

# Growth Facts

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Econ520

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# The Facts: Economic Growth

We want to understand two sets of facts:

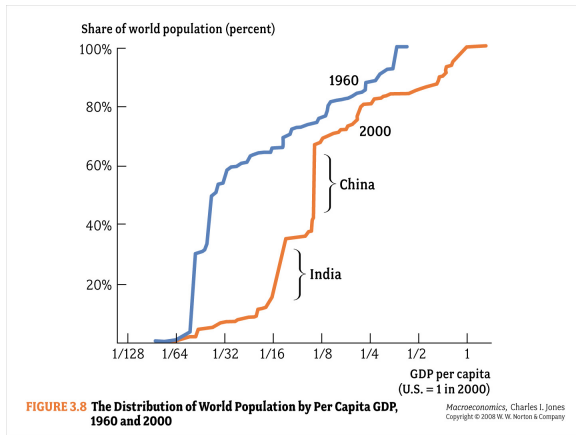
- ① Level gaps: Countries like the U.S. are about 25 times richer than countries like Bangladesh.
- ② Growth: Rich countries today about about 60 times richer than they were in 1700.

# Level Gaps

	<b>1980</b>	<b>2000</b>
United States	21,336	33,293
Canada	18,984	26,904
France	16,217	22,358
Germany	15,921	22,856
Japan	15,619	24,675
Italy	15,236	21,780
United Kingdom	14,315	22,190
Ireland	9,962	26,381
Mexico	7,655	8,762
Brazil	6,380	7,190
Indonesia	1,896	3,642
Kenya	1,239	1,244
India	1,159	2,479
China	1,069	3,747
Ethiopia	641	635

Source: Jones, Macroeconomics

# World income distribution



More than half of world population earns less than 10% of the U.S.

Question:

In which sector do poor countries have a **comparative advantage**?

Comparative advantage means...

**Table 1: Agriculture and Labor-Productivity Accounting**

**Panel A: Labor Productivity Differences**

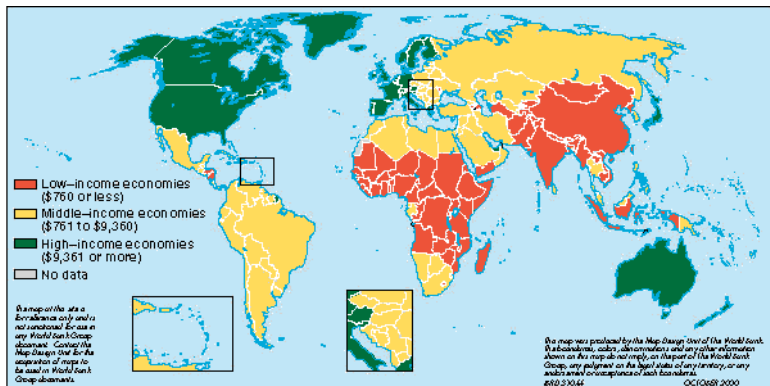
Sector	Ratio of 90th-10th Percentile
Aggregate	22
Agriculture	45
Non-Agriculture	4

**Panel B: Percent of Labor in Agriculture**

Country Income Percentile	Percent
90th	2.8
10th	78.3

Source: Caselli (2005)

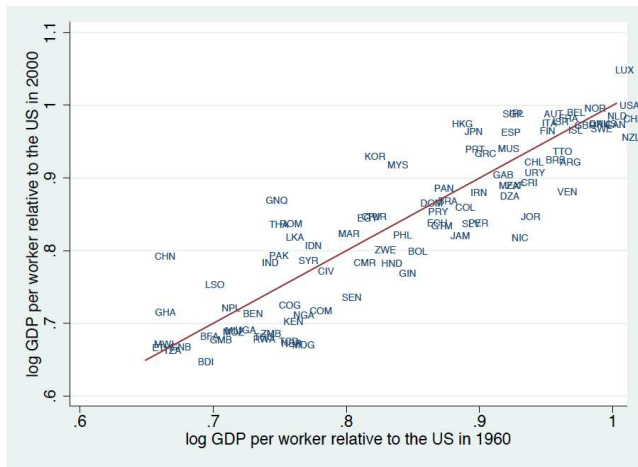
# Poverty is geographically concentrated



What do rich countries / poor countries have in common?

