ECON 202 - MACROECONOMIC PRINCIPLES

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Chapter 8 - Economic Growth

Economic Growth - Topics

1 Some Facts

2 Data

3 Calculate economic growth rates

4 Explain the role of capital in economic growth

5 Apply growth accounting to measure technological progress

6 Discuss the sources of technological progress

7 Assess the role of government in assisting economic growth

Definitions

- Capital deepening ($\frac{K}{N} \uparrow$):
    - Increases in the stock of capital per worker

- Technological progress ($A \uparrow$):
    - More efficient ways of organizing economic affairs that allow an economy to increase output without increasing inputs

- Human capital ($H = f(N) \uparrow$):
    - The knowledge and skills acquired by a worker through education and experience and used to produce goods and services

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 trend-less $\rightarrow \frac{K}{Y} \approx 3$ in U.S.
4. As a share of GDP compensation to labor and capital have been (very roughly) constant $\rightarrow \alpha \approx 0.33$
5. Growth rates differ widely across countries. Between 1960 and 1990
   1. East Asian countries grew very rapidly: South Korea grew at 6.7% per year on average $\rightarrow$ raising per capita real GDP by over 7 times its 1960 value
   2. By contrast, many countries (especially in sub-Saharan Africa) suffered negative average growth rates over this period. Iraq -2.1 on average$\rightarrow$ cuttings its real per capita GDP roughly in half

How do we measure a country's performance?

- GDP per person

- How does GDP per person increase in the long-run?
    1. Capital deepening
    2. Technological progress
    3. Human capital accumulation

Why Do Economies Grow?

- Economists believe that there are **two** basic mechanisms that increase GDP per capita over the long term:

  1. **Capital deepening:** an increase in the economy's stock of capital—plant and equipment—relative to its workforce

  2. **Technological progress:** the ability to produce more output without using any more inputs—capital or labor

- The role of education and investment in human beings in fostering economic development is called **human capital**
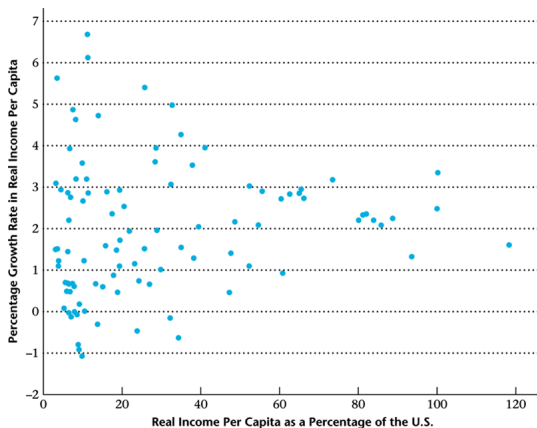
$$H = f(N^s)$$

Growth Rates

Annual Growth		Quarterly Growth
2016		
1.9%	Q4	1.9%
	Q3	3.5%
	Q2	1.4%
2015		
1.7%		

Table 1: U.S. Real GDP Growth

- China grew 6.7% in 2016 (lowest growth in 26 years)

Growth Convergence?

Convergence ?

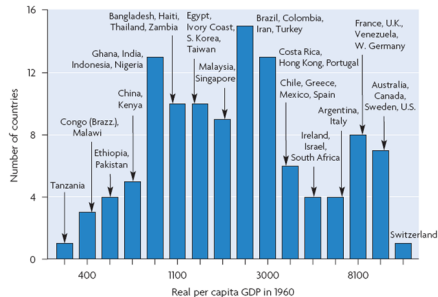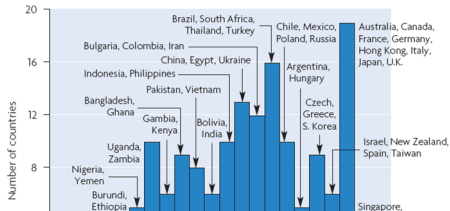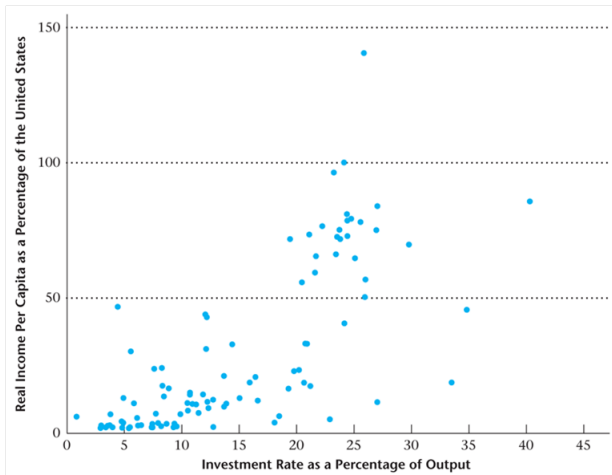Figure 3.2 — World Distribution of Real GDP per Person in 1960

