ECON 202 - MACROECONOMIC PRINCIPLES

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Chapter 8 - Economic Growth

Economic Growth - Topics

1. Calculate economic growth rates
2. Explain the role of capital in economic growth
3. Apply growth accounting to measure technological progress
4. Discuss the sources of technological progress
5. Assess the role of government in assisting economic growth

Long-Term Growth

- Economic growth over the long run (a century or more) is a feature of many economies in the modern world
- Over the last 130 years, the real GDP per capita has grown about 2% per year in the U.S.
- In a famous 1963 paper, the economist Nicholas Kaldor presented several"stylized facts" concerning economic growth

Kaldor Facts

1. Per capita output grows over time and the growth rate does not tend to diminish over time
2. Physical Capital per Worker grows over time (capital deepening)
3. The ratio of capital to GDP is trendless
4. As a share of GDP, compensation to labor and capital have been (very roughly) constant
5. Growth rates differ widely across countries

Growth Convergence?

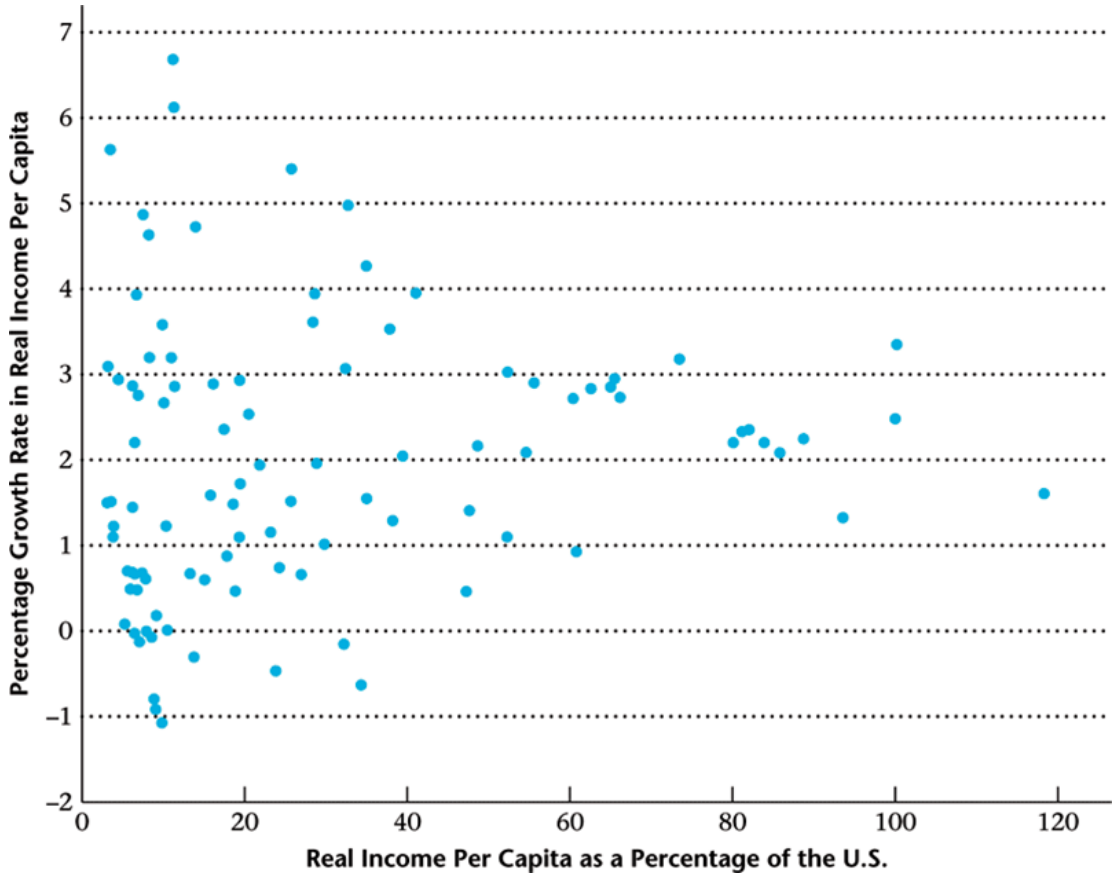


Figure 3.2 World Distribution of Real GDP per Person in 1960

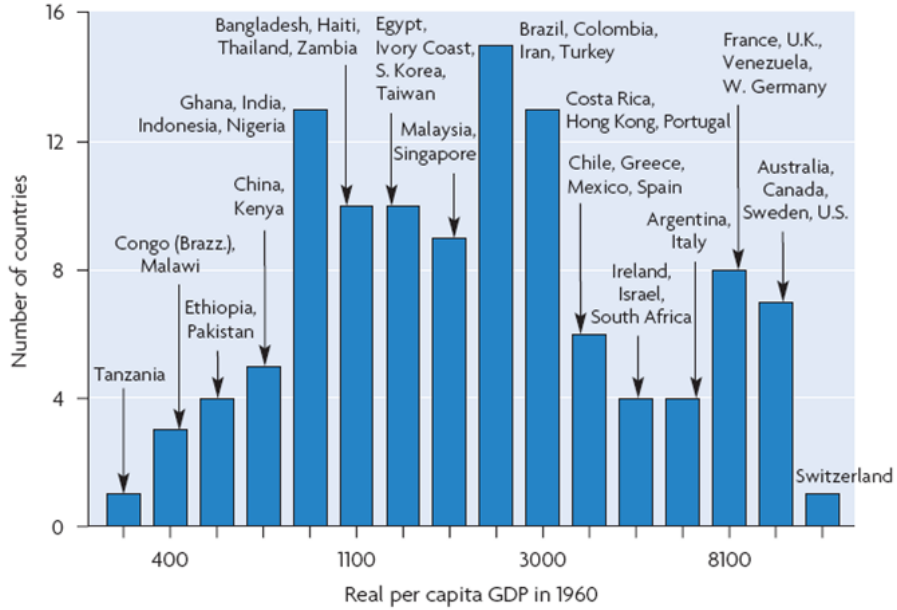
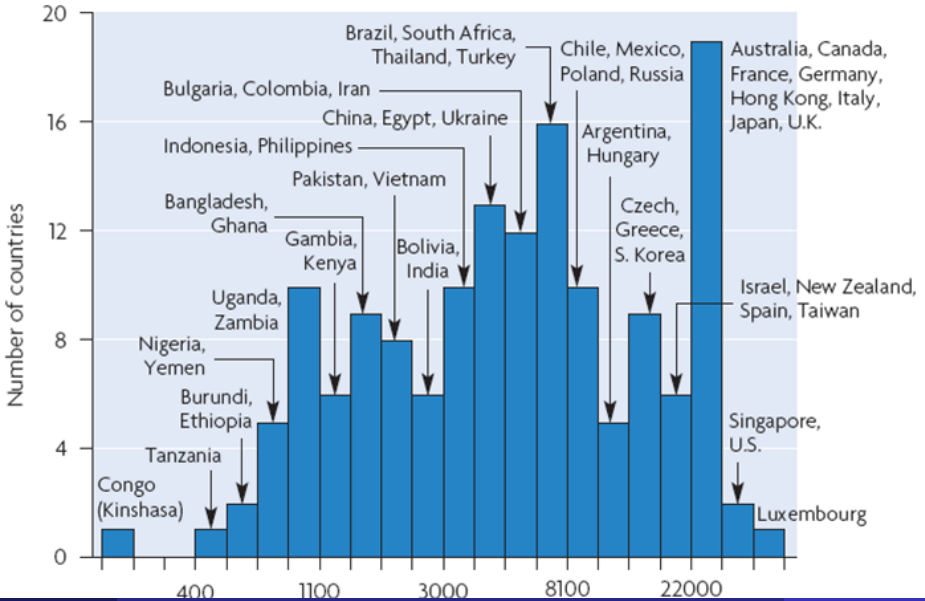
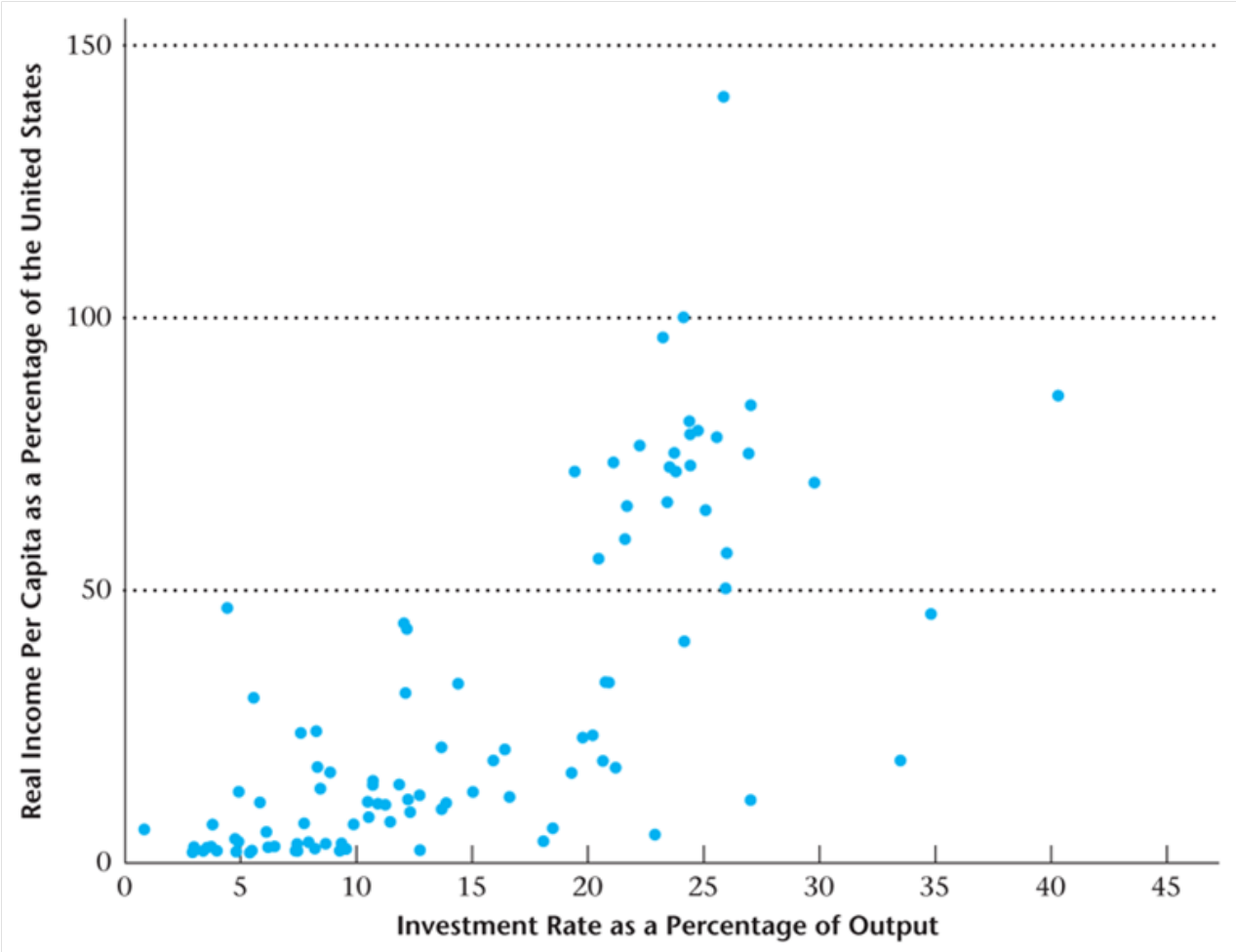


Figure 3.1 World Distribution of Real GDP per Person in 2000



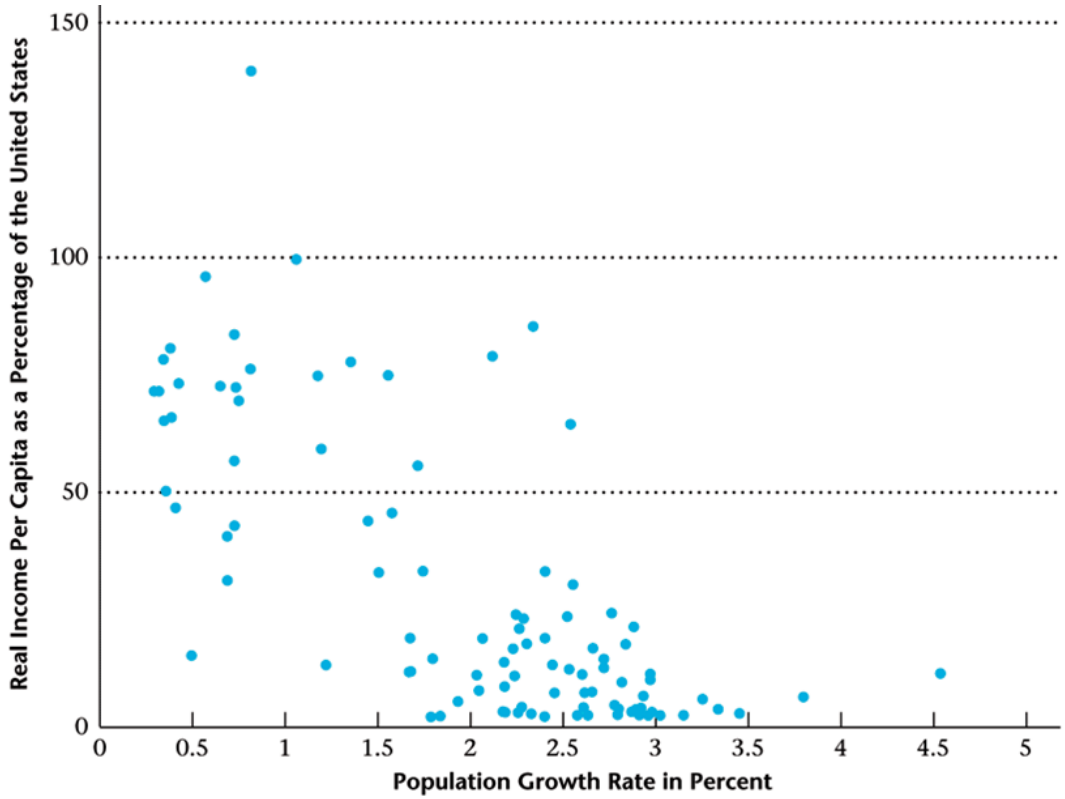
Capital Deepening is a Source of Growth

Figure 1: Output per worker vs. Investment rate



High Population Growth a Sign of Poverty?

