ECON 3510 - Intermediate Macroeconomic Theory

Fall 2013

Mankiw, *Macroeconomics, 8th ed.*, Chapter 9

Chapter 9: Economic Growth: Technology, Empirics, and Policy

Key points:

- Solow Growth Model w/ technological progress
- Stylized facts of economic growth
- Understand how and why policies affect economic growth
- Understand the endogenous growth model

****SHOW Graph of GDP and GDP per workers over time*****

Technological Change in the Solow Growth Model:

- Model w/o pop growth resulting in GDP growth only up to SS
- Model with population growth resulting in GDP growth in SS, but GDP per worker constant in SS
- Now, we'll add technology to get the GDP per worker growth we see in the data
- Recall our aggregate production function:
  - $Y = F(K, L \times E)$
  - E = efficiency of labor
  - $\Rightarrow L \times E = \#$ of effective workers
  - E grows at a rate g
- Now think about production per effective worker:
  - $y = \frac{Y}{L \times E}, k = \frac{K}{L \times E}, i = \frac{I}{L \times E}$
  - $y = f(k) = F(k, 1)$
  - $\Delta k = i - (\delta + n + g)k$
  - $\Delta k = sf(k) - (\delta + n + g)k$
  - Where δ is the rate of deprec, n the rate of pop growth, and g the rate of growth in efficiency per worker
  - DRAW "total" depreciation function, savings function and SS capital stock
- Model still converges to k^*, where $\Delta k = 0$ (i.e., k^* solves: $sf(k^*) = (\delta + n + g)k^*$
- At SS:

Golden Rule with Technological Growth:

- Max consumption per effective worker

Table 1: Add caption

	Variable	Growth
capital per effective worker	$k = \frac{K}{L \times E}$	$\Delta k = 0$
output per effective worker	$y = \frac{Y}{L \times E}$	$\Delta y = 0$
output per worker	$y \times E = \frac{Y}{L}$	$\Delta(\frac{Y}{L}) = \Delta y + \Delta E = g$
total output	$Y = y \times L \times E$	$\Delta Y = \Delta y + \Delta E + \Delta L = 0 + g + n = g + n$

- Solve: $c^* = f(k^*) - (\delta + n + g)k^*$
  - $\frac{\partial c^*}{\partial k^*} = MPK - \delta - n - g = 0$
  - $\Rightarrow MPK - \delta = n + g$
    - Net MPK = rate of growth in total output (more capital means net marginal product is less than growth in output - so losing some output to invest to offset deprec)
    - Intuition is that you will maximize consumption at the point that the net from more capital (the change in output minus the change in deprec) just equals the decrease in output per effective worker caused by population and technological growth

Growth Facts:

- SHOW graphs of $\frac{Y}{L}$ and $\frac{K}{L}$ in US
- SHOW $\frac{Y}{K}$ in US
- Balanced growth:
  - Balanced growth means that ratio of output to capital constant in SS
  - To find this:
  - Recall that in the SS, output per worker ($\frac{Y}{L}$) grew at a rate $= \Delta y + \Delta E = 0 + g = g$
  - Recall that in the SS, $\Delta k = 0$ (by dfn)
    - $\Rightarrow \Delta \frac{K}{L} = \Delta k + \Delta E = 0 + g = g$
  - $\frac{Y}{L}$ and $\frac{K}{L}$ both grow at rate g in the model
    - $\Rightarrow \frac{Y}{K} = \frac{\frac{Y}{L}}{\frac{K}{L}} = \frac{Y}{L} \times \frac{L}{K} = \frac{Y}{K}$
    - $\Delta(\frac{Y}{K}) = \Delta(\frac{Y}{L}) - \Delta(\frac{K}{L}) = g - g = 0$
- Convergence:
  - ***SHOW graphs from Cooper on convergence***
  - Prediction of models is the that all countried converge to the same SS
  - Poor countries grow faster than rich countries
  - This is an important prediction of the model and has some empirical support
  - When occur?
    - Different initial capital stocks
  - When not occur?
    - Different savings rate, s

    - $*$ Different tech growth rate, g
    - $*$ Different pop growth rate, n
    - $*$ Different production function, $f(k)$

<u>Endogenous Growth</u>:

- So far, we got SS growth only when we assumed that $g > 0$
- Now we develop a theory where growth is endogenous (recall that this means it is determined within the model)
- Endogenous Growth Model:
  - $Y = AK$
    - $A =$ technology
    - $K =$ capital stock
  - Note CRS $\rightarrow \uparrow K 10\% \Rightarrow \uparrow Y 10\%$
  - $\Rightarrow \Delta K = sY - \delta K$
  - $\Rightarrow \Delta K = sAK - \delta K$
  - $\Rightarrow \frac{\Delta K}{K} = sA - \delta$
    - $\Rightarrow$ If $sA > \delta$, growth (accumulate capital stock faster that it depreciates)
    - Result is growth forever (capital does't hit a SS value and stop)
- Note that effect is driven by assumptions on production function - namely, no longer have a diminishing MPK
  - More capital now results in permanent growth of capital stock
  - With DRS, return to SS capital stock determined by exogenous growth rate - level of capital today doesn't matter
- How justify CRS assumption?
  - Broader capital definition
  - Include knowledge in capital