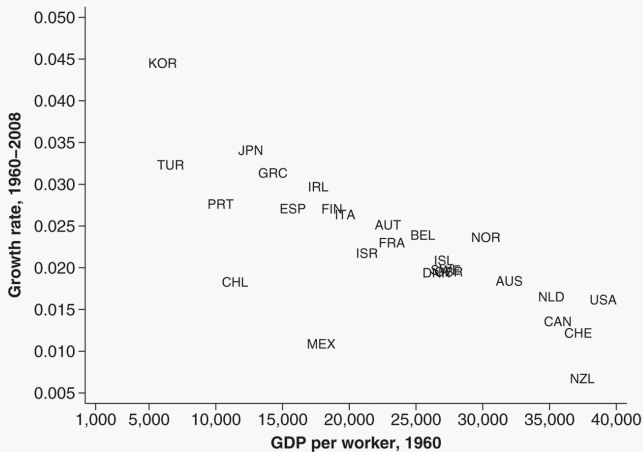


Convergence and explaining differences in growth rates

- Furthermore, figure 3.5, using a sample of OECD countries with GDP per worker in 1960, confirms the hypothesis of convergence between 1960 and 2008, that countries with lower GDP per worker in 1960 grew faster over the period
- however, when using a larger sample, a cross-section of the countries of the world between 1960 and 2008, and GDP per worker in 1960, the picture is not so clear-cut, it does not seem to be the case now that poor countries are catching up with the richer ones

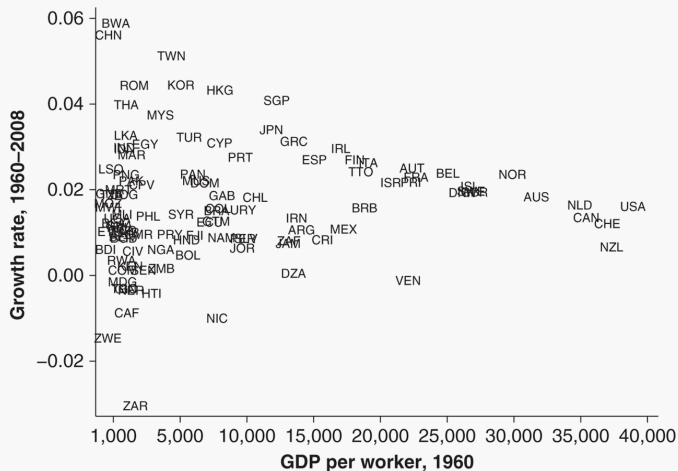
Convergence and explaining differences in growth rates

