Lecture 11. The Facts of Growth

Reading: Blanchard, Chapter 10.

Robert Lucas, a Nobel prize-winning economist, said…

- “Once one starts to think about them (growth), it is hard to think about anything else.”

- Lucas, Robert E. (1988), “On the Mechanics of Economic Development,” *Journal of Monetary Economics* 22, 3-42.

A Roadmap

- Lecture 11 (Chapter 10): The Facts of Growth
- Lecture 12 (Chapter 11): Saving, Capital Accumulation, and Output (The Solow Model)
- Lecture 13: Trends in Productivity and Policies Promote Innovations

Sources

- **Required reading:**
- Blanchard, O. (2017), Chapter 10.

- **Not required:**
- I heavily borrow figures from the following handbook chapter.
- Jones, C. I. (2016), “The Facts of Economic Growth,” *Handbook of Macroeconomics,* Volume 2A.

Outline

- Growth at the frontier (the US)
- The (non)-convergence of output (comparison across countries)
- The aggregate production function

Outline

- Growth at the frontier
- The (non)-convergence of output
- The aggregate production function

The Aggregate Production Function

- To study the business cycle in the short and medium run, we assumed that

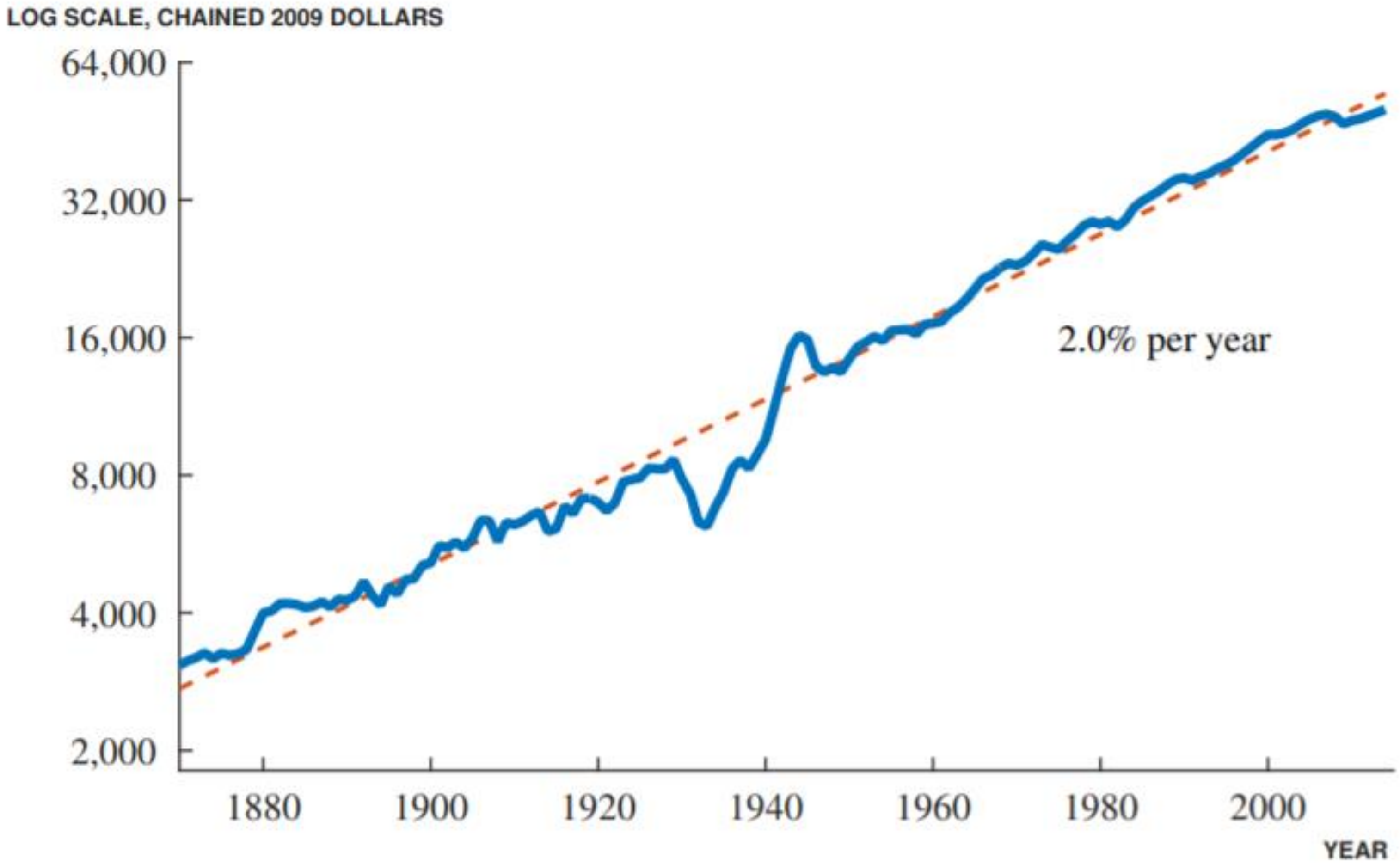
$$Y = \mathcal{A}N.$$

- To study the economic growth in the long run, we assume that

- Y: aggregate output
- K: = machines, plants, and office buildings, etc.
- N: labor = the number of workers in the economy

RGDP

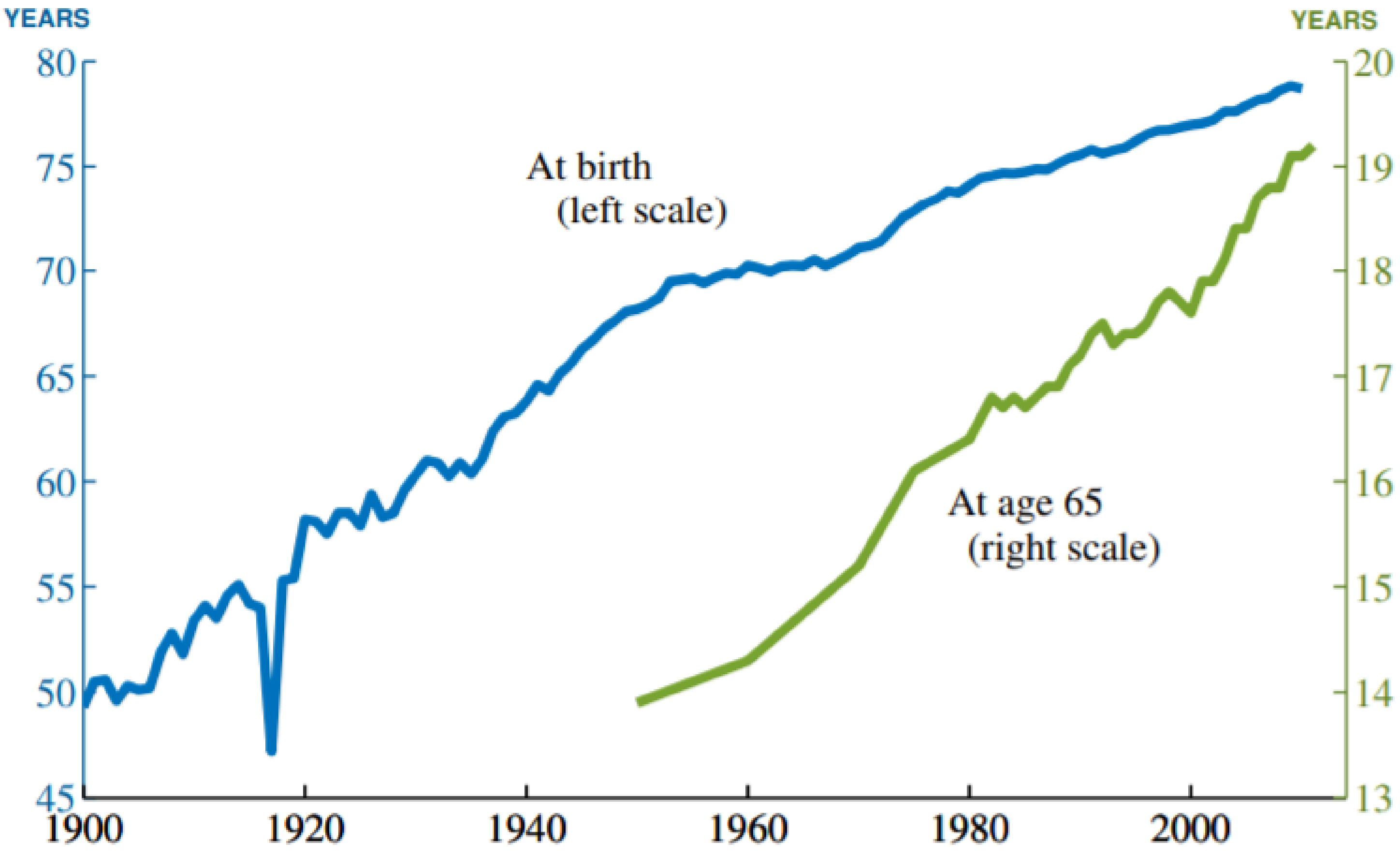
Figure 1: GDP per person in the United States



