Long-Run Economic Growth, Part 1

Agenda

- The Sources of Economic Growth
- Growth Dynamics: The Solow Model

Long-Run Economic Growth

- Countries have grown at very different rates over long spans of time.

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<tbody>
<tr>
<td>Australia</td>
<td>3.45</td>
<td>3.71</td>
<td>7.41</td>
<td>20.86</td>
<td>1.45</td>
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<tr>
<td>Canada</td>
<td>3.65</td>
<td>4.44</td>
<td>7.43</td>
<td>24.20</td>
<td>2.0</td>
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<tr>
<td>France</td>
<td>1.57</td>
<td>2.49</td>
<td>5.27</td>
<td>16.42</td>
<td>1.8</td>
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<tr>
<td>Germany</td>
<td>1.61</td>
<td>3.84</td>
<td>8.81</td>
<td>19.35</td>
<td>1.8</td>
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<tr>
<td>Japan</td>
<td>1.56</td>
<td>3.80</td>
<td>5.96</td>
<td>15.10</td>
<td>2.4</td>
</tr>
<tr>
<td>Sweden</td>
<td>1.66</td>
<td>5.06</td>
<td>6.78</td>
<td>22.10</td>
<td>1.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>3.19</td>
<td>4.93</td>
<td>6.67</td>
<td>21.98</td>
<td>1.4</td>
</tr>
<tr>
<td>United States</td>
<td>2.45</td>
<td>5.30</td>
<td>9.96</td>
<td>13.24</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Note: Figures are in U.S. dollars at 1990 prices adjusted for differences in the purchasing power of the various national currencies.


The Sources of Economic Growth

- The economy’s production function is:
  \[ Y = AF(K, N) \]

- The growth accounting formula:
  \[ \Delta Y/Y = \Delta A/A + a_K \Delta K/K + a_N \Delta N/N \]

  ➢ The \( a \) terms are the output elasticities with respect to the \( K \) and \( N \) inputs.
The Sources of Economic Growth

- According to the growth accounting formula:

\[
\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + a_K \frac{\Delta K}{K} + a_N \frac{\Delta N}{N}
\]

- A rise of 10% in \( A \) raises output by 10%.
- A rise of 10% in \( K \) raises output by \( a_K \) times 10%.
- A rise of 10% in \( N \) raises output by \( a_N \) times 10%.

Accounting for Growth:

- Collect data on \( \Delta Y/Y \), \( \Delta K/K \), and \( \Delta N/N \).
- Adjust for quality changes.
- Estimate \( a_K \) and \( a_N \) from historical data.

Table 6.3 Sources of Economic Growth

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Labor growth</td>
<td>1.47</td>
<td>1.40</td>
<td>1.13</td>
<td>1.54</td>
<td>0.95</td>
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<tr>
<td>Capital growth</td>
<td>0.11</td>
<td>0.27</td>
<td>0.00</td>
<td>0.56</td>
<td>0.80</td>
</tr>
<tr>
<td>Total input growth</td>
<td>1.53</td>
<td>2.17</td>
<td>1.82</td>
<td>1.80</td>
<td>1.76</td>
</tr>
<tr>
<td>Productivity growth</td>
<td>1.01</td>
<td>1.53</td>
<td>-0.27</td>
<td>1.62</td>
<td>0.99</td>
</tr>
<tr>
<td>Total output growth</td>
<td>2.54</td>
<td>3.39</td>
<td>1.55</td>
<td>2.52</td>
<td>2.75</td>
</tr>
</tbody>
</table>

The Sources of Economic Growth

• Accounting for Growth:
  ➢ Why the post-1973 productivity slowdown?
    • Measurement—inadequate accounting for quality improvements.
    • The legal and human environment—regulations for pollution control and worker safety, crime, and declines in educational quality.

The Sources of Economic Growth

• Accounting for Growth:
  ➢ Why the post-1973 productivity slowdown?
    • Oil prices—huge increase in oil prices reduced productivity of capital and labor, especially in basic industries.
    • New industrial revolution—learning process for information technology from 1973 to 1990 meant slower growth.

Growth Dynamics: The Solow Model

• Three basic questions about growth:
  ➢ What is the relationship between the long-run standard of living and the saving rate, population growth rate, and rate of technical progress?
  ➢ How does economic growth change over time?
    • Will it speed up, slow down, or stabilize?
  ➢ Are there economic forces that will allow poorer countries to catch up to richer countries?

The Solow Model

• Basic assumptions:
  ➢ Population and work force grow at same rate $n$.
  ➢ Economy is closed (i.e., $NX = 0$) and $G = 0$.
    • $C = Y - I$
The Per-Worker Production Function

- The per-worker production function is:
  \[ Y/N = A_0 f(K/N) \]
  or
  \[ y = A_0 f(k) \]
  - \( K/N \) or \( k \) is called the capital-labor ratio.
  - Assume no productivity growth, i.e., \( A \) is fixed.

