Economics 2
Fall 2024

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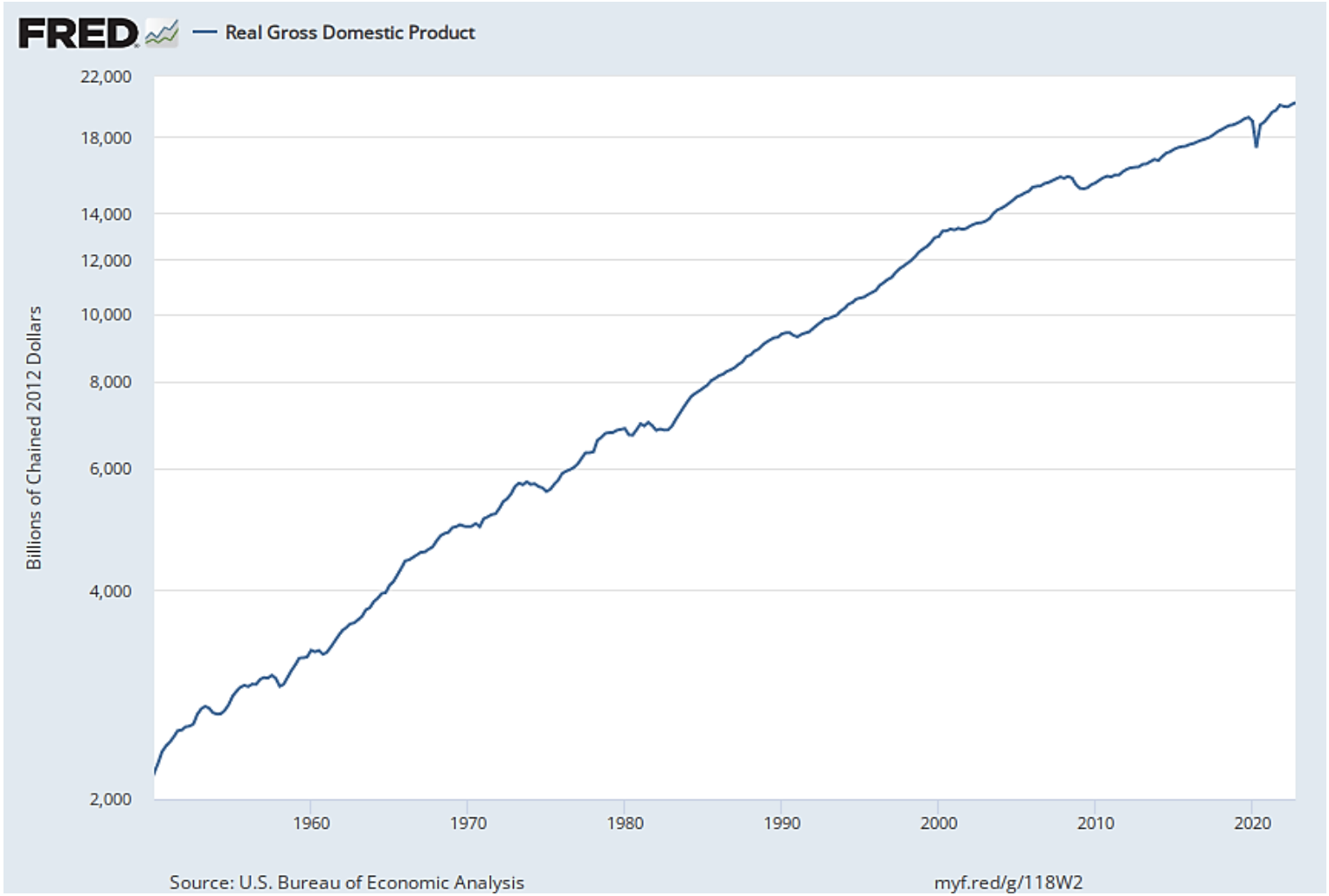
# LECTURE 15

## Long-run Economic Growth

# I. Output and Long-Run Growth

# Real GDP in the U.S., 1950–2022




Source: FRED (Federal Reserve Economic Data); data from Bureau of Economic Analysis.

# The Critical Importance of Potential Output to Long-Run Outcomes

- In the short run (in recessions and booms), the economy's use of its available resources can be above or below normal; this is central to short-run fluctuations.
- In the long run, output is determined by the economy's available productive resources.
- We call the amount of output the economy produces when using its resources at normal rates "potential output" (or "normal output"), denoted Y*.

