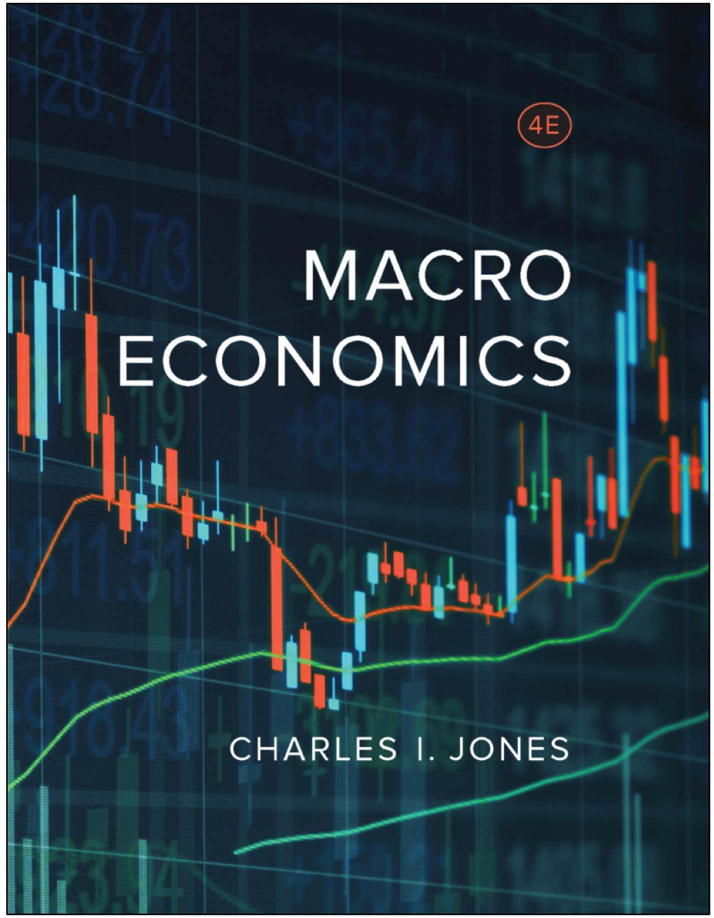
Chapter 3

An Overview of Long-Run Economic Growth



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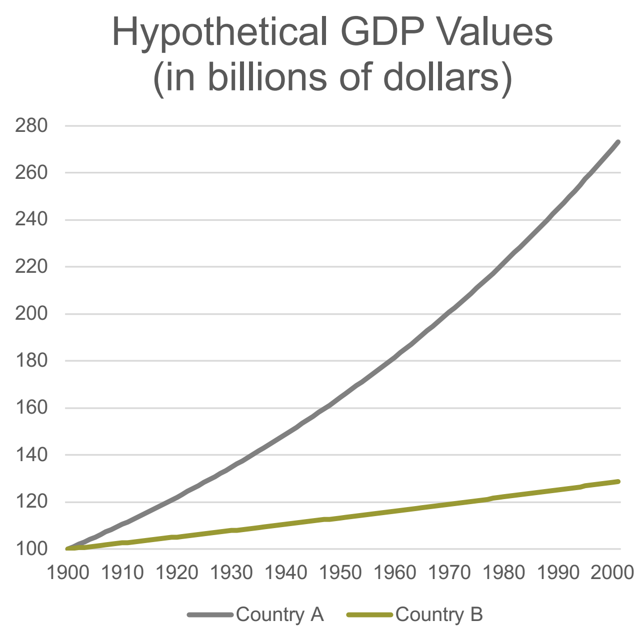
3.1 Introduction

- In this chapter, we learn:
  - some **facts** related to economic growth that later chapters will seek to explain
  - how economic growth has dramatically improved welfare around the world
  - growth is actually a relatively **recent** phenomenon.
  - some tools used to study economic growth, including how to calculate growth rates
  - why a “ratio scale” makes plots of per capita GDP easier to understand