Figure 2: Output per worker vs. Population growth



Source: A. Heston, R. Summers, and B. Aten, *Penn World Table Version 6.1*, Center for International Comparisons at the University of Pennsylvania (CICUP), October 18, 2002, available at pwt.econ.upenn.edu.

Measuring Economic Growth

- The growth rate of a variable is the percentage change in that variable from one period to another
- Growth rate is defined as:

$$g \text{ in } \% = \left(\frac{GDP \text{ in year } 2}{GDP \text{ in year } 1} - 1 \right) \times 100$$

Constant growth rate g

- $\text{GDP}_{[\text{in } n \text{ years}]} = (1 + \frac{g \text{ in } \%}{100})^n * \text{GDP}_{now}$
- Example - constant growth rate for 5 years:
  - GDP= \$120
  - $g = 4\%$
  - $\text{GDP}_{[\text{in } 5 \text{ years}]} = \$146$

Measuring Economic Growth

- To find out how many years it would take for GDP to double, we use the rule of 70:
- If an economy grows at g-percent per year, output will double in:

$$\text{Years-to-double} = \frac{70}{\%\text{-growth rate}} = \frac{70}{g \text{ in } \%}$$

Rule of 70 – years to double GDP

$$\text{GDP} \times (1+g)^t = 2 \times \text{GDP}$$

- which can be solved for time t as

$$t = \frac{ln(2)}{ln(1+g)},$$

- since for small g we know that

$$ln\,(1+g) \approx g$$

we then get

$$t = \frac{ln(2)}{g} = \frac{100 \times ln(2)}{g\%}$$

- Assume $g = 4\%$

$$t \approx \frac{69.4}{4} \approx \frac{70}{4} = 17.5 \text{ years}$$

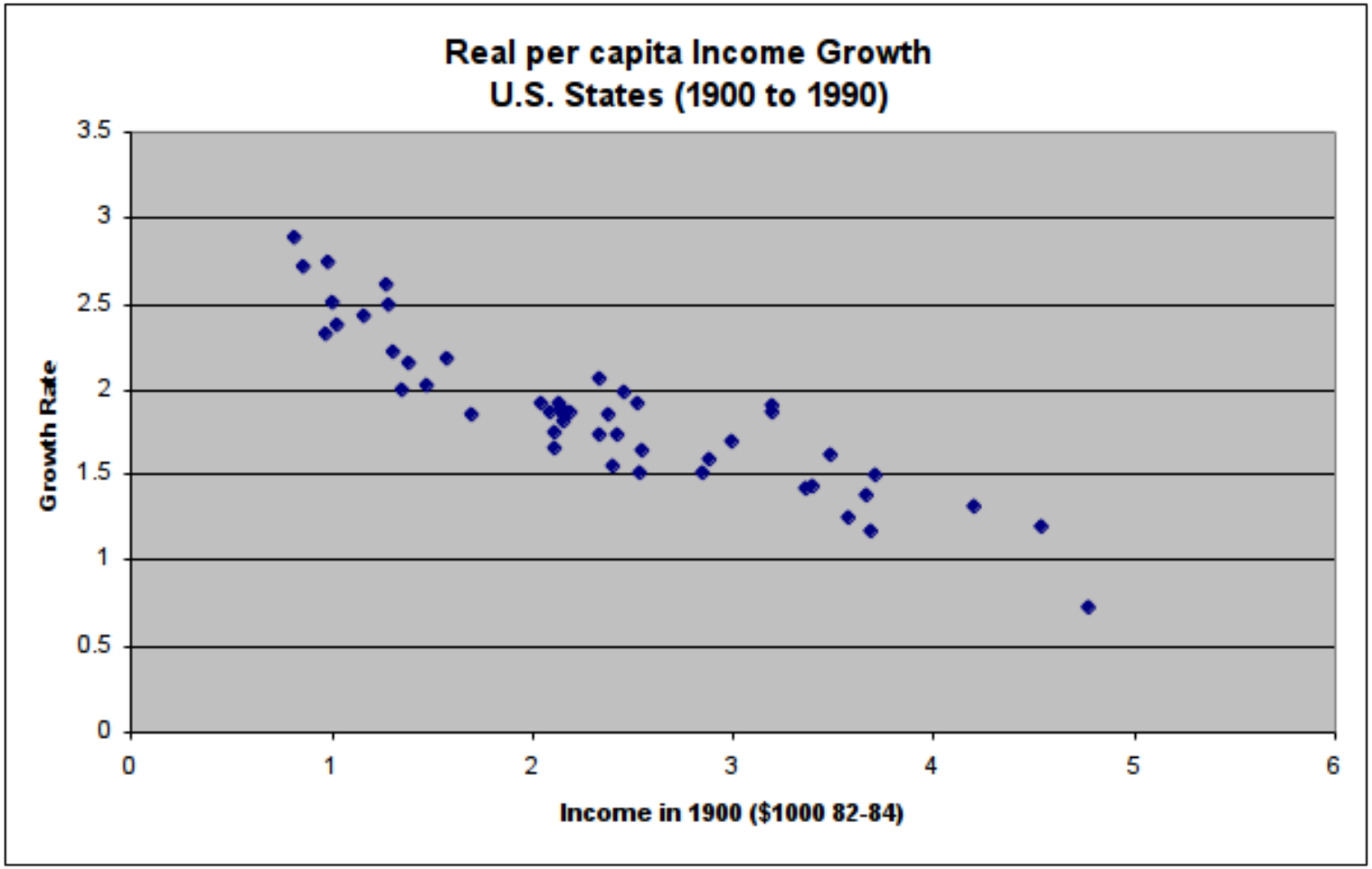
Comparing Per Capita Growth Rates Across Countries

TABLE 8.1 Gross National Income Per Capita and Economic Growth

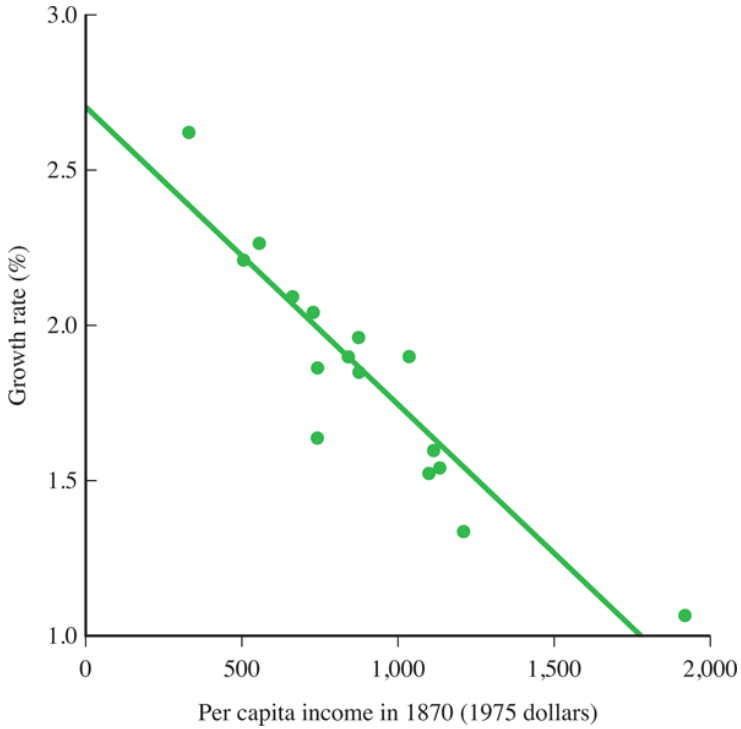
Country	Gross National Income Per Capita in 2008 Dollars	Per Capita Growth Rate 1960–2008
United States	$46,970	2.38%
United Kingdom	36,130	2.54
Japan	35,220	4.09
France	34,400	2.91
Italy	30,250	2.92
Mexico	14,270	2.95
Costa Rica	10,950	2.35
India	2,960	2.05
Pakistan	2,770	1.53
Nigeria	1,940	1.11
Zambia	1,230	–0.60