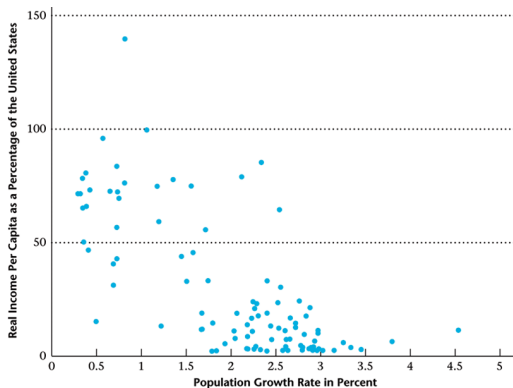Figure 3.1 — World Distribution of Real GDP per Person in 2000

Capital Deepening is a Source of Growth

Figure 1: Output per worker vs. Investment rate

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

- A meaningful measure of the standard of living in a given country is real GDP per capita

- Real GDP per capita typically grows over time

- 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

- $\text{GDP}_{[\text{in } n \, years]} = (1 + \frac{g \text{ in } \%}{100})^n * \text{GDP}_{now}$
- Assume:
  - GDP= \$120
  - $g = 4\%$
  - $\text{GDP}_{[\text{in } 5 \, years]} = (1 + 0.04)^5 \times \$120 = \$146$

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 GDP Across Countries

- Use
  - exchange rate and
  - Purchasing Power Parity (adjust for relative prices)

- In order to compare GDP and its growth across countries

- Heston and Summers Tables

Comparing Per Capita Growth Rates Across Countries

TABLE 8.1 Real Expenditures Per Capita and Economic Growth		
Country	**Real Expenditures Per Capita for 2011 in 2005 Dollars**	**Per Capita Growth Rate, 1960–2011**
United States	$42,646	2.02%
United Kingdom	32,259	2.23
France	31,437	2.39
Japan	30,427	4.03
Italy	29,081	2.99
Mexico	12,709	1.80
Costa Rica	10,123	1.67
India	3,601	2.54
Pakistan	2,472	1.84
Nigeria	2,338	0.77
Zambia	2,051	-0.77

*SOURCES: Penn World Table* Version 8.0, Center for International Comparisons at the University of Pennsylvania (CICUP), https://pwt.sas.upenn.edu, accessed March 2015.

Patterns of Growth

- Can poorer countries close the gap?

- **Convergence**→process by which poorer countries catch up with richer countries in terms of real GDP per capita

- To converge, poor countries have to grow at more rapid rates than richer countries are growing

- Is it observable in data?

