2015/2016, week 4

Cross-Country Income Differences

Romer, Chapter 1.6, 1.7, 4.2, 4.5, 4.6

Differences in growth rates

- Verdeling van inkomen en economische groei in geïndustrialiseerde landen

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Bron: *Economen kunnen niet rekenen*

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The power of economic growth

- Suppose China, the Netherlands and Venezuela were equivalent in terms of GDP 40 years ago
- In 40 years, China growing 5.7 percent a year, would have become 4 times as rich as the Netherlands
- Similarly, in 40 years time, the Netherlands would have become twice as rich as Venezuela growing 0.1 percent a year only

Economic growth; scope and definition

- Lecture is about structural economic growth
- It is not about business cycle fluctations of growth around its structural value
- Economic growth refers to growth of the Gross Domestic Product
  - Homework
  - Environmental damage
  - Natural resources

Growth accounting

- Adopts the concept of the aggregate production function
- Attributes economic growth to the contribution of different production factors

Growth accounting

- Consider the aggregate production function

$$Y(t) = F(K(t), A(t)L(t))$$

- Take the total derivative of the above function with respect to time:

$$\dot{Y}(t) = \frac{\partial Y(t)}{\partial K(t)}\dot{K}(t) + \frac{\partial Y(t)}{\partial L(t)}\dot{L}(t) + \frac{\partial Y(t)}{\partial A(t)}\dot{A}(t)$$

Growth accounting

- Dividing both sides of the equation by $Y(t)$, we get

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{K(t)}{Y(t)}\frac{\partial Y(t)}{\partial K(t)}\frac{\dot{K}(t)}{K(t)} + \frac{L(t)}{Y(t)}\frac{\partial Y(t)}{\partial L(t)}\frac{\dot{L}(t)}{L(t)} + \frac{A(t)}{Y(t)}\frac{\partial Y(t)}{\partial A(t)}\frac{\dot{A}(t)}{A(t)}$$

- Which can be further simplified:

$$\frac{\dot{Y}(t)}{Y(t)} = \alpha_K(t)\frac{\dot{K}(t)}{K(t)} + \alpha_L(t)\left[\frac{\dot{L}(t)}{L(t)} + \frac{\dot{A}(t)}{A(t)}\right]$$

Growth accounting

- Given that we have CRS, $\alpha_K(t) = 1 - \alpha_L(t)$, we have the growth accounting equation:

$$\frac{\dot{Y}(t)}{Y(t)} = \frac{\dot{L}(t)}{L(t)} + \alpha_K(t)\left[\frac{\dot{K}(t)}{K(t)} - \frac{\dot{L}(t)}{L(t)}\right] + (1 - \alpha_K(t))\frac{\dot{A}(t)}{A(t)}$$

- An alternative formula is the following:

$$\frac{\dot{Y}(t)}{Y(t)} - \frac{\dot{L}(t)}{L(t)} = \alpha_K(t)\left[\frac{\dot{K}(t)}{K(t)} - \frac{\dot{L}(t)}{L(t)}\right] + R(t)$$

Growth accounting

- According to the growth accounting equation, economic growth is attributed to
  - Growth in the input of labour
  - Growth in the input of physical capital
  - The Solow residual:
    - Technological progress
    - All other elements

Empirical application

- Interesting application is Young (1995)
- He adopts technique of growth accounting to explain the extraordinary postwar growth of Hong Kong, Singapore, South Korea and Taiwan (Newly Industrializing Economies)

Empirical application

- Result: economic growth has been high due to
  - Rising investment rates
  - Increasing labour force participation rates
  - Increasing levels of education
  - Intersectoral reallocations of labour towards the non-agricultural and manufacturing sector
- Additionally, the contribution of other factors such as total factor productivity growth has been limited

Growth accounting: caveat

- The factors that, according to growth accounting, drive economic growth, may be dependent on one another
- For example,
  - Labour force participation and education may both be related to labour productivity growth
  - Capital accumulation and also labour force participation may depend on technological progress

Growth accounting: caveat

- Hence, the technique of growth accounting may overstate on understate the contribution of a factor of production
- For example, suppose $A(t)$ increases with one percent
  - According to growth accounting, this increases GDP with $(1-\alpha_K(t))$ percent
  - If capital accumulation increases upon an increase in the level of technology, the growth effect is higher