FIGURE 3.5 CONVERGENCE IN THE OECD, 1960-2008



Convergence and explaining differences in growth rates

FIGURE 3.6 THE LACK OF CONVERGENCE FOR THE WORLD, 1960-2008

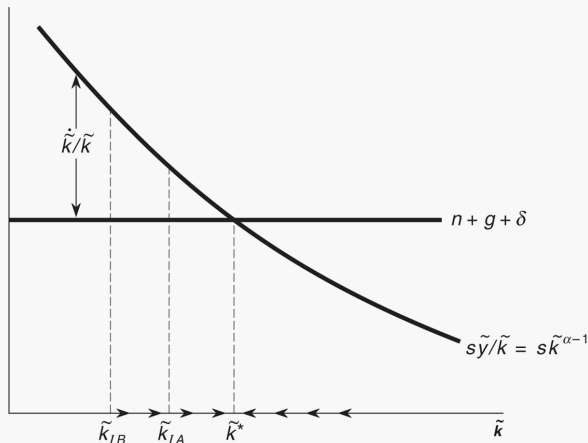


Convergence and explaining differences in growth rates

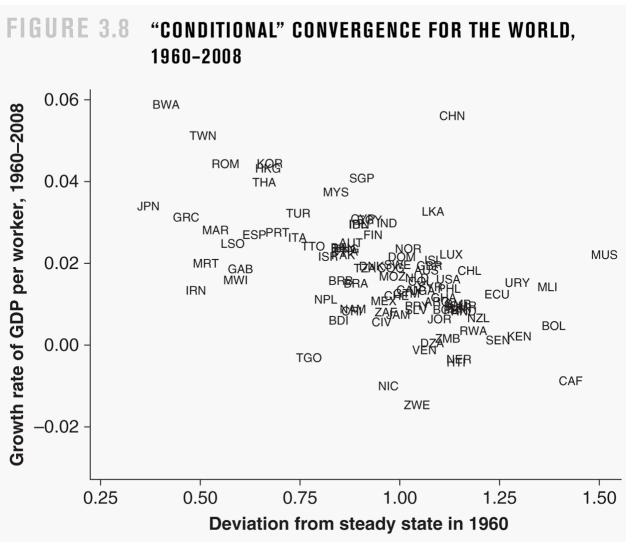
- The prediction of the neoclassical model is that amongst countries that have the same level of steady-state, or the same levels of technology, rates of investment and population growth, the initially behind will catch up with the initially ahead. The conditional convergence hypothesis holds for countries that have the same steady state, American states, OECD countries, European Union states, *etc.*
- what about lack of unconditional convergence? How can we explain figure 3.6? We can speculate that that happens because the poor countries of today do not have the same steady state as rich countries
- what if the poor countries of today are for some reason below their own steady states? Figure 3.8 plots the deviation from steady state in 1960 against the growth rate of GDP per worker between 1960 and 2008

Convergence and explaining differences in growth rates

FIGURE 3.7 TRANSITION DYNAMICS IN THE NEOCLASSICAL MODEL



Convergence and explaining differences in growth rates



Convergence and explaining differences in growth rates

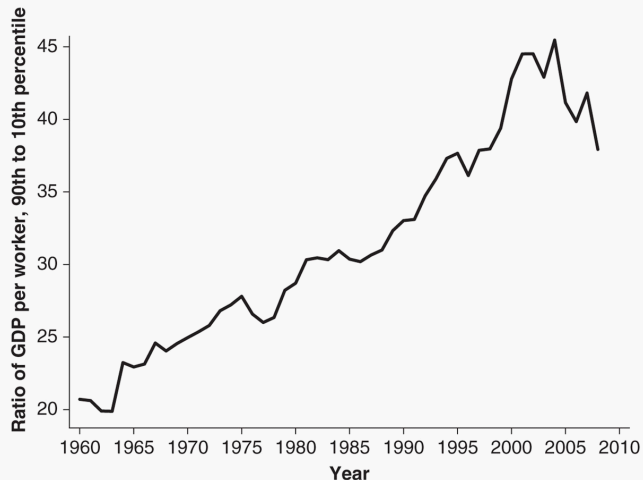
- There are some possible explanations for some countries to be below or above their steady states, (civil) wars (destruction of capital, for instance, Japan and Germany after WWII, African countries and civil (tribal) conflicts), oil prices (abnormal revenues in the short run), mismanagement of the economy (high budget deficits, high inflation, hyperinflation (Germany in the 1920s, Israel in the 1970s, South America in the 1980s and 1990s, and Zimbabwe), skill accumulation (investment in education), higher technology (investment in R&D), *etc.*

The evolution of income distribution

- The question now is, if there is convergence, then the gap between the rich and the poor should be decreasing, is this the case? Let's see how the income distribution is doing in the world
- figure 3.9 illustrates that the income distribution is, in fact, widening, the difference between the rich and the poor(est) is increasing

The evolution of income distribution

FIGURE 3.9 INCOME RATIOS, 90TH PERCENTILE COUNTRY TO 10TH PERCENTILE COUNTRY, 1960-2008



The evolution of income distribution

- However, it is not all bad news, figure 3.10 suggests that by 2008 the accelerated growth rates in China and India are already having an effect on how the world income distribution looks like, look at how 60% of the world population lived in 1960 and how they live in 2008

The evolution of income distribution

FIGURE 3.10 THE EVOLUTION OF THE WORLD INCOME DISTRIBUTION