- Where do the enormous differences in income come from?
- How long have the rich been rich and the poor been poor?

# Income Dispersion: Post-war Period



# Post-war Period

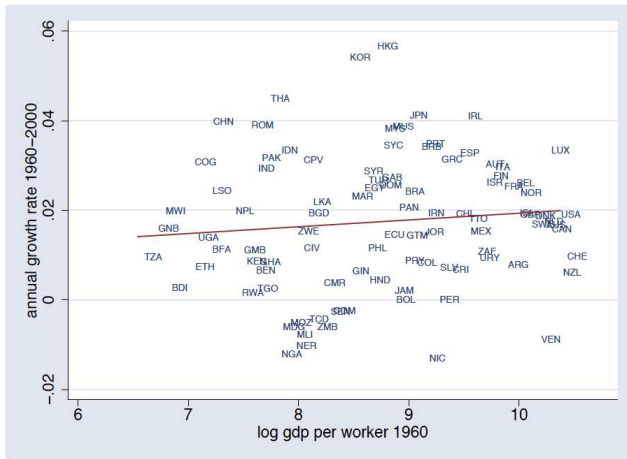


FIGURE 1.13. Annual growth rate of GDP per worker between 1960 and 2000 versus log GDP per worker in 1960 for the entire world.

What is the message of this graph?

# The Great Divergence

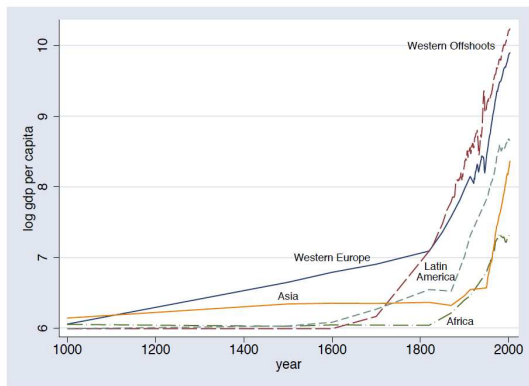
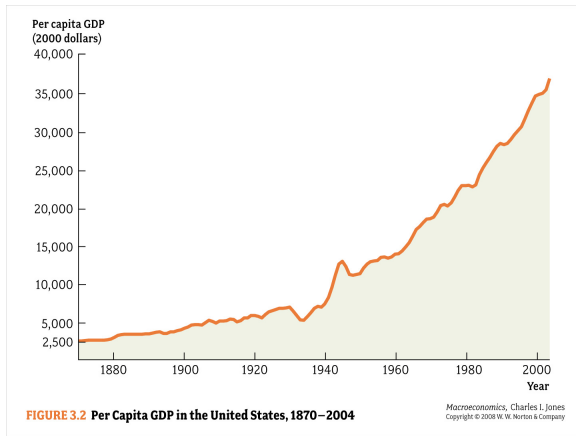


FIGURE 1.11. The evolution of average GDP per capita in Western Offshoots, Western Europe, Latin America, Asia and Africa, 1000-2000.

Source: Acemoglu (2008)

What is the message of this graph?

# U.S. Economic Growth



What is the message of this graph?

# What Is a Growth Rate?

- We need to understand the math of growth rates.
- The growth rate  $g$  is defined as

$$g = \frac{x(t+1) - x(t)}{x(t)} \quad (1)$$

- Or:

$$x(t+1) = (1 + g)x(t) \quad (2)$$

- Example:  $x(t) = 100$ ,  $g = 5\%$ . Then  $x(t+1) = 1.05 \times 100$ .

# Growth rates over multiple periods

- If we take multiple periods:

$$x(t+n) = (1+g)^n x(t) \quad (3)$$

- Example:

- GDP per capita grows at 1.8% per year.
- $y_{2002} = 30,000$
- $y_{2003} = 1.018 \cdot \$30,000 = \$30,540$ .
- $y_{2003} = 1.018y_{2002} = 1.018^2 y_{2001}$ .

- Example:

- In 50 years,  $y$  grows by  $1.018^{50} = 2.44$ .

# Calculating the average growth rate

- The average growth rate answers the question:
  - Which constant growth rate would change  $y_t$  to  $y_{t+n}$  in  $n$  years?

