Today’s Lecture

1. Productivity and productivity growth
2. The neoclassical model of growth
3. The “new economy”
What is productivity?

• Productivity = Output / Input
• And productivity growth is the growth in output per unit input.
• *Warning*: each of these measures is full of analytical and empirical complexities and difficulties
• *Important species*:
  1. Labor productivity = Q / L
  2. Total factor productivity:
     \[ A = \frac{Q}{\text{(All inputs)}} \]
Productivity growth fell in 1973-95 period and rebounded since 1995...
Important questions

1. What is relationship between real incomes and labor productivity?
2. What determines labor productivity over the long run?

Importance of Productivity

Over the long run, real wages, real incomes, and living standards grow proportionately with labor productivity.
Listen up to Paul Krugman (Yale ’75 and Prof of Economics at Princeton and NYT Econ correspondent)

“Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker.”
Proof of growth pudding

- Real wages
- GDP per capita

Index (1800 = 1)
Real Wages and Per Capita Growth, USA

![Graph showing average annual growth rate (% per year) for Real wages and GDP/Pop over different periods: 1800-2000, 1800-1900, 1900-2000.](image)
Why/when do wages grow with labor productivity?

Reason:
If share of labor \((wL/pQ)\) is constant, then real wages \((w/p)\) grow at same rate as labor productivity \((Q/L)\).
Economics of productivity

• Economists rely on neoclassical growth model (NCM)
• Output is related to inputs by an "aggregate production function"
  \[ Q = AF(K, L,...) \]

...where
  \( Q \) = potential output,
  \( K \) = capital services
  \( L \) = labor services
  \( A \) = level of technology
  \( y = \frac{Q}{L} \) = output per worker
  \( k = \frac{K}{L} \) = capital per worker
The Aggregate Production Function

\[ y = \frac{Q}{L} = \text{output per worker} \]

Production function shows the output per worker as a function of capital per worker

\[ k = \frac{K}{L} = \text{capital per worker} \]
Shift in the Production Function

\[ y = \frac{Q}{L} = \text{output per worker} \]

\[ k = \frac{K}{L} = \text{capital per worker} \]

Why did the p.f. shift??
Under these assumptions, can get growth accounting formula:* 

\[ g_Q = \text{sh}(K) \ g_K + \text{sh}(L) \ g_L + \text{T. C.} \]

where \( g_z \) = growth rate of variable \( z \)  
\( \text{sh}(z) \) = share of \( z \) in national income  
\( \text{T. C.} \) = rate of technological change  
\( g_A \) = rate of growth of \( A \)

*Technical extra credit footnote: Get the growth accounting formula by: taking logarithms, taking time derivative, and setting factor prices equal to marginal products. See web page for notes and intermediate macro for follow-up.
Numerical example for the US:

Period is 1900 to 1999:

\( g(Q) = 3.2 \% \text{ per year}; \ g(K) = 3.0; \ g(L) = 1.0 \)

\( sh(K) = .25; \ sh(L) = .75. \)

\[
g_Q = sh(K) \times g_K + sh(L) \times g_L + T. C.
\]

\[
3.2 = (.25) \times 3 + (.75) \times 1 + T. C.
\]

T. C. = 3.2 – 1.5 = 1.7 % per year

T. C. = 1.7/3.2 = 53 % of output growth

= 1.7/2.2 = 77 % of output per capita growth

Note: the denominator here is 2.2 = 3.2 minus 1.0. Why? Because the growth of output per worker = 2.2 = growth of output minus growth of workers = 3.2 - 1.0. Further note for the mathematically inquisitive: Why is this so? Because the growth rate of \( z = x/y \) is \( g(z) = g(x) - g(y) \). To show this, recall that \( g(z) = [dz/dt]/z \). Then take the time derivative of \( z \) and after spending some (possibly considerable) time, you can show the result. This will be covered in mathematics for economists and in advanced courses.
Economic Growth Illustrated

$y$

$p.f. \ 2000$

$y_{2000}$

$p.f. \ 1950$

$y_{1950}$

$1950$

$k_{1950}$

$k_{2000}$

$k$
Understanding economic history
- What were the sources of US growth?
- Source of the productivity slowdown and rebound
- Japanese v. Russian history
- Miracle economies
- Economic regress
- How can we speed growth?
- Role of monetary and fiscal policy
- Promoting technological change
- The “new economy”
Also, the technique has been applied to try to understand US productivity movements

- productivity slowdown and rebound...
  - Basic facts
- Explanations of slowdown:
  - Rising energy prices
  - High inflation and declining investment and R&D
  - environmental restrictions
Sources of Rebound:

• About half directly or indirectly due to the new economy
  – [New economy is computers, software, communications]

• Balance is spread through rest of the economy
Real output of computers and the economy

Real GDP
Computers

Output (1960 = 1)


3.4 % p.a.
32 % p.a.
### Table 2-3. Accounting for the Productivity Acceleration in the 1990s

[Average annual percent change, except as noted]

<table>
<thead>
<tr>
<th>Item</th>
<th>1973 to 1995</th>
<th>1995 to 1999</th>
<th>Acceleration¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labor productivity</td>
<td>1.43</td>
<td>2.90</td>
<td>1.47</td>
</tr>
<tr>
<td>LESS: Contribution of</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capital services</td>
<td>1.06</td>
<td>1.53</td>
<td>.47</td>
</tr>
<tr>
<td>Labor quality</td>
<td>.26</td>
<td>.31</td>
<td>.05</td>
</tr>
<tr>
<td>Computer sector total factor productivity</td>
<td>.16</td>
<td>.39</td>
<td>.23</td>
</tr>
<tr>
<td>EQUALS: Total factor productivity excluding computers</td>
<td>-.06</td>
<td>.65</td>
<td>.70</td>
</tr>
</tbody>
</table>

¹Percentage points.

Policies to Increase Economic Growth

• Focus on growth in potential output per capita using the NCM

• Policies generally focus on either
  - capital deepening or
  - increase technological change
Investment accounting:

For closed economy:

\[ I = S = \text{Priv. Sav.} + (T - G) \]

For open economy:

\[ I + NX = I + \text{Exp} - \text{Imp} = S = \text{Priv. Sav.} + (T - G) \]
Increasing National S and I

Two basic kinds of policies:
- “Price” or incentive approaches use tax policy to affect incentives to increase S or I
- “Income” or “output” approaches change the level of saving through taxation and expenditure
Price approach

• Higher post-tax returns, higher private saving, higher national saving, higher investment increases growth in output.
  – Examples: Tax incentives for saving, higher returns on saving, IRAs, capital gains tax cuts.
  – This is the rationale for “supply side economics”: emphasizes increasing saving and investment through higher returns.
  – Note some proposals have partial temporary “expensing” for investment – good bang for buck.

• Questionable whether have big impact on private saving and may actually lower national saving.
**Income approach**

- Another approach is to increase public saving. Can do through increasing T or reducing G.

- **Mechanism:** Higher public S → higher national S → higher I → increase growth in Q
  - Clinton policy 1993 focused primarily on public saving through deficit reduction
  - Economists’ concerns about 2001 tax cuts that would lower govt saving and thereby decrease natl saving

- **Reasoning:** lower (G-T) → higher S → higher I → more rapid growth in K → more rapid growth in pot Q
- Current economic rational for running budget surplus