SOURCES: World Bank Development Indicators (2010) and Alan Heston, Robert Summers, and Bettina Aten, *Penn World Table* Version 6.3, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2010.

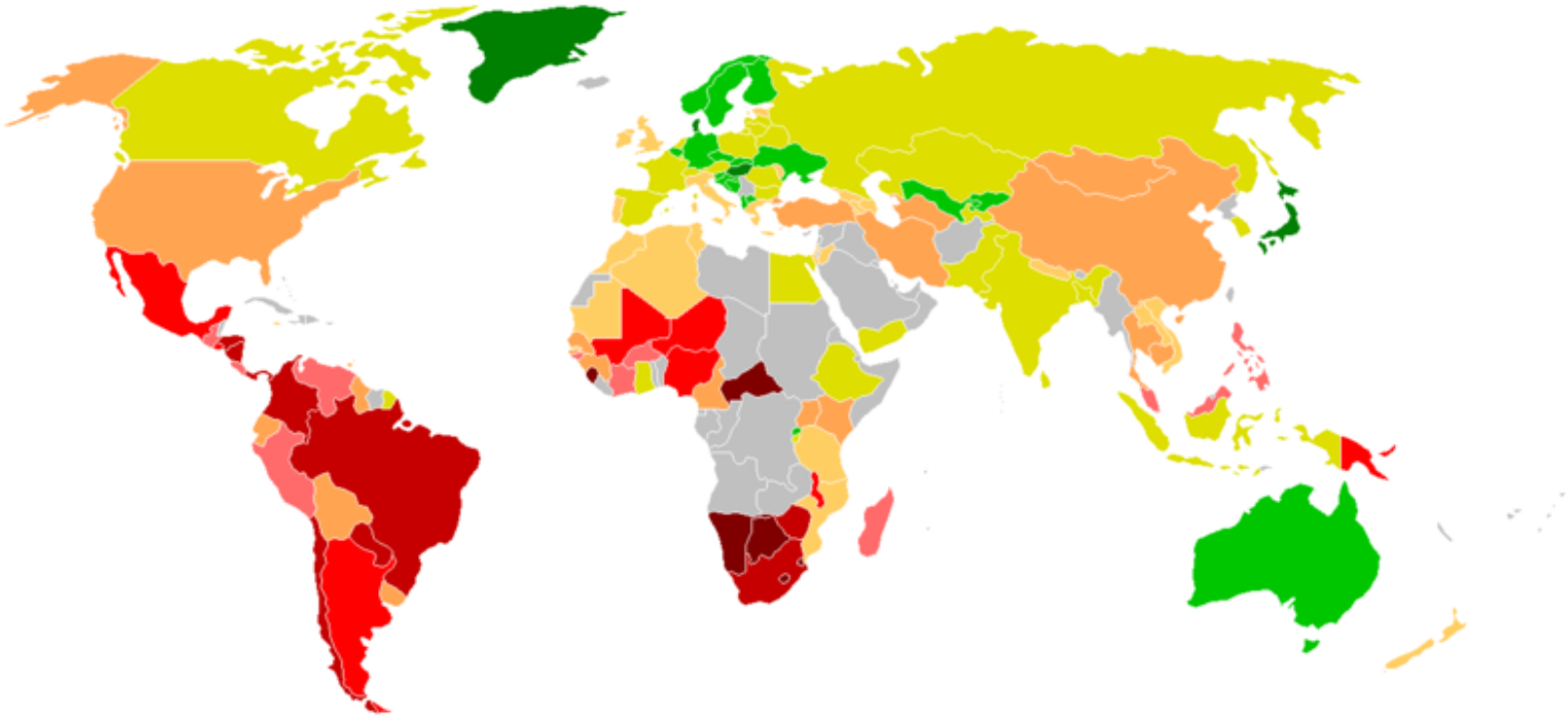
Convergence of US States



Countries with Lower Income in 1870 Grew Faster

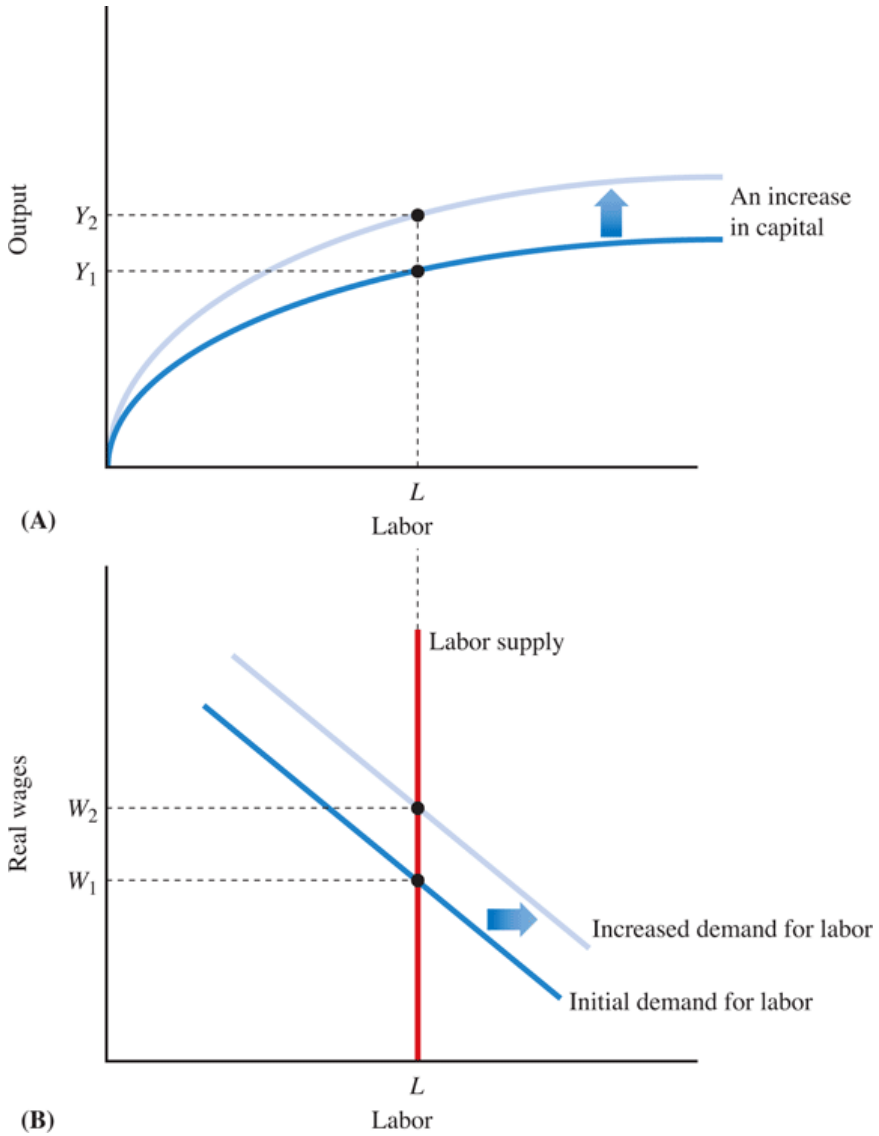


Gini Coefficient



Color	Gini coefficient
	< 0,25
	0,25 - 0,29
	0,30 - 0,34
	0,35 - 0,39
	0,40 - 0,44
	0,45 - 0,49
	0,50 - 0,54
	0,55 - 0,59
	> 0,60
	NA

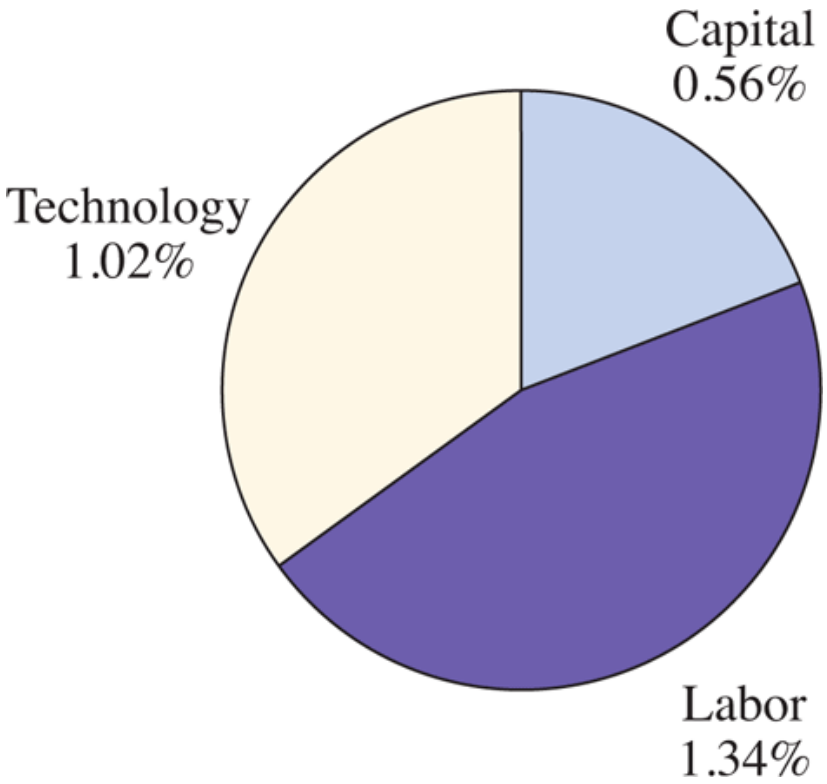
Capital Deepening and Growth



Technological Progress

- How to measure technological progress?
- Solow Growth Model (Robert Solow, a Nobel laureate in economics)
- $Y = A \times F(K, L)$
- Growth accounting found that
  - 20% due to capital accumulation
  - 45% due to labor growth
  - 35% due to technological progress

