Long Run Macroeconomics

Prof. Giacomo Rondina
University of California, San Diego

Spring, 2023

Lecture 4
(note: this lecture will be recorded)

Econ 110A - Housekeeping

- Be sure to watch Lecture 3 Addendum video (GDP and Prices)

- Solutions to Problem Set 1:
    - End of Chapter 2 are posted on Canvas
    - Problems A, B: same problems solved in this week's discussion
    - Problem D: Lecture 3 Addendum just different numbers
    - Problems C, E in next week's discussion

- Practice Problem Set 2 posted today

- Remember to submit Week 2 Reflection Notes by Sunday

- Office Hours today: 5:30 pm to 7 pm

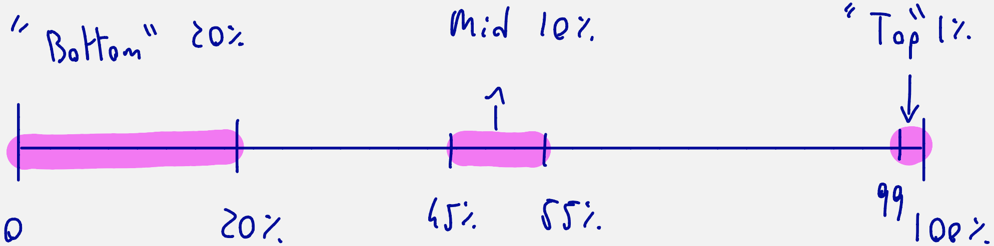
Plan for Lecture 4

- Beyond GDP: “Distributional Accounting”