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).

- For nearly 150 years, RGDP per person in the US has grown at a remarkably steady average rate of around 2% per year.
- \$3,000 in 1870 → about \$50,000 in 2014. 17-fold increase.

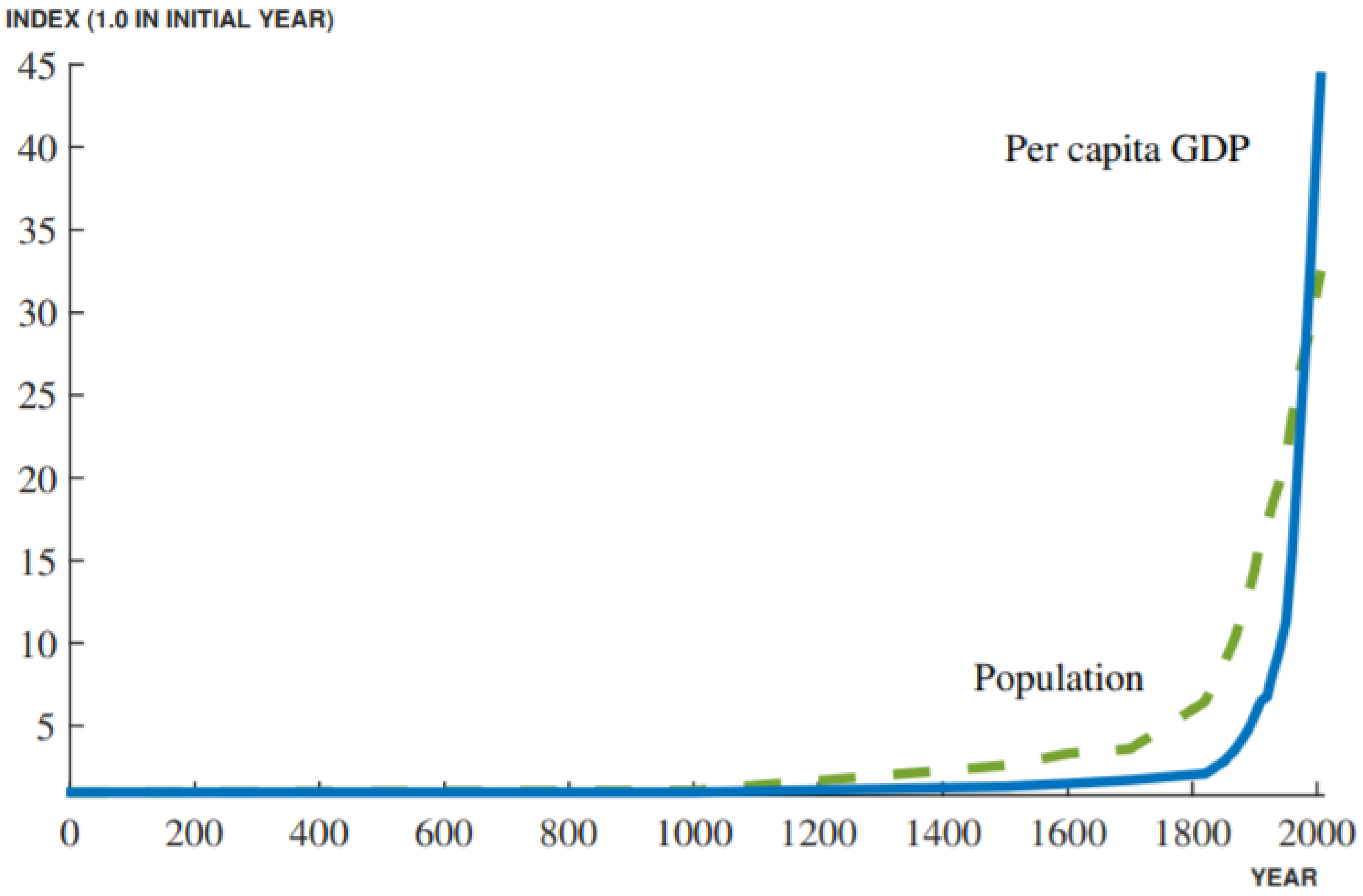
Figure 14: Life Expectancy at Birth and at Age 65, United States



Source: *Health, United States 2013* and https://www.clio-infra.eu.

- Not only people produce more, they live longer.