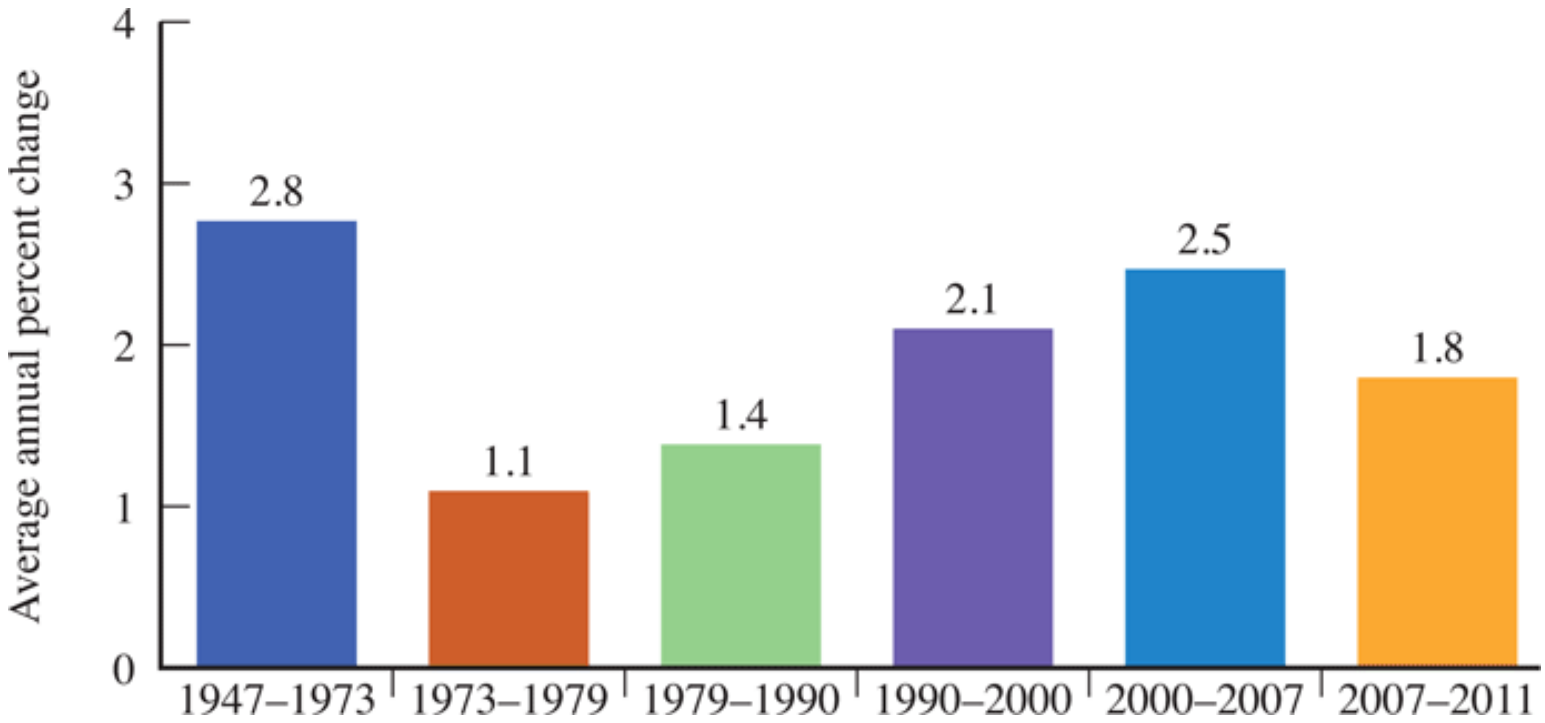
Sources of real GDP Growth 1929-1982



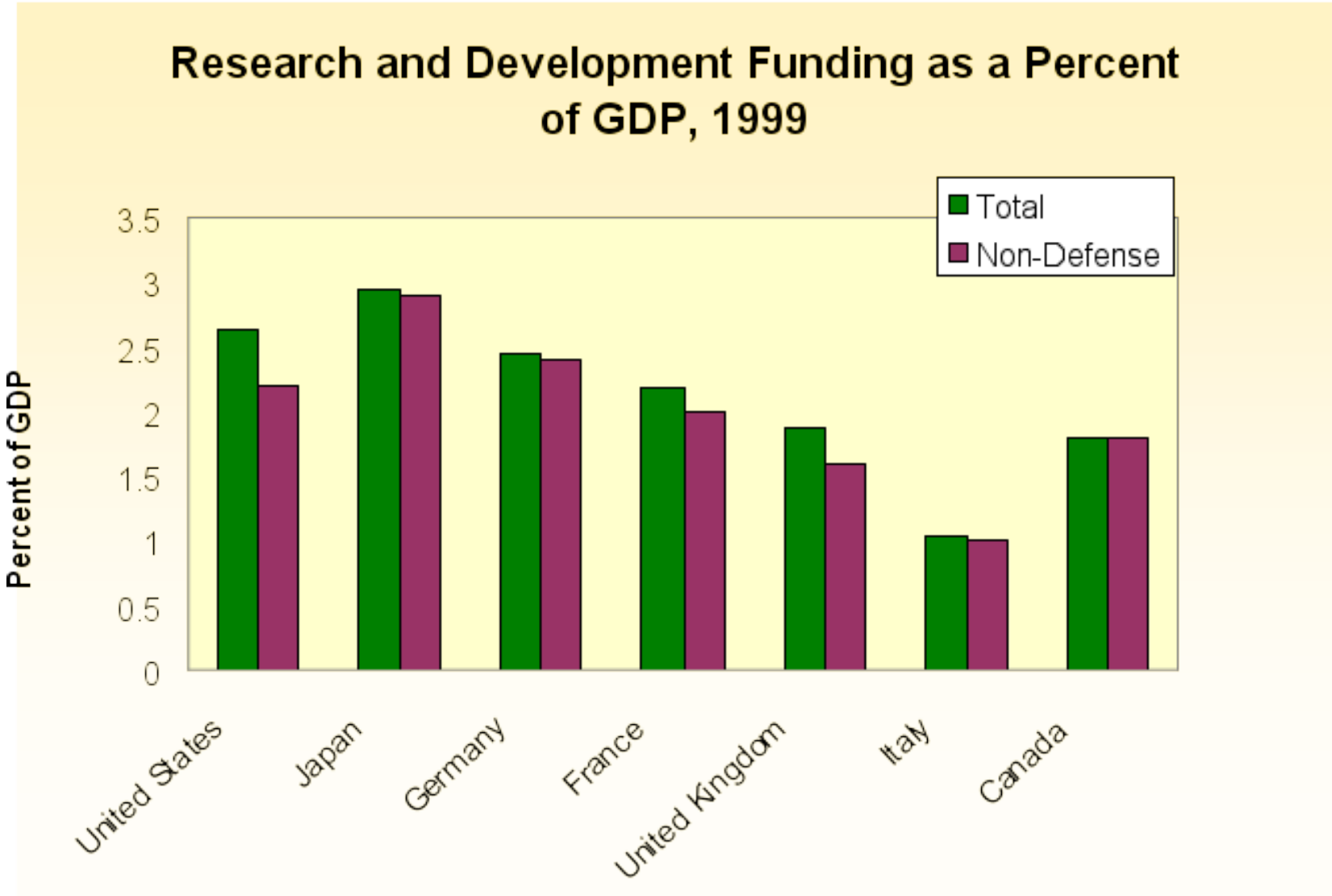
Explanations for the Slowdown since the 70's?

- Declines in education and skills of workforce
- Lower investment levels
- Less spending on infrastructure
- Concentration on short-term profits
- Oil price shock and high energy prices

US Annual Productivity Growth 1947–2011



Research and Development Funding as a % of GDP



What Causes Technological Progress?

1. Monopolies that spur innovation (Joseph Schumpeter)
2. The scale of the market
3. Induced innovations
4. Education and the accumulation of knowledge

A Key Governmental Role: Getting the Incentives Right

- Governments must design institutions in a society in which individuals and firms work, save, and invest
- Basic rule $\rightarrow$ individuals and firms respond to incentives
- Policies that tax exports, lead to rampant inflation, or inhibit the growth of the banking and financial sectors can cripple the economy's growth prospects

New Growth Theory

- The work of economists that developed models of growth that contained technological progress as essential features came to be known as new growth theory, which accounts for technological progress within a model of growth

- Economists in this field study how incentives for
  - research and development,
  - new product development, or
  - international trade
  - interact with the accumulation of physical capital

Appendix
The Solow Growth Model

Appendix: The Solow Growth Model

- The basic model in economics today is a version of the neo-classical model that we learned earlier
- A model of capital deepening, or capital accumulation
- The Solow model shows that:
  - Capital deepening, the increase in the stock of capital per worker, will occur as long as total saving exceeds depreciation. Capital deepening results in economic growth and increased real wages.
  - Eventually, the process of capital deepening will come to a halt as depreciation catches up with total saving

Solow Growth Model

- The Solow growth model assumes a fixed (exogenous) savings rate: s
- Total savings from income is therefore: $S = s \times Y$
- Savings becomes investment (closed model, no gov't): $I = S$
- The key mechanism in this model is the assumption of decreasing returns to scale in capital (holding all other factors fixed)
  - When the capital stock is low, adding more makes a big difference in how much can be produced
  - When the capital stock is high, however, adding more capital still allows you to produce more, but the difference is not as large