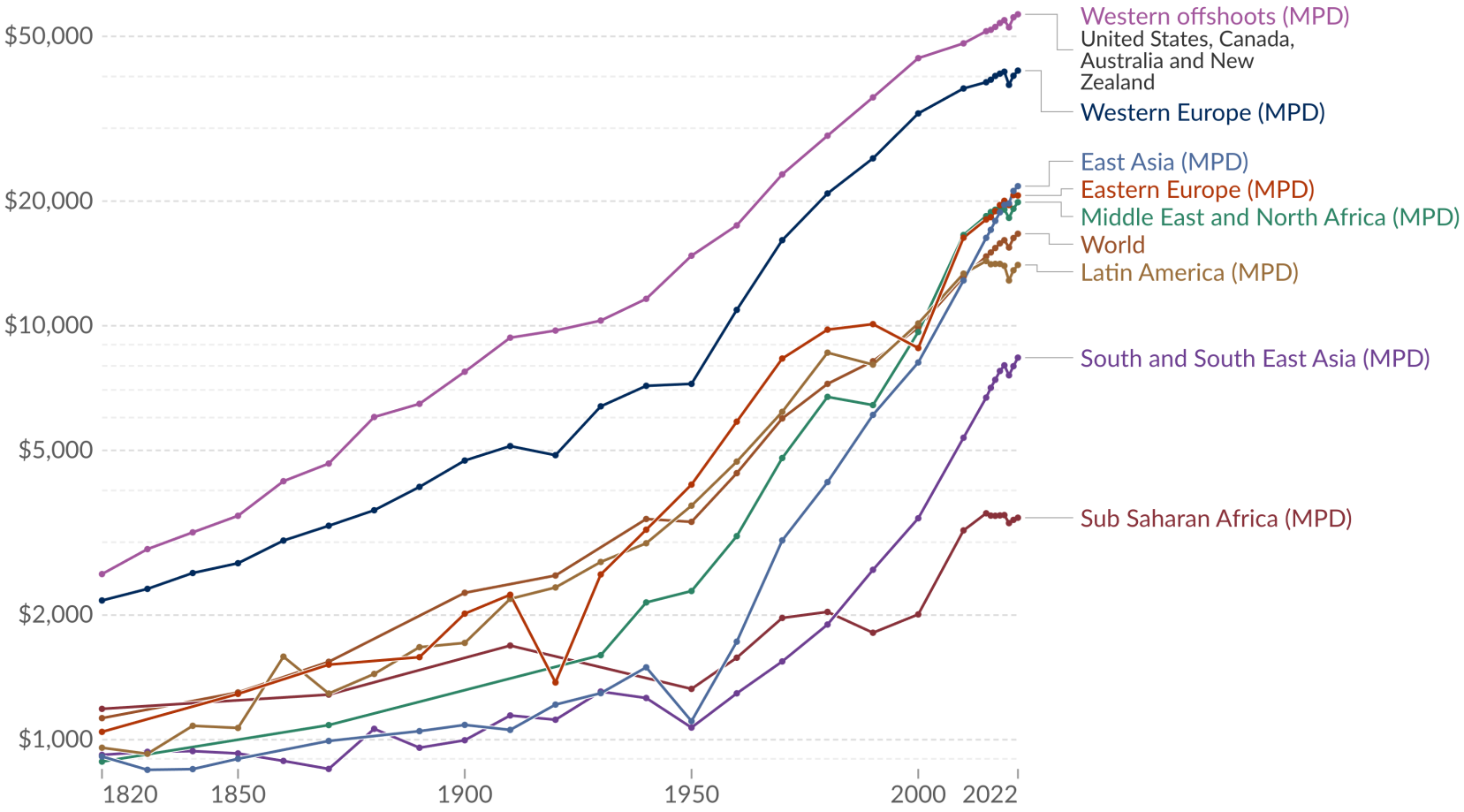
# History of Economic Growth

- Before 19th century, agriculture is the main economic activity, almost no growth in GDP per capita, mostly population growth
- Industrialization starts first in the United Kingdom in 19th century and then spreads to Europe and Western offshoots
- In 20th century, most other regions develop (with some exceptions mostly in sub-Saharan Africa)
- In 21st century, still enormous disparities in GDP per capita across countries

# GDP per capita, 1820 to 2022

This data is adjusted for inflation and for differences in the cost of living between countries.

