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.

	Levels of real GDP per capita				
Country	1870	1913	1950	2005	Annual growth rate 1870–2005
Australia	3,645	5,715	7,493	23,868	1.4%
Canada	1,695	4,447	7,437	24,200	2.0
France	1,876	3,485	5,270	21,662	1.8
Germany	1,821	3,648	3,881	19,325	1.8
Japan	737	1,385	1,926	21,610	2.5
Sweden	1,664	3,096	6,738	22,310	1.9
United Kingdom	3,191	4,921	6,907	21,981	1.4
United States	2,445	5,301	9,561	31,242	1.9

Note: Figures are in U.S. dollars at 1990 prices, adjusted for differences in the purchasing power of the various national currencies.
Source: Data for 1870, 1913, and 1950 from Angus Maddison, *The World Economy: A Millennial Perspective*, Paris: OECD, 2001; data for 2005 from Bureau of Labor Statistics, *www.bls.gov/fls*, rescaled to 1990 prices.

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%.

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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.

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The Sources of Economic Growth

- Accounting for Growth:
  - Calculate the contribution of K as $a_K \Delta K/K$.
  - Calculate the contribution of N as $a_N \Delta N/N$.
  - Calculate productivity growth as the residual:

$$\Delta A/A = \Delta Y/Y - a_K \Delta K/K - a_N \Delta N/N$$

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Table 6.3 Sources of Economic Growth

	(1) 1929–1948	(2) 1948–1973	(3) 1973–1982	(4) 1929–1982	(5) 1982–2004
Source of Growth					
Labor growth	1.42	1.40	1.13	1.34	0.96
Capital growth	0.11	0.77	0.69	0.56	0.80
Total input growth	1.53	2.17	1.82	1.90	1.76
Productivity growth	1.01	1.53	−0.27	1.02	0.99
Total output growth	2.54	3.70	1.55	2.92	2.75

Sources: Columns (1)–(4) from Edward F. Denison, *Trends in American Economic Growth, 1929–1982*, Washington, D.C.: The Brookings Institution, 1985, Table 8.1, p. 111. Column (5) from Bureau of Labor Statistics Web site, Multifactor Productivity Trends news release, Table 1, accessed through *www.bls.gov/news.release/prod3.t01.htm*.

8-8

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.

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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.

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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?

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The Solow Model

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

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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.

8-13

The Per-Worker Production Function

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The Per-Worker Production Function

- What happens if:
  - N changes?
  - K changes?
  - A changes?

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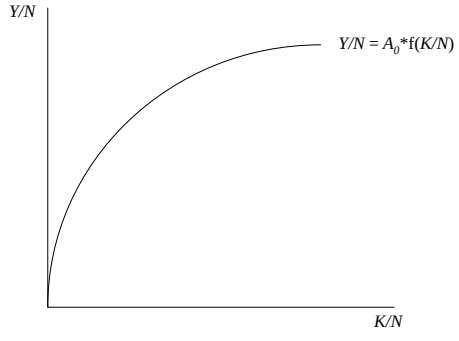
Changes in *N* or *K*



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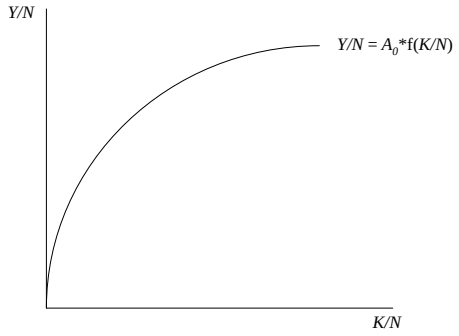
Changes in *A*



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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:

$$S/N = sY/N$$

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The Per-Worker Production, Saving Functions

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The Per-Worker Production, Saving Functions

- What happens if:
  - *s* changes?
  - *A* changes?

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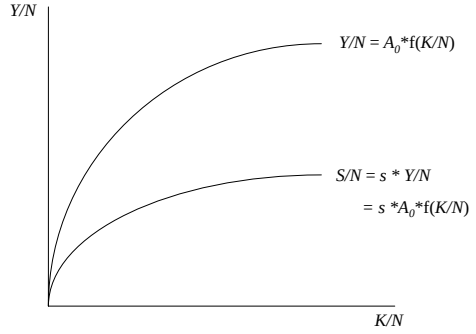
Changes is *s*



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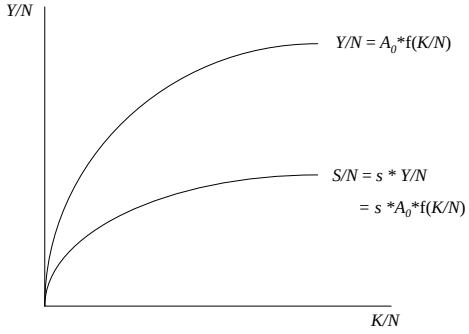
Changes in *A*



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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:

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

8-23

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

$$k = n$$

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Balanced Investment Function

- If

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

  - and

$$k = n$$

  - Then **balanced investment** is given by:

$$I_b/N = (n + d)K/N$$

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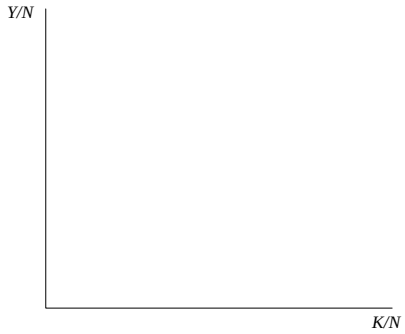
The Per-Worker Balanced Investment Function



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The Per-Worker Balanced Investment Function

- What happens if:
  - *n* changes?
  - *d* changes?