- What happens if:
  - \( N \) changes?
  - \( K \) changes?
  - \( A \) changes?
The Per-Worker Saving Function

- The per-worker saving function:
  - Assume that saving is proportional to income:
    \[ S = sY \]
    - where \( s \) is the saving rate and is between 0 and 1.
  - In per-worker terms, this would be:
    \[ S/N = sY/N \]

The Per-Worker Production, Saving Functions

- What happens if:
  - \( s \) changes?
  - \( A \) changes?
Gross Investment

- Gross investment, $I$, must:
  - Replace worn out capital, $dK$, and
  - Expand the capital stock, $kK$

$$I = dK + kK = (k + d)K$$

- Or, in per-worker terms:

$$I/N = (k + d)K/N$$

Balanced Investment Function

- Balanced Investment, $I_b$, is defined as:
  - The gross investment that is required to keep $K/N$ steady at its current level.
  - If $K/N$ is constant, then $\Delta K/K = \Delta N/N$, or

$$k = n$$
Balanced Investment Function

- If
  \[ \frac{I}{N} = (k + d)\frac{K}{N} \]
  - and
    \[ k = n \]
  - Then balanced investment is given by:
  \[ I_b/N = (n + d)K/N \]
The Solow Model

- The Solow Model combines:
  - The per-worker production function,
  - The per-worker saving function, and
  - The per-worker balanced investment function.
- Initially assumes that $A$ is constant.
  - So there is no productivity growth.

Determining the Steady State

- How fast is the economy growing at $A$?
  - At the steady state, $Y/N$ is constant.
  - Therefore,

$$\Delta Y/Y = \Delta N/N$$

- The economy grows at the same rate as the labor force.
The Solow Model

• How fast is the capital stock growing at A?
  ➢ At the steady state, $K/N$ is constant.
  ➢ Therefore,

\[
\frac{\Delta K}{K} = \frac{\Delta N}{N}
\]

• The capital stock grows at the same rate as the labor force.

Therefore, in a steady state:

\[
\frac{\Delta Y}{Y} = \frac{\Delta N}{N} = \frac{\Delta K}{K}
\]

➢ so $Y/N$ and $K/N$ are constant over time, assuming no productivity growth.

The Solow Model

• Disequilibrium dynamics:
  ➢ What if the economy is not at its steady-state?
    • Suppose $(K/N)_1 < (K/N)_c$.

\[
\frac{S}{N} = s\cdot A^\theta (K/N)
\]

\[
I_{b}/N = (n + d)K/N
\]

\[
Y/N = A^\theta (K/N)
\]

\[
(S/N)_1 = (I/N)_1
\]

\[
(S/N)_2 = (I/N)_2
\]

\[
Y/N = A^\theta (K/N)
\]

\[
I_{b}/N = (n + d)K/N
\]

\[
S/N = s\cdot A^\theta (K/N)
\]
The Solow Model

• Disequilibrium dynamics:
  ➢ What adjustment mechanism moves the economy?
  • If \((K/N)_1 < (K/N)_A\), then at \((K/N)_1\), \(S/N > I_p/N\).
  • If \(S/N > I_p/N\), then \(K/N\) will increase.
  • This process will continue until \(K/N = (K/N)_A\).

The Solow Model

• Disequilibrium dynamics:
  ➢ What if the economy is not at its steady-state?
  • Suppose \((K/N)_1 > (K/N)_A\).

\[
\begin{align*}
\frac{Y}{N} &= \frac{Y}{(Y/N)_A} \\
\frac{S/N}{I_p/N} &= \frac{(S/N)_1}{(I_p/N)_1} \\
\frac{S/N}{I_p/N} &= \frac{(S/N)_1}{(I_p/N)_1} = \frac{s*A*H(K/N)}{(n + d)K/N} \\
\frac{Y}{N} &= \frac{A*H(K/N)}{(Y/N)_A} \\
\frac{K/N}{(K/N)_A} &= \frac{I_p/N}{(I_p/N)_A} = \frac{(n + d)K/N}{s*A*H(K/N)}
\end{align*}
\]
The Solow Model

- Disequilibrium dynamics:
  - The growth process is stable.
  - The economy will always converge over time to the SAME steady state.
  - However, growth rates during the transition period will be different.
    - When $K/N < (K/N)_A$, $\Delta Y/Y > \Delta N/N$.
    - When $K/N > (K/N)_A$, $\Delta Y/Y < \Delta N/N$.

- With no productivity growth:
  - The economy reaches a steady state,
  - with a constant capital-labor ratio, $K/N$, and
  - with a constant output per worker, $Y/N$.

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Key Diagram #4: The Solow Model

- Factors that Shift the:
  - Production Function: $A$
  - Saving Function: $s$ and $A$
  - Balanced Investment Function: $n$ and $d$