Figure 2: Economic Growth over the Very Long Run

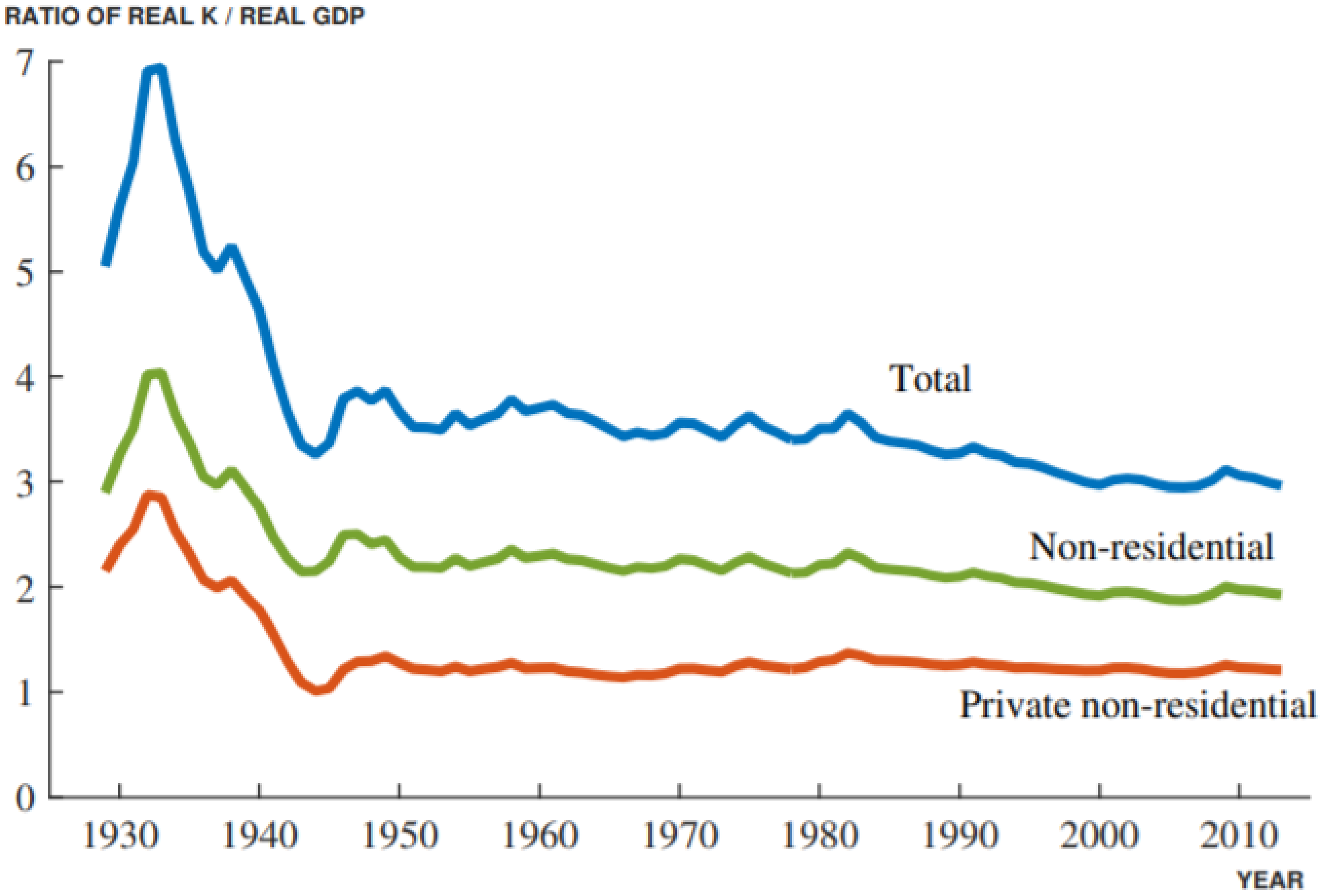


Note: Data are from Maddison (2008) for the "West," i.e. Western Europe plus the United States. A similar pattern holds using the "world" numbers from Maddison.

- Over the very long run: Before the industrial revolution, life was, in the evocative language of Thomas Hobbes, "nasty, brutish, and short."

Factors

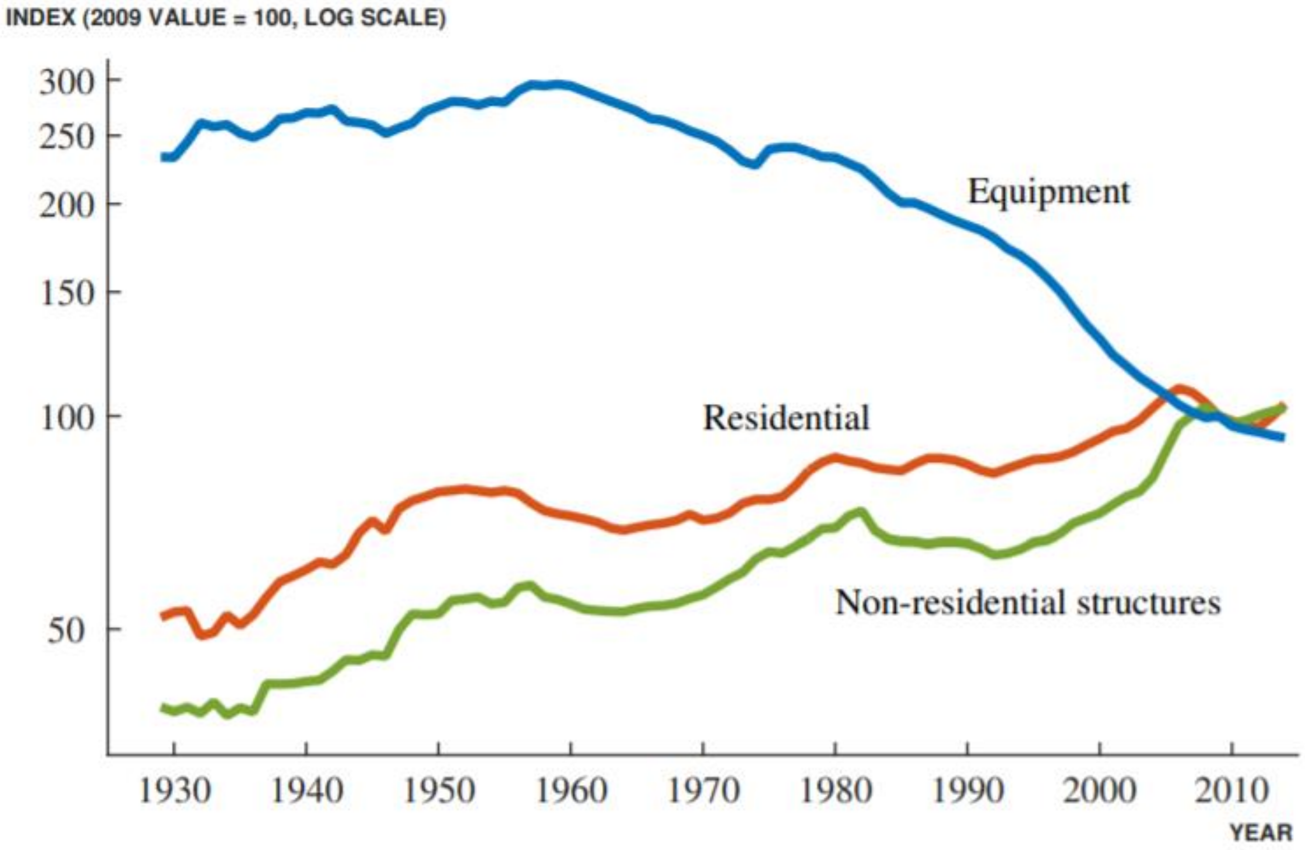
Figure 3: The Ratio of Physical Capital to GDP



Source: Burea of Economic Analysis Fixed Assets Tables 1.1 and 1.2. The numerator in each case is a different measure of the real stock of physical capital, while the denominator is real GDP.

- Capital to Output ratio (K/Y) has been stable around 3 or 4.