- Long-Run Growth Tools
  - Compounding
  - Ratio-Scale and Log-Scale

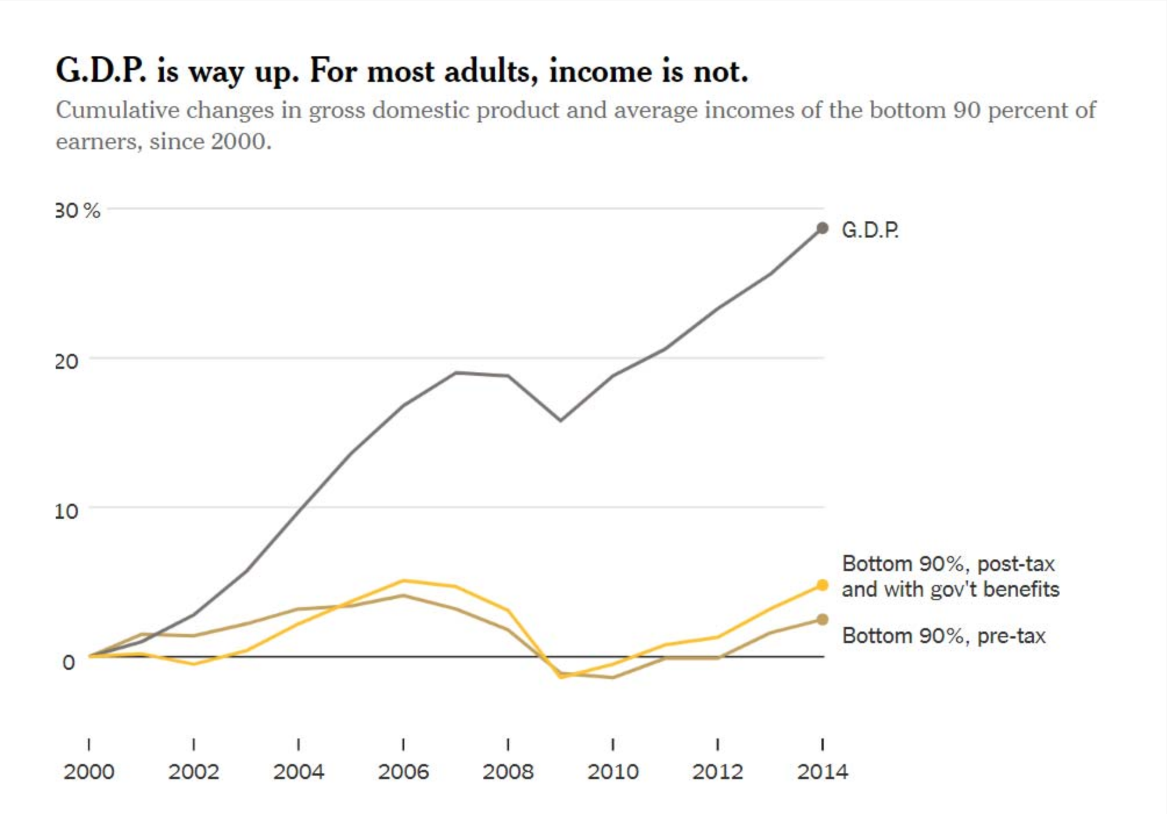
- Long-Run Growth Facts

Beyond GDP: Distributional Accounting



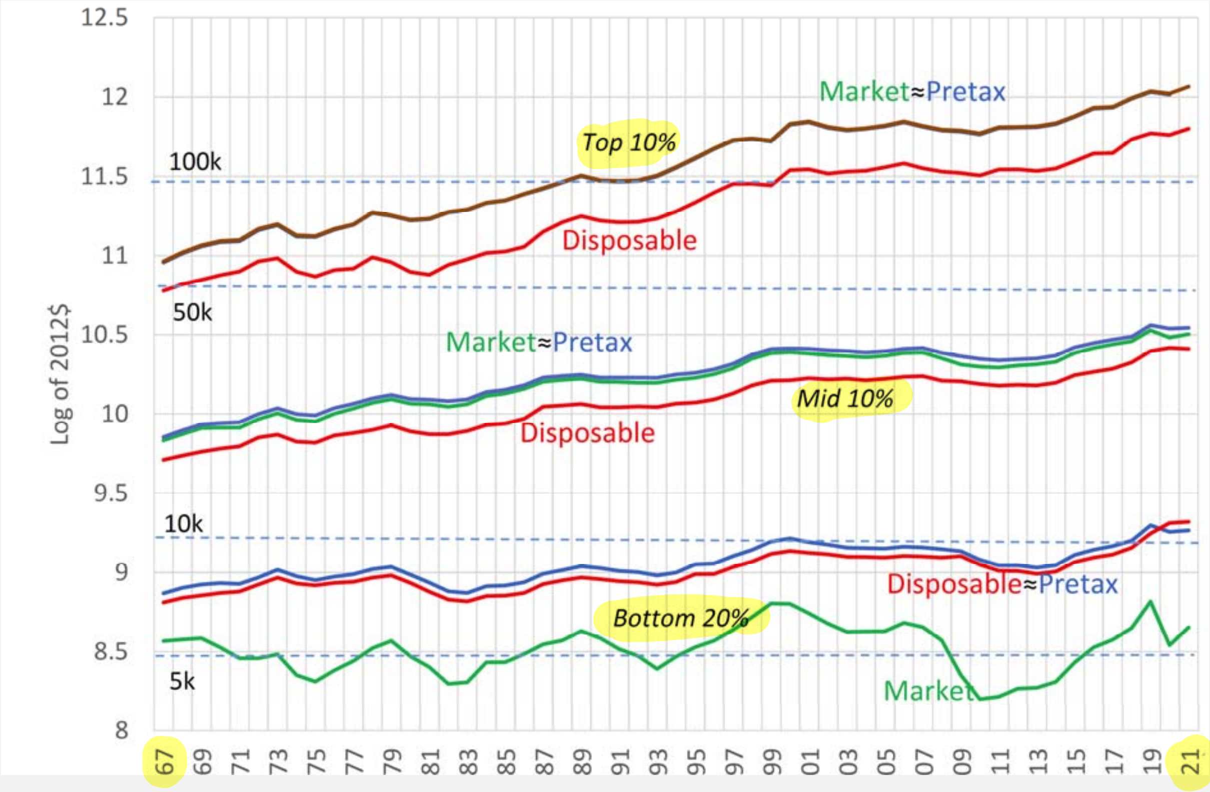
Beyond GDP: Top 10%, Bottom 90%

"We're Measuring the Economy All Wrong", NYT, Sept 2018



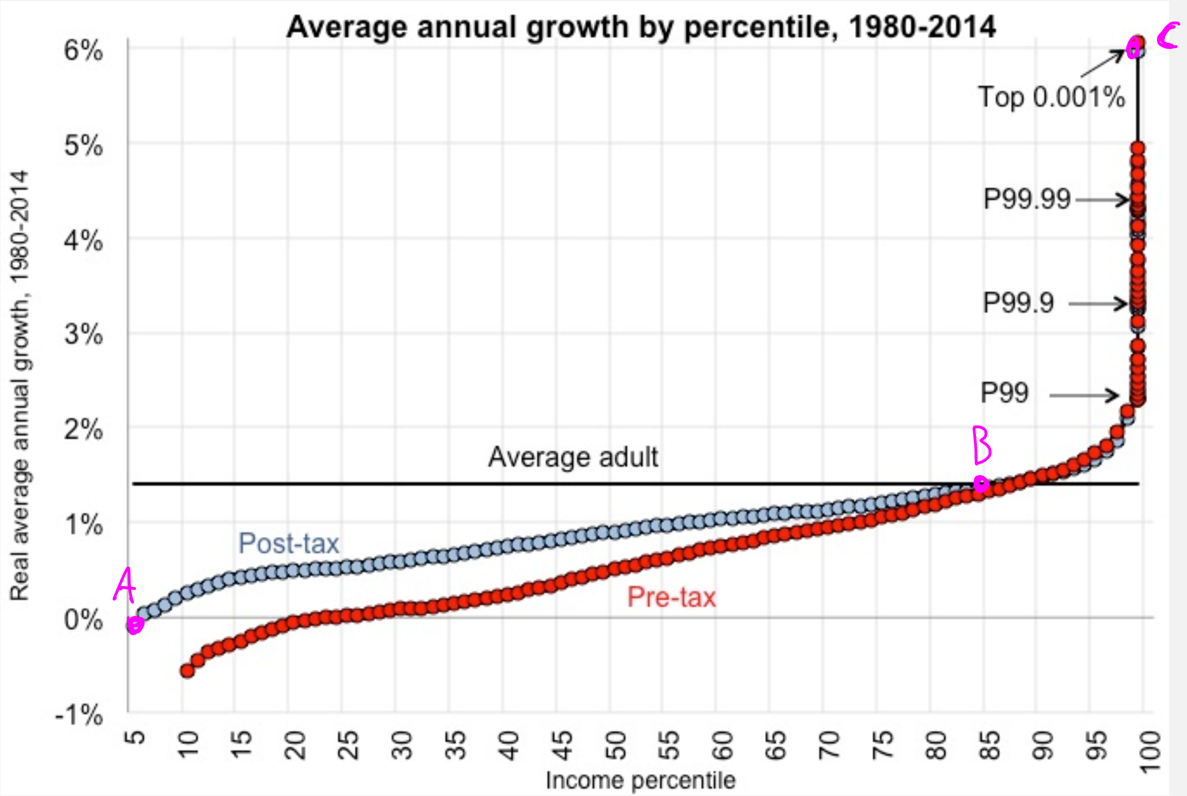
Beyond GDP: Household Income

Household Income by Top 10%, Mid 10%, Bottom 20%



"More Unequal We Stand," Heathcote, Perri, Violante, Zhang (2023)

Beyond GDP: Growth by Income Percentiles



“Distributional National Accounts” Piketty, Saez, Zucman, 2018

Plan for Lecture 4

- Beyond GDP: “Distributional Accounting”
- Long-Run Growth Tools
  - Compounding
  - Ratio-Scale and Log-Scale
- Long-Run Growth Facts

Growth Rate and Compounding

Growth rate g of variable y between t and $t+1$

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

In percentage: $\underline{100 \times g}$

Compounding: current period growth applies to past period growth

JAN 1 2018 : $\$1{,}000$, g_{18} , $\$1{,}000(1+g_{18})$

JAN 1 2019 : $\$1{,}000(1+g_{18})$, g_{19} , $\$1{,}000(1+g_{18})(1+g_{19})$

JAN 1 2020 : $\$1{,}000(1+g_{18})(1+g_{19})$

key observation: small differences in growth compounded for a long period of time lead to large differences in levels

Compounded Constant Growth Rate

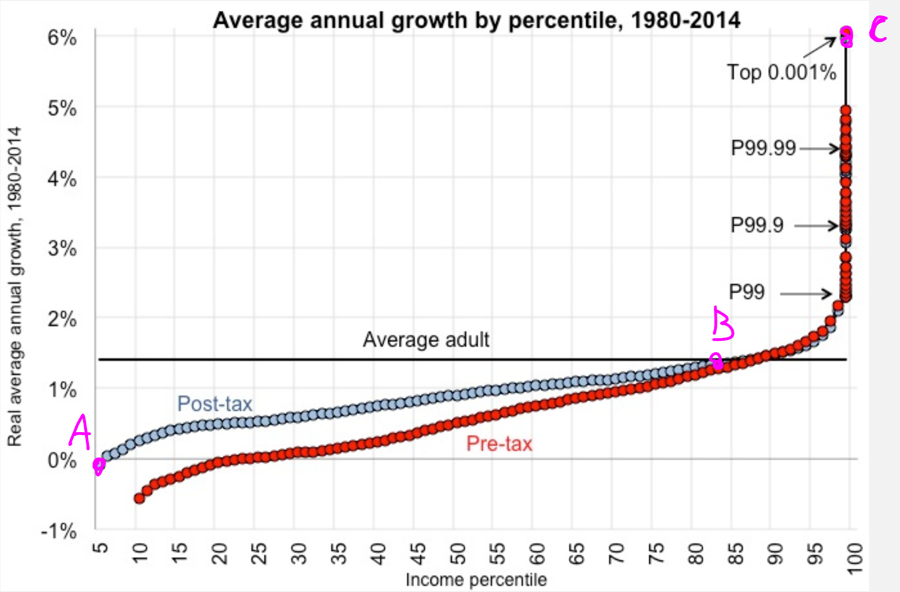
Annualized growth rate $\bar{g}$ of variable y between year *0* and t assuming that previous growth is "reinvested".

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

ex: $g_{18} = g_{19} = \bar{g}$

$\$1{,}000\,(1+\bar{g})(1+\bar{g}) = \$1{,}000\,(1+\bar{g})^2$

Example 1: Compounding and Inequality



A. $\$10{,}000 \times (1 + 0.00)^{40} = \$\ \$10{,}000$

B. $\$10{,}000 \times (1 + 0.015)^{40} = \$18{,}140$

C. $\$10{,}000 \times (1 + 0.06)^{40} = \$102{,}857$

Example 2: Population Growth

Let L_0 be world population in 2000. Assume population is expected to grow over the next 100 years at constant rate $\bar{n}$. What will population be in year 2100?