- Start from

$$y_{t+n} = y_t \cdot (1 + g)^n \quad (4)$$

and solve for  $g$ .

$$(1 + g)^n = y_{t+n}/y_t \quad (5)$$

$$1 + g = (y_{t+n}/y_t)^{1/n} \quad (6)$$

- Example: Average GDP growth since 1870.
  - The annual growth rate is calculated from  $y_{2000} = y_{1870} (1 + g)^{130}$ .
  - Therefore:  $g = (y_{2000}/y_{1870})^{1/130} - 1 = 0.0179 = 1.79\%$  p.a.

# Large long-term effects of small changes in growth

- How much lower would U.S. GDP be today, had it grown **0.5%** more slowly?
- The answer:

$$\hat{y}_{2000} = y_{1870} 1.013^{130} = \$17,900$$

or 46% lower than the actual 2000 level.

- **A 0.5% drop in long-run growth cuts GDP in half over 140 years.**

# Important growth rate rules

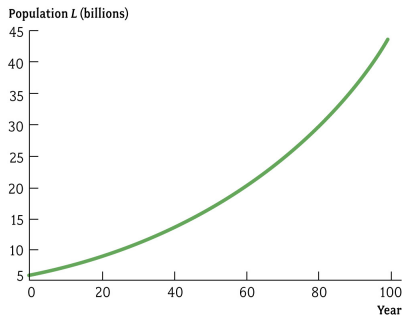
$$g(xy) = g(x) + g(y)$$

$$g(x/y) = g(x) - g(y)$$

$$g(x^\alpha) = \alpha g(x)$$

Note: These rules hold exactly in continuous time, but only approximately in discrete time.

# How to plot growing variables?



**FIGURE 3.3** Population over Time

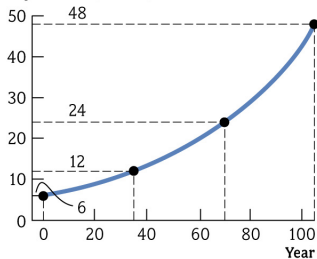
Macroeconomics, Charles I. Jones  
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Example: Population grows at constant rate  $\bar{g}$ .  
But the graph looks as if growth were accelerating.

- How can we visualize that something grows at a constant rate?
- Constant growth means:  $x$  grows by the same factor every year:
- $x_1 \rightarrow x_2 = (1 + \bar{g})x_1 \rightarrow x_3 = (1 + \bar{g})x_2$  etc.
- Rescale the vertical axis so that constant distances mean constant growth factors.
  - E.g.: each inch represents 10 fold growth.

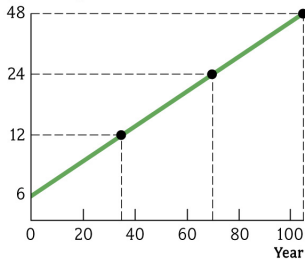
# Ratio scale

Population  $L$  (billions)



(a) On a standard scale...

Population  $L$  (billions)  
(ratio scale)

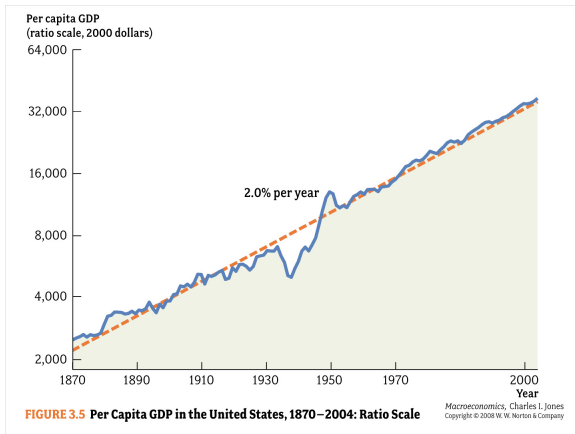


(b) and a ratio scale.

**FIGURE 3.4** Population over Time, Revisited

Macroeconomics, Charles I. Jones  
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# U.S. GDP: Ratio scale



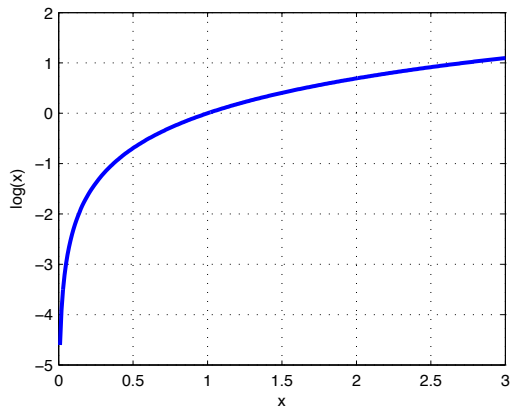
A striking fact: Since 1870 the U.S. has grown at a constant, 2% per year rate.