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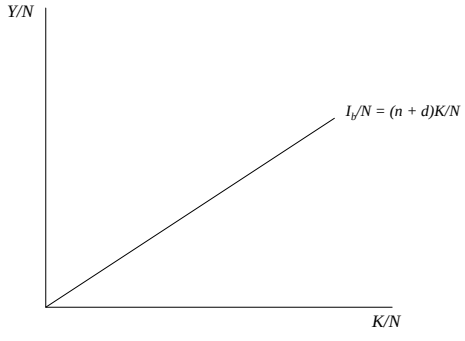
Changes in *n*



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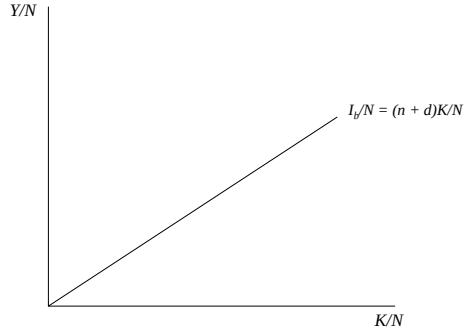
Changes in *d*



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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.

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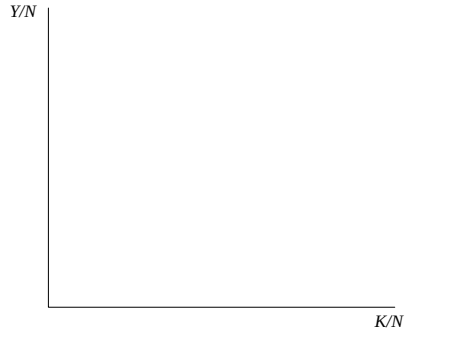
Determining the Steady State



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The Solow Model

- 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.

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The Solow Model

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

$$\Delta K/K = \Delta N/N$$

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

8-33

The Solow Model

- Therefore, in a steady state:

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

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

8-34

The Solow Model

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

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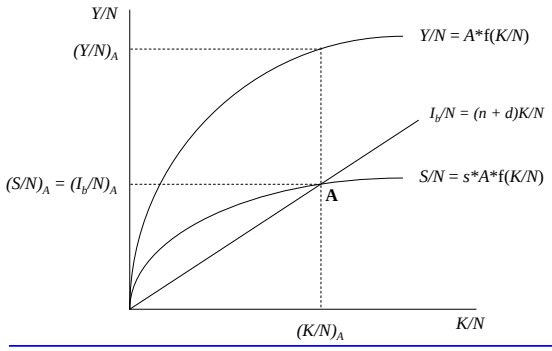
Disequilibrium dynamics



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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 $K/N = (K/N)_A$.

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The Solow Model

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

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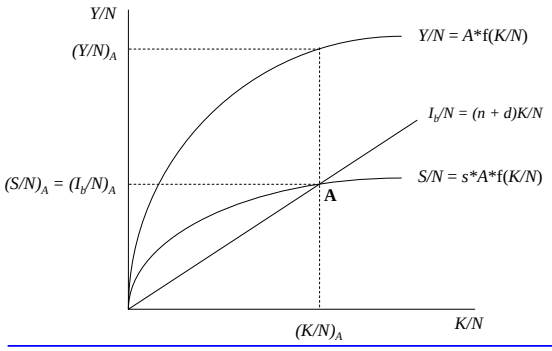
Disequilibrium dynamics



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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 decrease.
    - This process will continue until $K/N = (K/N)_A$.

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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 $K/N > (K/N)_A$, $\Delta K/K < \Delta N/N$.

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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*.

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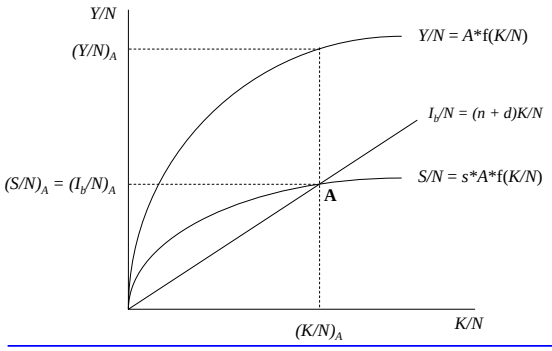
Key Diagram #4: The Solow Model



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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*

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