

Economic Text: Becoming Number one

- 1) Summarize the analysis and main finding of the text.
- 2) Why is the size of China's economy further behind that of the U.S. if measured in current U.S. dollars rather than at purchasing power parity?
- 3) Explain why each of the factors
 - the relative speed of real GDP growth in China and the U.S., respectively
 - the inflation gap between the two economies
 - the rate at which the yuan rises or falls againstis important to determine how fast the nominal GDP gap between the U.S. and China closes.
- 4) What is the Balassa-Samuelson effect?
- 5) How does the inflation differential between the U.S. and China influence the real exchange rate? How will this likely affect the trade deficit of the U.S. vis-à-vis China?

Chapter 8: Economic Growth II: Technology, Empirics, and Policy*

MACROECONOMICS

Seventh Edition

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* Slides based on Ron Cronovich's slides, adjusted for course in Macroeconomics for International Masters Program at the Wang Yanan Institute for Studies in Economics at Xiamen University.

Learning Objectives

This chapter introduces you to understanding:

- technological progress in the Solow model
- the connection between growth theory and growth empirics
- policies to promote growth
- endogenous growth theory



8.1) Technological Progress (TP)

→ SGM: So Far Assumed Constant Technology

In the Solow model of Chapter 7,

- the production technology is held constant.
- income per capita is constant in the steady state.

Neither point is true in the real world:

- examples of technological progress abound (see next slide).
- 1908-2008: U.S. real GDP per person grew by a factor of 7.8, or 2.05% per year.

8.1) Technological Progress (TP)

→ Examples For TP

- From 1950 to 2000, U.S. farm sector productivity nearly tripled.
- The real price of computer power has fallen an average of 30% per year over the past three decades.
- 2000: 361 million Internet users, 740 million cell phone users
2010: 2.0 billion Internet users, 3.8 billion cell phone users
- 2001: iPod capacity = 5gb, 1000 songs. Not capable of playing episodes of True Blood.
2010: iPod touch capacity = 64gb, 16,000 songs. Can play episodes of True Blood.

8.1) Technological Progress (TP)

→ SGM: Including TP

A new variable: E = labor efficiency

Assume:

Technological progress is **labor-augmenting**:
it increases labor efficiency at the exogenous rate g :

$$g = \frac{\Delta E}{E}$$

8.1) Technological Progress (TP)

→ SGM: Including TP

We now write the production function as:

$$Y = F(K, L \times E)$$

- where $L \times E$ = the number of effective workers.
- increases in labor efficiency have the same effect on output as increases in the labor force.

8.1) Technological Progress (TP)

→ SGM: Including TP (ctd.)

Notation:

$y = Y/LE$ = output per effective worker

$k = K/LE$ = capital per effective worker

Production function per effective worker:

$$y = f(k)$$

Saving and investment per effective worker:

$$s y = s f(k)$$

8.1) Technological Progress (TP)

→ SGM: Including TP (ctd.)

$(\delta + n + g)k$ = break-even investment:
the amount of investment necessary to keep k constant.

Consists of:

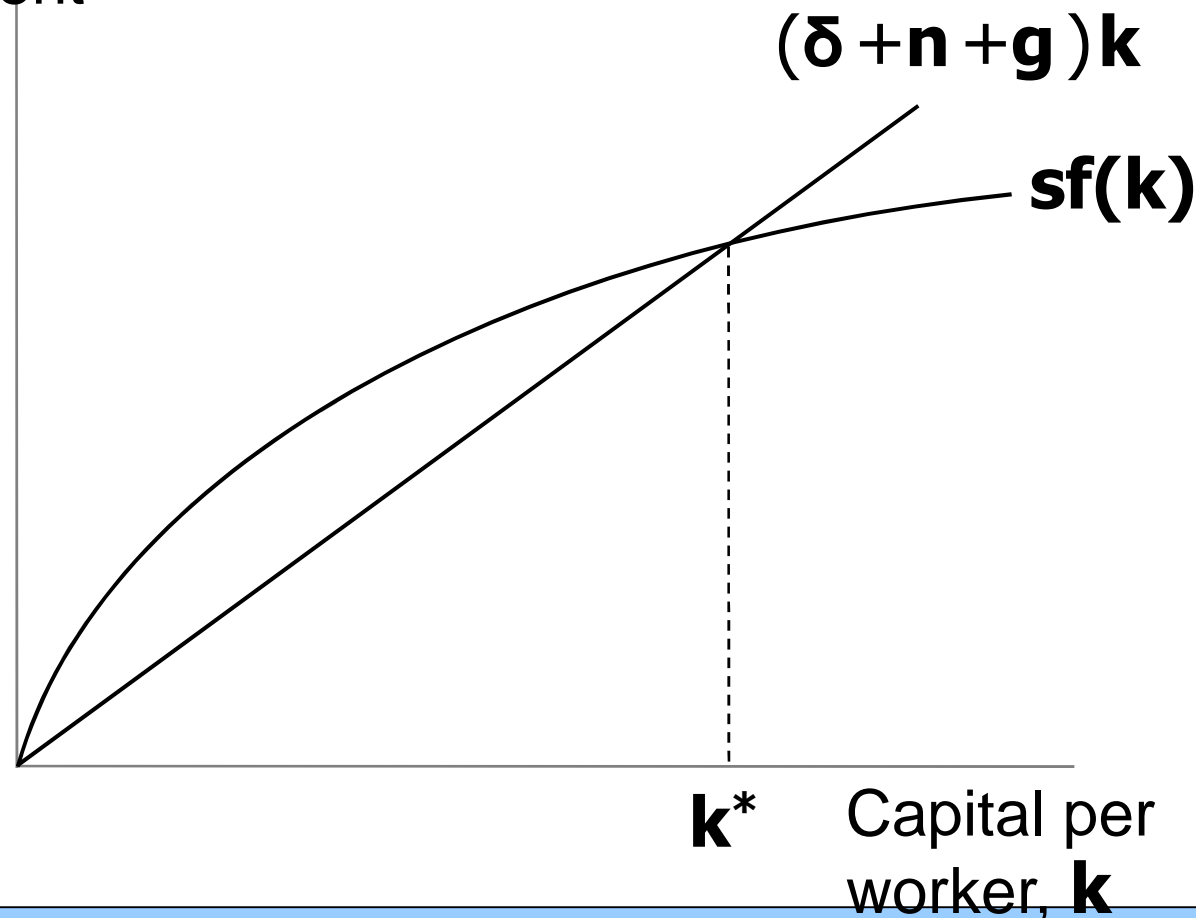
- δk to replace depreciating capital
- $n k$ to provide capital for new workers
- $g k$ to provide capital for the new “effective” workers created by technological progress

8.1) Technological Progress (TP)

→ SGM: Including TP (ctd.)

Investment,
break-even
investment

$$\Delta k = s f(k) - (\delta + n + g)k$$



8.1) Technological Progress (TP)

→ SGM with TP: Steady-State Growth Rates

<i>Variable</i>	<i>Symbol</i>	<i>Steady-state growth rate</i>
Capital per effective worker	$k = K/(L \times E)$	0
Output per effective worker	$y = Y/(L \times E)$	0
Output per worker	$(Y/L) = y \times E$	g
Total output	$Y = y \times E \times L$	$n + g$

8.1) Technological Progress (TP)

→ SGM with TP: The Golden Rule

To find the Golden Rule capital stock, express c^* in terms of k^* :

$$\begin{aligned}c^* &= y^* - i^* \\ &= f(k^*) - (\delta + n + g) k^*\end{aligned}$$

c^* is maximized when

$$MPK = \delta + n + g$$

or equivalently,

$$MPK - \delta = n + g$$

In the Golden Rule steady state, the marginal product of capital net of depreciation equals the pop. growth rate plus the rate of tech progress.

8.2) Growth Empirics



→该你们了

An economy described by the Solow growth model has the following production function: $y = k^{1/2}$.

- a. Solve for the steady-state value of y as a function of s , n , g , and δ .
- b. A developed country has a saving rate of 28 percent and a population growth rate of 1 percent per year. A less developed country has a saving rate of 10 percent and a population growth rate of 4 percent per year. In both countries, $g = 0.02$ and $\delta = 0.04$. Find the steady-state value of y for each country.
- c. What policies might the less developed country pursue to raise its level of income?

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8.2) Growth Empirics

→ Balanced Growth

Solow model's steady state exhibits **balanced growth** - many variables grow at the same rate.

Solow model predicts Y/L and K/L grow at the same rate (g).

→ This is true in the real world.

Solow model predicts real wage grows at same rate as Y/L , while real rental price is constant.

→ Also true in the real world.

8.2) Growth Empirics

→ Convergence

- Solow model predicts that, other things equal, “poor” countries (with lower Y/L and K/L) should grow faster than “rich” ones.
- If true, then the income gap between rich & poor countries would shrink over time, causing living standards to “converge.”
- In real world, many poor countries do NOT grow faster than rich ones. Does this mean the Solow model fails?