Savings Rate in the US

- Average US savings rate (private) from 1959-2016: 8.3%

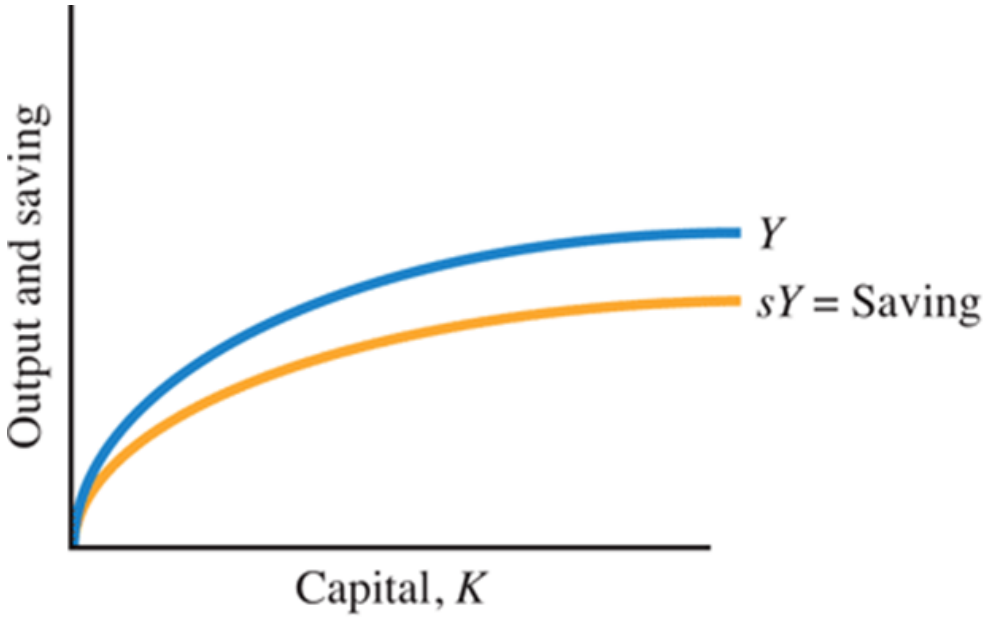
Capital Deepening

- In the absence of government or the foreign sector, private-sector saving equals gross investment, $S = I$
- Output Y increases with the stock of capital K
- Net investment $= \overbrace{s \times Y}^{S=I} - \overbrace{d \times K}^{\text{Depreciation}}$, where d is depreciation rate in %
- K increases as long as net investment is positive
  - $K \uparrow$ if $I - d \times K > 0$
  - $K \downarrow$ if $I - d \times K < 0$
- Capital stock evolves according to:

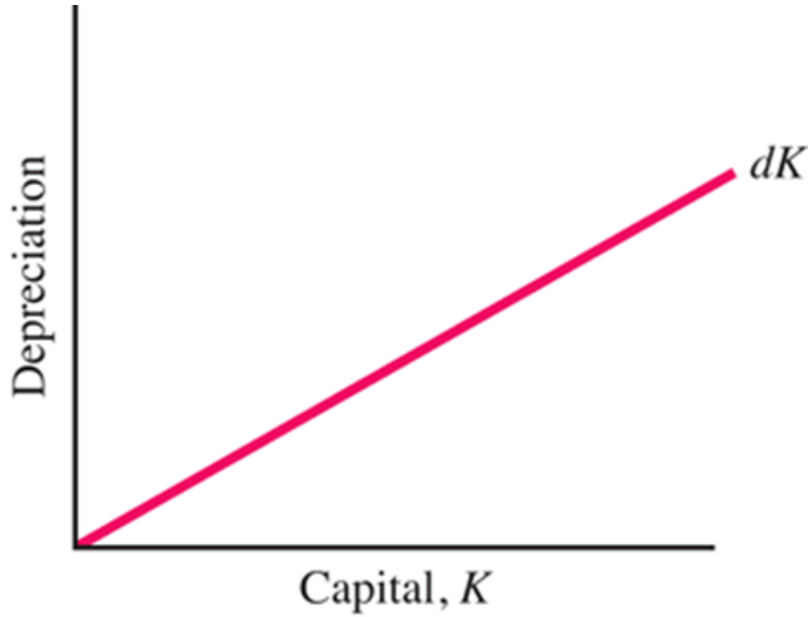
$$K_{t+1} = \overbrace{I_t - d \times K_t}^{\text{net investment}} + \overbrace{K_t}^{\text{old capital stock}}, \text{ or}$$

