Long-Run Economic Growth

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

<table>
<thead>
<tr>
<th>Country</th>
<th>Levels of real GDP per capita</th>
<th>Annual growth rate 1870-2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>3.45</td>
<td>5.71</td>
</tr>
<tr>
<td>Canada</td>
<td>5.05</td>
<td>4.47</td>
</tr>
<tr>
<td>France</td>
<td>4.81</td>
<td>3.26</td>
</tr>
<tr>
<td>Germany</td>
<td>8.21</td>
<td>3.86</td>
</tr>
<tr>
<td>Japan</td>
<td>4.97</td>
<td>1.35</td>
</tr>
<tr>
<td>Sweden</td>
<td>6.64</td>
<td>5.06</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>3.91</td>
<td>4.67</td>
</tr>
<tr>
<td>United States</td>
<td>2.45</td>
<td>1.31</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:

\[ \Delta Y/Y = \Delta A/A + a_K \Delta K/K + a_N \Delta N/N \]

- 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%.

The Sources of Economic Growth

• 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>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor growth</td>
<td>0.47</td>
<td>1.40</td>
<td>1.51</td>
<td>1.54</td>
</tr>
<tr>
<td>Capital growth</td>
<td>0.11</td>
<td>0.77</td>
<td>0.03</td>
<td>0.56</td>
</tr>
<tr>
<td>Total input growth</td>
<td>1.53</td>
<td>2.17</td>
<td>1.82</td>
<td>1.90</td>
</tr>
<tr>
<td>Productivity growth</td>
<td>1.01</td>
<td>1.53</td>
<td>-0.27</td>
<td>1.02</td>
</tr>
<tr>
<td>Total output growth</td>
<td>2.54</td>
<td>3.30</td>
<td>1.55</td>
<td>2.02</td>
</tr>
</tbody>
</table>


Table extracted from "The Sources of Economic Growth".
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.

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?
Changes in $s$

\[ Y/N = A_0 \cdot f(K/N) \]

\[ S/N = s \cdot Y/N = s \cdot A_0 \cdot f(K/N) \]

Changes in $A$

\[ Y/N = A_0 \cdot f(K/N) \]

\[ S/N = s \cdot Y/N = s \cdot A_0 \cdot f(K/N) \]

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**, $I_p$, 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

\[ I/N = (k + d)K/N \]

and

\[ k = n \]

Then balanced investment is given by:

\[ I_b/N = (n + d)K/N \]

The Per-Worker Balanced Investment Function

• What happens if:

  ➢ \( n \) changes?

  ➢ \( d \) changes?
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 $(K/N)_t < (K/N)_c$.

Disequilibrium dynamics

\[
\begin{align*}
  Y/N & = A^*(K/N) \\
  (S/N)_t & = (I/N)_t \\
  I_t/N & = (s + d)K/N \\
  S/N & = sA^*(K/N) \\
\end{align*}
\]
The Solow Model

• Disequilibrium dynamics:

  ➢ What adjustment mechanism moves the economy?

    • If \((K/N)_1 < (K/N)_A\), then at \((K/N)_1\), \(S/N > I_b/N\).
    • If \(S/N > I_b/N\), then \(K/N\) will increase.
    • This process will continue until \(K/N = (K/N)_A\).
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 \( K/N > (K/N)_A \), \( \Delta K/K < \Delta N/N \).

The Solow Model

• With no productivity growth:
  ➢ The economy reaches a steady state,
  ➢ with a constant capital-to-labor ratio, \( K/N \), and
  ➢ with constant output-per-worker, \( Y/N \).

Key Diagram #4: The Solow Model

• Factors that Shift the:
  ➢ Production Function: \( A \)
  ➢ Saving Function: \( s \) and \( A \)
  ➢ Balanced Investment Function: \( n \) and \( d \)