Long-Run Economic Growth, Part 2

Agenda

• Fundamental Determinants of Living Standards.
• Endogenous Growth Theory.
• Policies to Raise Long-Run Living Standards.

The Solow Model

• Fundamental determinants of living standards:
  ➢ The saving rate.
  ➢ Population growth.
  ➢ Productivity growth.

The Solow Model

• Fundamental determinants of living standards:
  ➢ Increasing the saving rate:
The Solow Model

- The adjustment mechanism:
  - A higher saving rate shifts the saving function up.
  - At the original \( K/N \), at \( (K/N)_A \), \( S/N \) is now greater than \( I_b/N \).
  - Consequently, \( K/N \) will increase, causing:
    - \( Y/N \) to increase along the production function,
    - \( S/N \) to increase along the new saving function, and
    - \( I_b/N \) to increase along the balanced investment function.

- The Solow Model (continued):
  - A higher saving rate shifts the saving function up.
  - At the original \( K/N \), at \( (K/N)_A \), \( S/N \) is now greater than \( I_b/N \).
  - Consequently, \( K/N \) will increase, causing:
    - \( Y/N \) to increase along the production function,
    - \( S/N \) to increase along the new saving function, and
    - \( I_b/N \) to increase along the balanced investment function.

- The Solow Model (continued):
  - Because of diminishing marginal product of capital, the increase in \( S/N \) is smaller than the increase in \( I_b/N \) for every increase in \( K/N \).
  - Eventually \( S/N \) will equal \( I_b/N \) at a new, higher steady state at B.

- The Solow Model (continued):
  - At B, \( Y/N \) has increased, \( K/N \) has increased, \( S/N \) has increased, and \( I_b/N \) has increased.
  - At steady state B, \( \Delta Y/Y = \Delta N/N = \Delta K/K \).
  - During the transition period from steady state A to steady state B:
    - \( \Delta Y/Y > \Delta N/N \) because \( Y/N \) was increasing, and
    - \( \Delta Y/Y > \Delta K/K \) because \( K/N \) was increasing.
The Solow Model

- Fundamental determinants of living standards:
  - Increasing the saving rate means:
    - A higher capital-labor ratio, $K/N$,
    - A higher output per worker, $Y/N$, and
    - A higher consumption per worker, $C/N$.

- Slowing the population growth rate:

Effect of a faster population growth rate

- $Y/N = A^*(K/N)$
- $I_t/N = (s + d)K/N$
- $S/N = sA^*(K/N)$
- $(S/N) = (I_t/N)$
- $(K/N)$
The Solow Model

- The adjustment mechanism:
  - A slower population growth rate rotates the balanced investment function down.
  - At the original $K/N$, at $(K/N)_A$, $S/N$ is now greater than $I_b/N$.
  - Consequently, $K/N$ will increase, causing:
    - $Y/N$ to increase along the production function,
    - $S/N$ to increase along the saving function, and
    - $I_b/N$ to increase along the new $I_b/N$ function.

- The adjustment mechanism (continued):
  - Because of diminishing marginal product of capital, the increase in $S/N$ is smaller than the increase in $I_b/N$ for every increase in $K/N$.
  - Eventually $S/N$ will equal $I_b/N$ at a new, higher steady state at B.

- Fundamental determinants of living standards:
  - Slowing the population growth rate means:
    - A higher capital-labor ratio, $K/N$,
    - A higher output per worker, $Y/N$, and
    - A higher consumption per worker, $C/N$. 

- The adjustment mechanism (continued):
  - At B, $Y/N$ has increased, $K/N$ has increased, $S/N$ has increased, and $I_b/N$ has increased.
  - At steady state B, $\Delta Y/Y = \Delta N/N = \Delta K/K$.
  - During the transition period from steady state A to steady state B:
    - $\Delta Y/Y > \Delta N/N$ because $Y/N$ was increasing, and
    - $\Delta Y/Y > \Delta K/K$ because $K/N$ was increasing.
The Solow Model

• Fundamental determinants of living standards:
  - Slowing the population growth rate:
    - Should reducing population growth be a policy goal?
      - Doing so will raise consumption per worker but it will reduce total output and consumption.
      - We have also assumed that the proportion of the population of working age is fixed which may not be true.

• Increasing the productivity growth rate:
  - An improvement in productivity shifts both the production and saving functions up.
  - At the original $K/N$, at $(K/N)_A$, $Y/N$ is now higher.
  - Also at the original $K/N$, at $(K/N)_A$, $S/N$ is now greater than $I_y/N$.

Effect of a productivity improvement

$$\frac{Y}{N} = \frac{A^* f(\frac{K}{N})}{Y/N}$$
$$I_y/N = (n + d)K/N$$
$$S/N = \frac{s^*A^*f(K/N)}{S/N}$$
The Solow Model

• The adjustment mechanism:
  
  ➢ Consequently, \( K/N \) will increase, causing:
    • \( Y/N \) to increase along the new production function,
    • \( S/N \) to increase along the new saving function, and
    • \( I_b/N \) to increase along the balanced investment function.

• The adjustment mechanism (continued):
  
  ➢ Because of diminishing marginal product of capital, the increase in \( S/N \) is smaller than the increase in \( I_b/N \) for every increase in \( K/N \).
  
  ➢ Eventually \( S/N \) will equal \( I_b/N \) at a new, higher steady state at B.

• The adjustment mechanism (continued):
  
  ➢ At B, \( Y/N \) has increased, \( K/N \) has increased, \( S/N \) has increased, and \( I_b/N \) has increased.
  
  ➢ At steady state B, \( \Delta Y/Y = \Delta N/N = \Delta K/K \). 
  