Our World in Data




**Data source:** Bolt and van Zanden - Maddison Project Database 2023

OurWorldinData.org/economic-growth | CC BY

**Note:** This data is expressed in international-$[1] at 2011 prices.

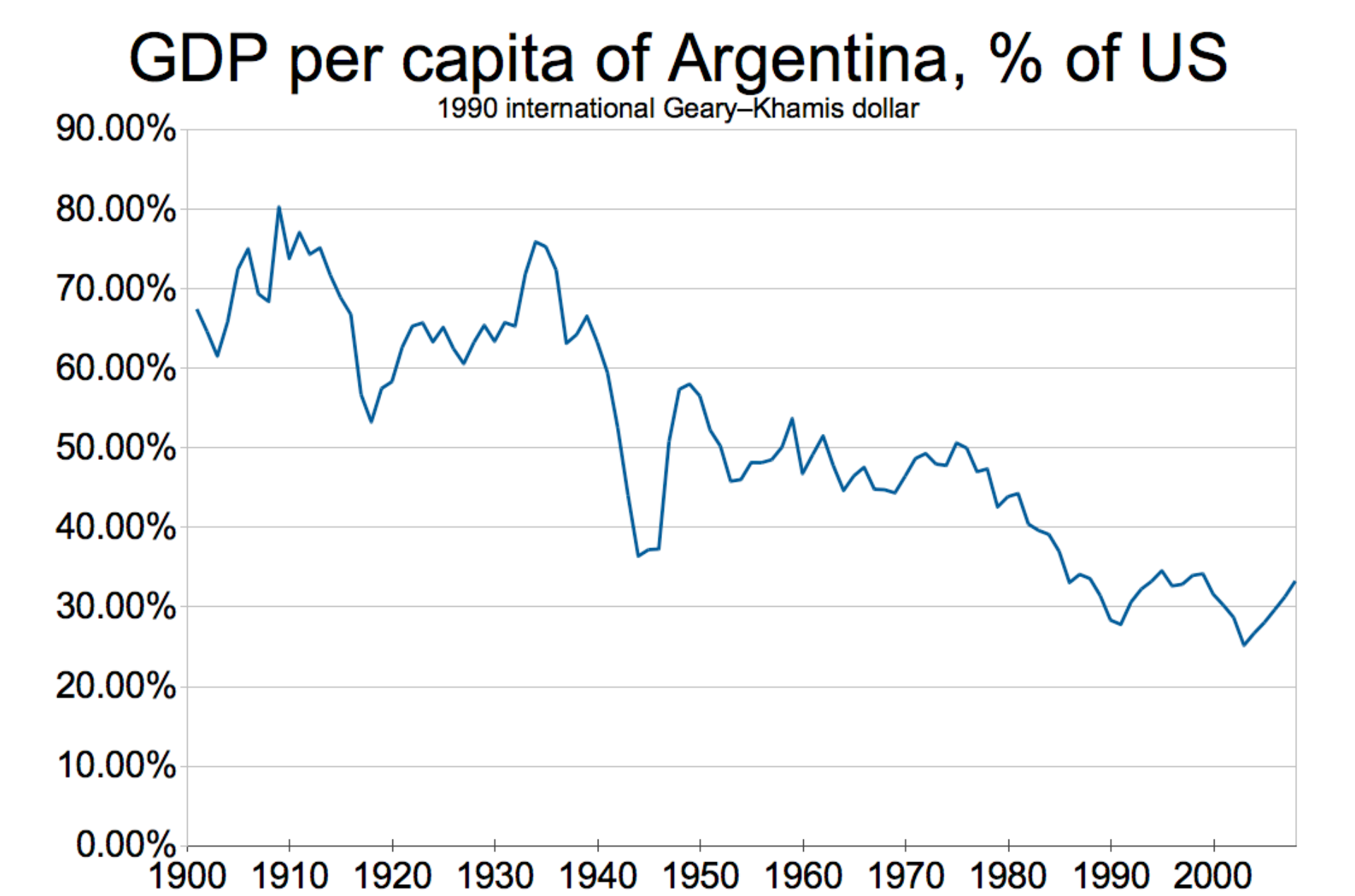
**1. International dollars**: International dollars are a hypothetical currency that is used to make meaningful comparisons of monetary indicators of living standards. Figures expressed in international dollars are adjusted for inflation within countries over time, and for differences in the cost of living between countries. The goal of such adjustments is to provide a unit whose purchasing power is held fixed over time and across countries, such that one international dollar can buy the same quantity and quality of goods and services no matter where or when it is spent. Read more in our article: What are Purchasing Power Parity adjustments and why do we need them?

# Issues Relating to Potential Output (GDP)

- The ***level*** of potential output per person.
  - This is an indicator of standards of living.
  - It differs enormously across countries.
  - What are the reasons for this variation?
- The ***growth rate*** of potential output per person over time.
  - In many (but not all) countries, it has grown enormously over time.
  - Over time, small differences in normal growth can have large impacts on standards of living.

# The Long-Run Consequences of Small Differences in Growth Rates

- Suppose countries A and B start with the same real income per person.
- But annual growth in real income per person is 1 percentage point higher in A than in B (for example, 1% vs. 0%, or 2% vs. 1%).
- For example, Argentina GDP per capita about the same as Western Europe in early 20$^{th}$ century




Argentina was a rich country in 1900 but lost ground relative to advanced economies over the next 120 years.

# Suppose country A grows 1% faster than country B each year

- After 1 year: It is 1% higher.
- After 2 years: It is slightly more than 2% higher ($1.01 \bullet 1.01 = 1.0201$. So it is 2.01% higher.)
- After 70 years: It is twice as high ($1.01^{70} \approx 2$).
- After 2 centuries: It is more than 7 times higher ($1.01^{200} \approx 7.3$).

# Quiz

China's real GDP/capita has been growing faster than the United States since 1980: about 8% vs. 2% growth per year. If this continues what will happen in the long-run?