$L_1 = (1+\bar{n})L_0$

$L_0 = 6B$

$L_2 = (1+\bar{n})L_1 = (1+\bar{n})(1+\bar{n})L_0 = (1+\bar{n})^2 L_0$

$\vdots$

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

$\vdots$

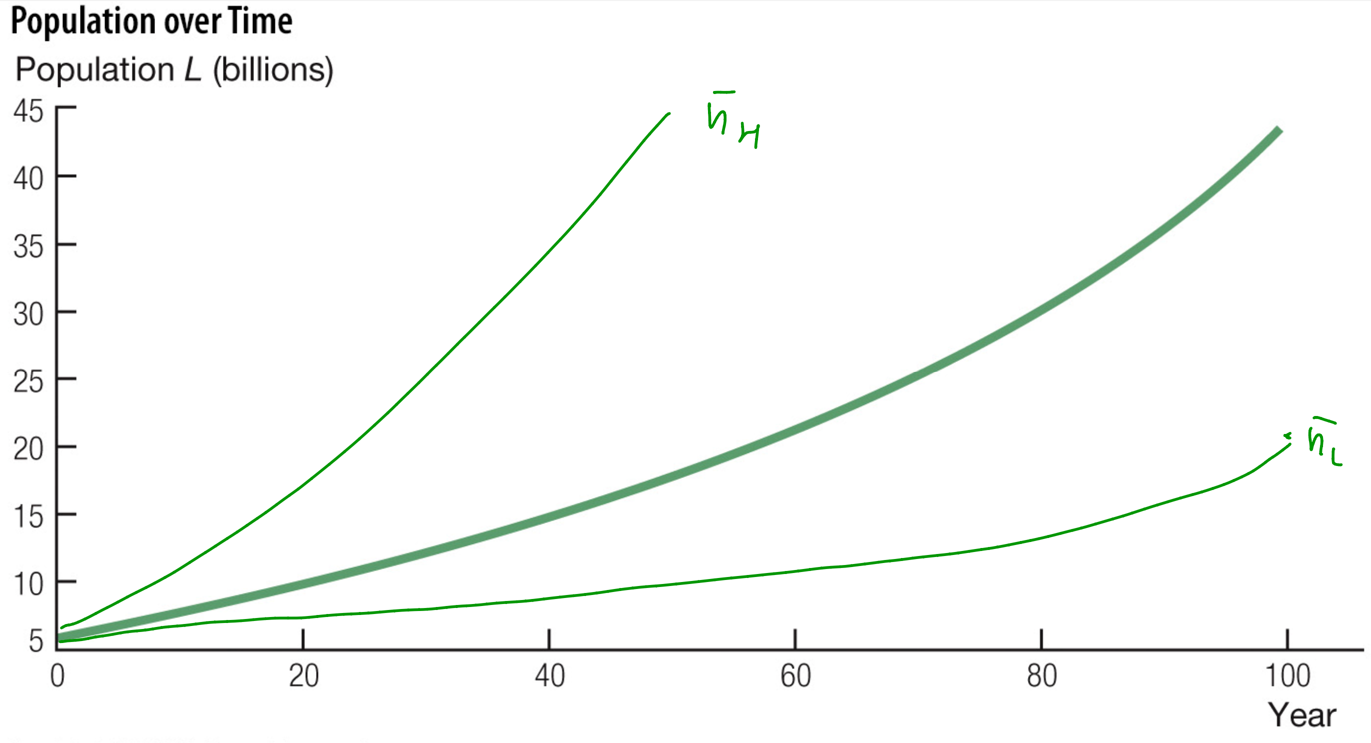
$L_{100} = (1+\bar{n})^{100} L_0$

$\bar{n}_L = 0.01 \qquad L^L_{100} = (1+0.01)^{100} \times L_0 = 16.2B$

$\bar{n}_M = 0.02 \qquad L^M_{100} = (1+0.02)^{100} \times L_0 = 43.4B$

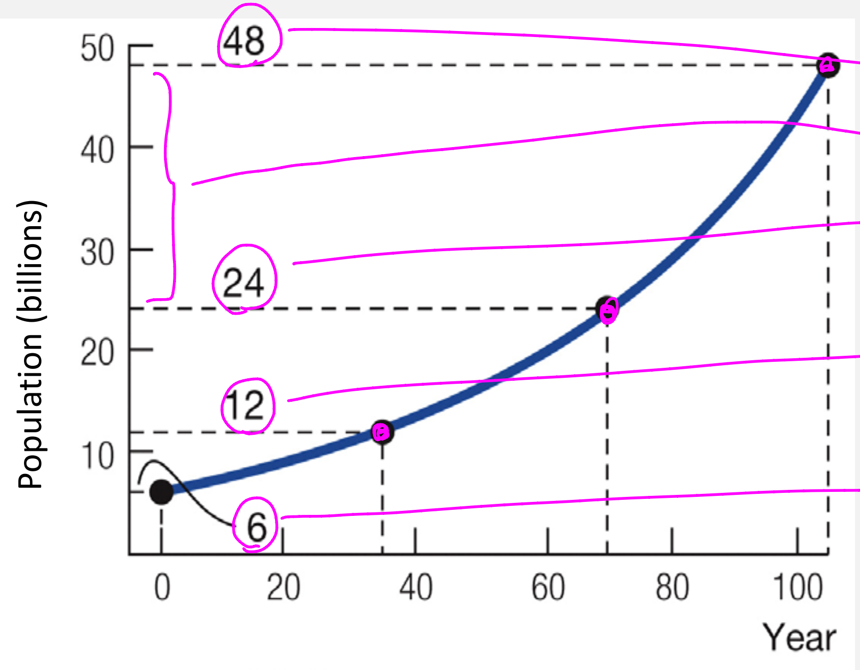
$\bar{n}_H = 0.04 \qquad L^H_{100} = (1+0.04)^{100} \times L_0 = 303B$