Motivation: The Big Effect of Small Growth Rates

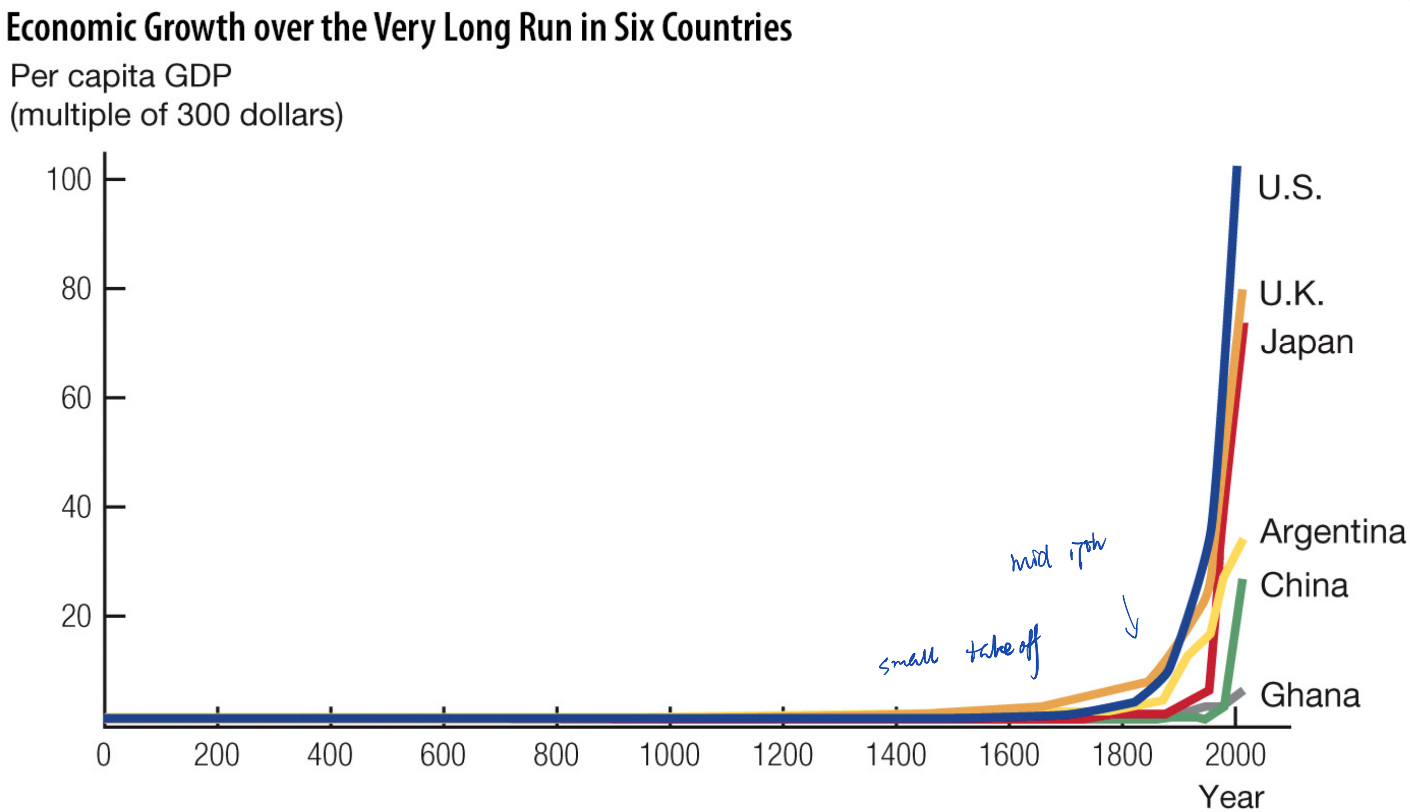
- A 1 percent change in annual growth appears small
- But it may lead to large differences in level of output over time
- Consider a 100-year period:
  - Country A and B begin at the same level of GDP ($100 billion)
  - Country A grows at 1 percent each year 28% growth
  - Country B grows at 0.25 percent each year 25% growth



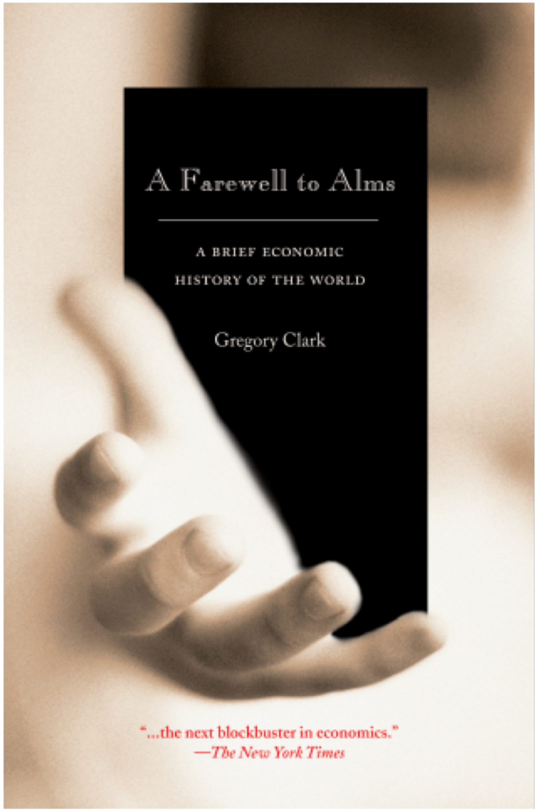
3.2 Growth Over the Very Long Run

- Sustained increases in standards of living are a recent phenomenon.
- Economic growth emerges in different places at different times.
- As a result, today's per capita GDPs differ remarkably around the world.

Growth Over the Very Long Run



Data on Growth and Incomes a Long Time Ago



Angus Maddison (1926-2010)

