Dynamics of Capital and Output
## Dynamics of Capital and Output

### Table 12-1: The Characteristics of Balanced Growth

<table>
<thead>
<tr>
<th>Rate of growth of:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Capital per effective worker</td>
<td>0</td>
</tr>
<tr>
<td>2 Output per effective worker</td>
<td>0</td>
</tr>
<tr>
<td>3 Capital per worker</td>
<td>$g_A$</td>
</tr>
<tr>
<td>4 Output per worker</td>
<td>$g_A$</td>
</tr>
<tr>
<td>5 Labor</td>
<td>$g_N$</td>
</tr>
<tr>
<td>6 Capital</td>
<td>$g_A + g_N$</td>
</tr>
<tr>
<td>7 Output</td>
<td>$g_A + g_N$</td>
</tr>
</tbody>
</table>
The Effects of the Saving Rate

[Diagram showing the relationship between output per effective worker, capital per effective worker, and changes in saving rates]
The Effects of the Saving Rate

Diagram:

- Capital, $K$ (log scale)
- Output, $Y$ (log scale)
- Slope: $(g_A + g_N)$
- Associated with $s_t > s_0$
- Associated with $s_0$
- Time, $t$
What determines Technological Progress?

- Technological progress is the outcome of firms’ research and development (R&D) activities. R&D expenditures accounts for about 3% of the GDP of US, UK, France, Germany, and Japan.

- Spending on R&D depends on:
  - The *fertility* of the research process, or how spending on R&D translates into new ideas and new products,
  - The *appropriability* of research results, or the extent to which firms benefit from the results of their own R&D.
The determinants of fertility include:

- The interaction between basic research and applied research
- The country: some countries are more successful at basic research; others are more successful at applied research and development.
  - Educational system
  - Culture of entrepreneurship
- But, high fertility could quickly render new products obsolete, leading to small payoff and low R&D spending
The Appropriability of Research Results

- If firms cannot appropriate the profits from the development of new products, they will not engage in R&D.
  - Is there a payoff in being first at developing a new product?
  - Legal protection. *Patents* give a firm that has discovered a new product the right to exclude anyone else from the production or use of the new product for a period of time.
How Strong Should the Patent protection be?

- Needs to be strong enough to provide enough incentive for firms to spend in R&D (rewards of a temporary statutory monopoly)

- Not so strong, so as to allow society to benefit fully from discoveries and new technologies
The Facts of growth Revisited

- Sustained growth in rich countries b/w 50-73
- Slowdown in OECD growth since 73;
- Convergence of growth rates for OECD countries
- No sustained growth and no convergence for many LDC’s countries

- Does the Solow Model with Tech progress explain these facts?
Fast growth may come from two sources

- **Technological Progress:** If $g_A$ is higher, balanced output growth ($g_Y = g_A + g_N$) will also be higher. In this case, the rate of output growth equals the rate of technological progress.

- **Capital Accumulation:** Adjustment of capital per effective worker, $K/AN$, to a higher level. In this case, the growth rate of output exceeds the rate of technological progress.
Empirical Evidence

**Table 12-2**  
Average Annual Rates of Growth of Output per Capita and of Technological Progress in Five Rich Countries, 1950-1987

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>4.0</td>
<td>1.8</td>
<td>-2.2</td>
<td>4.9</td>
<td>2.3</td>
<td>-2.6</td>
</tr>
<tr>
<td>Germany</td>
<td>4.9</td>
<td>2.1</td>
<td>-2.8</td>
<td>5.6</td>
<td>1.9</td>
<td>-3.7</td>
</tr>
<tr>
<td>Japan</td>
<td>8.0</td>
<td>3.1</td>
<td>-4.9</td>
<td>6.4</td>
<td>1.7</td>
<td>-4.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2.5</td>
<td>1.8</td>
<td>-0.7</td>
<td>2.3</td>
<td>1.7</td>
<td>-0.6</td>
</tr>
<tr>
<td>United States</td>
<td>2.2</td>
<td>1.6</td>
<td>-0.6</td>
<td>2.6</td>
<td>0.6</td>
<td>-2.0</td>
</tr>
<tr>
<td>Average</td>
<td>4.3</td>
<td>2.1</td>
<td>-2.2</td>
<td>4.4</td>
<td>1.6</td>
<td>-2.8</td>
</tr>
</tbody>
</table>
Table 12-2 illustrates three main facts:

1. The period of high growth of output per capita, from 1950 to 1973, was due to rapid technological progress, not to unusually high capital accumulation.

2. The slowdown in growth of output per capita since 1973 has come from a decrease in the rate of technological growth, not from unusually low capital accumulation (low savings).

3. Convergence of output per capita across countries has come from higher technological progress rather than from faster capital accumulation.
Why Did Technological Progress Slow Down in the mid-1970s?

- measurement error
  - Productivity is not easily measured: First subtract off that part due to the increase in K, what is left is due to the increase in A
  - What should be counted as productivity growth could be counted instead as inflation.
- Decrease in Fertility -
- Increase in service sector
- Decrease in R&D – (As a % of GDP, spending on R&D remained constant or increased b/w 1963-1989)
Why Did Technological Progress Slow Down in the mid-1970s?

Table 12-2: Spending on R&D as a Percentage of GDP

<table>
<thead>
<tr>
<th></th>
<th>1963</th>
<th>1975</th>
<th>1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>1.6</td>
<td>1.8</td>
<td>2.3</td>
</tr>
<tr>
<td>Germany</td>
<td>1.4</td>
<td>2.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Japan</td>
<td>1.5</td>
<td>2.0</td>
<td>3.0</td>
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<tr>
<td>United Kingdom</td>
<td>2.3</td>
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</tbody>
</table>
Why have not LDC’s which are tech backward, not seen high $g_a$ and high $g_y$?

Differences in output per worker between rich and poor countries are mostly attributed to:

- differences in the measured level of technology
- For various reasons, poor countries are unable to close this *technology gap*.
- Accumulation of physical and human capital
- Institutions: Corruption, political instability, poorly established property rights, lack of entrepreneurs, and poorly developed financial markets.
Why did some poor countries escape the poverty trap and start growing?

- The poor countries that have grown rapidly in the last 20 years have experienced a rapid accumulation of both physical and human capital.
- Some of those countries have relied on the importance of foreign trade, free markets, and limited government intervention, while others have relied on government intervention and *industrial policy*—a policy aimed at helping specific sectors of the economy.
All we know about Growth

- RGDP Per Capita
- Labor, capital (K), H
- A (technology)
- Foreign Trade
- Institutions
Think about this!

- “Once one starts to think about [economic growth], it is hard to think about anything else” (Lucas, 1988 – Nobel Prize winner)

- “But this constant interest in a theory of growth was focused on the rich countries only” (Easterly, 2002 – “growth economist” of the World Bank for several years)
Two ways to think about convergence

- Poorer countries start out with lower capital stock (K), so they accumulate K faster, leading to high growth of GDP per capita and convergence.

- Countries are poorer because they are less technologically advanced than others. Over time they become more sophisticated either by importing technology from advanced countries or developing their own technology (diminishing returns in tech progress).