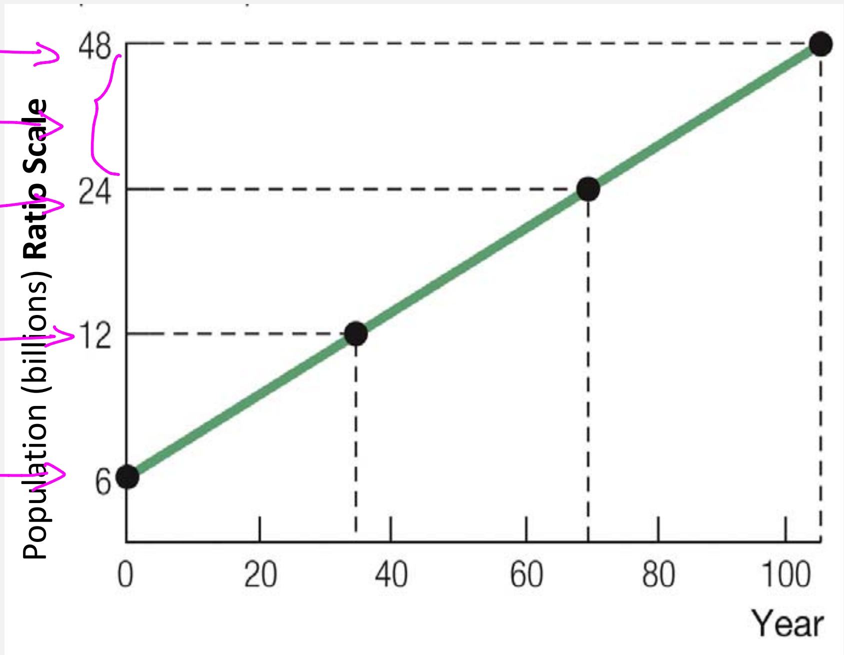
Example 2: Population Growth



key observation: compounding leads to exponential increase in levels

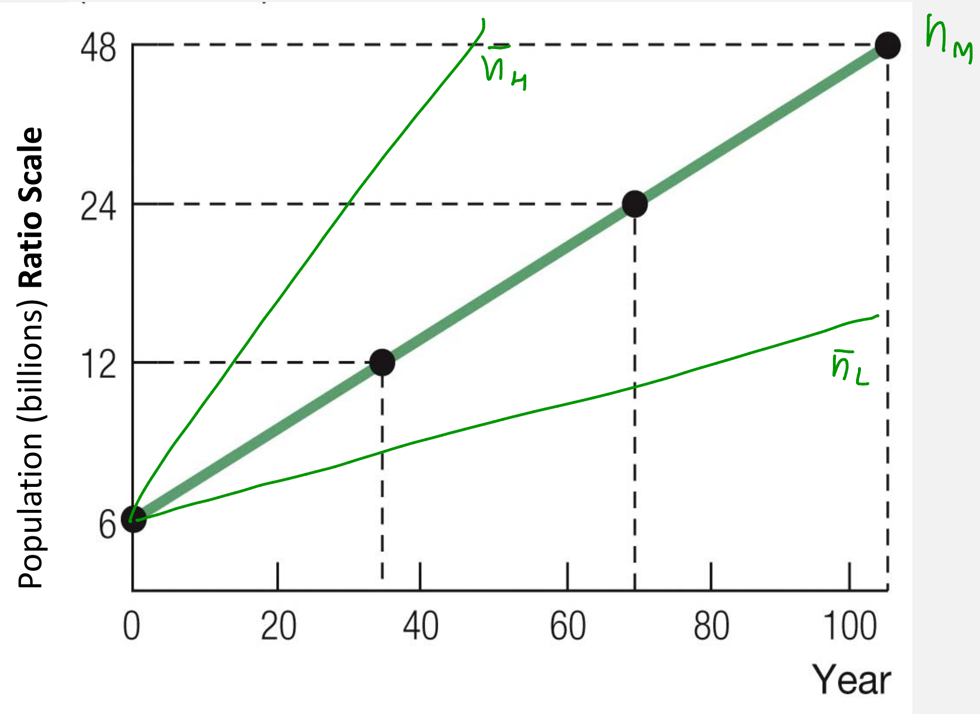
Ratio Scale





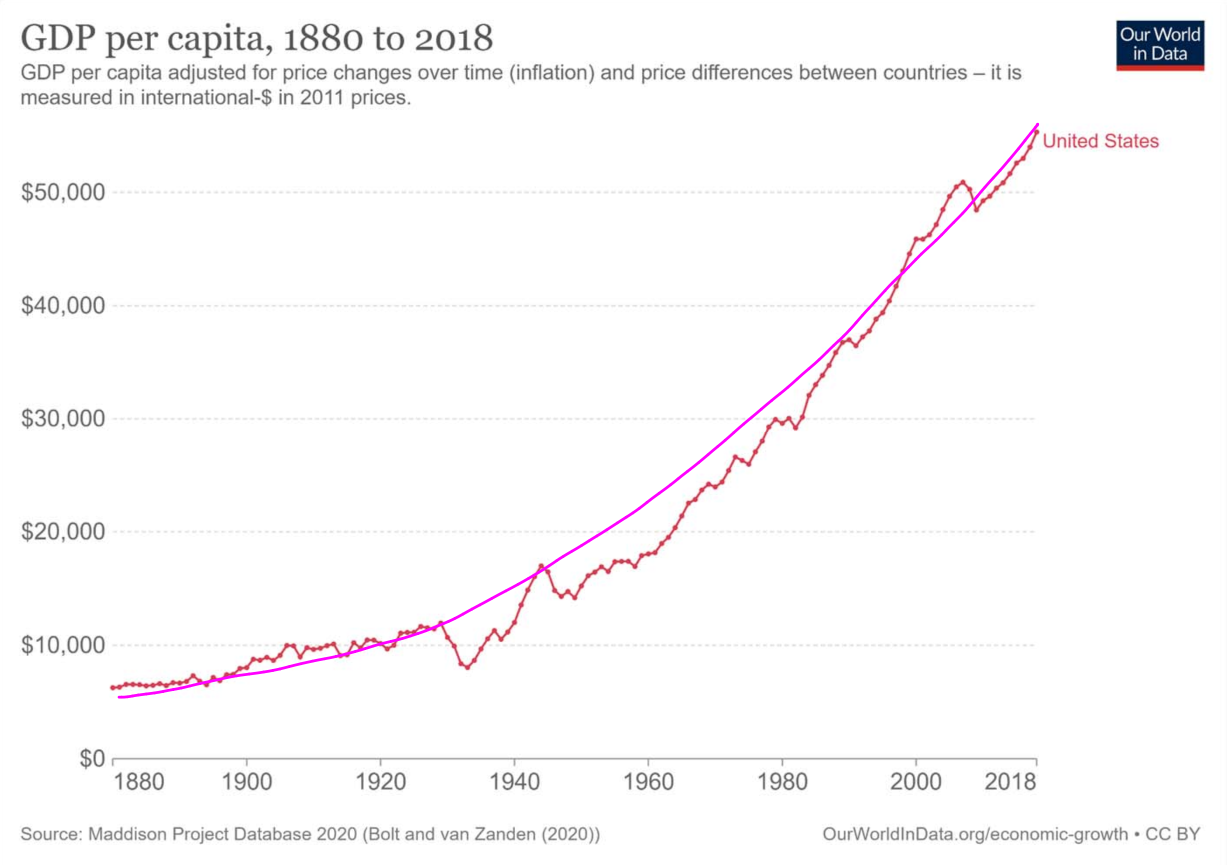
key idea: re-scale vertical axis so each tick mark represents doubling of value

Ratio Scale



The slope of the ratio scale graph of a variable that grows at a compounded constant growth rate $\bar{g}$ is constant and proportional to the growth rate $\bar{g}$.

U.S. Per-Capita Real GDP



Computing a Compounded Constant Growth Rate

Suppose we know y_0 (initial level) and y_t (current level). How do we compute the compounded constant growth rate $\bar{g}$ from 0 to t?

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

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

$$y_0 = y_{1870}^{US} = \$5{,}000$$

$$y_t = y_{2015}^{US} = \$50{,}800$$

$$\bar{g}_{US} = \left(\frac{\$50{,}800}{\$5{,}000}\right)^{1/145} - 1 = 0.0193 \approx 2\%$$

Log-Scale

The logarithm of a variable that grows at a compounded constant growth rate $\bar{g}$ is linear in time and the slope is the growth rate $\bar{g}$.

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

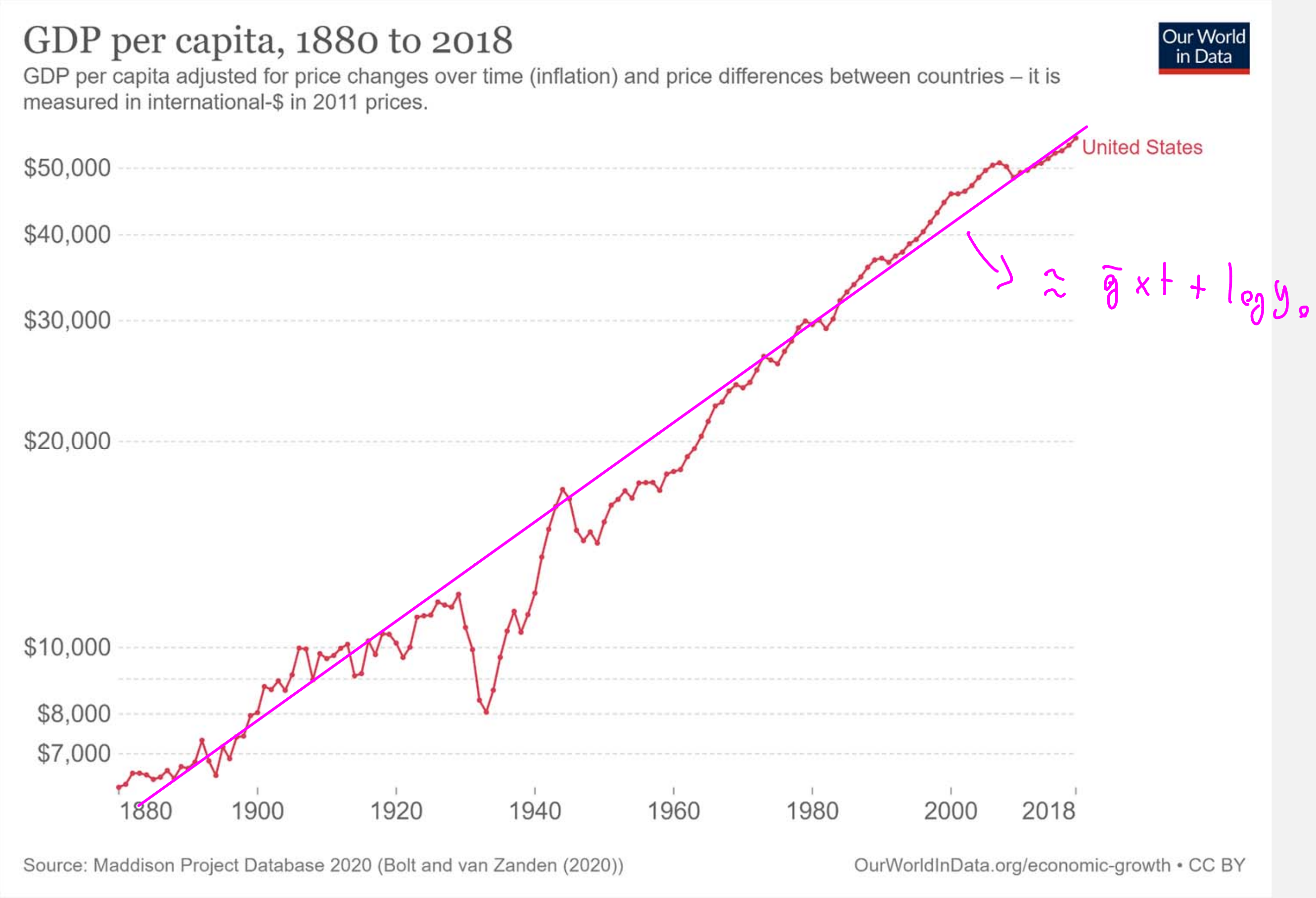
$$\log y_t = \log \left[(1+\bar{g})^t y_0 \right]$$