Convergence of US States

Average of Annual Growth Rates from 1913 to 2003
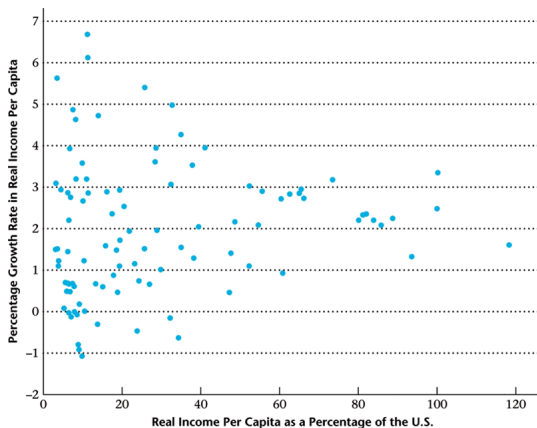versus Initial State Personal Income
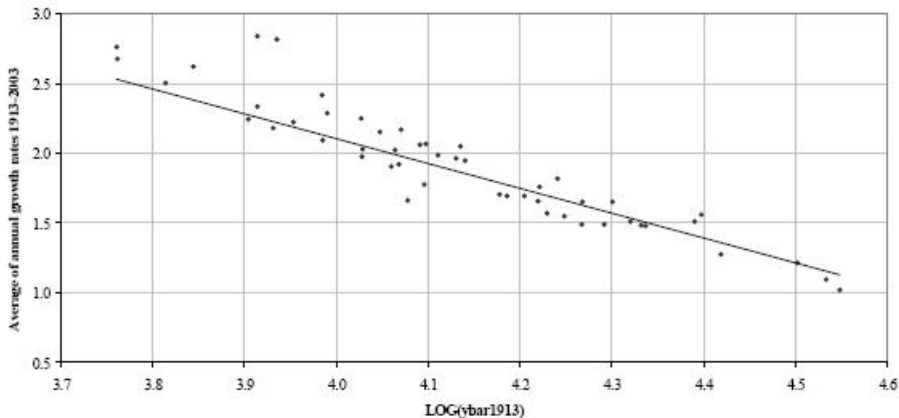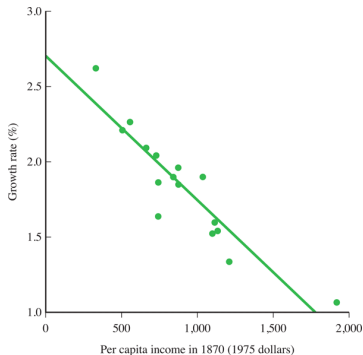
Careful with convergence results

- Sample selection bias

- Including poorer countries and convergence cannot be observed anymore

- On average poorer countries **do not** seem to grow faster than richer countries
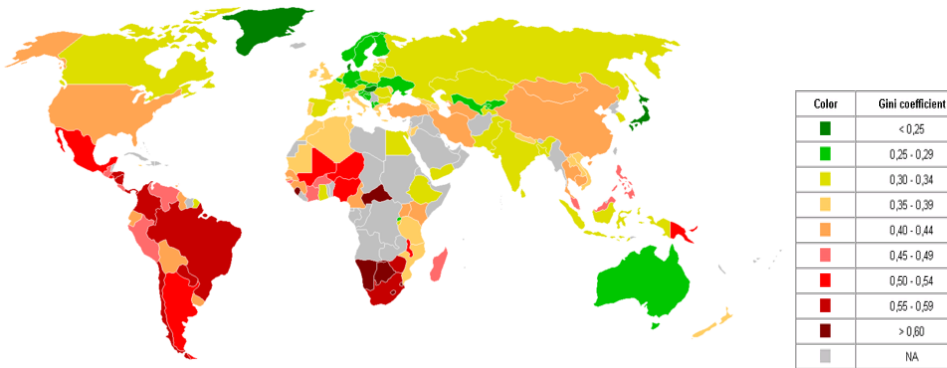
Growth Inequality Trade-off

- Is there a trade-off such that higher growth can only occur if there is increased inequality?

- Recent research suggests that this may not be the case—**equality may be beneficial** to economic growth.

- Andrew Beg and Jonathan Ostry explored the factors that determined why some countries had longer spells of sustained growth than others.
  - Almost all countries can begin to grow, but it is more difficult to sustain growth.
  - What they found was that when there was more equality, spells of growth within a country tended to last longer.

- Why might equality have a beneficial effect?
    - More equality $\rightarrow$ governments may be able to have enough power/authority to make the tough choices to sustain growth.
    - Growth and equality could, however, be possibly caused by some common factor. For example, well-functioning markets for credit and loans may lead to both more growth and more equality.
    - The good news is that it **does not appear necessary to create inequality** in order to promote growth

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

- One of the most important mechanisms of economic growth economists have identified is increases in the amount of capital per worker due to capital deepening
    - Increase in capital supply
    - Increase in labor demand
    - Real wage rise
    - Output increases

Capital Deepening and Growth
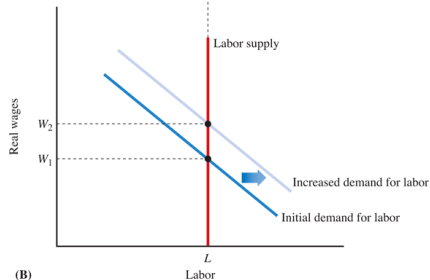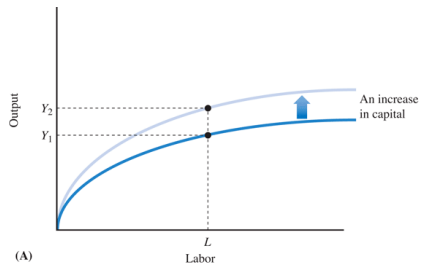
Capital Deepening

How does an economy increase its stock of capital?