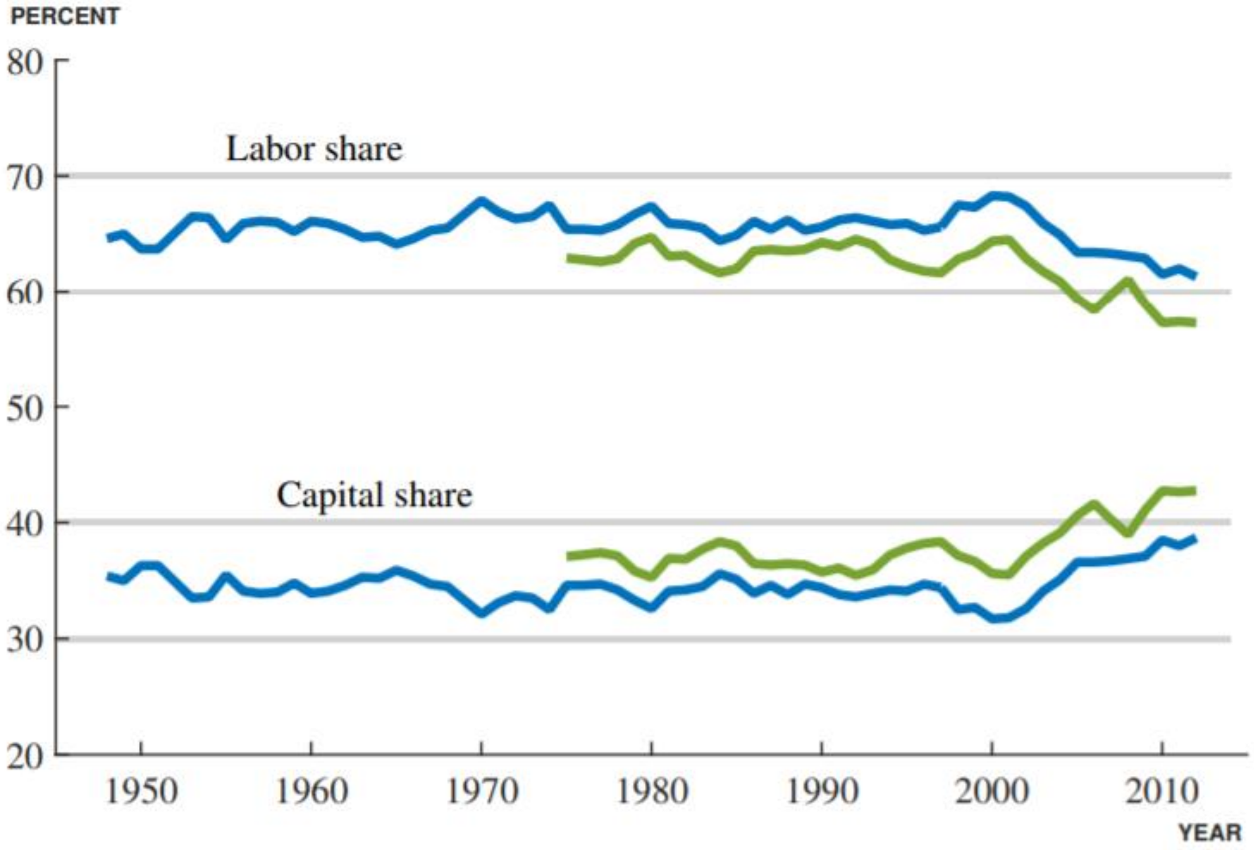
Figure 5: Relative Price of Investment, United States



Note: The chained price index for various categories of private investment is divided by the chained price index for GDP. Source: National Income and Product Accounts, U.S. Bureau of Economic Analysis Table 1.1.4.

- The price of equipment has fallen sharply since 1960.
- The price of structures has risen steadily for both residential and nonresidential ones.

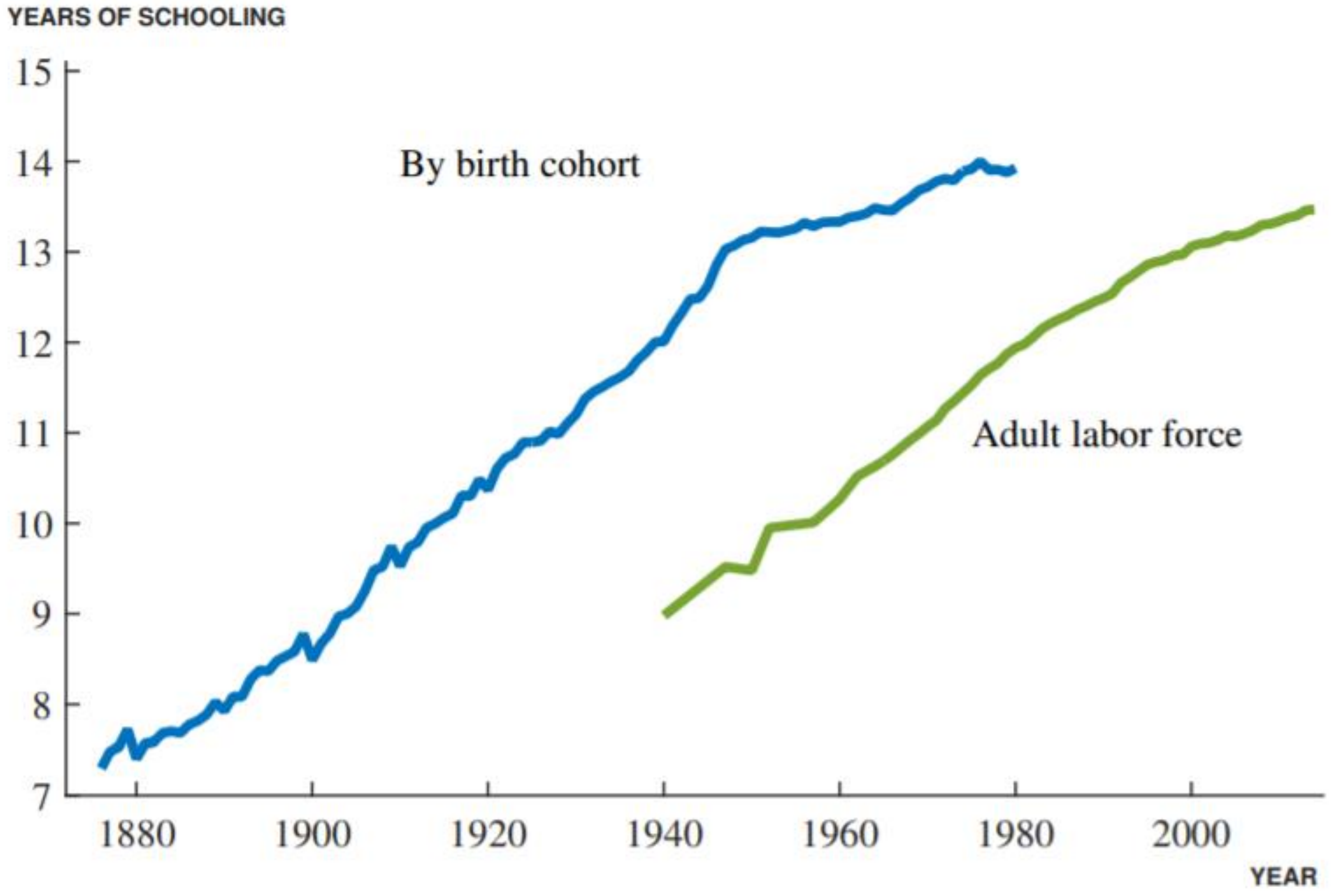
Figure 6: Capital and Labor Shares of Factor Payments, United States



Note: The series starting in 1975 are from Karabarbounis and Neiman (2014) and measure the factor shares for the corporate sector, which the authors argue is helpful in eliminating issues related to self-employment. The series starting in 1948 is from the Bureau of Labor Statistics *Multifactor Productivity Trends*, August 21, 2014, for the private business sector. The factor shares add to 100 percent.

- Labor income share ↓ since 1980 or 2000.
- Capital income share ↑ since 1980 or 2000.