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

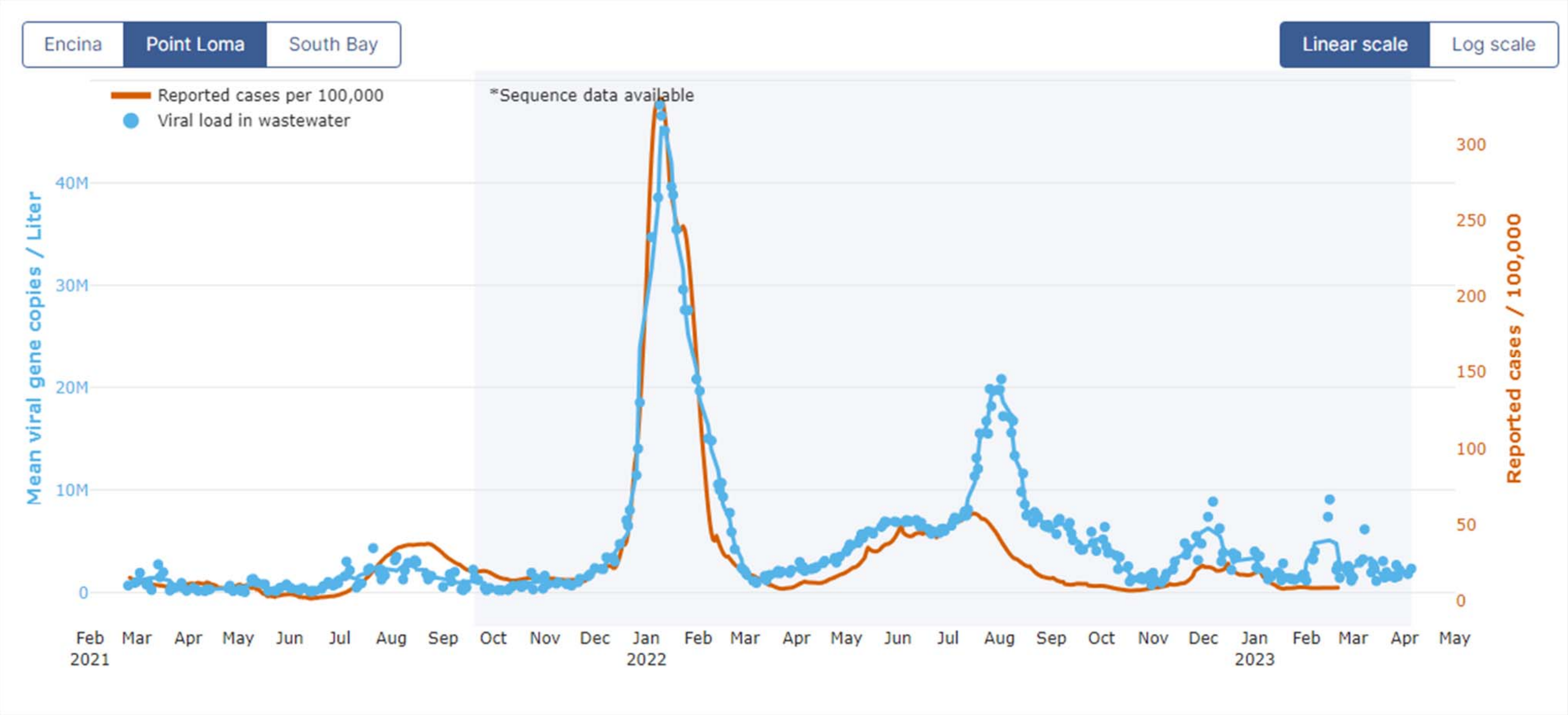
$$\log y_t = t \log (1+\bar{g}) + \log y_0$$

$$\log y_t \approx t \times \bar{g} + \log y_0$$

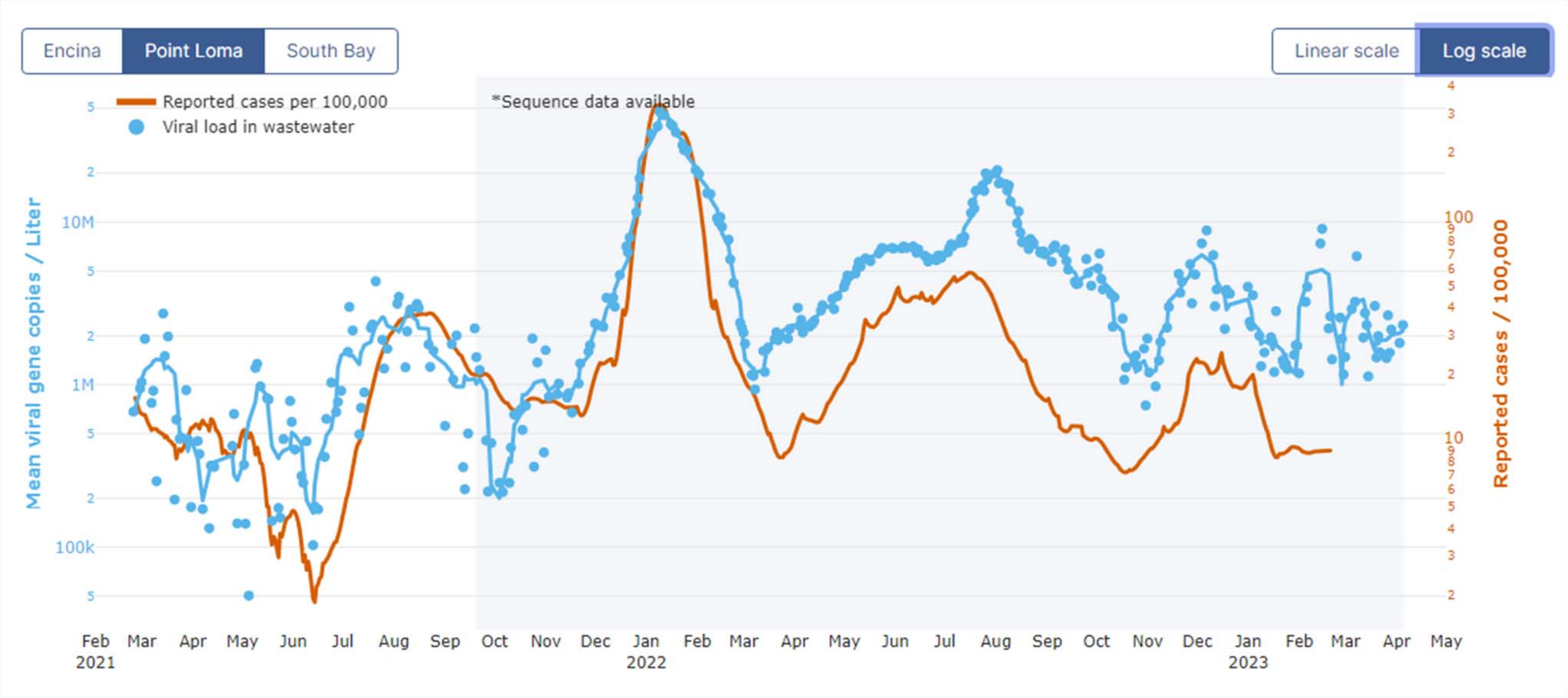
U.S. Per Capita GDP in Log Scale



Covid and Log Scale



Covid and Log-Scale



Plan for Lecture 4

- Beyond GDP: “Distributional Accounting”

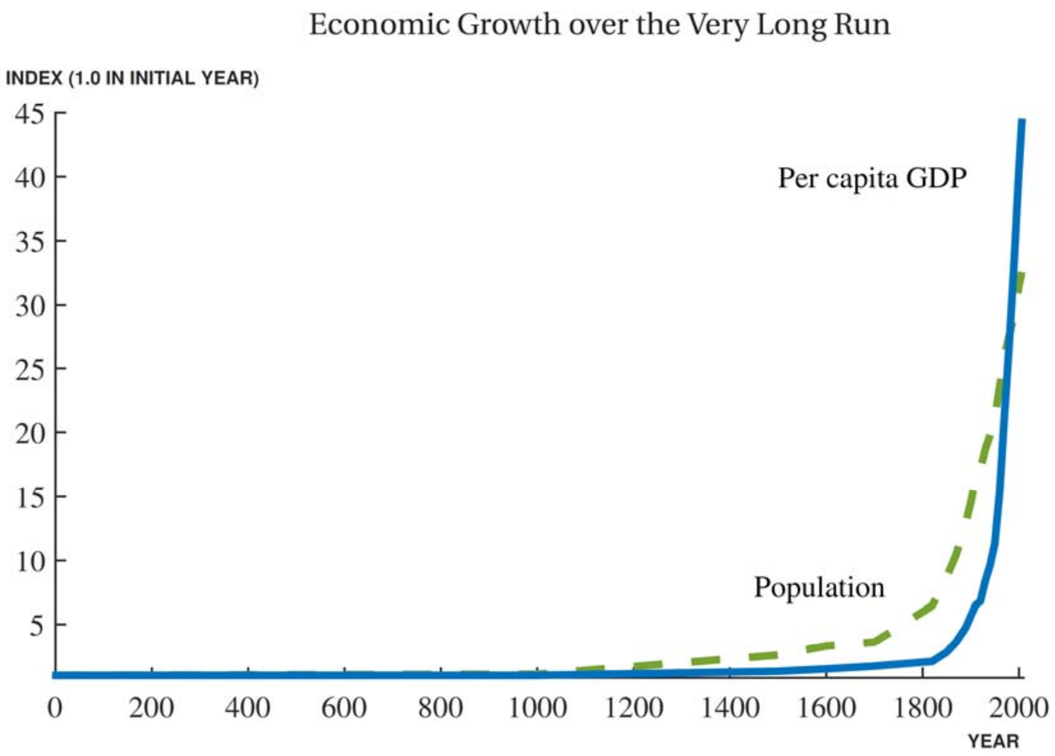
- Long-Run Growth Tools
  - Compounding
  - Ratio-Scale and Log-Scale