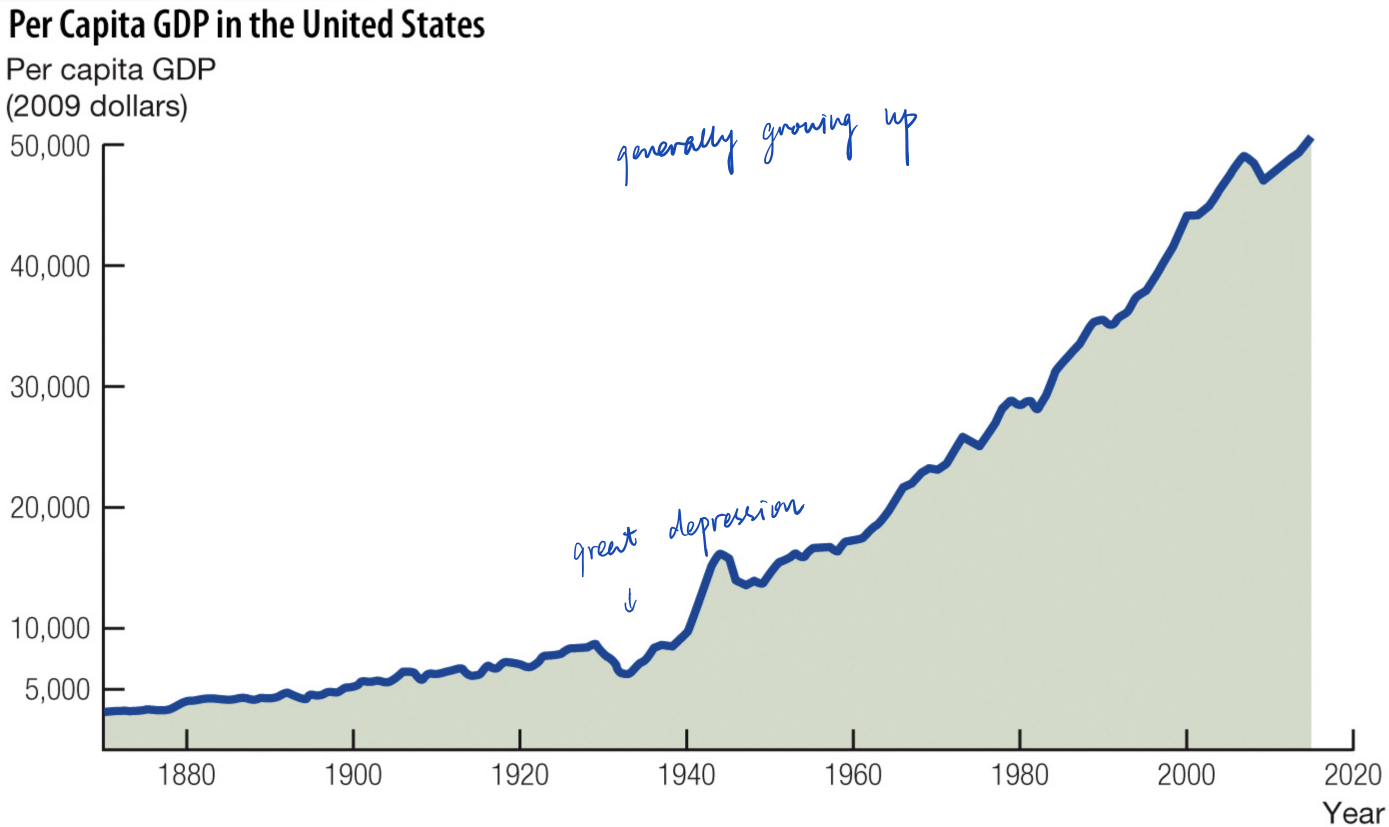
3.3 Modern Economic Growth

- Timeline: from 1870 to 2000, United States real per capita GDP rose by a factor of 15.

one generation ay twice better than last one

- A typical college student today will earn a lifetime income about twice that of his or her parents.

Modern Economic Growth



Definition of Economic Growth

- Growth of per capita GDP
  - The exact rate of change of per capita GDP
- A percentage change
  - The change between two periods divided by the value of the variable in the initial period
- Percentage change in GDP between period *t* and *t + 1:*

1+g growth factor

$$\bar{g} = \frac{y_{t+1} - y_t}{y_t}$$

$$y_{t+1} = y_t(1 + \bar{g})$$

Population Growth—1

- Population growth evolves the same way:

growth factor

$$(1) \quad L_{t+1} = L_t(1 + \bar{n})$$

growth rate

- Intuitively, tomorrow's population in time period *t + 1* depends on today's population in period *t*.
- If equation (1) is true in time *t*, it also applies to time *t+1*. It follows that:

$$(2) \quad L_{t+2} = L_{t+1}(1 + \bar{n})$$

Population Growth—2

- But, equation (1) gives us the value for L_{t+1}. So, we can plug (1) into (2)

$$(3) \quad L_{t+2} = L_t(1+\bar{n})(1+\bar{n})$$

$$(4) \quad L_{t+2} = L_t(1+\bar{n})^2$$

- And we could continue this process for any number of time periods.
- Until we recognize the pattern:

$$(5) \quad L_t = L_0(1+\bar{n})^t$$

The Constant Growth Rate Rule

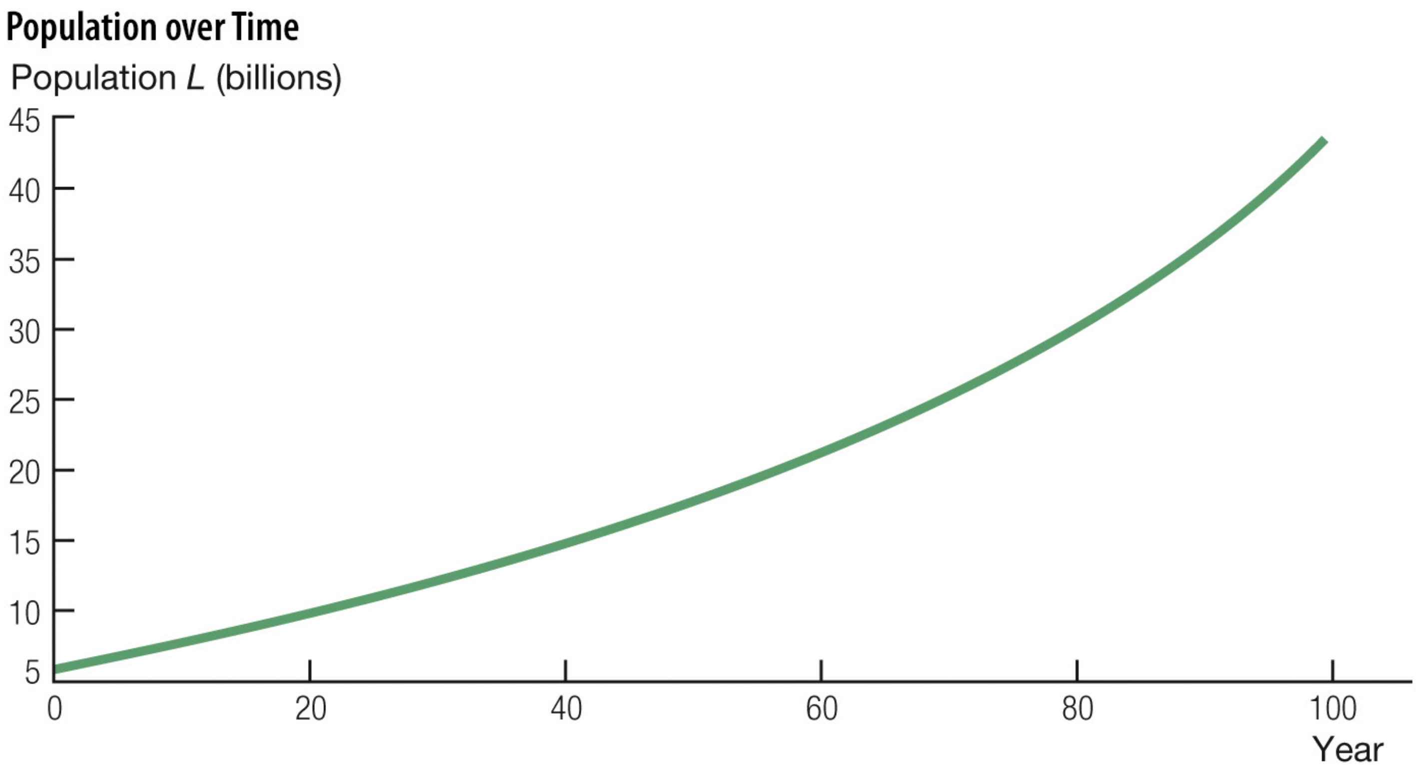
- The constant growth rate rule states that:

(6) $$y_t = y_0(1 + \bar{g})^t$$

where

- $\mathbf{t}$ is the time period
- $\mathbf{y_t}$ is the value of variable y in time t
- $\boldsymbol{y_0}$ is the initial value of variable y in period 0
- $\boldsymbol{\bar{g}}$ is the constant growth rate

Population over Time



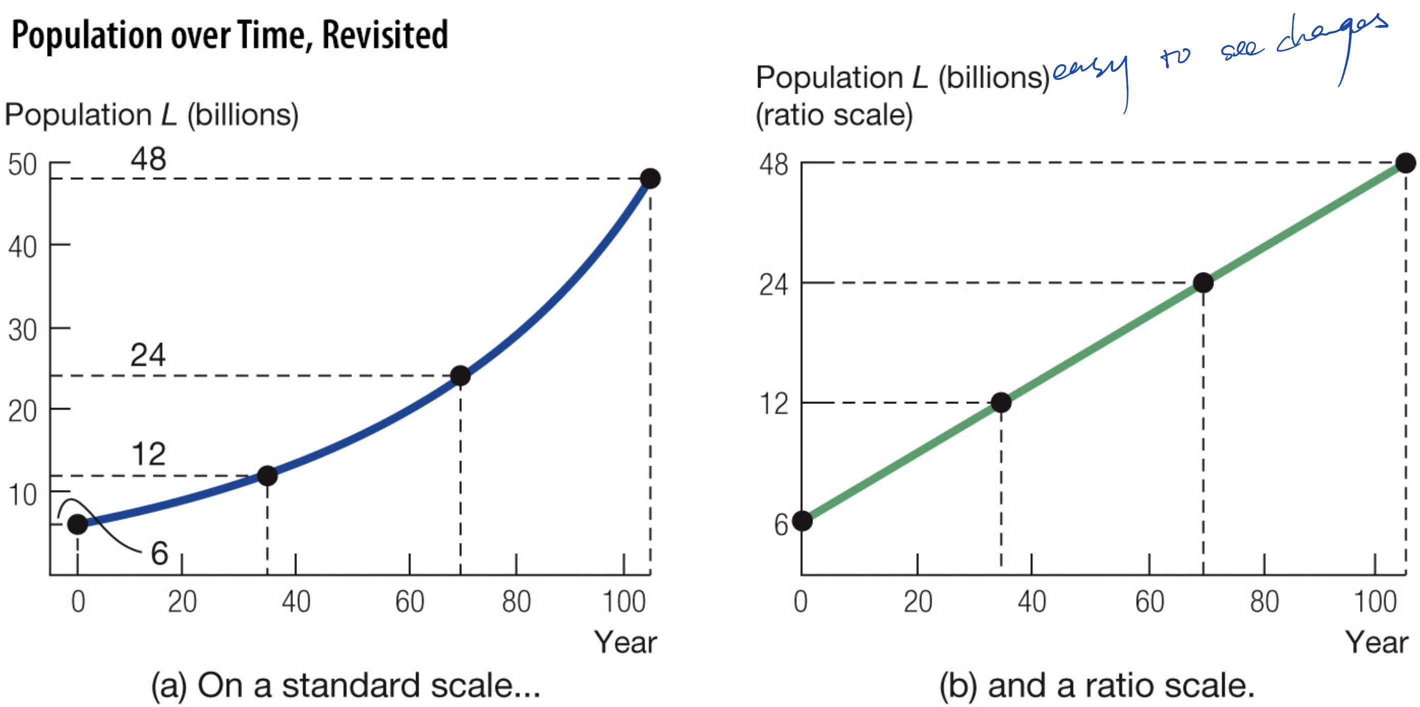
The Rule of 70

- The Rule of 70
  - If y grows at a rate of g percent per year, then the number of years it takes y to double is approximately equal to $70/g$. growth rate 2 → 70/2 = 35 years
    a generation
- Notes:
  - Small differences in growth rates result in large differences over time.
  - The time it takes to double only depends on the growth rate and not the initial value.