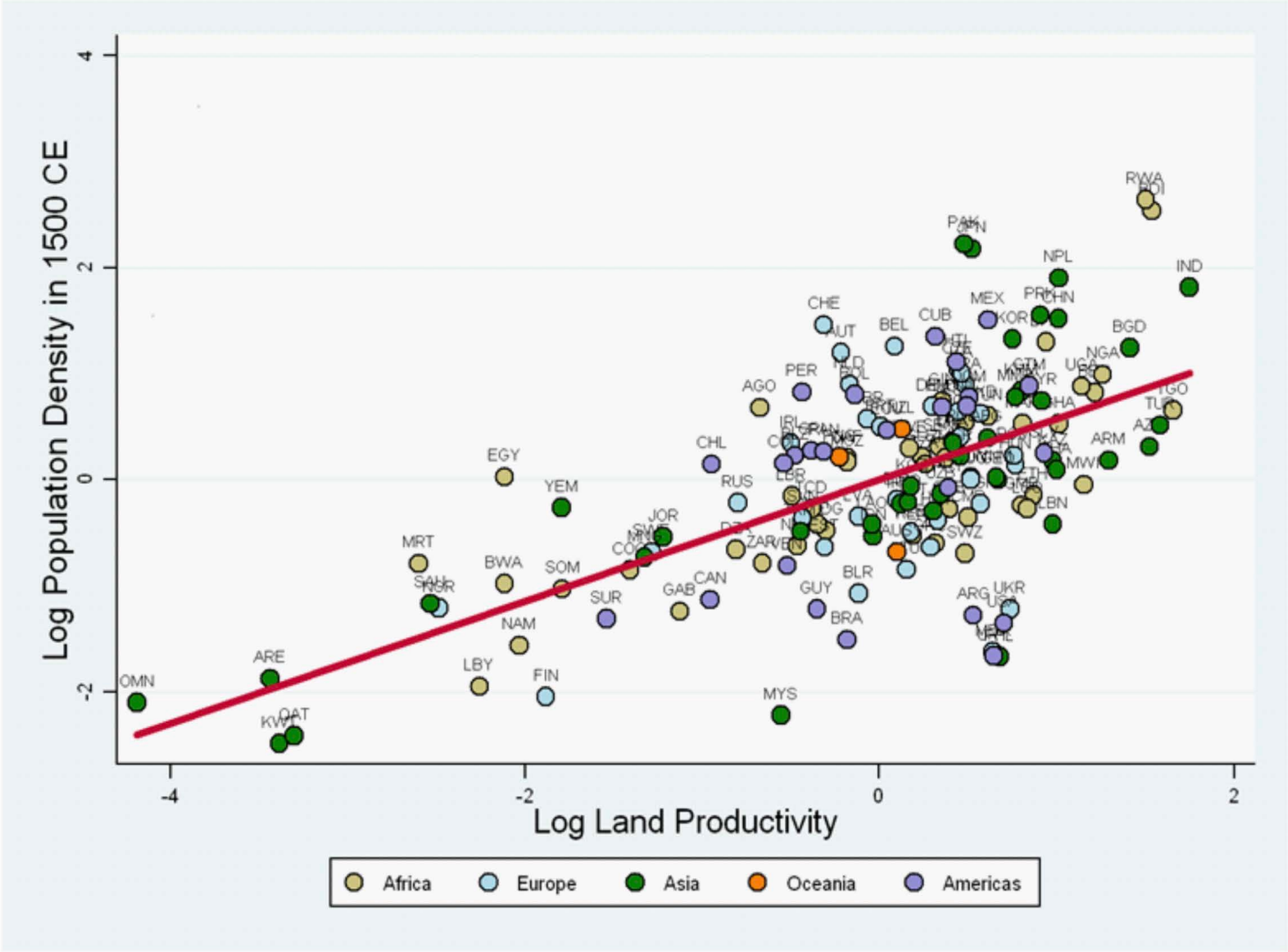
- A. China's GDP/capita will catch up to the US GDP/capita
- B. China's GDP/capita will surpass the US GDP/capita
- C. China's GDP/capita will eventually be more than 10 times higher than the US GDP/capita
- D. All of the above
- E. None of the above. The US will stay ahead of China

# II. Historical Context:
# Malthusian Pre-Industrial Stagnation

# Malthusian Trap in Agricultural Economies

- 10K+ years ago: Hunters/gatherers live in an ecological subsistence equilibrium (population density depends on resources just like other species)
- 10K years ago: Humans invent agriculture: much higher food production allows for population growth
- But with fixed land, additional workers become less and less productive
  - Productivity gains are swallowed by population growth
  - Malthus (1798): impossible to increase standards of living in the long-run