Growth accounting: caveat

- Growth accounting can thus be used for linking economic growth to different factors of production
- Growth accounting should thus not be used for ‘what if’ simulation analysis

The Solow Growth model: the balanced growth path

- Along the balanced growth path, Y/L and K/L grow at rate g
- But g is exogenous
- So the Solow model describes long-run growth by just imposing it!
- In addition, the model is very abstract as regards the description of knowledge (or effectiveness of labour)

The Solow Growth model: convergence

- The Solow Growth model predicts convergence to a state of balanced growth
- Hence, countries starting below their long-run paths grow faster than those starting above
- To see that consider a case where differences in Y/L stem only from physical capital per worker K/L. That is, human capital per worker and output for given inputs are the same across countries

The Solow Growth model: convergence

- Assume again the CRS production function

$$Y(t) = F(K(t), A(t)L(t))$$

- Recall the adjustment equation for capital per effective worker:

$$\dot{k} = \lambda \left[k_i^* - k_i(t) \right]$$

- $\lambda > 0$ measures the rate of convergence

The Solow Growth model: convergence

- This says that the farther is the economy below its balanced growth path, the faster does K/L grow
- For Y/L a similar expression applies
- Hence, also Y/L grows faster the more Y/L differs from its steady-state level

The Solow Growth model: convergence

- As to the value of k^*, one can make two alternative assumptions
- One is that k^* is the same in all countries
  - In this case, all countries grow towards the same Y/L
  - The lower is the initial level Y/L, the faster is the growth of Y/L
  - We call this *unconditional convergence*

The Solow Growth model: convergence

- A second assumption is that k^* varies across countries
  - In this case, there is a persistent component of cross-country income differences
  - Poor countries (e.g., with low saving rates) may not grow faster than other countries
  - There is still convergence towards the own balanced growth path
  - We call this *conditional convergence*

The Solow Growth model: convergence

- Unconditional convergence gives a good description of differences in growth among industrialized countries in the post-war period
  - This is so since saving rates, levels of education and other factors related to long-run fundamentals are similar across industrialized countries
- For the same reason, it does not work that well for countries all over the world
  - In terms of the Solow Growth model, s, n and g can differ a lot between countries

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Estimating convergence

- Baumol (1986) addresses the question whether the growth performance of countries features convergence
- Baumol (1986) examines convergence from 1870 to 1979 among 16 industrialized countries
  - He regresses output growth over this period on a constant and initial income
  - Model specification:

$$\ln\left[\left(\frac{Y}{N}\right)_{i,1979}\right] - \ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right] = a + b\ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right] + \varepsilon_i$$

Estimating convergence

- ln(Y/N) is log income per person, ε is an error term, and i indexes countries
- Convergence if b <0: countries with higher initial incomes have lower growth
- Perfect convergence if b = -1
- No convergence if b = 0

Estimating convergence

- Estimation result:

$$\ln\left[\left(\frac{Y}{N}\right)_{i,1979}\right] - \ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right] = 8.457 - \underset{(0.094)}{0.995} \ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right],$$

$$R^2 = 0.87, \qquad \text{s.e.e.} = 0.15,$$

Estimating convergence

- DeLong (1988) shows that Baumol's finding is largely spurious, due to
- Sample selection:
  - since historical data are constructed retrospectively, the countries that have long data series are generally those that are the most industrialized today
- Measurement error:
  - estimates of real income per capita in 1870 are imprecise. Measurement error creates bias toward finding convergence

Estimating convergence

- One way to tackle the first problem is to increase the sample and compare the richest countries as of 1870
- DeLong (1988) creates a sample that consists of all countries at least as rich as the second poorest country in Baumol's sample in 1870, Finland
- Hence, he adds 7 countries (Argentina, Chile, East Germany, Ireland, New Zealand, Portugal, and Spain) and drops one (Japan)
- Result:
  - the estimate of b of -0.995 drops to -0.566 and becomes less statistically significant

Estimating convergence

- Way to tackle the second problem (i.e. measurement error) is to estimate:

$$\ln\left[\left(\frac{Y}{N}\right)_{i,1979}\right] - \ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right]^{*} = a + b\ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right]^{*} + \varepsilon_i,$$

$$\ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right] = \ln\left[\left(\frac{Y}{N}\right)_{i,1870}\right]^{*} + u_i.$$