- The ratio scale universally used to plot growing variables is the **log scale**.
- Log is the natural logarithm.
- It is defined by

$$\log(e^x) = x \quad (7)$$

- $e$  is the Euler constant:  $e = 2.718\dots$

# Logarithmic Scale



- Suppose a variable grows according to  $y_t = e^{gt}$ .
- This variable grows at a constant rate.
- To see this:

$$\frac{y_{t+1}}{y_t} = \frac{e^{g \times (t+1)}}{e^{gt}} = e^g \quad (8)$$

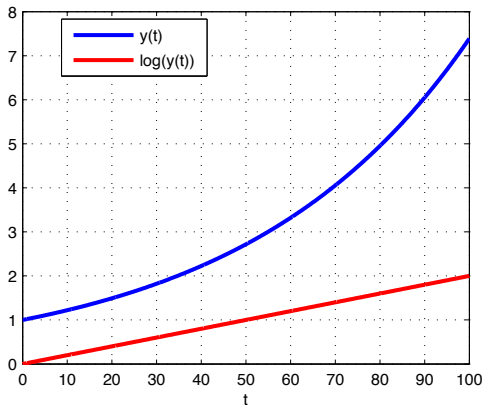
- The growth rate is  $e^g - 1 \approx g$ .
- Note: In continuous time, the growth rate of  $y$  is exactly  $g$ .

# Logarithmic scale

- What if we plot  $\log(y_t)$  against  $t$ ?
- $\log(y_t) = \log(e^{gt}) = gt$  - this is the definition of  $\log$ .
- This is useful - a variable that grows a constant rate  $g$  yields a straight line with slope  $g$ .
- That's why people use the log scale.
- An important feature for reading log graphs:  $\log(y)$  increases by 0.1 means that  $y$  roughly rises by 10%

# Logarithmic scale

Example:  $y(t)$  grows by 2% per year.



# Growth Miracles and Disasters

- Most rich countries grow at 1.5 to 2% per year.
  - It takes 40-50 years to double income per person.
  - Over 40 years,  $Y/L$  rises by factor  $1.018^{40} = 2$ .
- There are **growth miracles** with growth rates above 5%.
  - It takes 12 years to double income per person.
  - Over 40 years,  $Y/L$  rises by factor  $1.05^{40} = 7$ .
  - All of the growth miracles were middle income countries in 1960.
- There are **growth disasters** with negative growth rates.
  - Over 40 year,  $Y/L$  rises by factor  $0.99^{40} = 0.67$ .
  - All of these are in Africa and South America.

# Growth Miracles and Disasters

TABLE 2  
GROWTH MIRACLES AND DISASTERS, 1960–90  
ANNUAL GROWTH RATES OF OUTPUT PER WORKER

Miracles	Growth	Disasters	Growth
Korea	6.1	Ghana	-0.3
Botswana	5.9	Venezuela	-0.5
Hong Kong	5.8	Mozambique	-0.7
Taiwan	5.8	Nicaragua	-0.7
Singapore	5.4	Mauritania	-0.8
Japan	5.2	Zambia	-0.8
Malta	4.8	Mali	-1.0
Cyprus	4.4	Madagascar	-1.3
Seychelles	4.4	Chad	-1.7
Lesotho	4.4	Guyana	-2.1

Source: Temple (1999)

- **Enormous level gaps:** rich countries are 25 times richer than poor countries.
- **Great Divergence:** modern growth and large inequality started in the Industrial Revolution.
- **Steady growth:** Since 1870, the U.S. has grown at a constant 2% rate.
- **Large growth rate gaps:** there are growth miracles and disasters.
- **No convergence:** poorer countries do not generally grow faster.

- Jones, Introduction to Economic Growth, ch. 1
- Jones, Macroeconomics, ch. 3
- Acemoglu, Introduction to Modern Economic Growth, ch. 1