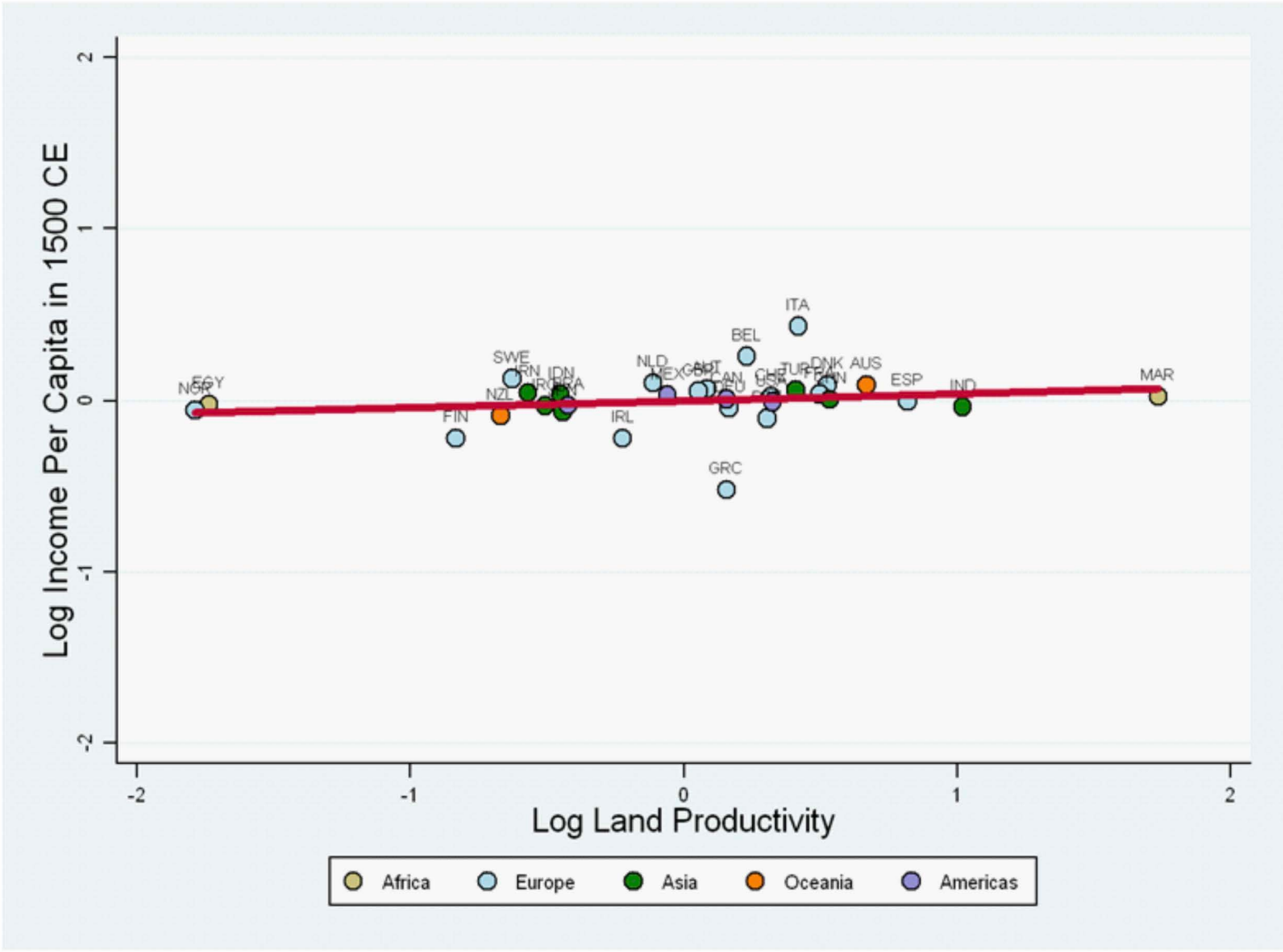
# HIGH LAND PRODUCTIVITY LEADS TO HIGH POPULATION…






Source: Ashraf and Galor (2011)