Estimating convergence

- ln[(Y/N)1870]* is the true value of log income per capita in 1870
- ln[(Y/N)1870] is the measured value
- ε and u are assumed to be uncorrelated with each other and with ln[(Y/N)1870]*
- Result:
  - depending on the guess for the standard deviation of the estimation error, the estimate for b drops further, to 0 or even 1, thereby eliminating all of the remainder of Baumol's estimate of convergence

Cross-country income differences: the role of capital

- Where do income differences (i.e., differences in Y/L) between countries stem from?
- Similarly, what makes income differ between time periods?
- According to the Solow model, there are two candidate factors:
  - Differences in the capital per worker (K/L)
  - Differences in the effectiveness of labour (A)

Cross-country income differences: the role of capital

- Take the production function. This reads as follows:
  - $Y = F(K, AL) \quad \rightarrow \quad y = F(k, A)$
  - Where y and k are defined as output and capital respectively per worker (!):
  - $y = \frac{Y}{L}; k = \frac{K}{L}$

Cross-country income differences: the role of capital

- Assume the production function is Cobb-Douglas:
  - $Y = K^{\alpha}(AL)^{1-\alpha} \quad \rightarrow$
  - $y = k^{\alpha}A^{1-\alpha}$
- Income difference between countries A and B:
  - $y = k^{\alpha}A^{1-\alpha}$
  - $\left(\frac{y^A}{y^B}\right) = \left(\frac{k^A}{k^B}\right)^{\alpha}\left(\frac{A^A}{A^B}\right)^{1-\alpha}$

Cross-country income differences: the role of capital

- Can differences in the stocks of capital per worker explain income differences between countries?
- In order to account for the difference in income between a rich country and a poor country of a factor 10, the stocks of capital need to differ a factor $(10)^{1/\alpha}$
  - Formally, solve $\left(\frac{y^A}{y^B}\right) = 10 = \left(\frac{k^A}{k^B}\right)^{\alpha} \rightarrow \left(\frac{k^A}{k^B}\right) = (10)^{1/\alpha}$

Cross-country income differences: the role of capital

- Standard elasticity of output w.r.t. capital
- α =1/3: $\left(\frac{k^A}{k^B}\right) = (10)^{1/(\frac{1}{3})} = 1000$
- Elasticity using broad measure of capital
- α =1/2: $\left(\frac{k^A}{k^B}\right) = (10)^{1/(\frac{1}{2})} = 100$
- Capital stocks differ not more than a factor 20 to 30 between rich and poor countries

Cross-country income differences: the role of capital

- The marginal product of capital in the Cobb-Douglas case:
  - $y = f(k) = k^{\alpha} \quad \rightarrow$
  - $f'(k) = \alpha k^{\alpha-1} = \alpha y^{(\alpha-1)/\alpha}$
- In order to account for the difference in income between a rich country and a poor country of a factor 10, the marginal products of capital differ a factor $(10)^{(\alpha-1)/\alpha}$

Cross-country income differences: the role of capital

- Standard elasticity of output w.r.t. capital
- α =1/3: $\left(\frac{f'(k)^A}{f'(k)^B}\right) = (10)^{(\frac{-2}{3})/(\frac{1}{3})} = 0.01$
- Elasticity using broad measure of capital
- α =1/2: $\left(\frac{f'(k)^A}{f'(k)^B}\right) = (10)^{(\frac{-1}{2})/(\frac{1}{2})} = 0.1$
- Rates of return do not differ a factor 10 or 100 between countries
- If they did so, we would observe massive capital flows from rich to poor countries

Income differences over time: the role of capital

- For differences in income over time, the same holds true as for differences in income between countries:
  - In the data, capital stocks and rate of return on capital do not differ enough to account for the output differences
- This implies
  - That countries and time periods differ a lot in terms of *A*
  - Or, that capital is much more valuable than is reflected in its price

Cross-country income differences: human capital

- How about extending the approach by including human capital?
- Would that increase the contribution from capital (and decrease the role of technology or, better, the residual)?
- Take the following Cobb-Douglas production function

$$Y(t) = K(t)^{a}(A(t)H(t))^{1-a}$$

Cross-country income differences: human capital

- One can think of human capital H as the contribution of skills, expertise or education to the quality of labour
- The more educated, skilled or experienced the labour force, the higher is human capital H