$$\rightarrow K_{t+1} = I_t + (1 - d) K_t$$

Savings and Depreciation as Functions of the Capital Stock

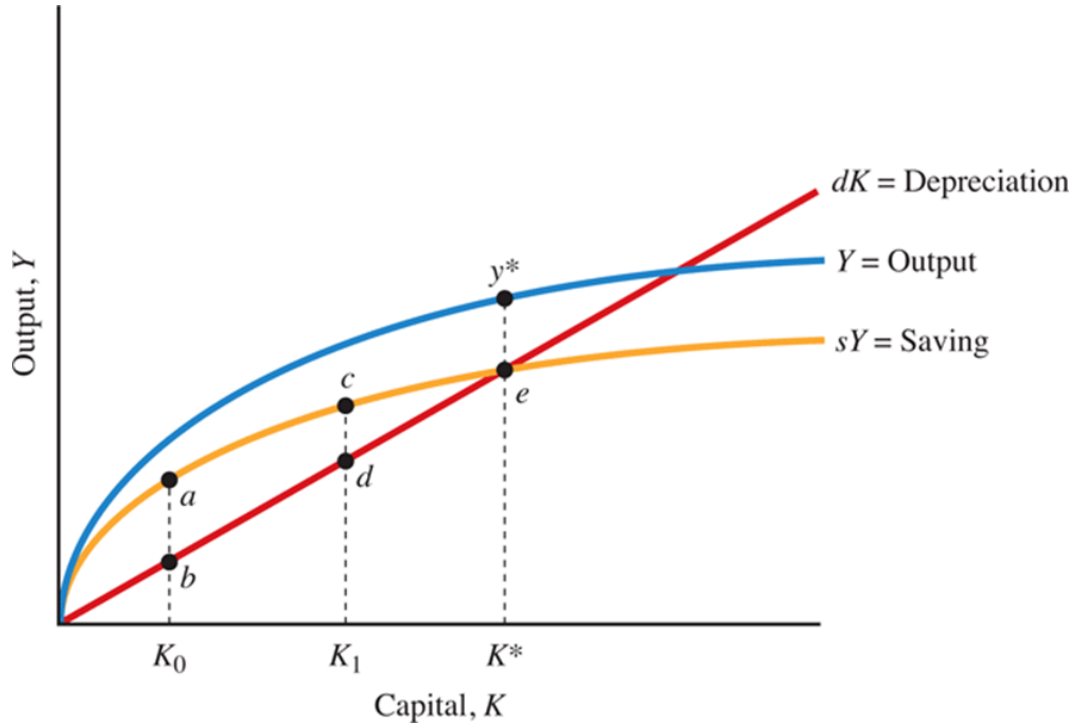


(A) Saving as a Function of the Stock of Capital



(B) Depreciation as a Function of the Stock of Capital

Change in Stock of Capital

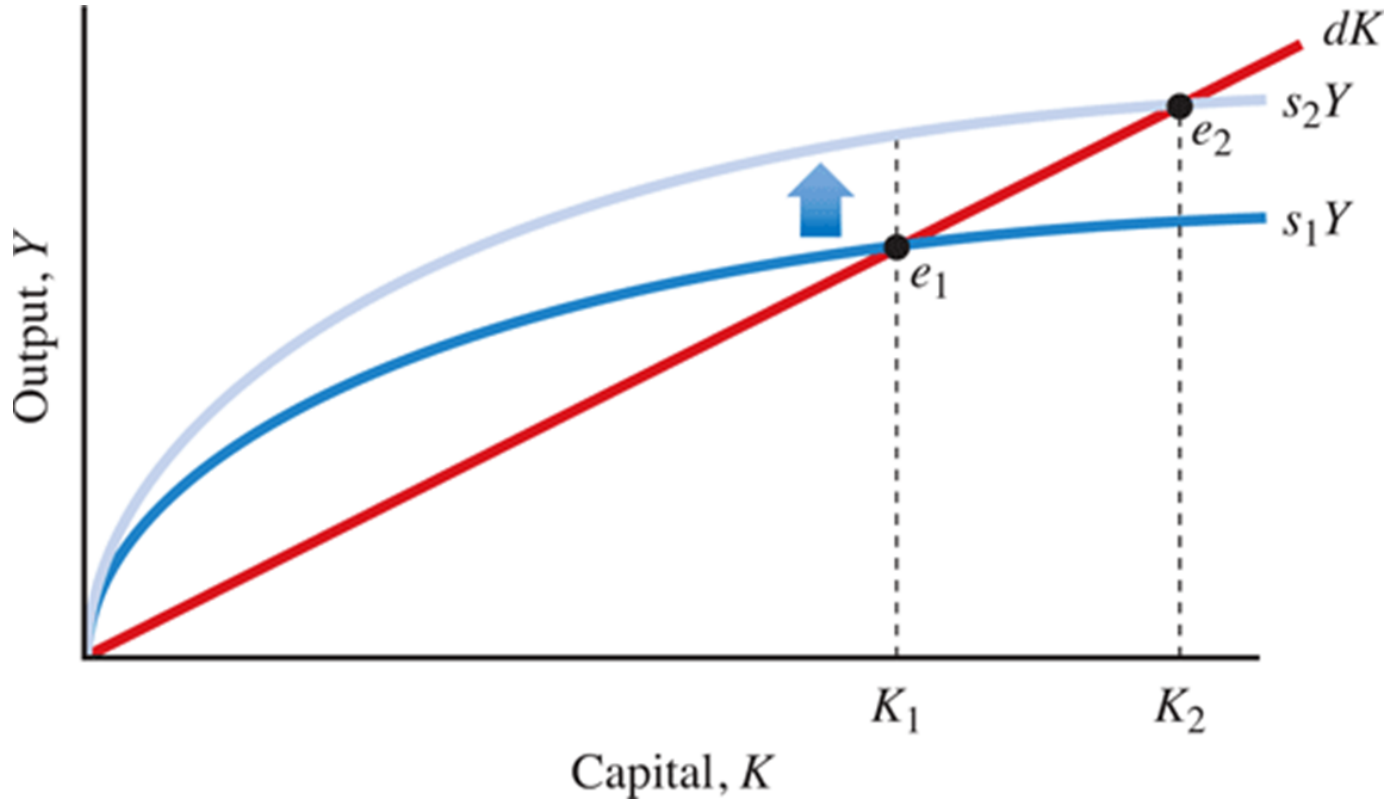


- At K_0, $sY > d \times K$ then K will rise
- At K_1, $sY > d \times K$ then K continues to rise
- At $K*$, $sY = d \times K$ then K no longer increases

Solow

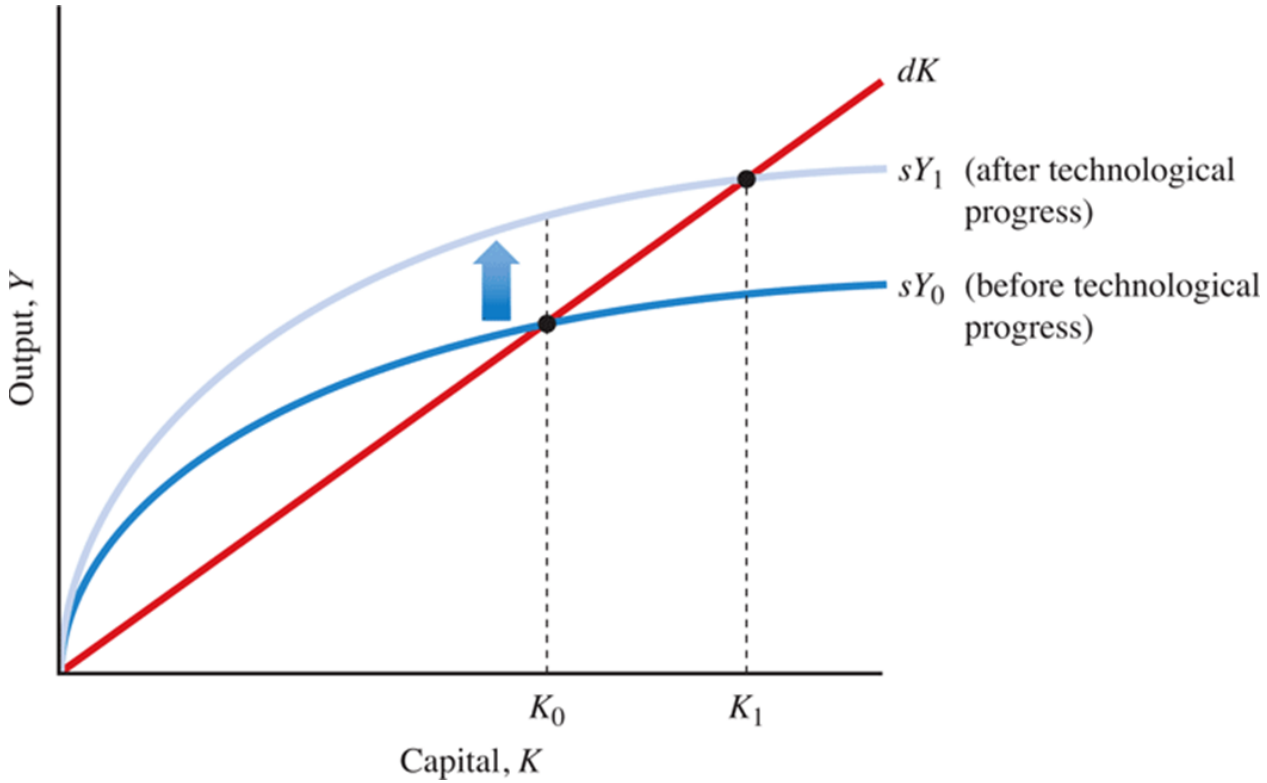
- As long as total saving exceeds depreciation, economic growth, through capital deepening, will continue
- The process continues until the stock of capital reaches its long-run equilibrium $K*$

Increase in Savings Rate



- A higher saving rate will lead to a higher stock of capital in the long run
- Starting from an initial capital stock of K1, the increase in the saving rate leads the economy to K2

Technological Progress



- Technological progress shifts up the saving schedule and promotes capital deepening

Solow Growth Model Predictions

- If capital stock is below the steady state level, it will 'iterate' towards the steady state level from below
- If the capital stock is above the steady state level, it will 'iterate' from above back to the steady state level
  - At such levels, individuals reduce investment (i.e. consume more) and the capital stock falls back towards its steady-state level
- In the long-run, with a given population and technology, growth in per capita GDP falls to zero
- The economy approaches a steady-state in which all real variables are constant
- Thus, in the Solow Model, long-term growth of the kind we see in the data must be due to
  - growth in the number of workers, or the hours that they work on average or
  - growth in TFP

The Solow Model and Real Business Cycle Models

- Some economists have suggested that the Solow model provides insight into the origin of business cycle fluctuations
  - If capital accumulation is driven primarily by growth in TFP, then perhaps fluctuations in GDP growth are due to fluctuations in TFP
  - In this case, business cycles would actually be optimal adjustments of the economy to changed real circumstances – and counter-cyclical policy would actually be inefficient
- Although they have been something like the standard model, RBCs do suffer from problems
  - First, is it really the case the TFP is completely exogenous, or does it depend itself on the state of the economy?
  - Second, RBCs typically predict pro-cyclical real interest rates, whereas real interest rates appear to be counter-cyclical