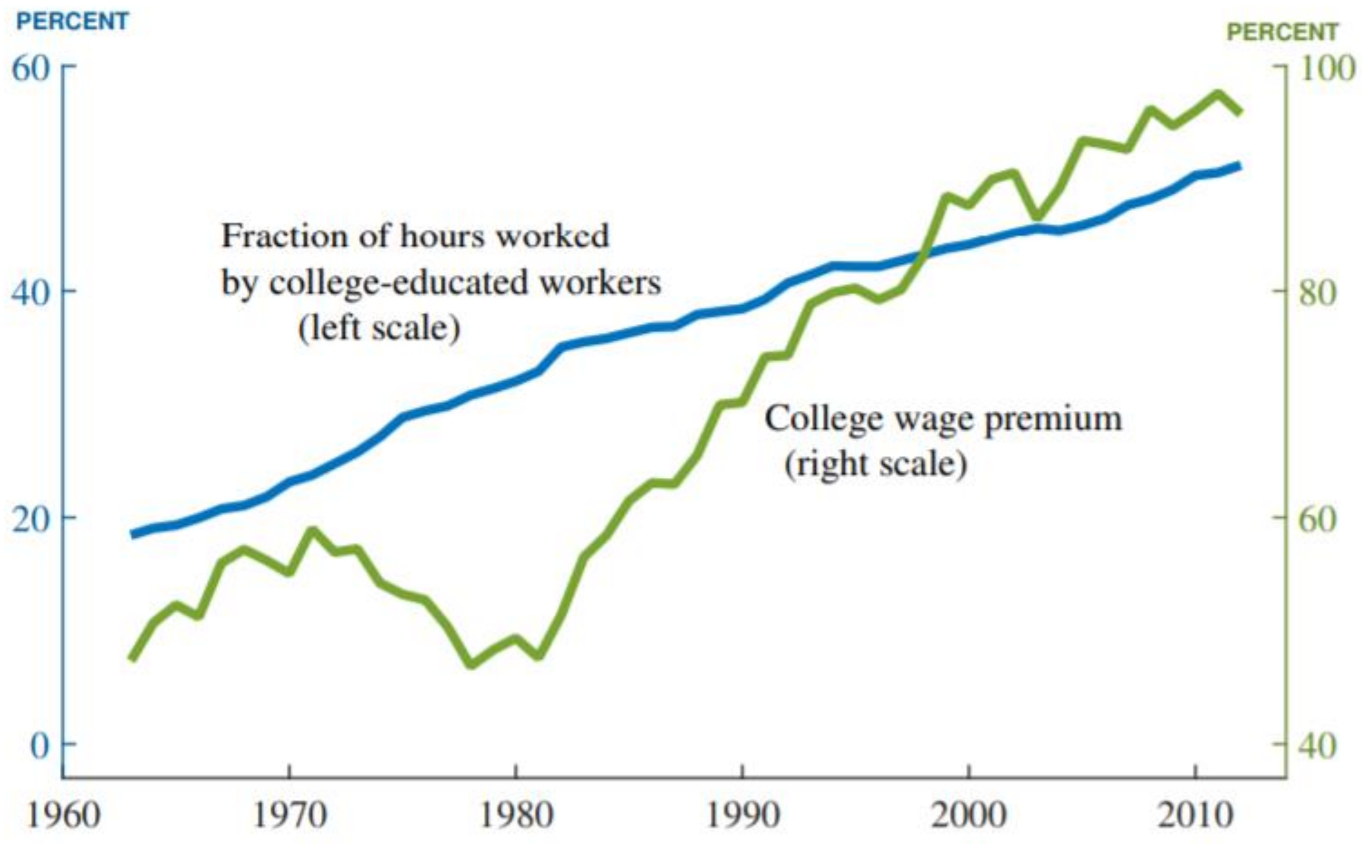
Figure 7: Educational Attainment, United States



Note: The blue line shows educational attainment by birth cohort from Goldin and Katz (2007). The green line shows average educational attainment for the labor force aged 25 and over from the Current Population Survey.

- Productivity of workers ↑ over time as people get more education.

Figure 8: The Supply of College Graduates and the College Wage Premium, 1963–2012



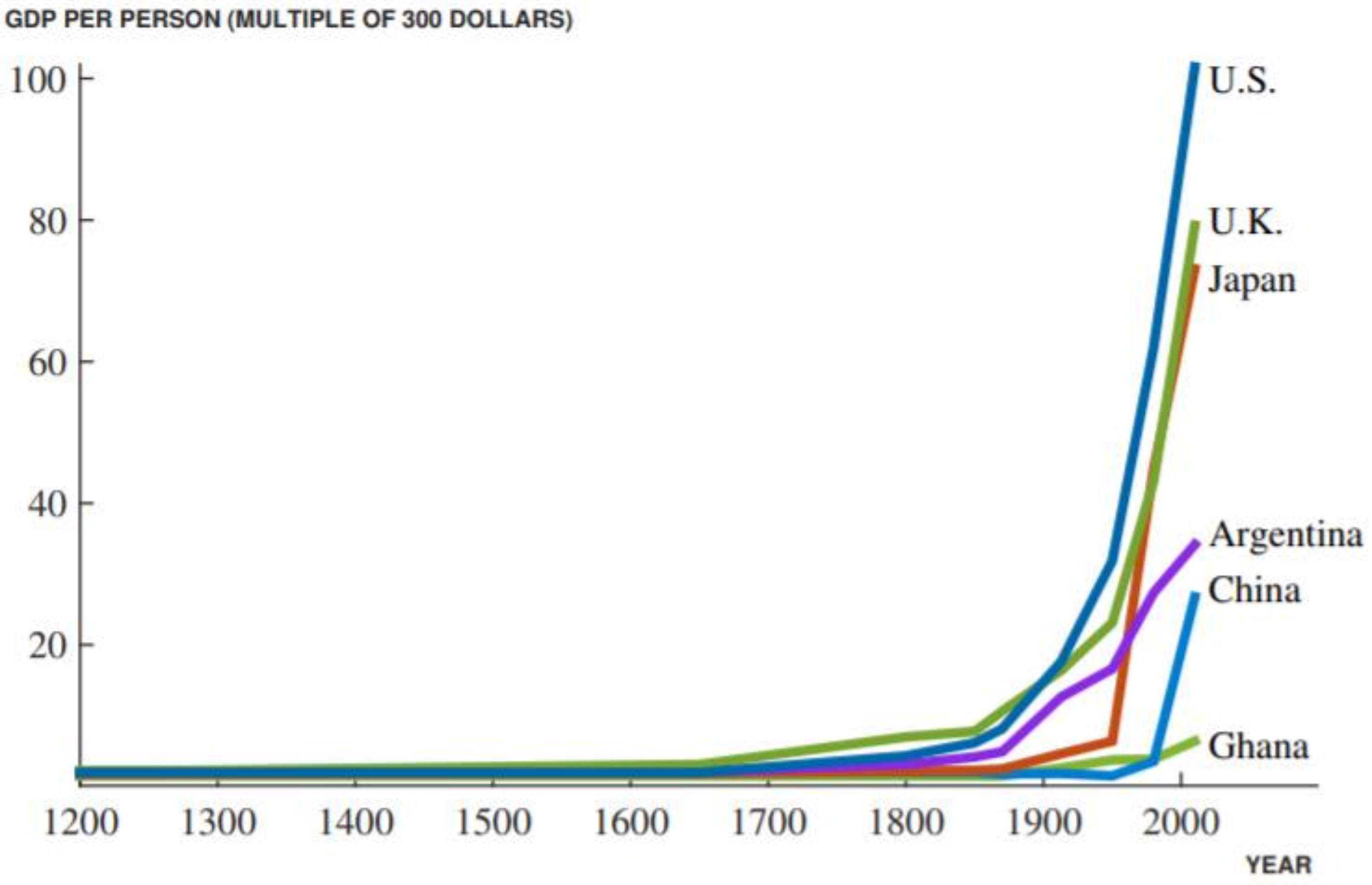
Note: The supply of U.S. college graduates, measured by their share of total hours worked, has risen from below 20 percent to more than 50 percent by 2012. The U.S. college wage premium is calculated as the average excess amount earned by college graduates relative to non-graduates, controlling for experience and gender composition within each educational group. Source: Autor (2014), Figure 3.