8.2) Growth Empirics

→ Convergence (ctd.)

- Solow model predicts that, other things equal, “poor” countries (with lower Y/L and K/L) should grow faster than “rich” ones.
- No, because “other things” aren’t equal.
- In samples of countries with similar savings & pop. growth rates, income gaps shrink about 2% per year.
- In larger samples, after controlling for differences in saving, pop. growth, and human capital, incomes converge by about 2% per year.

8.2) Growth Empirics

→ Convergence (ctd.)

What the Solow model really predicts is **conditional convergence** - countries converge to their own steady states, which are determined by saving, population growth, and education.

→ This prediction comes true in the real world.

8.2) Growth Empirics

→ Factor Accumulation vs. Efficiency

- Differences in income per capita among countries can be due to differences in:
 1. capital – physical or human – per worker
 2. the efficiency of production
(the height of the production function)
- Studies:
 1. Both factors are important.
 2. The two factors are correlated: countries with higher physical or human capital per worker also tend to have higher production efficiency.

8.2) Growth Empirics

→ Factor Accumulation vs. Efficiency (ctd.)

Possible explanations for the correlation between capital per worker and production efficiency:

1. Production efficiency encourages capital accumulation.
2. Capital accumulation has externalities that raise efficiency.
3. A third, unknown variable causes capital accumulation and efficiency to be higher in some countries than others.

8.2) Growth Empirics

→ Production Efficiency and Free Trade

Since Adam Smith, economists have argued that free trade can increase production efficiency and living standards.

Research by Sachs & Warner:

Average annual growth rates, 1970-89		
	open	closed
developed nations	2.3%	0.7%
developing nations	4.5%	0.7%

8.2) Growth Empirics

→ Production Efficiency and Free Trade

- To determine causation, Frankel and Romer exploit geographic differences among countries:
- Some nations trade less because they are farther from other nations, or landlocked.
- Such geographical differences are correlated with trade but not with other determinants of income.
- Hence, they can be used to isolate the impact of trade on income.
- Findings: increasing trade/GDP by 2% causes GDP per capita to rise 1%, other things equal.

Economic Text:

→ The Big Question China has to Answer

- 1) Which are the challenges China has to face in the short and in the long run?
- 2) According to the author, why is China's growth model unsustainable?
- 3) What is meant with 'middle income trap'?
- 4) In which areas should China adjust according to the author to keep on its rapid pace of growth? Do you already see signs of that adjustment?
- 5) Why is the rule of law essential for the economy? Do you have examples from your home country or other countries as to why a lack of rule of law can harm the economy?
- 6) Which 'economic rebalancing' is the author referring to in the first paragraph of the text?
- 7) In summary, what is the big question China has to answer?

Learning Objectives

This chapter introduces you to understanding:

- technological progress in the Solow model ✓
- the connection between growth theory and growth empirics ✓
- policies to promote growth ←
- endogenous growth theory

8.3) Policy Issues

- Are we saving enough? Too much?
- What policies might change the saving rate?
- How should we allocate our investment between privately owned physical capital, public infrastructure, and “human capital”?
- How do a country’s institutions affect production efficiency and capital accumulation?
- What policies might encourage faster technological progress?

8.3) Policy Issues

→ Evaluating the Rate of Saving

Use the Golden Rule to determine whether the U.S. saving rate and capital stock are too high, too low, or about right.

- If $(MPK - \delta) > (n + g)$, U.S. is below the Golden Rule steady state and should increase s .
- If $(MPK - \delta) < (n + g)$, U.S. economy is above the Golden Rule steady state and should reduce s .

8.3) Policy Issues

→ Evaluating the Rate of Saving (ctd.)

To estimate $(MPK - \delta)$, use three facts about the U.S. economy:

1. $k = 2.5 y$

The capital stock is about 2.5 times one year's GDP.

2. $\delta k = 0.1 y$

About 10% of GDP is used to replace depreciating capital.

3. $MPK \times k = 0.3 y$

Capital income is about 30% of GDP.

8.3) Policy Issues

→ Evaluating the Rate of Saving (ctd.)

1. $k = 2.5 y$
2. $\delta k = 0.1 y$
3. $MPK \times k = 0.3 y$

To determine δ , divide **2** by **1**:

$$\frac{\delta k}{k} = \frac{0.1y}{2.5y} \implies \delta = \frac{0.1}{2.5} = 0.04$$

8.3) Policy Issues

→ Evaluating the Rate of Saving (ctd.)