- Long-Run Growth Facts

Long-Run Growth Facts

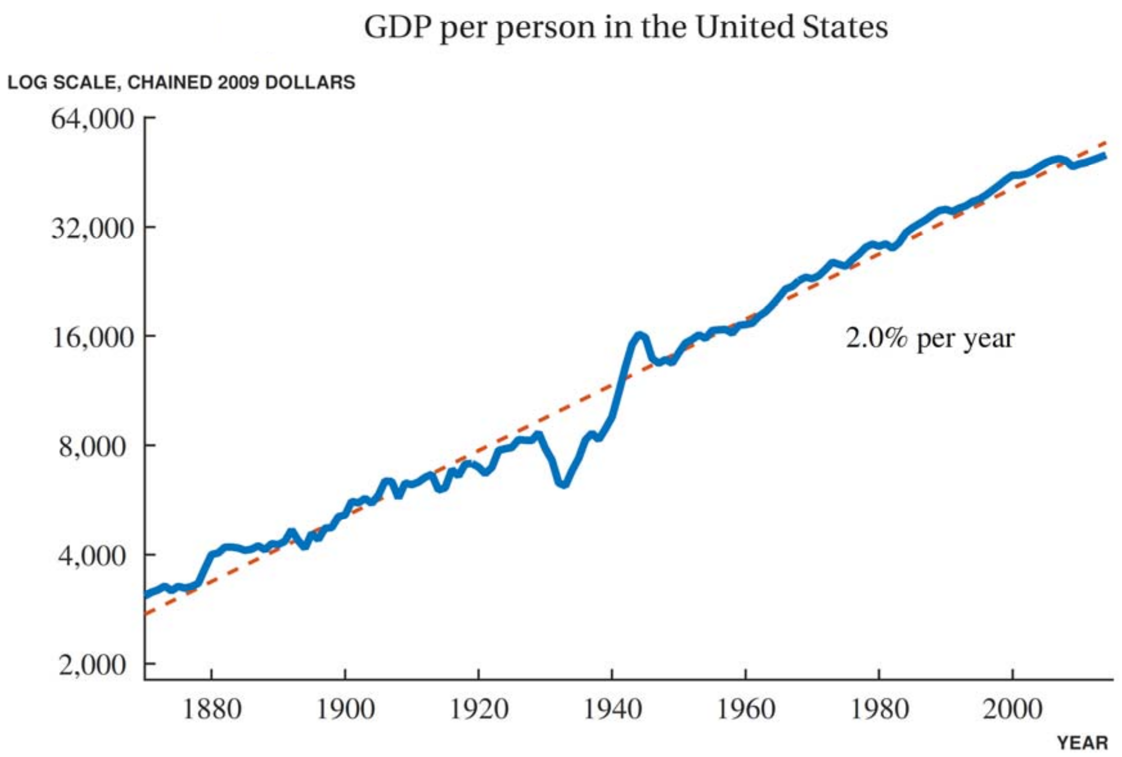
Additional References:
Chad Jones, "The Facts of Economic Growth," Handbook of Macroeconomics, Ch. 1, 2016
Daron Acemoglu, "Introduction to Modern Economic Growth," Ch.1, 2014

Fact 1: growth is a relatively recent phenomenon



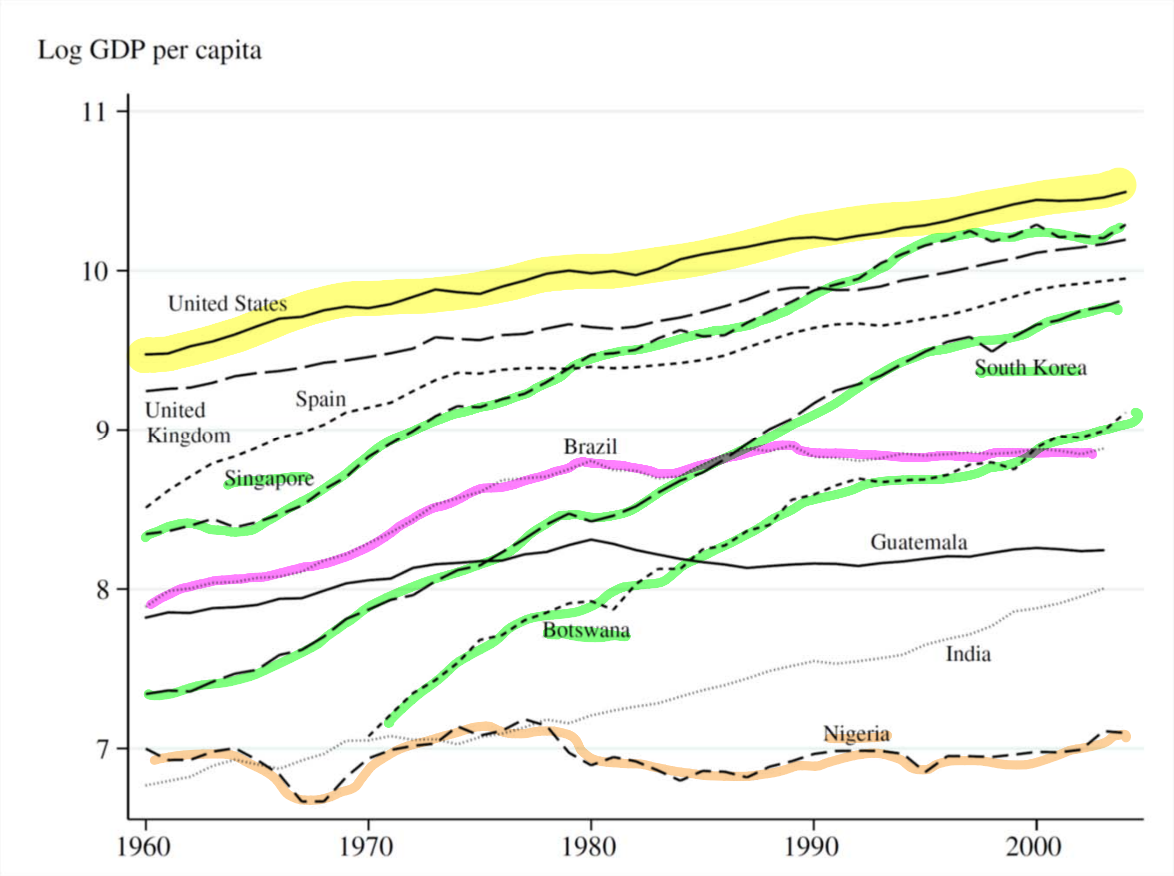
Note: Data are from Maddison (2008) for the "West," i.e. Western Europe plus the United States. A similar pattern holds using the "world" numbers from Maddison.

Fact 2: continued persistent growth at the “frontier”



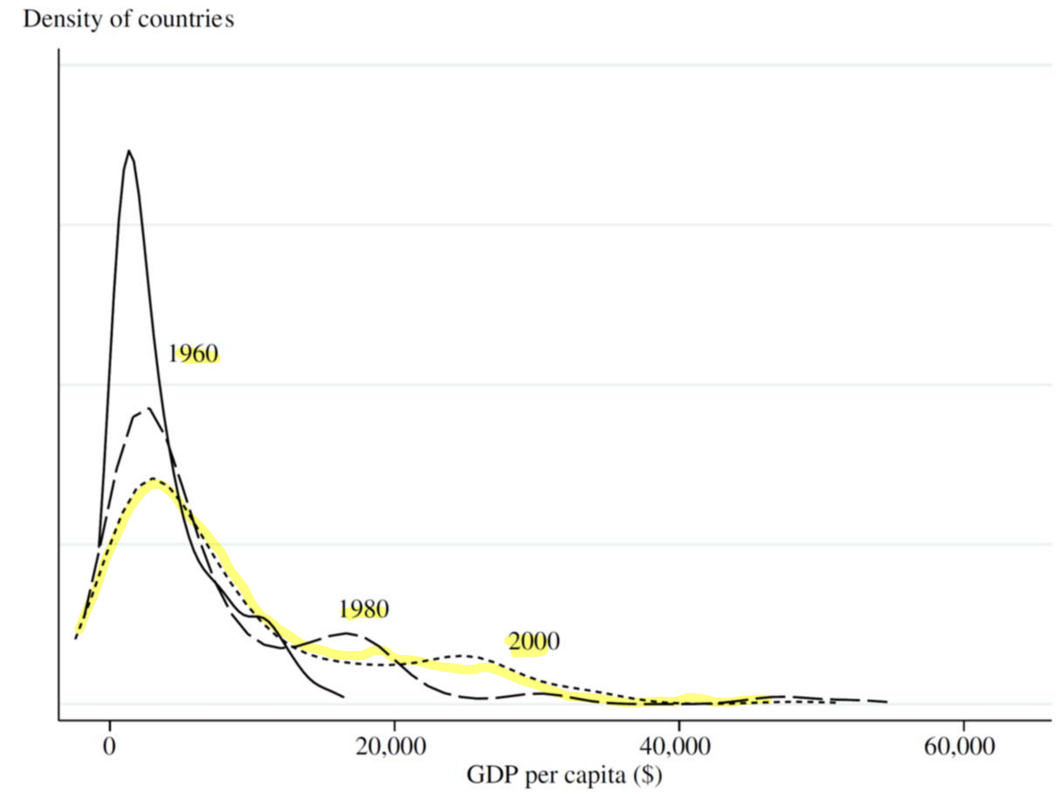
Note: Data for 1929–2014 are from the U.S. Bureau of Economic Analysis, NIPA Table 7.1. Data before 1929 are spliced from Maddison (2008).