- High-skilled workers become more and more important.
- The number of college graduates ↑ and their wage ↑

Outline

- Growth at the frontier
- The (non)-convergence of output
- The aggregate production function

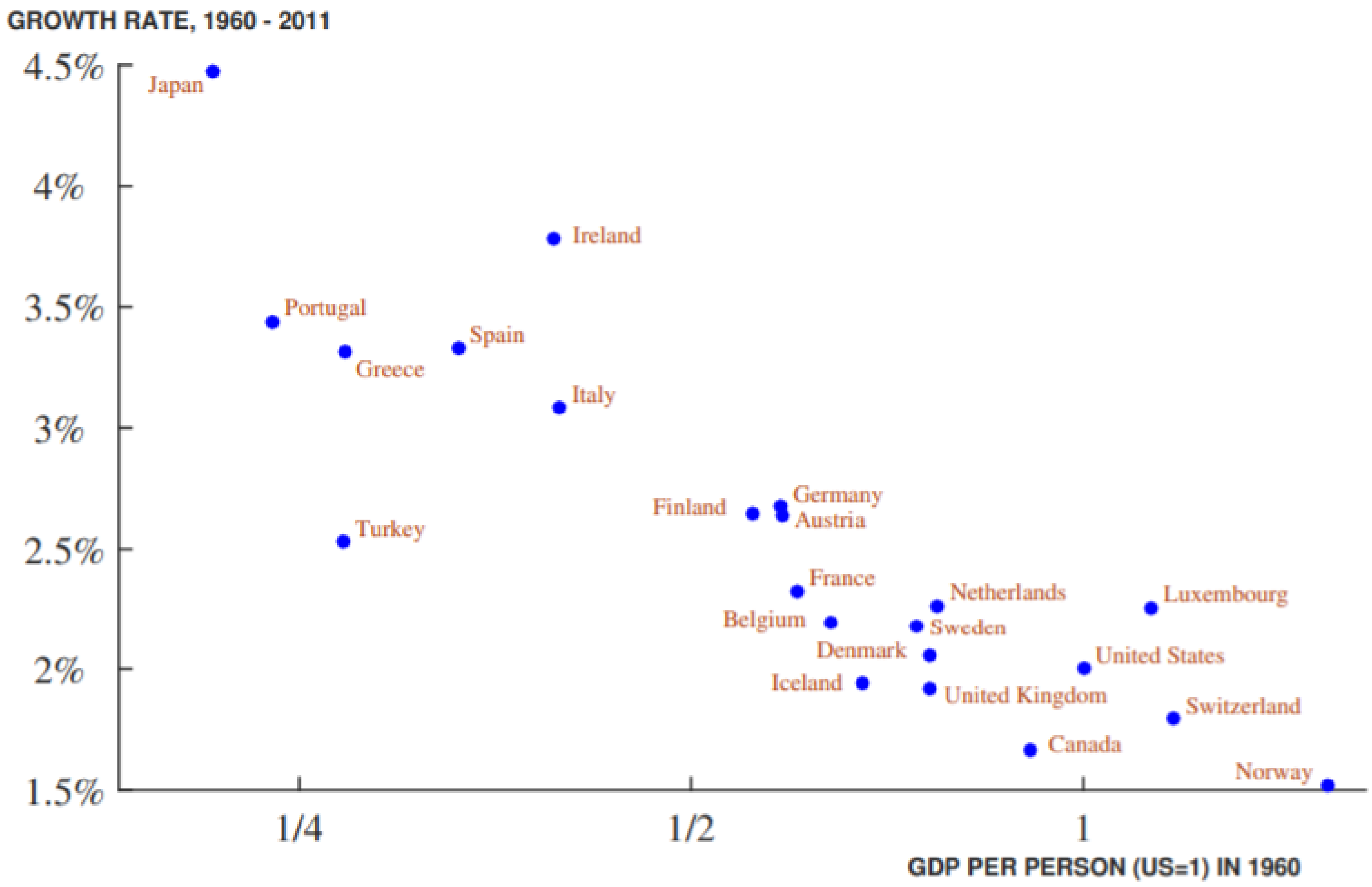
Figure 21: The Great Divergence



Note: The graph shows GDP per person for various countries, normalized by the value in the United Kingdom in the initial year. Source: The Maddison Project, Bolt and van Zanden (2014).

- Modern growth began at different points in time, resulting in "The Great Divergence."

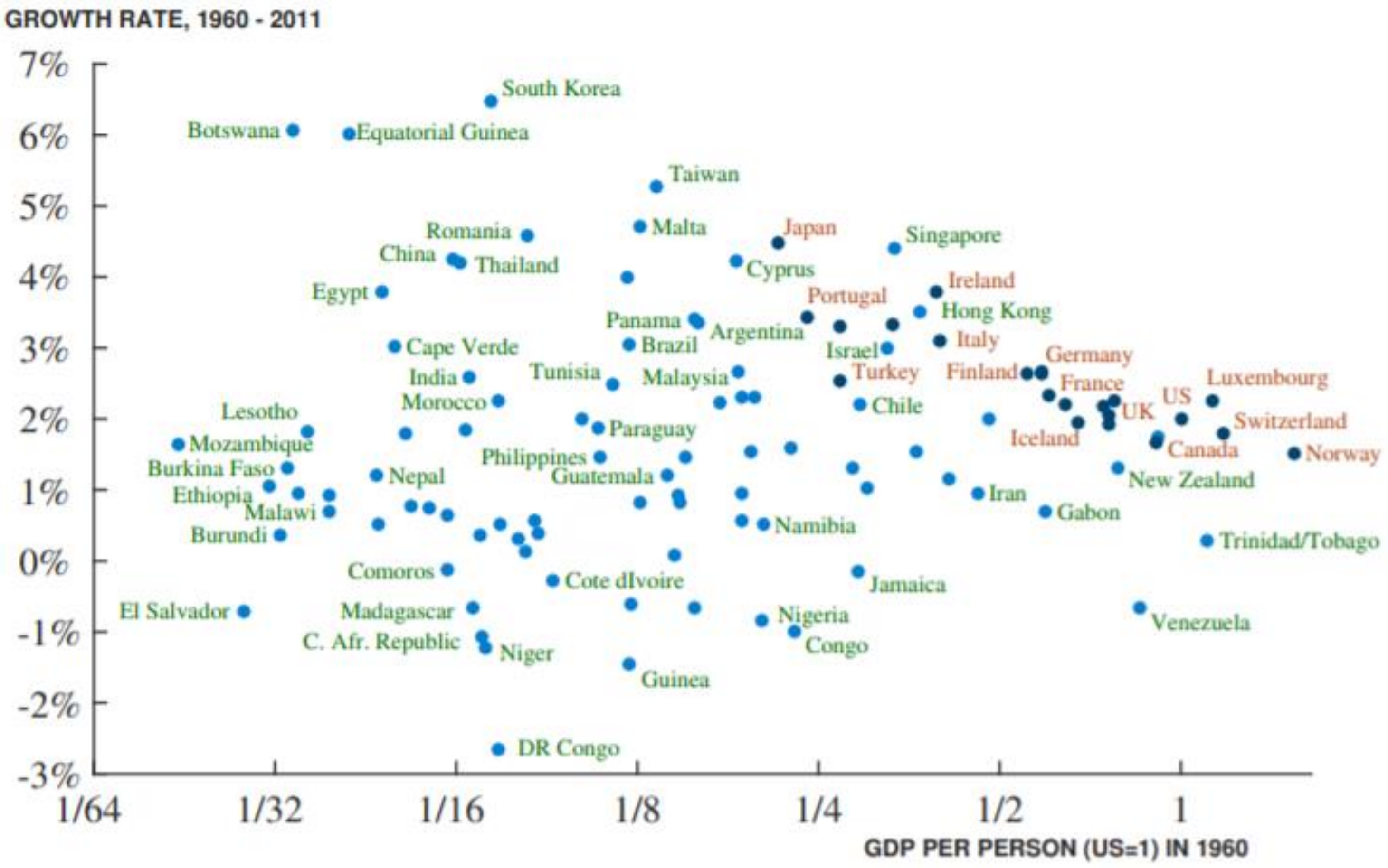
Figure 25: Convergence in the OECD



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

- Do poor countries grow faster than rich countries?
- Among OECD countries, the answer is "yes." Poor countries catch-up rich ones.
- But if a poor country did not grow fast, it would not be a member of OECD…