1. $k = 2.5 y$
2. $\delta k = 0.1 y$
3. $MPK \times k = 0.3 y$

To determine MPK , divide **3** by **1**:

$$\frac{MPK \times k}{k} = \frac{0.3y}{2.5y} \implies MPK = \frac{0.3}{2.5} = 0.12$$

$$\text{Hence, } MPK - \delta = 0.12 - 0.04 = \underline{0.08}$$

8.3) Policy Issues

→ Evaluating the Rate of Saving (ctd.)

- From the last slide: $MPK - \delta = 0.08$
- U.S. real GDP grows an average of 3% per year, so $n + g = 0.03$
- Thus, $MPK - \delta = 0.08 > 0.03 = n + g$
- Conclusion:

The U.S. is below the Golden Rule steady state: Increasing the U.S. saving rate would increase consumption per capita in the long run.

8.3) Policy Issues

→ How to Increase the Savings Rate

- Reduce the government budget deficit (or increase the budget surplus).
- Increase incentives for private saving:
- reduce capital gains tax, corporate income tax, estate tax as they discourage saving.
- replace federal income tax with a consumption tax.
- expand tax incentives for IRAs (individual retirement accounts) and other retirement savings accounts.

8.3) Policy Issues

→ Allocating the Economy's Investment

- In the Solow model, there's one type of capital.
- In the real world, there are many types, which we can divide into three categories:
 - private capital stock
 - public infrastructure
 - **human capital**: the knowledge and skills that workers acquire through education
- How should we allocate investment among these types?

8.3) Policy Issues

→ Allocating the Economy's Investment

Two viewpoints:

1. Equalize tax treatment of all types of capital in all industries, then let the market allocate investment to the type with the highest marginal product.
2. **Industrial policy:**
Govt should actively encourage investment in capital of certain types or in certain industries, because they may have positive externalities that private investors don't consider.

8.3) Policy Issues

→ Possible Problems With Industrial Policy

- The government may not have the ability to “pick winners” (choose industries with the highest return to capital or biggest externalities).
- Politics (e.g., campaign contributions) rather than economics may influence which industries get preferential treatment.

8.3) Policy Issues

→ Establishing the Right Institutions

- Creating the right institutions is important for ensuring that resources are allocated to their best use. Examples:
 - Legal institutions, to protect property rights.
 - Capital markets, to help financial capital flow to the best investment projects.
 - A corruption-free government, to promote competition, enforce contracts, etc.

8.3) Policy Issues

→ Encouraging Technological Progress

- Patent laws:
encourage innovation by granting temporary monopolies to inventors of new products.
- Tax incentives for R&D
- Grants to fund basic research at universities
- Industrial policy:
encourages specific industries that are key for rapid tech. progress (*subject to the preceding concerns*).

8.3) Policy Issues

→ Case Study: Productivity Slowdown

	<i>Growth in output per person (percent per year)</i>	
	<i>1948-72</i>	<i>1972-95</i>
Canada	2.9	1.8
France	4.3	1.6
Germany	5.7	2.0
Italy	4.9	2.3
Japan	8.2	2.6
U.K.	2.4	1.8
U.S.	2.2	1.5

8.3) Policy Issues

→ Possible Expl. for Productivity Slowdown

- *Measurement problems:*
Productivity increases not fully measured.
 - But: Why would measurement problems be worse after 1972 than before?
- *Oil prices:*
Oil shocks occurred about when productivity slowdown began.
 - But: Then why didn't productivity speed up when oil prices fell in the mid-1980s?

8.3) Policy Issues

→ Possible Expl. for Productivity Slowdown

- *Worker quality:*
1970s - large influx of new entrants into labor force (baby boomers, women). New workers tend to be less productive than experienced workers.
- *The depletion of ideas:*
Perhaps the slow growth of 1972-1995 is normal, and the rapid growth during 1948-1972 is the anomaly.

8.3) Policy Issues

→ Case Study: IT and the New Economy

	<i>Growth in output per person (percent per year)</i>		
	<i>1948-72</i>	<i>1972-95</i>	<i>1995-2008</i>
Canada	2.9	1.8	2.0
France	4.3	1.6	1.6
Germany	5.7	2.0	1.5
Italy	4.9	2.3	1.0
Japan	8.2	2.6	1.1
U.K.	2.4	1.8	2.3
U.S.	2.2	1.5	1.9

8.3) Policy Issues

→ Case Study: IT and the New Economy (ctd.)

- Apparently, the computer revolution did not affect aggregate productivity until the mid-1990s.
- Two reasons:
 - 1. Computer industry's share of GDP much bigger in late 1990s than earlier.
 - 2. Takes time for firms to determine how to utilize new technology most effectively.
- The big, open question:
 - How long will I.T. remain an engine of growth?