  ➢ During the transition period from steady state A to steady state B:
    • \( \Delta Y/Y > \Delta N/N \) because \( Y/N \) was increasing, and
    • \( \Delta Y/Y > \Delta K/K \) because \( K/N \) was increasing.

The Solow Model

• Fundamental determinants of living standards:
  
  ➢ An improvement in productivity means:
    • A higher capital-labor ratio, \( K/N \),
    • Higher output per worker, \( Y/N \), and
    • Higher consumption per worker, \( C/N \).
The Solow Model

• Fundamental determinants of living standards:
  - An improvement in productivity means:
    - Productivity improvement *directly* improves the amount that can be produced at any capital-labor ratio.
    - The increase in output per worker also increases the supply of saving, and *indirectly* causes the long-run capital-labor ratio to rise.

Application: The growth of China

• Population of 1.3 billion people.
  - A huge labor force with a comparative advantage in labor-intensive industries where wages are low.
• A low, but rapidly growing, level of GDP.
  - About 1/7 of US GDP per capita in 2007.
Real GDP growth in China and the US

Application: The growth of China

• Rapid output growth attributable to:
  - Saving is very high.
    - Current consumption is very low.
    - Huge increases in capital investment.
  - Productivity growth is very rapid.
    - Due in part from changing to a market economy.
    - Due to adopting foreign technologies through FDI, etc.
  - Population growth has slowed.

Application: The growth of China

• Will China ever catch up to the U.S.?
  - Problems China faces:
    - Weak banking system.
    - Rapidly aging population.
    - Increasing income inequality.
    - Much unemployment in rural areas.
Endogenous Growth Theory

- **Endogenous growth theory** attempts to explain the sources of productivity growth.
  - Assume the aggregate production function is:
    \[ Y = AK \]
    - which implies constant MPK.

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Endogenous Growth Theory

- How can the MPK be constant?:
  - The existence of **human capital**:
    - Human capital is the knowledge, skills, and training of the labor force.
    - Human capital tends to increase in the same proportion as physical capital.

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Endogenous Growth Theory

- How can the MPK be constant?:
  - The presence of research and development.
    - Increases in capital and output generate increased technical knowledge, which offsets decline in MPK from having more capital.

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Endogenous Growth Theory

- Implications of a constant MPK:
  - Assume saving is a constant fraction of output:
    - \( S = sY = sAK \)
  - Investment = net investment + depreciation,
    - \( I = \Delta K + dK \).
Endogenous Growth Theory

- Implications of a constant $MPK$:
  
  - In equilibrium, saving equals investment so:
    
    $$sAK = \Delta K + dK$$
    
    - or
    
    $$\Delta K/K = sA - d$$

- Summary:
  
  - Endogenous growth theory attempts to explain, rather than assume, changes in productivity.
  
  - The growth rate depends on many things which can be affected by government policies, including the saving rate.

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Endogenous Growth Theory

- Implications of a constant $MPK$:
  
  - If $Y$ is proportional to $K$, then $\Delta Y/Y = \Delta K/K$, so
    
    $$\Delta K/K = sA - d \Rightarrow \Delta Y/Y = sA - d$$
    
  - And the saving rate does affect long-run growth.
    
    - Which is not true in Solow model.

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Policies to Raise Long-Run Living Standards

- Policies to increase the saving rate:
  
  - If private markets are efficient, the government should not try to change the saving rate.
    
    - The private markets’ saving rate represents its optimal trade-off of present for future consumption.
    
    - However, if tax laws or myopia cause an inefficiently low level of saving, government policy to raise the saving rate may be justified.
Policies to Raise Long-Run Living Standards

• Policies to increase the saving rate:
  ➢ Increase private saving.
    • Raise the real interest rate to encourage saving.
      – The response of saving to changes in the real interest rate seems to be small.
    • Provide tax incentives to encourage saving.
      – The response of saving to changes in tax incentives also seems to be small.

• Policies to increase the saving rate:
  ➢ Increase government saving.
    • Reduce the government deficit or run a surplus.
      – Through reduced government purchases or higher taxes.
    » But under Ricardian equivalence, tax increases to reduce the deficit won’t affect national saving.

Policies to Raise Long-Run Living Standards

• Policies to raise the productivity growth rate:
  ➢ Improve the infrastructure:
    • Infrastructure is the highways, bridges, utilities, dams, airports, etc.
      – Research suggests a link between the amount and quality of infrastructure and productivity growth.

• Policies to raise the productivity growth rate:
  ➢ Build human capital:
    • Research shows a strong connection between productivity and human capital.
    • Government can encourage human capital formation through educational policies, worker training and relocation programs, and health programs.
    • Another form of human capital is entrepreneurial skill.
      – Government could help by removing barriers like red tape.
Policies to Raise Long-Run Living Standards

- Policies to raise the **productivity growth rate**:
  - Encourage research and development:
    - Encourage R & D through direct and/or indirect means:
      - Government funding of R & D efforts.
      - Government tax incentives for R & D activities.
      - Enforcement of patents, trademarks, etc.

Summary

- Fundamental determinants of living standards:
  - The saving rate,
  - The population growth rate, and
  - Productivity growth.
- The productivity growth rate is the **dominant factor** in determining how quickly living standards increase.

Summary

- Endogenous growth theory is an explicit attempt to explain changes in productivity.
  - If improvements in human capital and research and development programs can keep the **MPK** constant (as \( K \) increases), then saving will also be an important factor in determining living standards.

Summary

- Government can influence living standards with policies designed to:
  - Increase the saving rate,
  - Slow the population growth rate, and/or
  - Raise the productivity growth rate.