Fact 3: we observe heterogeneous growth experiences



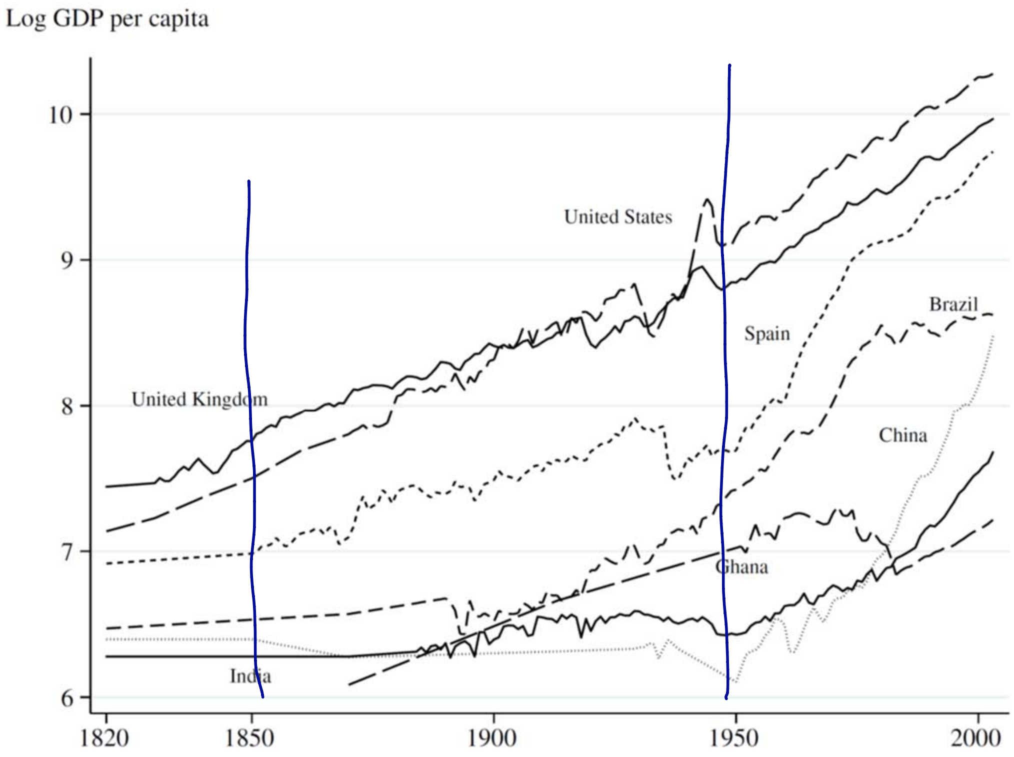
Reproduced from Ch. 1 of Daron Acemoglu, "Introduction to Modern Economic Growth," 2014

Fact 4: increasing divergence in gdp per person



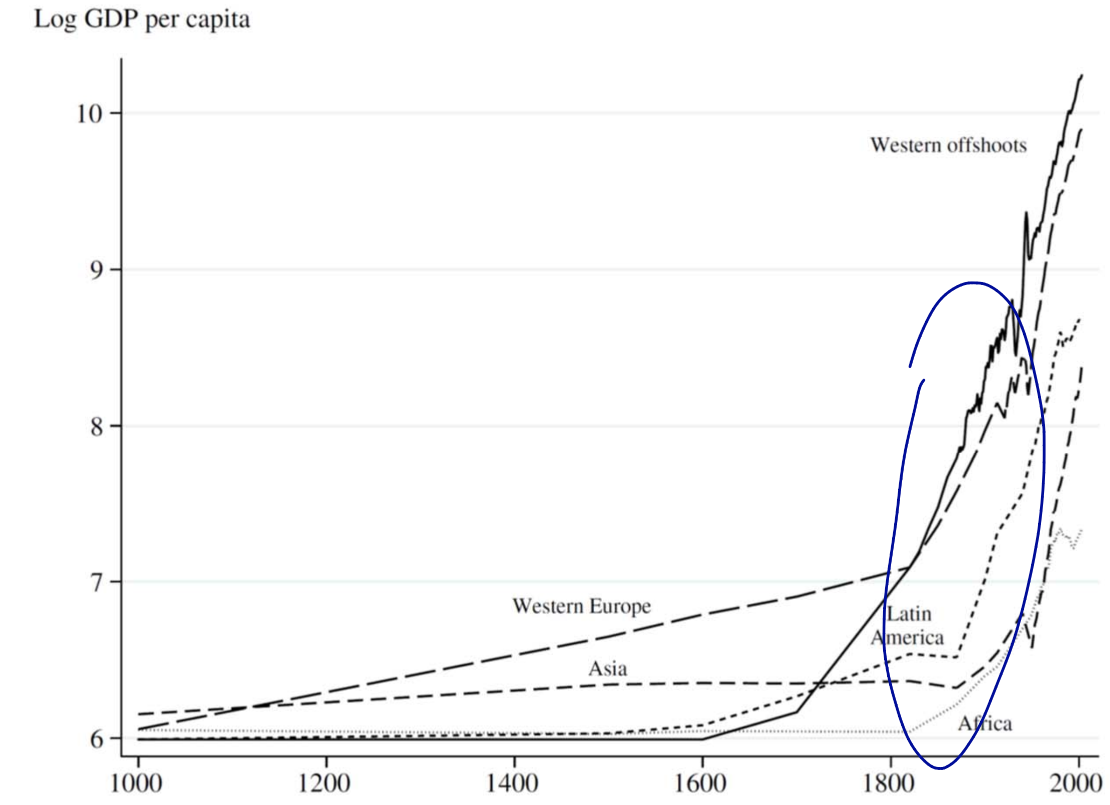
Estimates of the distribution of countries according to PPP-adjusted GDP per capita in 1960, 1980, and 2000.