Learning Objectives

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- endogenous growth theory ←

8.4) Endogenous Growth Theory

- Solow model:
 - sustained growth in living standards is due to tech progress.
 - the rate of tech progress is exogenous.
- Endogenous growth theory:
 - a set of models in which the growth rate of productivity and living standards is endogenous.

8.4) Endogenous Growth Theory

→ Basic Model

- Production function: $Y = A K$
where A is the amount of output for each unit of capital (A is exogenous & constant)
- Key difference between this model & the SGM: MPK is constant here, diminishes in SGM
- Investment: $s Y$
- Depreciation: δK
- Equation of motion for total capital: $\Delta K = s Y - \delta K$

8.4) Endogenous Growth Theory

→ Basic Model (ctd.)

- $\Delta K = s Y - \delta K$
- Divide through by K and use $Y = A K$ to get:

$$\frac{\Delta Y}{Y} = \frac{\Delta K}{K} = sA - \delta$$

- If $sA > \delta$, then income will grow forever, and investment is the “engine of growth.”
- Here, the permanent growth rate depends on s . In Solow model, it does not.

8.4) Endogenous Growth Theory

→ Basic Model: Has Capital Diminishing Returns?

- Depends on definition of “capital.”
- If “capital” is narrowly defined (only plant & equipment), then yes.
- Advocates of endogenous growth theory argue that knowledge is a type of capital.
- If so, then constant returns to capital is more plausible, and this model may be a good description of economic growth.

8.4) Endogenous Growth Theory

→ Two-Sector Model

- Two sectors:
 - manufacturing firms produce goods.
 - research universities produce knowledge that increases labor efficiency in manufacturing.
- u = fraction of labor in research
(u is exogenous)
- Manufacturing production function: $Y = F[K, (1-u)EL]$
- Research production function: $\Delta E = g(u)E$
- Capital accumulation: $\Delta K = sY - \delta K$

8.4) Endogenous Growth Theory

→ Two-Sector Model (ctd.)

- In the steady state, manufacturing output per worker and the standard of living grow at rate $\Delta E/E = g(u)$.
- Key variables:
 - **s**: affects the level of income, but not its growth rate (same as in Solow model)
 - **u**: affects level and growth rate of income

8.4) Endogenous Growth Theory

→ Discussion Question: Merits of Raising “ u ”

Question:

Would an increase in u be unambiguously good for the economy?

Why or why not?

8.4) Endogenous Growth Theory

→ Facts About R&D

1. Much research is done by firms seeking profits.
2. Firms profit from research:
 - Patents create a stream of monopoly profits.
 - Extra profit from being first on the market with a new product.
3. Innovation produces externalities that reduce the cost of subsequent innovation.

Much of the new endogenous growth theory attempts to incorporate these facts into models to better understand technological progress.

8.4) Endogenous Growth Theory

→ Enough Research in the Private Sector?

- On the one hand positive social returns through research via enable other firms to build upon the discovery.
- But, there is much duplication of R&D effort among competing firms.
- Estimates:
Social return to R&D $\geq 40\%$ per year.
- Thus, many believe government should encourage R&D.

8.4) Endogenous Growth Theory

→ Economic Growth as Creative Destruction

- Schumpeter (1942) coined term “creative destruction” to describe displacements resulting from technological progress:
 - the introduction of a new product is good for consumers, but often bad for incumbent producers, who may be forced out of the market.
- Examples:
 - Luddites (1811-12) destroyed machines that displaced skilled knitting workers in England.
 - Walmart displaces many “mom and pop” stores.

Summary

1. Key results from Solow model with tech progress

- steady state growth rate of income per person depends solely on the exogenous rate of tech progress
- the U.S. has much less capital than the Golden Rule steady state

2. Ways to increase the saving rate

- increase public saving (reduce budget deficit)
- tax incentives for private saving

Summary (ctd.)

3. Productivity slowdown & “new economy”

- Early 1970s: productivity growth fell in the U.S. and other countries.
- Mid 1990s: productivity growth increased, probably because of advances in I.T.

4. Empirical studies

- Solow model explains balanced growth, conditional convergence
- Cross-country variation in living standards is due to differences in cap. accumulation and in production efficiency

Summary (ctd.)

5. Endogenous growth theory: Models that
- examine the determinants of the rate of tech. progress, which Solow takes as given.
 - explain decisions that determine the creation of knowledge through R&D.