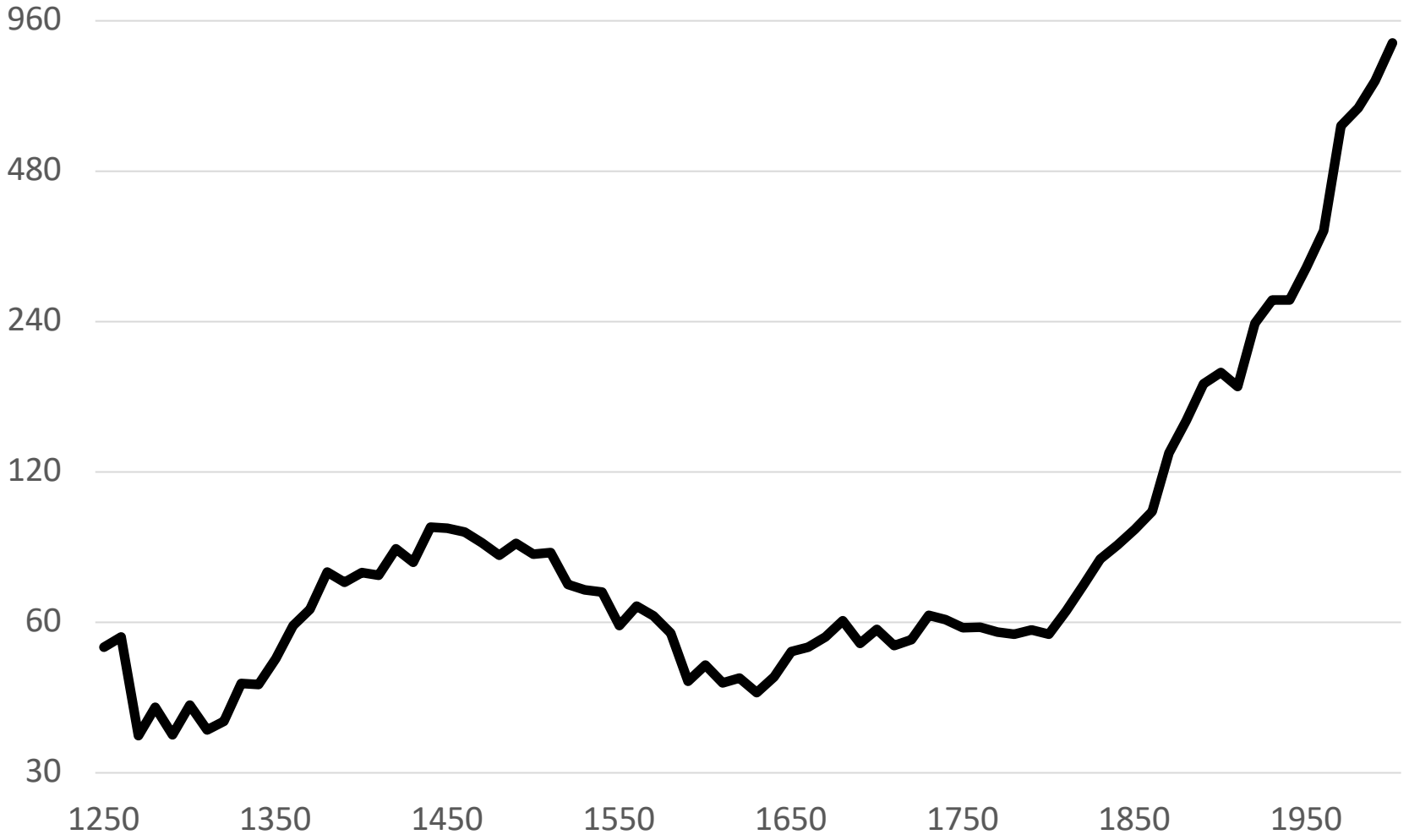
# …BUT HAS NO EFFECT ON INCOME PER CAPITA!