The Ratio Scale

- Plot where equally spaced tick marks on the vertical axis are labeled consecutively with numbers that exhibit a **constant ratio**.
- When plotted on a ratio scale, a variable that grows at a **constant rate** will be a **straight line**.

Population over Time, Revisited

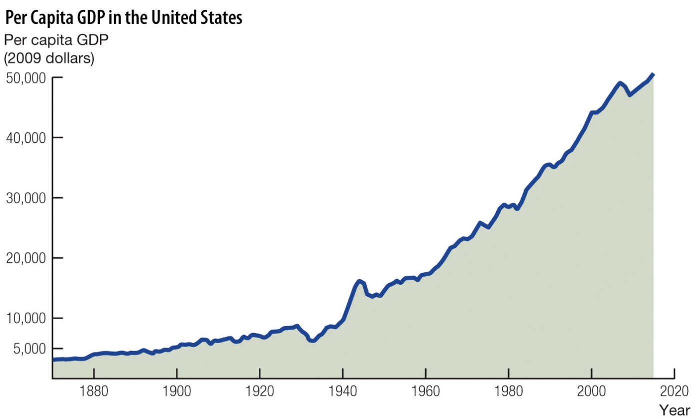


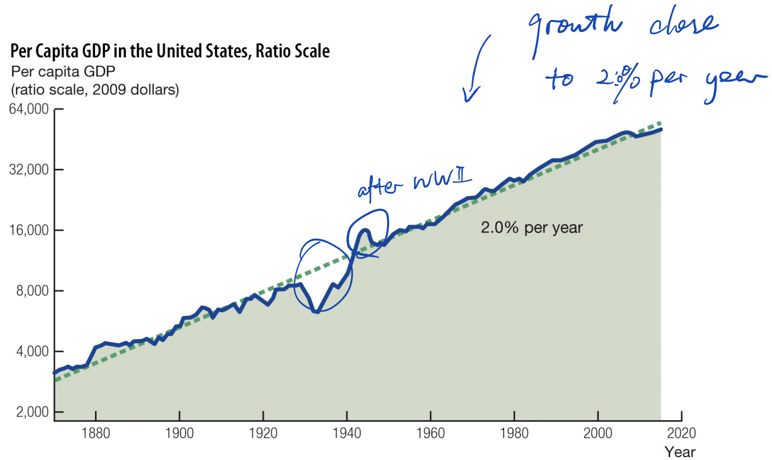
(a) On a standard scale... (b) and a ratio scale.

U.S. GDP on a Ratio Scale

- If growth rates are constant, the slope will be constant.
- If growth rates are rising, the slope will be increasing.
- Per capita GDP in the United States has grown at approximately 2 percent per year over the last 130 years.
  - Easy to see with a ratio scale
  - Approximately linear

Per Capita GDP in the United States, Ratio Scale





Calculating Growth Rates

- Begin with the constant growth rate rule:

$$y_t = y_0(1 + \bar{g})^{\,t}$$

- Use data for y to solve for $\bar{g}$
- Divide both sides by y_0:

$$\frac{y_t}{y_0} = (1 + \bar{g})^{\,t}$$

- Raise both sides to the $1/t$ power:

$$\left(\frac{y_t}{y_0}\right)^{1/t} = 1 + \bar{g}$$

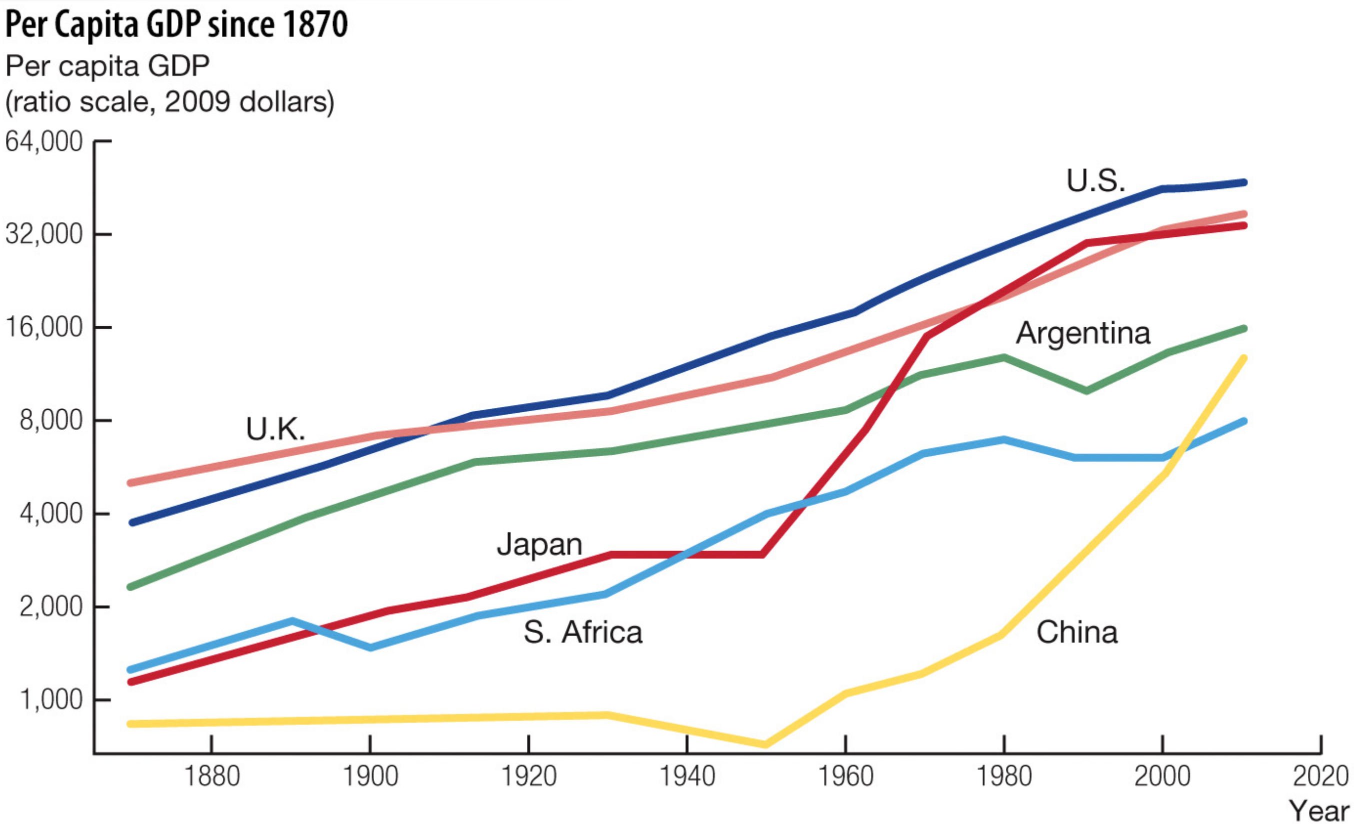
- Subtract 1 from both sides:

$$\bar{g} = \left(\frac{y_t}{y_0}\right)^{1/t} - 1$$

3.4 Modern Growth around the World

- Convergence (definition):
  Occurs when relatively poor countries ”catch up” to richer countries
- After World War II, growth in Germany and Japan accelerated.
- Other convergence / divergence patterns:
  - Latin America converged in the first half of the 19th century, followed by divergence
  - India / China first diverged, then caught up.