Cross-country income differences: human capital

- To see how the introduction of human capital improves the ability of the model to explain income per capita growth and, hence, cross-country income differences, consider our new production function (in per capita terms) in logs

$$\ln \frac{Y_i}{L_i} = a \ln \frac{K_i}{L_i} + (1-a) \ln \frac{H_i}{L_i} + (1-a) \ln A_i$$

Cross-country income differences: human capital

- The above equation can be further rearranged as

  - $ln\frac{Y_i}{L_i} = \frac{a}{1-a} ln\frac{K_i}{Y_i} + ln\frac{H_i}{L_i} + lnA_i$

Cross-country income differences: human capital

- Empirical Results; the hard part is to find a good proxy for the human capital term *H*
  - In empirical studies, it is proxied with years of schooling
- Hall & Jones (1999) compare the five richest countries in their sample with the five poorest ones
- Average Y/L in the rich group exceeds that in the poor group by 31.7 (or 3.5 in logs)
- The contribution of (a/(1-a))ln(K/Y) is 0.6, that of ln(H/L) is 0.8, and that of ln(A) is 2.1

Cross-country income differences: human capital

- That is, only about a sixth in the gap between the richest countries and the poorest ones is due to differences in physical capital intensity
- Only a slightly larger fraction is due to differences in schooling
- The largest part of country differences in income per capita is due to differences in technology or other factors included in the Solow residual

Cross-country income differences: human capital

- Extensions:
  - Human capital also depends on nationality worker (Klenow and Rodríguez-Claire 1997, Hendricks 2002)
  - Return to education may be different for different types of education
  - Low-skilled labour and high-skilled labour may be complements in production
- Conclusion does not change:
  - The inclusion of human capital into the production function does not lead to dramatically different results

Cross-country income differences: the residual A

- The fact that the residual term A is not well defined makes the empirical analysis tough. Why?
- Because we want to know the determinants of growth.
  - What are the determinants of economic growth?
  - Are they exogenous or endogenously related to economic policies?
  - If so, which kind of economic policies?

Cross-country income differences: the residual A

- A bunch of other possible factors exist that can contribute to an explanation of economic growth
- Charles Jones introduced the term social infrastructure
  - The whole of government activities that impact on the wedge between social and private returns
  - The definition is very broad: the activities may increase or deteriorate social welfare

Cross-country income differences: social infrastructure

- Taxation and subsidization of various activities (labour supply, saving, investment, education)
  - Operational costs
  - Costs in terms of changed economic behaviour
  - Costs in terms of an expansion of the informal economy
- Legislation
  - Crime
  - Enforceability of contracts
- Government expropriation, bribery

Cross-country income differences: social infrastructure

- Values and norms
  - Religion
  - Individual initiative
- Interest groups
  - Dictatorship
  - Bribe-taking officials
  - Firms that benefit from a lack of competition

Cross-country income differences: geography

- Average incomes in countries within 20 degrees of the equator are less than a sixth of those in countries at more than 40 degrees of latitude
- The former countries feature environments more conducive to disease
- The former countries feature climates less favourable to agriculture

Cross-country income differences: colonization strategies

- Acemoglu, Johnson and Robinson argue that today's institutions – which are important for economic growth – have been shaped by colonization strategies as pursued by European countries in the past few centuries
- 1 Establishment of "extractive states" that focus on exploitation without creating democratic institutions in high-mortality regions (Latin American countries)
- 2 Establishment of "settler colonies" that create institutions similar to those in the colonist countries in low-mortality regions (United States, Australia, New Zealand)

Cross-country income differences: colonization strategies

- Acemoglu and Robinson (2012), Why Nations Fail – The origins of power, prosperity and poverty
- Book blends economics, politics and history
- Argues that economic growth stems from inclusive institutions
- On the contrary, extractive institutions hinder economic growth

Cross-country income differences: the residual A

- The precise role of all these factors is still unknown, but currently widely investigated
- Economists may fail to ever produce definitive answers to the question of the ultimate determinants of economic growth on account of
  - a lack of empirical data
  - a lack of social experiments