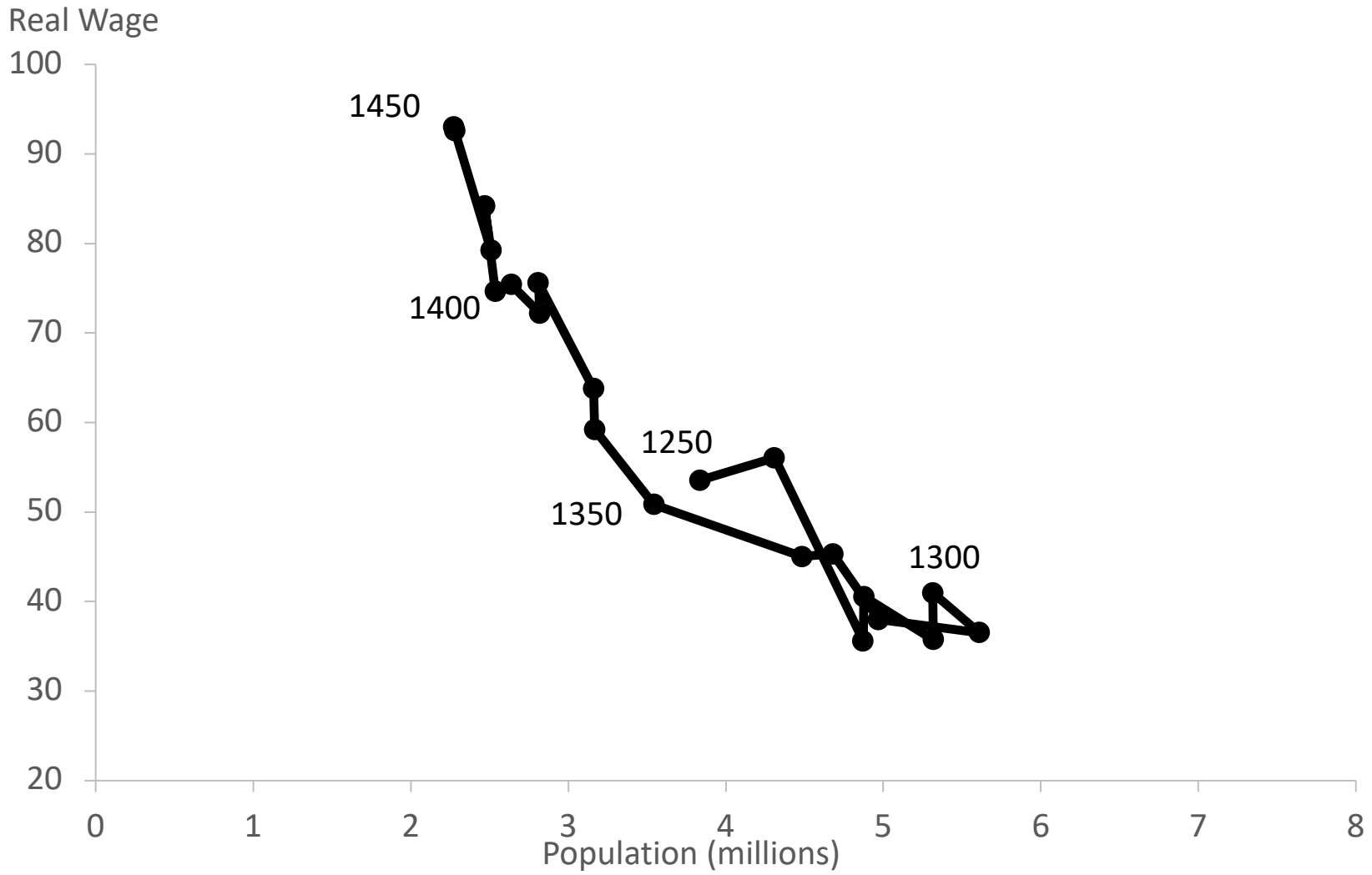

Source: Ashraf and Galor (2011)

# Real Wages (log-scale) of Workers in England from 1250 to 2000



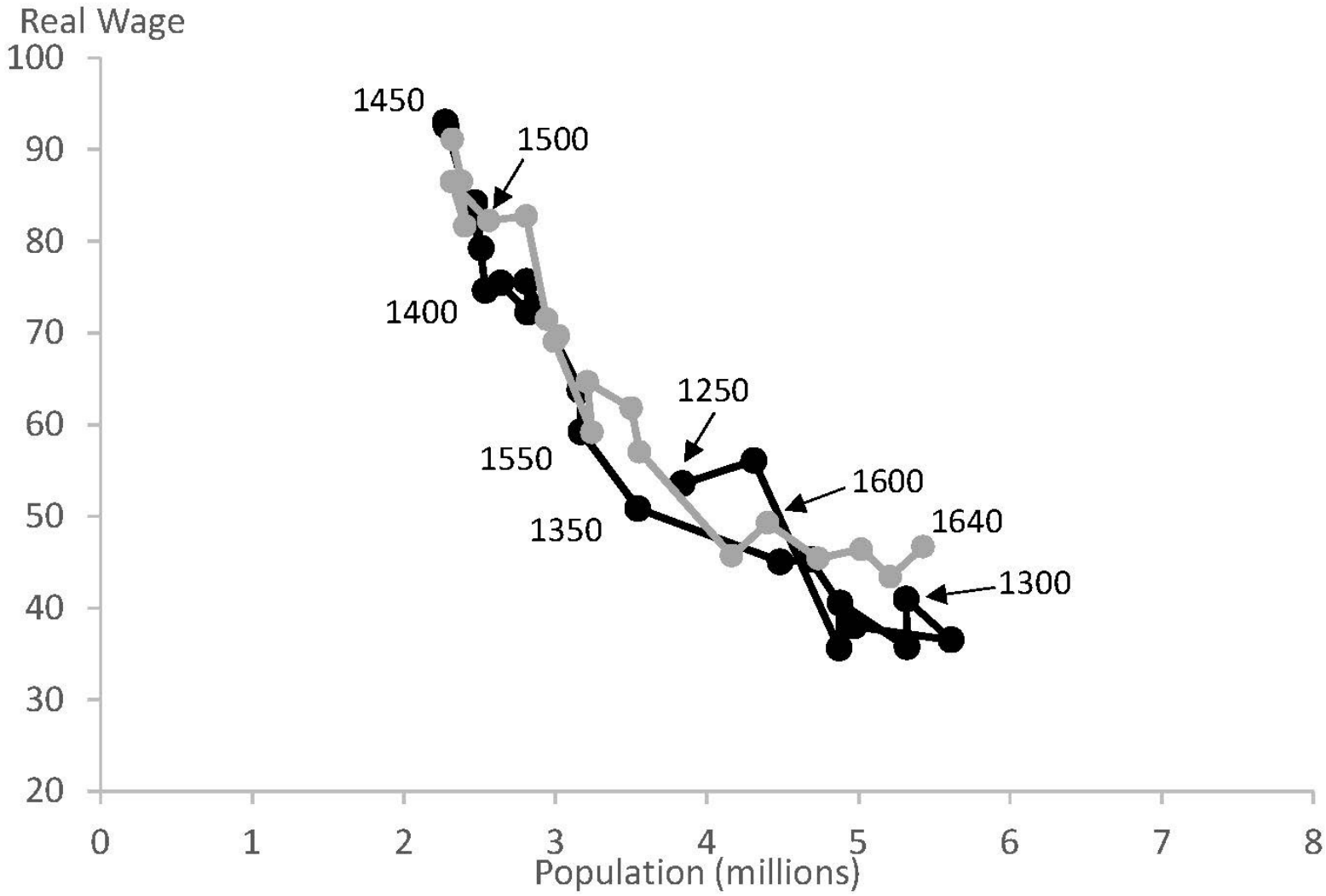

Source: Clark (2005)