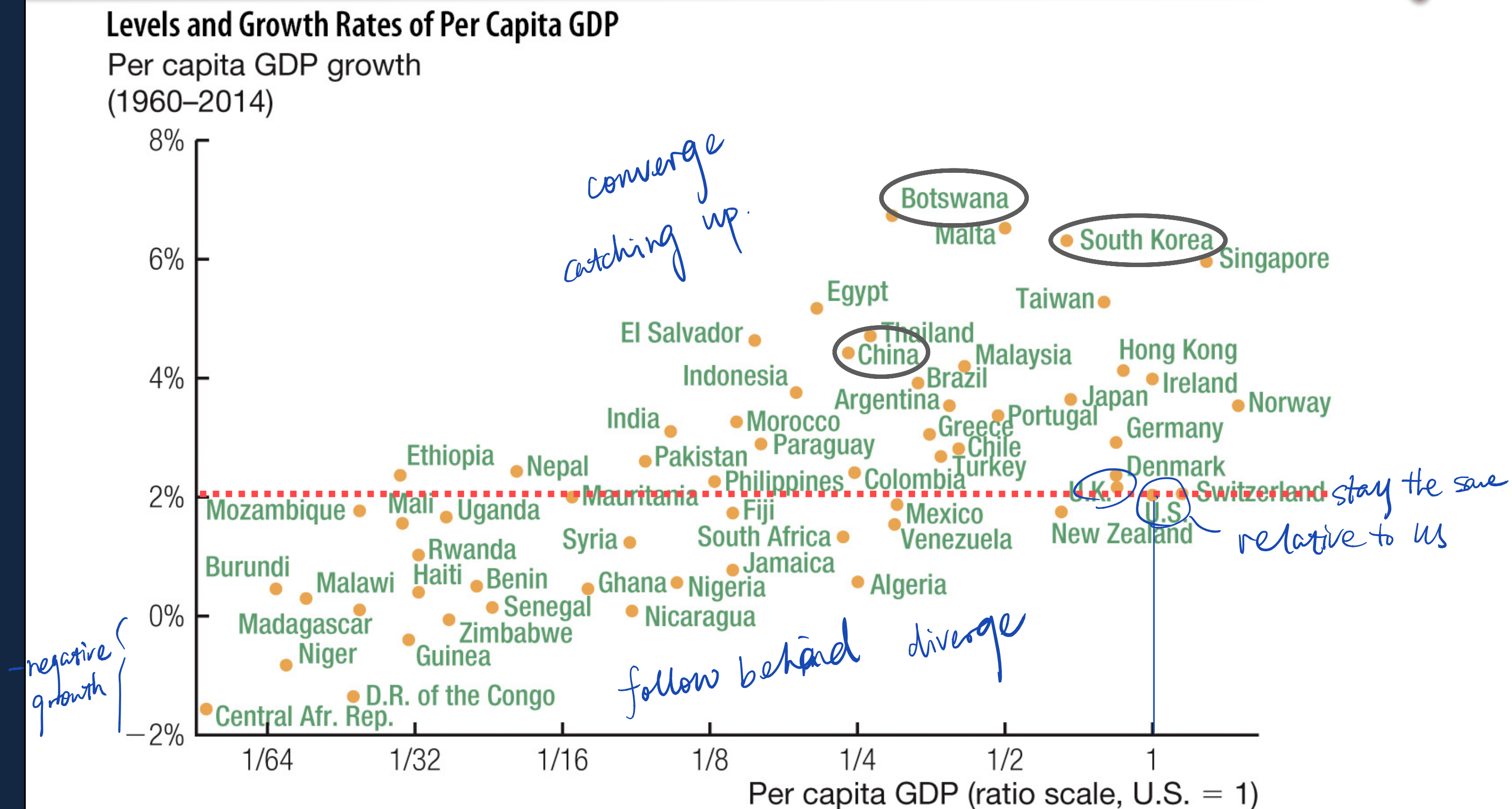
Per Capita GDP since 1870



Broader Sample of Countries

- Over the period 1960–2007
  - Some countries have exhibited a negative growth rate.
  - Other countries have sustained nearly 7 percent growth. a country in africa
- Small differences in growth rates result in large differences in standards of living.

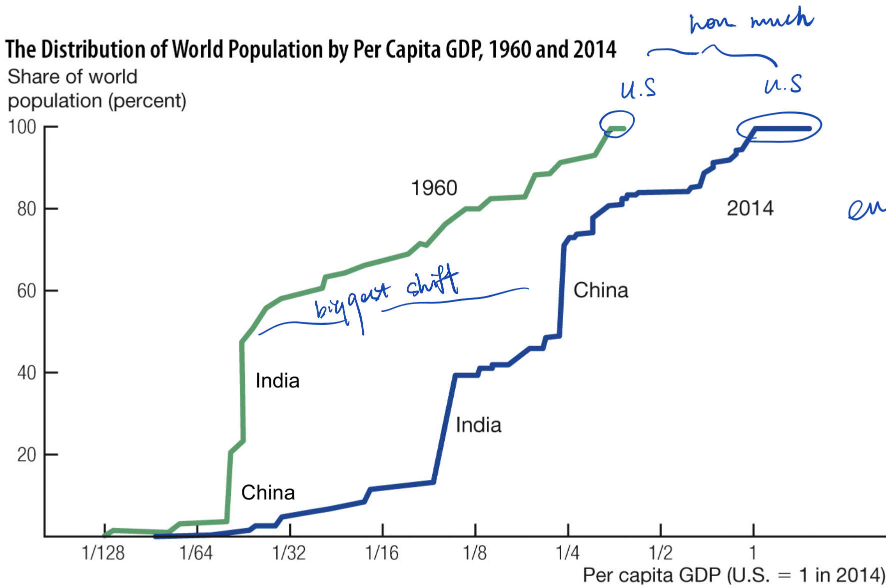
Levels and Growth Rates of Per Capita GDP



Case Study: People versus Countries

- Since 1960:
  - The bulk of the world's population is substantially richer.
  - The fraction of people living in poverty has fallen.
- A major reason for changes:
  - Economic growth in China and India
  - These two countries account for 40 percent of the world population.