- The economy must increase its net investment
- To increase net investment, gross investment must also rise
- The amount of income available for investment comes from saving

Saving and Investment

- C+S=Y
- C + I=Y
- Hence, S=I
- Net investment = saving – depreciation
- It follows that in order for the stock of capital to increase, gross investment must exceed depreciation.
- However, as capital grows, depreciation also grows, eventually catching up to the level of gross investment, and putting a stop to the growth of capital deepening

Factors influencing capital deepening

- Population growth
- Government actions
    - Increase in investment $\rightarrow$ capital deepening
    - Increase in gov't consumption . $\rightarrow$ no deepening
- Trade deficits

How Does the Government Affect Capital Deepening?

The government can affect the process of capital deepening in several ways:

- **Higher taxes** $\downarrow$ total income

- Assuming that households save a fixed fraction of their income, an increase in taxes will cause savings to fall.

$$T \uparrow \to S \downarrow \to I \downarrow \to \frac{K}{N} \downarrow$$

- This occurs when the government uses the taxes collected from the private sector to engage in **consumption spending**, not investment

- However, if the government taxes the private sector in order to increase investment, then it will be promoting capital deepening

How Does Trade Affect Capital Deepening?

- The foreign sector can also affect capital deepening

- An economy can run a trade deficit and import investment goods to aid capital deepening.
    - It can finance the purchase of those goods by borrowing and, as investment raises, GDP and economic wealth rises and the country can afford to pay back the borrowed funds

- Trade deficits that fund current consumption do not aid in the process of capital deepening

Limits to Capital Deepening

- Remember decreasing returns to scale in production function
- There is a limit to growth through capital deepening because even though at higher rate of saving can increase the level of real GDP, eventually the process comes to a halt
- However, it takes time—decades—for this point to be reached
- Capital deepening can be an important source of economic growth for a long time
- So how can an economy grow endlessly?
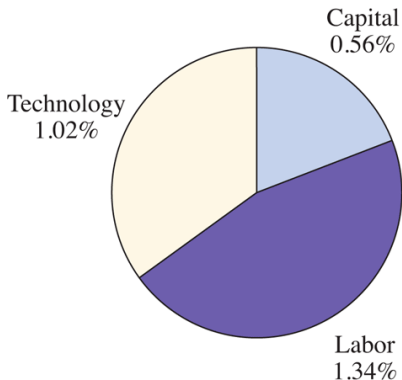
The Key Role of Technological Progress

- **Technological progress** (A↑) is the ability of an economy to produce more output without using any more inputs

- With higher output per person, we enjoy a higher standard of living

- Technological progress, or the birth of new ideas, is what makes us more productive

- Per capita output will rise when we discover new and more effective uses of capital and labor

Technological Progress

- How to measure technological progress?

- Solow Growth Model (Robert Solow, a Nobel laureate in economics)

- $Y = F(A, K, N)$
- 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

- Total output grew at a rate of nearly 3%
    - Because capital and labor growth are measured at 0.56% and 1.34%, respectively, the remaining portion of output growth, 1.02%, must be due to technological progress.
    - That means that approximately 35% of output growth came directly from technological progress.

Capital
0.56%

Technology
1.02%

Labor
1.34%

Singapore and Hong Kong

- Singapore's growth due to increases in labor and capital

- Hong Kong's due to technological progress

- Careful with this result
    - Singapore's capital growth was probably a reaction to technological progress, so the conclusion is not correct

Labor Productivity

- Is output per hour of work per worker

- Slowdown of productivity growth in the U.S. leads to slower growth in real wages and in GDP

What Caused Lower U.S. Labor Productivity?