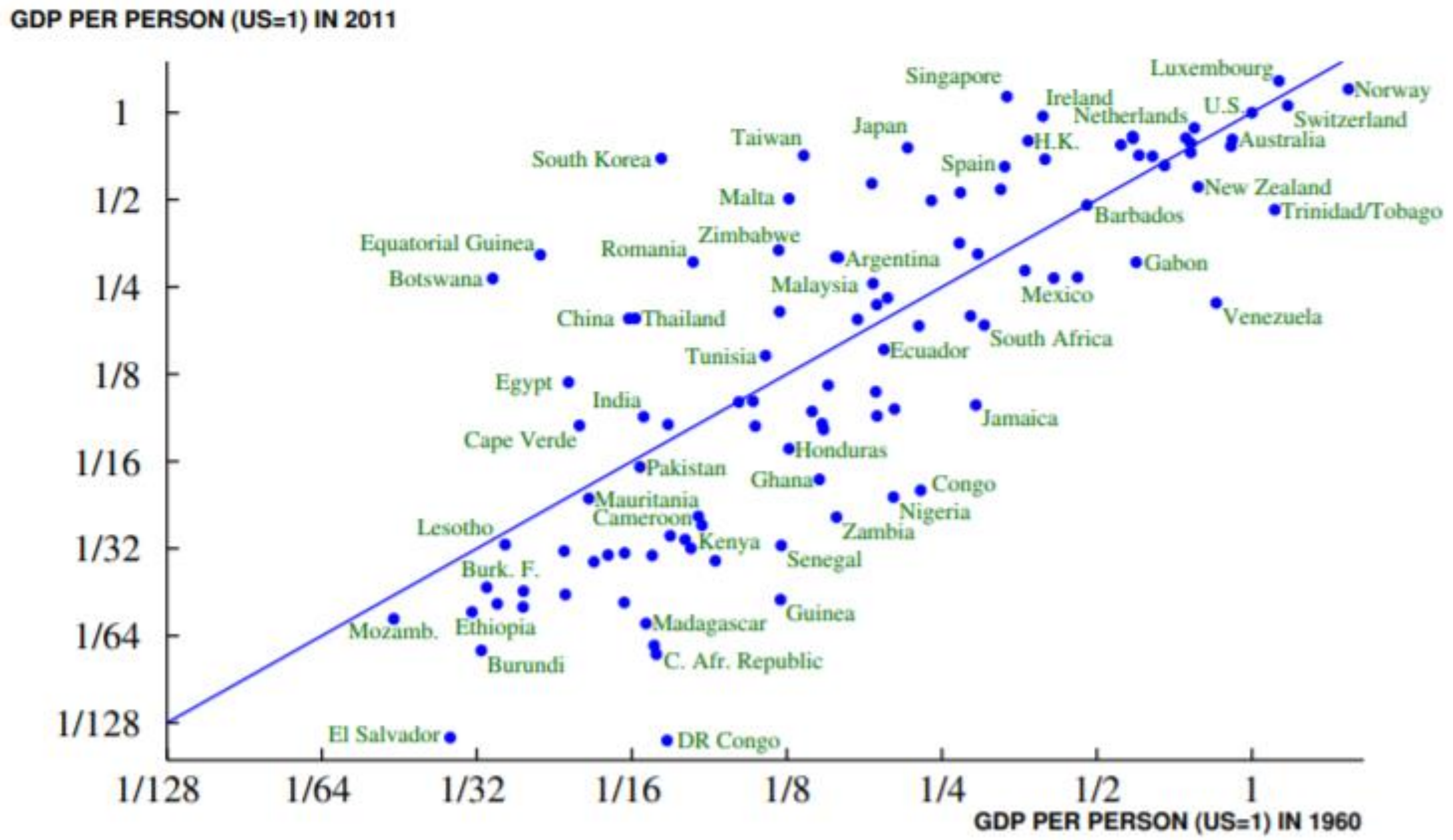
Figure 26: The Lack of Convergence Worldwide



Source: The Penn World Tables 8.0.

- There is no tendency for poor countries around the world to grow faster than rich countries.

Figure 24: GDP per Person, 1960 and 2011



Source: The Penn World Tables 8.0.

- RGDP per person relative to that in the US in 1960 and 2011
- South Korea, Taiwan, Singapore, and Hong Kong successfully catch-up.

Outline

- Growth at the frontier
- The (non)-convergence of output
- The aggregate production function

The Aggregate Production Function

- To study the business cycle in the short/medium-run, we assumed that

$$Y = \mathcal{A}N.$$

- To study the economic growth in the long-run, we assume that

$$Y = F(K, N).$$

- Y: aggregate output
- K: capital-the sum of all the machines, plants, and office buildings in the economy
- N: labor-the number of workers in the economy

Returns to scale and factors

- We assume that the production function, F, satisfies the followings.
- : $xY = F(xK, xN)$ for all $x > 0$.
- Decreasing returns to capital: $\frac{\partial F}{\partial K}$ decreases in K.

  marginal productivity of capital (MPK) decreases in capital.
- Decreasing returns to labor: $\frac{\partial F}{\partial N}$ decreases in N.

  marginal productivity of labor (MPL) decreases in labor.

An Example: A Cobb-Douglas function

- $Y = \mathcal{A}K^{\alpha}N^{1-\alpha}$, where $0 < \alpha < 1$.
- $\mathcal{A}$: productivity / state of technology

- CRS: $\mathcal{A}(2K)^{\alpha}(2N)^{1-\alpha} = \mathcal{A}2^{\alpha}K^{\alpha}2^{1-\alpha}N^{1-\alpha} = 2\mathcal{A}K^{\alpha}N^{1-\alpha}$
- If we double *both* the number of workers and the amount of capital, output also doubles.
- MPK: $\frac{\partial Y}{\partial K} = \alpha\mathcal{A}K^{\alpha-1}N^{1-\alpha}$ decreases in K *given* N.
- Imagine how your study efficiency will increase when you have the first laptop, the second one, the third one, and so on.

Output per worker, Capital per worker

- CRS: $xY = F(xK, xN)$ for all $x > 0$
- Let $x = \frac{1}{N}$. $\frac{Y}{N} =$

- We re-write the above function as follows:

$$y = f(k).$$

- $y = \frac{Y}{N}$:
- $k = \frac{K}{N}$:
- $f(k) = F\left(\frac{K}{N}, 1\right)$.

The Cobb-Douglas function

- $Y = \mathcal{A}K^{\alpha}N^{1-\alpha}$, where $0 < \alpha < 1$.

Divide both hand sides by N.

$\Rightarrow \quad y =$

$\quad\quad = \mathcal{A}k^{\alpha}$.

- To make y grow, we need to make either or grow.