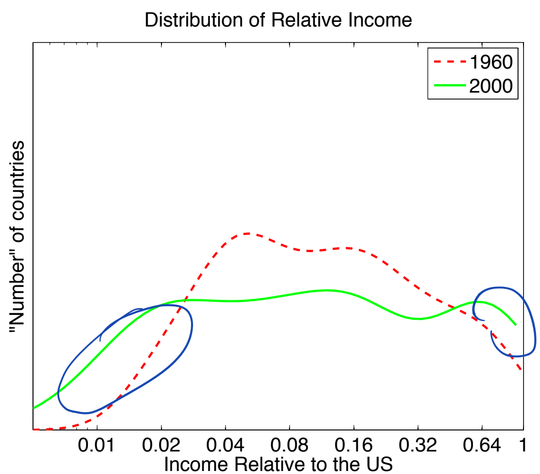
ratio scale



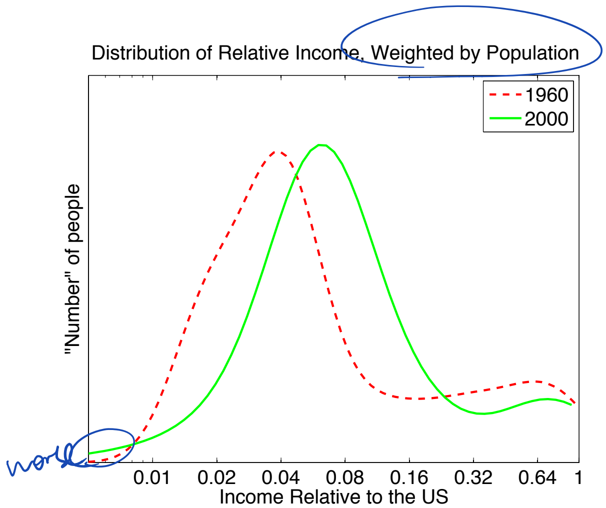
entire plot shifts right

Case Study: People versus Countries

x weighted

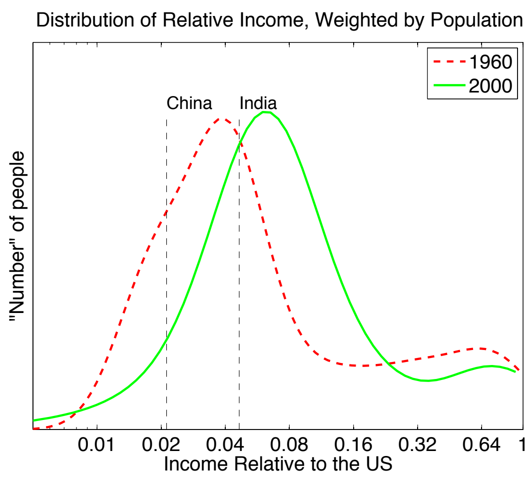


Case Study: People versus Countries



China / India factor

Case Study: People versus Countries



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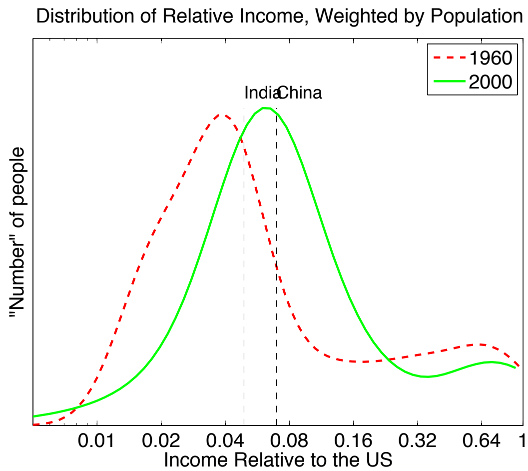
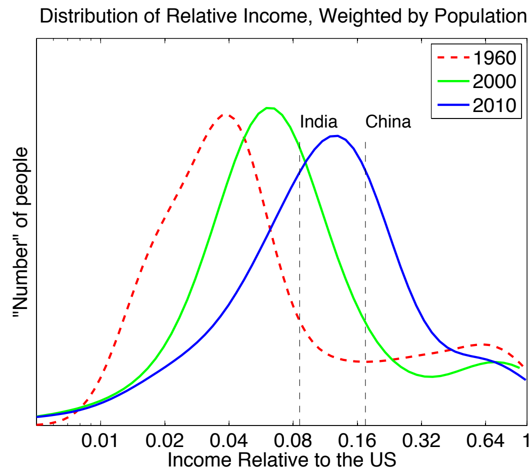


Case Study: People versus Countries



3.5 Some Useful Properties of Growth Rates

- Growth rates of ratios, products, and powers follow several simple rules.
- Growth rates obey mathematical operations that are a level simpler than the operation on the original variable.
  - Variables divided → growth rates subtracted
  - Variables multiplied → growth rates added
  - Variable taken to a power number→ growth rate multiplied by that number

Some Useful Properties of Growth Rates

- Suppose two variables x and y have average annual growth rates of g_x and g_y, respectively.
- Assume also that g_z is the average annual growth rate of z.
- Then the following rules apply:

1.	If	$z =$	x/y	then	$g_z = g_x - g_y$
2.	If	$z =$	$x \times y$	then	$g_z = g_x + g_y$
3.	If	$z =$	x^a	then	$g_z = a \times g_x$

Examples of Growth Rate Calculations

TABLE 3.1

Examples of Growth Rate Calculations

Suppose x grows at rate $g_x = 0.10$ and y grows at rate $g_y = 0.03$. What is the growth rate of z in the following cases?

$z = x \times y$	$\Rightarrow$	$g_z = g_x + g_y =$ 0.13
$z = x/y$	$\Rightarrow$	$g_z = g_x - g_y =$ 0.07
$z = y/x$	$\Rightarrow$	$g_z = g_y - g_x =$ -0.07
$z = x^2$	$\Rightarrow$	$g_z = 2 \times g_x =$ 0.20
$z = y^{1/2}$	$\Rightarrow$	$g_z = 0.5 \times g_y =$ 0.015
$z = x^{1/2}y^{-1/4}$	$\Rightarrow$	$g_z = 0.5 \times g_x - 0.25 \times g_y =$ 0.0425

Growth Rules with Cobb-Douglas Production

- Applying rules of growth rates to a Cobb Douglas production function:
- Original output equation:

$$Y_t = A_t K_t^{1/3} L_t^{2/3}$$

- Use multiplication rule to get:

Labor income share

$$g(Y_t) = g(A_t) + g\left(K_t^{\frac{1}{3}}\right) + g\left(L_t^{\frac{2}{3}}\right)$$

- Use exponent rule to get:

$$g(Y_t) = g(A_t) + \frac{1}{3} g(K_t) + \frac{2}{3} g(L_t)$$

3.6 The Benefits and Costs of Economic Growth

- The benefits of economic growth
  - Improvements in health
  - Higher incomes
  - Increase in the variety of goods and services
- Costs of economic growth include:
  - Environmental problems
  - Income inequality across and within countries (?)
  - Loss of certain types of jobs
- Economists generally have a consensus that the benefits of economic growth outweigh the costs.

3.7 A Long-Run Roadmap

- The next few chapters examine the following:
  - Chapter 4: How can we measure differences in income levels across countries?
  - Chapter 5: Develops the Solow growth model
  - Chapter 6: Is human capital a driver of economic growth?
- Also part of the long-run discussion is:
  - Chapter 7: The labor market, wages, and unemployment in the long run
  - Chapter 8: Determinants of long-run inflation