- Labor productivity is defined as output per hour of work for the economy as a whole

- Labor productivity measures how much a typical worker can produce with the current amount of capital and given the state of technological progress

- A significant slow-down in productivity in the United States since 1973 meant slow growth in real wages and in GDP

- In recent years, there has been a resurgence in productivity growth, which reached 2.5% from 1994-2000

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
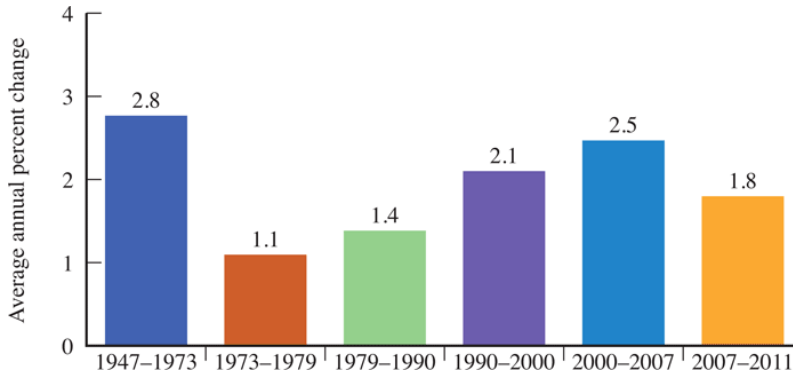
The New Economy

- Permanent increases in productivity growth?

- Not clear, maybe just temporary

- Technological progress confined to just 12% of the economy

- Hence, skepticism whether we really operate at a higher productivity level

Causes for Technological Progress

- Research and development in fundamental science.

- (temporary) monopoly rents for innovators

- Scale of the market (globalization) creates incentive to invest in R&D

- Education and human capital theory

What Causes Technological Progress?

- R&D in science

- Government or large firms who employ workers and scientists to advance physics, chemistry, and biology are engaged in technological progress in the long run

- The United States has the highest percentage of scientists and engineers in the labor force in the world

- Not all technological progress is "high tech"

Research and Development Funding as a Percent of GDP, 1999
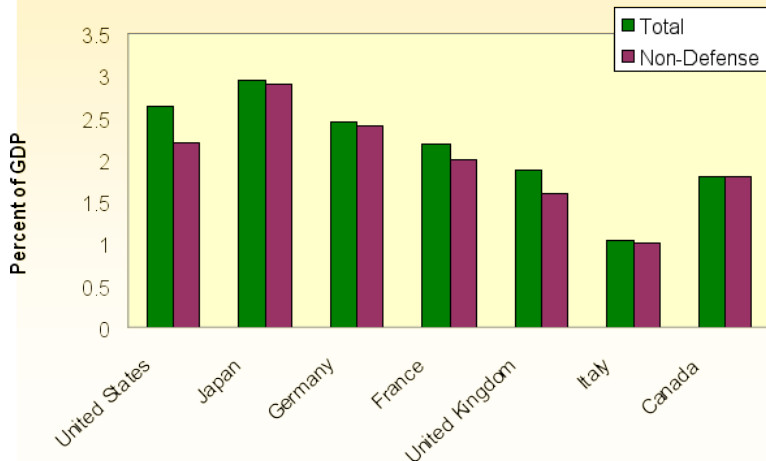
What Causes Technological Progress?

1. Monopolies that spur innovation (Joseph Schumpeter)
   - The process by which competition for monopoly profits leads to technological progress is called creative destruction by Schumpeter
   - By allowing firms to compete to be monopolies, society benefits from increased innovation

2. The scale of the market
   - Adam Smith stressed the importance of the size of a market for economic development
   - There are more incentives for firms to come up with new products and methods of production in larger markets

3. Induced innovations.
   - Some economists emphasize that innovations come about through inventive activity designed specifically to reduce costs.

4. Education and the accumulation of knowledge.
   - Modern theories of growth that try to explain the origins of technological progress are know as new growth theory.

A Key Governmental Role: Getting the Incentives Right

- Governments must design institutions in a society in which individuals and firms work, save, and invest

- One of the basic laws of economics is that 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

Human Capital

- Human capital is an investment in human beings—in their knowledge, skills, and health

- In terms of understanding economic growth, human capital investment has two implications:
    - Not all labor is equal: Individuals with more education will, on average, be more productive
    - Health and fitness affect productivity. If workers are frail and ill, they can't contribute much to national output