Fact 5: divergence in gdp per person seems to originate in 1850-1900



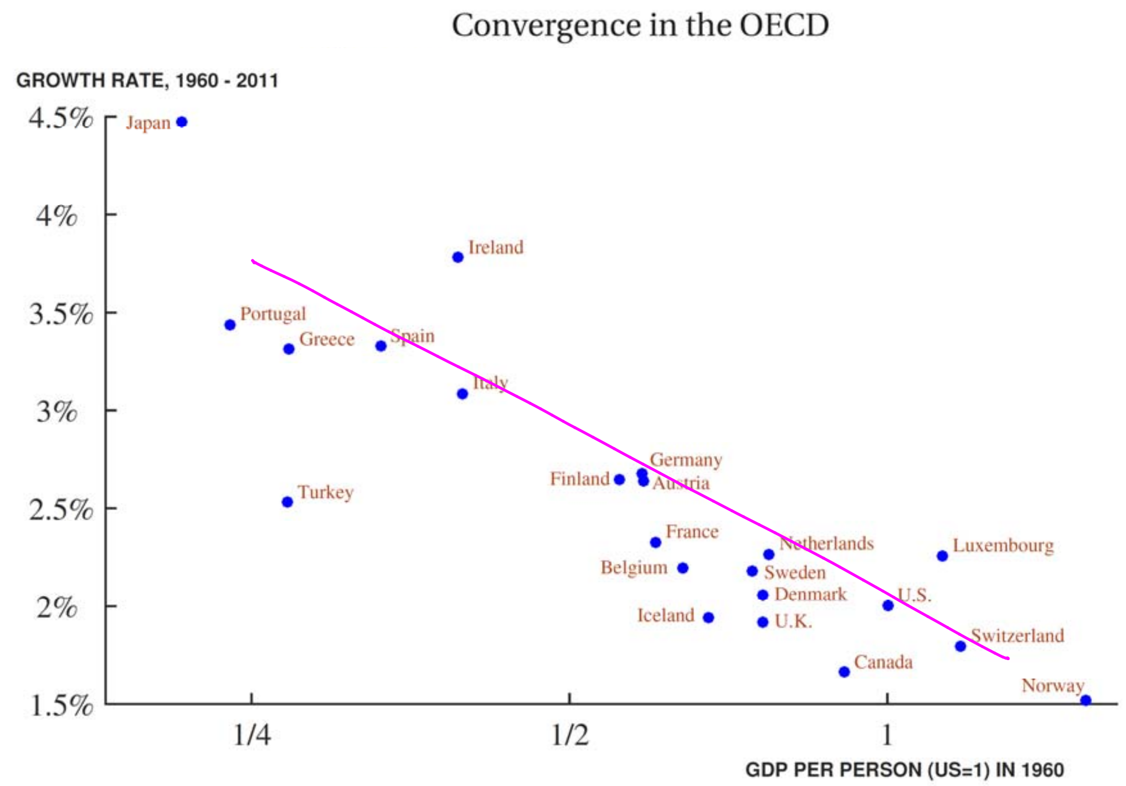
The evolution of income per capita in the United States, the United Kindgom, Spain, Brazil, China, India, and Ghana, 1820–2000.

Fact 5: divergence in gdp per person seems to originate in 1850-1900



The evolution of average GDP per capita in Western offshoots, Western Europe, Latin America, Asia, and Africa, 1000–2000.

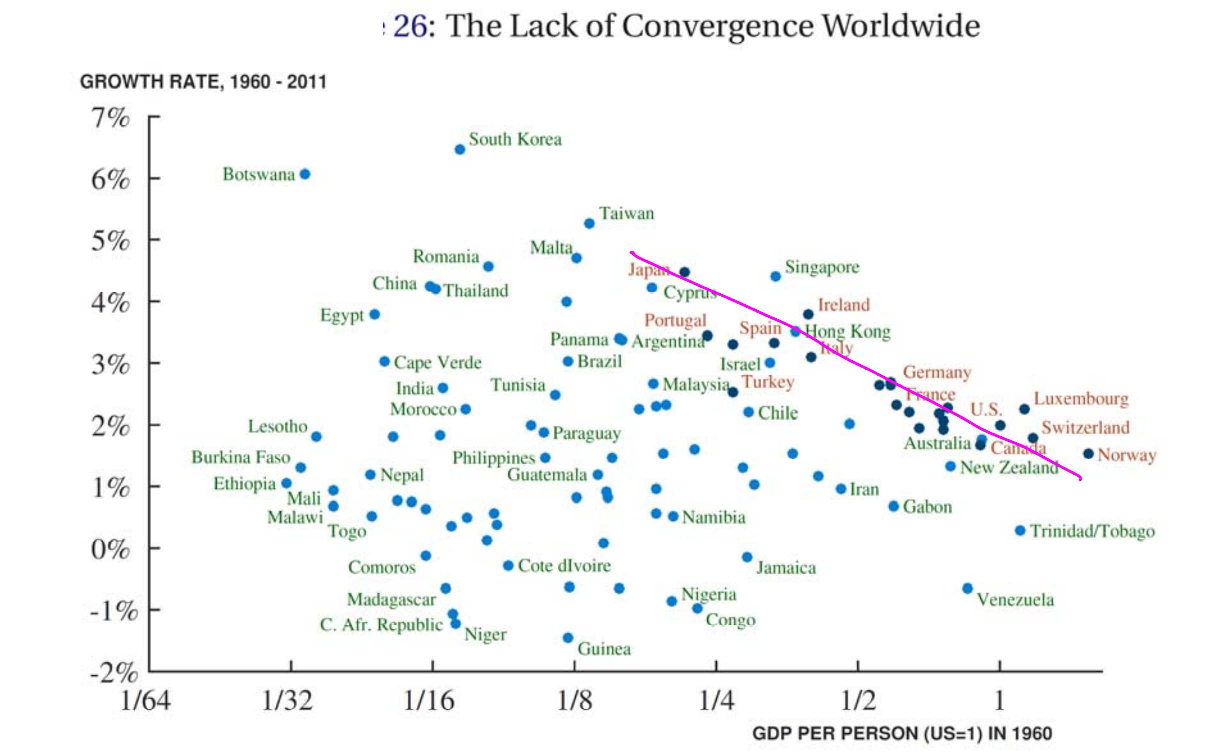
Fact 6: conditional convergence



Source: The Penn World Tables 8.0. Countries in the OECD as of 1970 are shown.

Did countries with low GDP per-person in 1960 grew faster between 1960-2011?

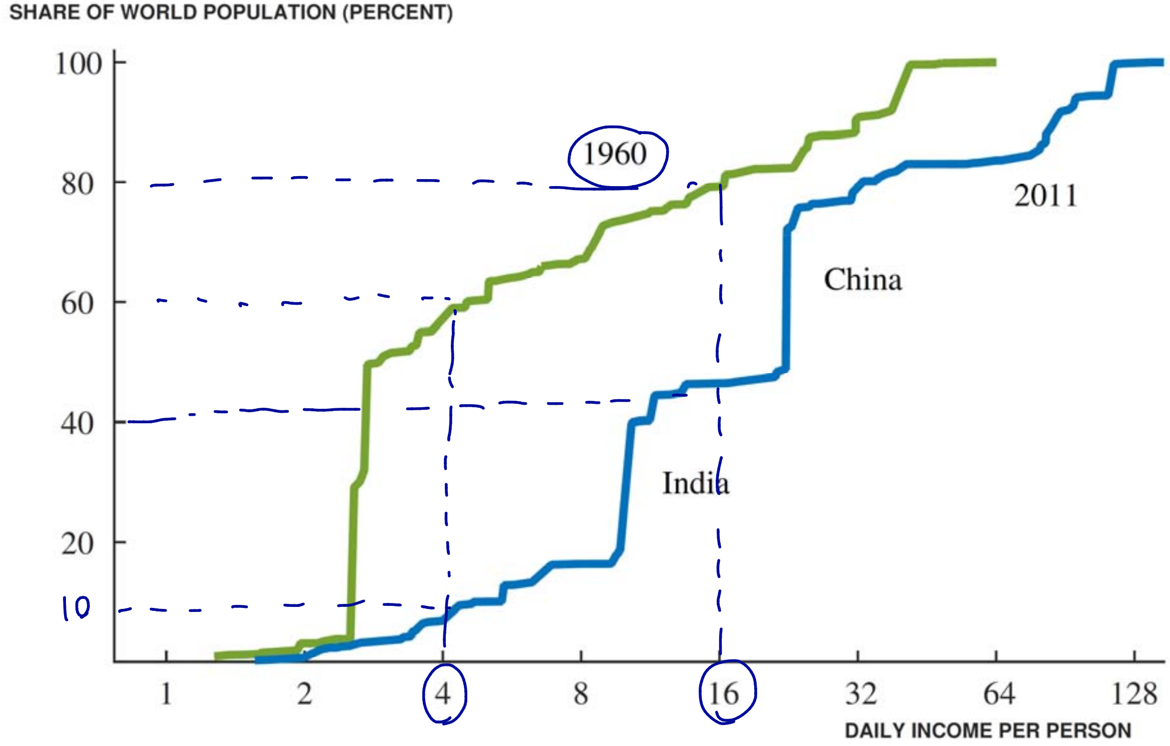
Fact 6: conditional convergence



Source: The Penn World Tables 8.0.

Did countries with low GDP per-person in 1960 grew faster between 1960-2011?

Fact 7: Lower Fraction of World Population Living in Poverty



Source: The Penn World Tables 8.0, calculated across a stable sample of 100 countries.

ON THE MECHANICS OF ECONOMIC DEVELOPMENT*

Robert E. LUCAS, Jr.

University of Chicago, Chicago, IL 60637, USA

I do not see how one can look at figures like these without seeing them as representing *possibilities*. Is there some action a government of India could take that would lead the Indian economy to grow like Indonesia's or Egypt's? If so, *what*, exactly? If not, what is it about the 'nature of India' that makes it so? The consequences for human welfare involved in questions like these are simply staggering: Once one starts to think about them, it is hard to think about anything else.