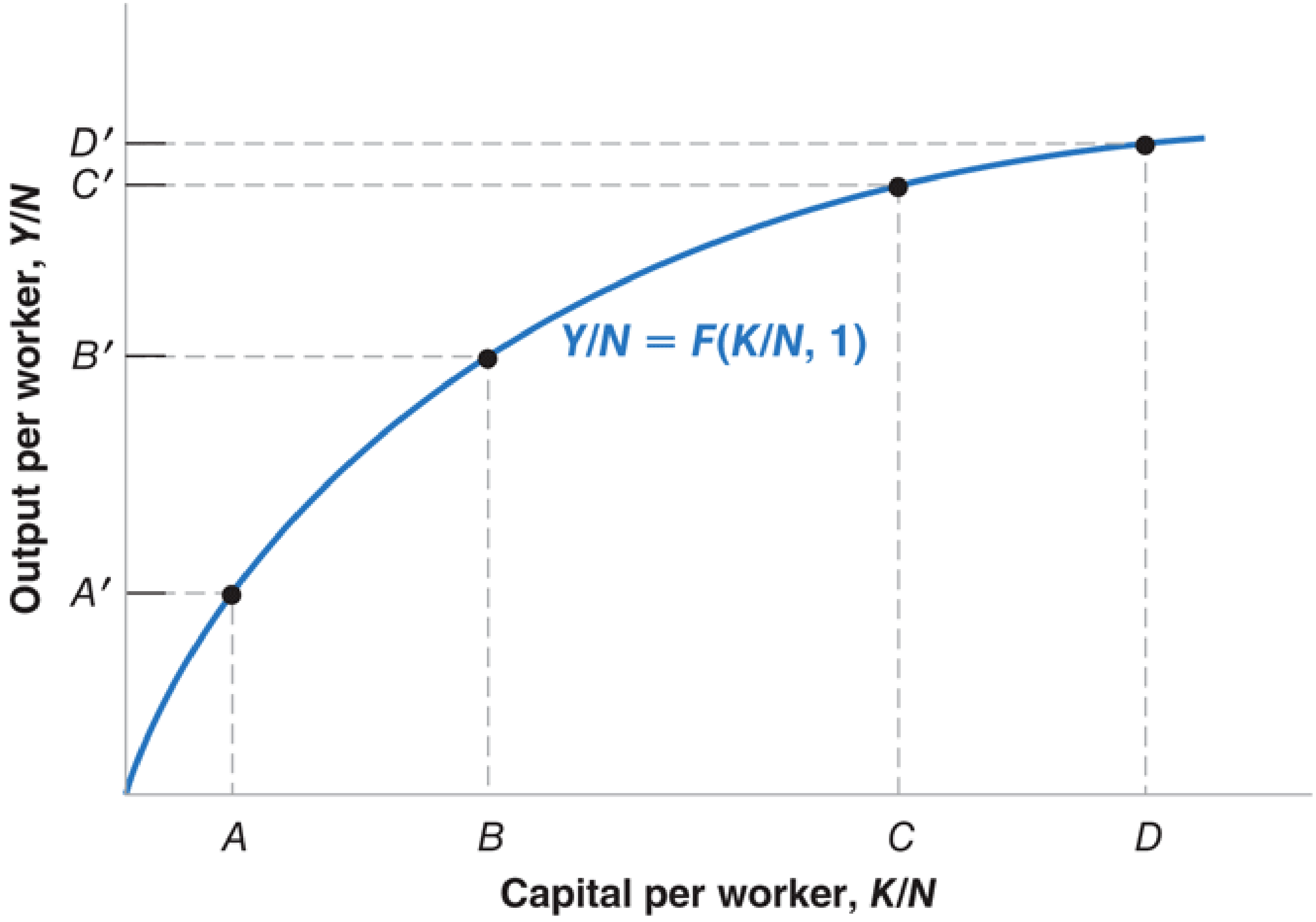
output per worker capital per worker or productivity

Growth due to capital accumulation

- Given $\mathcal{A}$,
  as k increases from A to D,
  y increases from A' to D'.

- f is concave, i.e., the slope decreases as k increases (This property holds because we assume decreasing returns to capital).

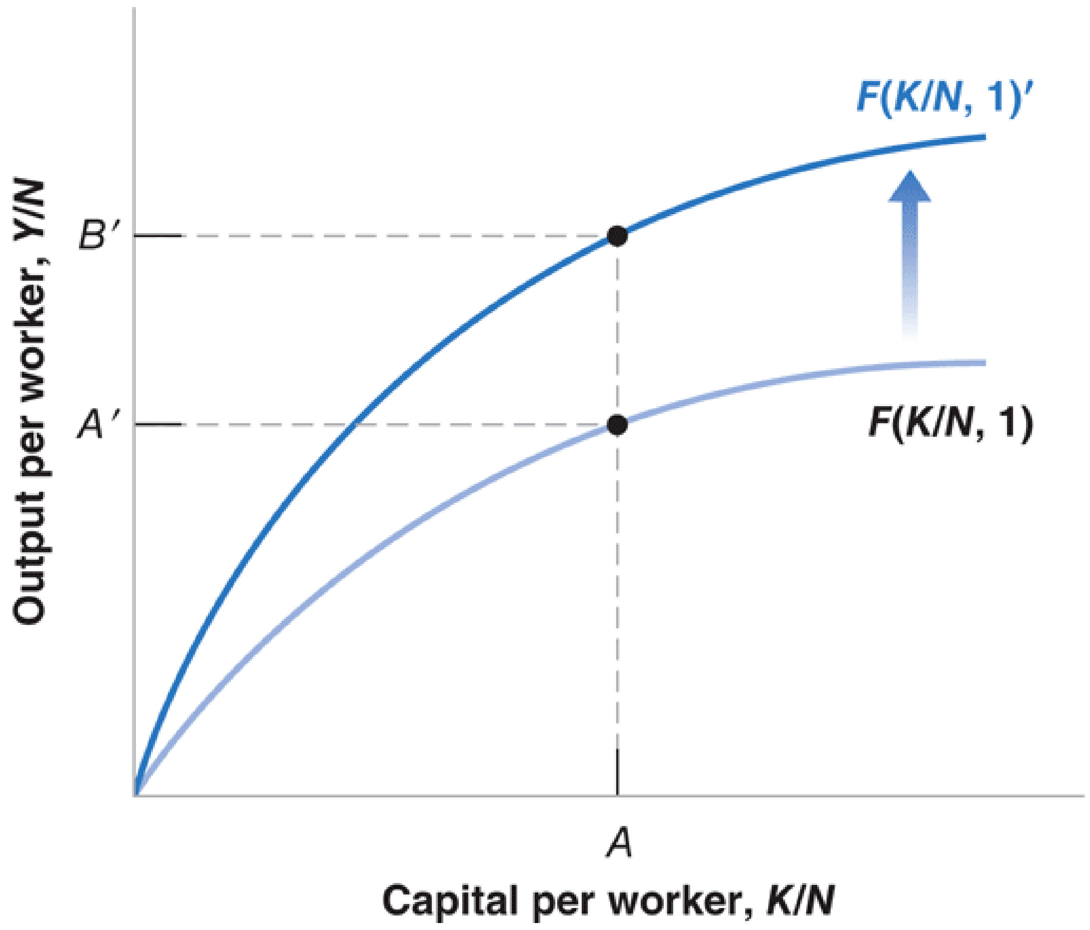
- Lecture 12 focuses on the role of k.



Growth due to technological progress

- Given k at A, as $\mathcal{A}$ increases, y increases from A' to B'.

- Lecture 13 concentrates on the improvement of $\mathcal{A}$.



In the next class…

- We study the Solow growth model to study the role of capital accumulation in economic growth.