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%

US PERSONAL SAVINGS RATE
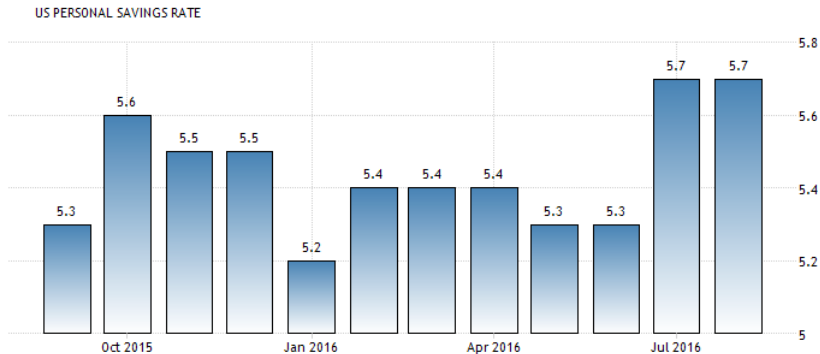
SOURCE: WWW.TRADINGECONOMICS.COM | U.S. BUREAU OF ECONOMIC ANALYSIS

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 %
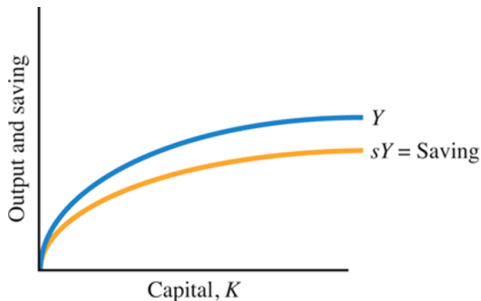- K increases as long as net investment is positive
    - $K \uparrow$ if $I - d \times K > 0$
    - $K \downarrow$ if $I - d \times K < 0$
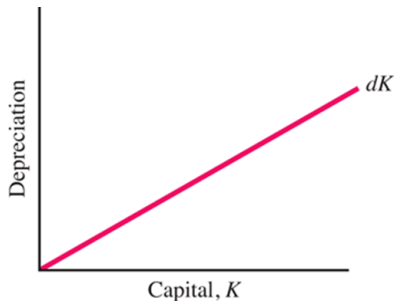- Capital stock evolves according to:

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

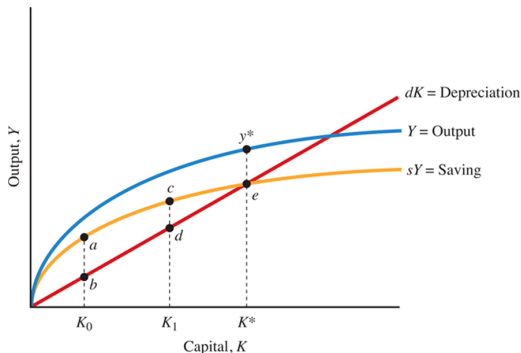$$\rightarrow K_{t+1} = I_t + (1-d)\, K_t$$

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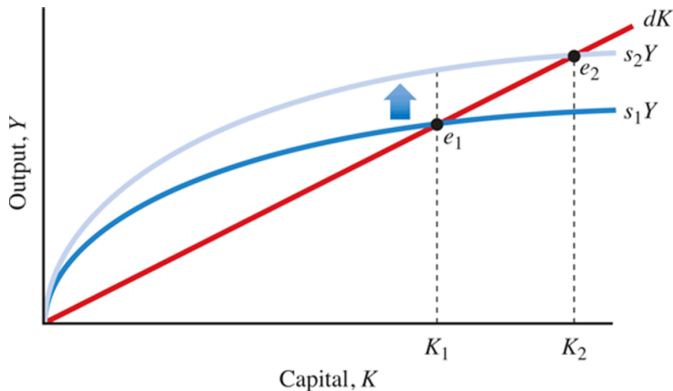
- A higher saving rate will lead to a higher stock of capital in the long run
- Starting from an initial capital stock of K1, the increase in the saving rate leads the economy to K2

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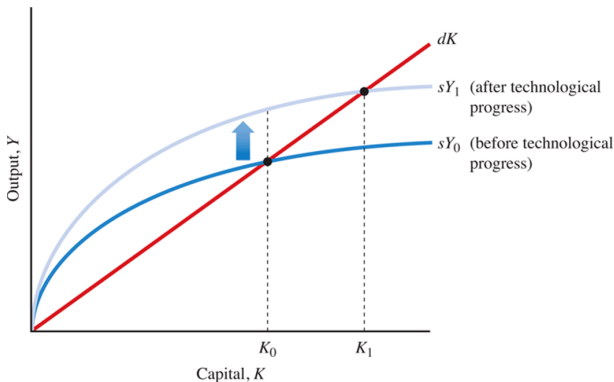
- Technological progress shifts up the saving schedule and promotes capital deepening

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