# Real Wages of Laborers in England 1250-1450




Source: Clark (2010)

# Real Wages of Laborers in England 1250-1640



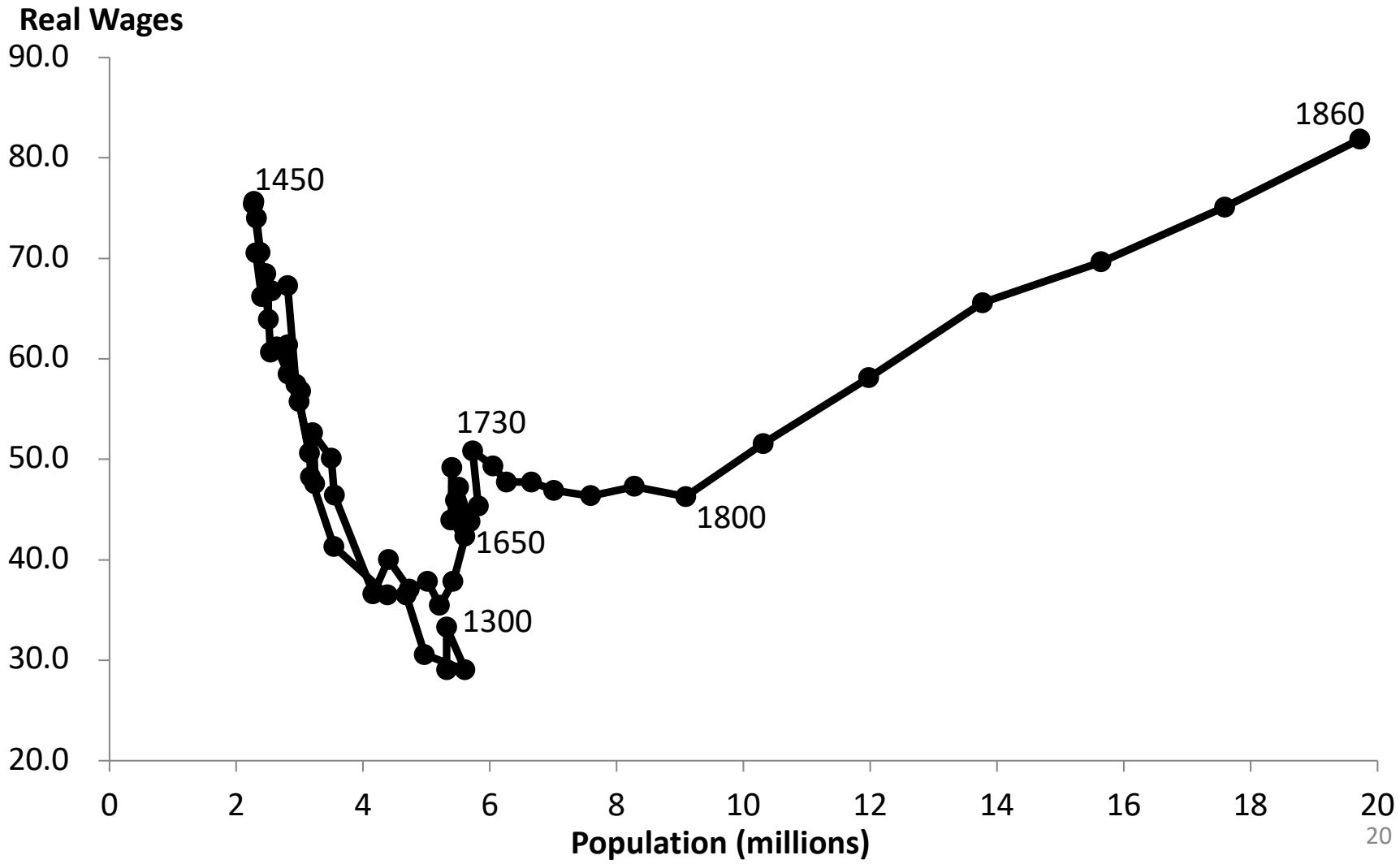

Source: Clark (2010)

# Quiz

Are these movements depicting a stable demand curve for labor in England from 1250 to 1640?

- A. Yes: with lower wages, landlords are willing to hire more labor to work the land
- B. Yes: there wasn't much technological progress so the demand curve didn't shift
- C. Yes: only the supply curve of workers shifts in and out
- D. All of the above
- E. No: it's about people dying when wages are too low and families growing when wages are better

# Real Wages of Laborers in England 1290-1860



# Quiz

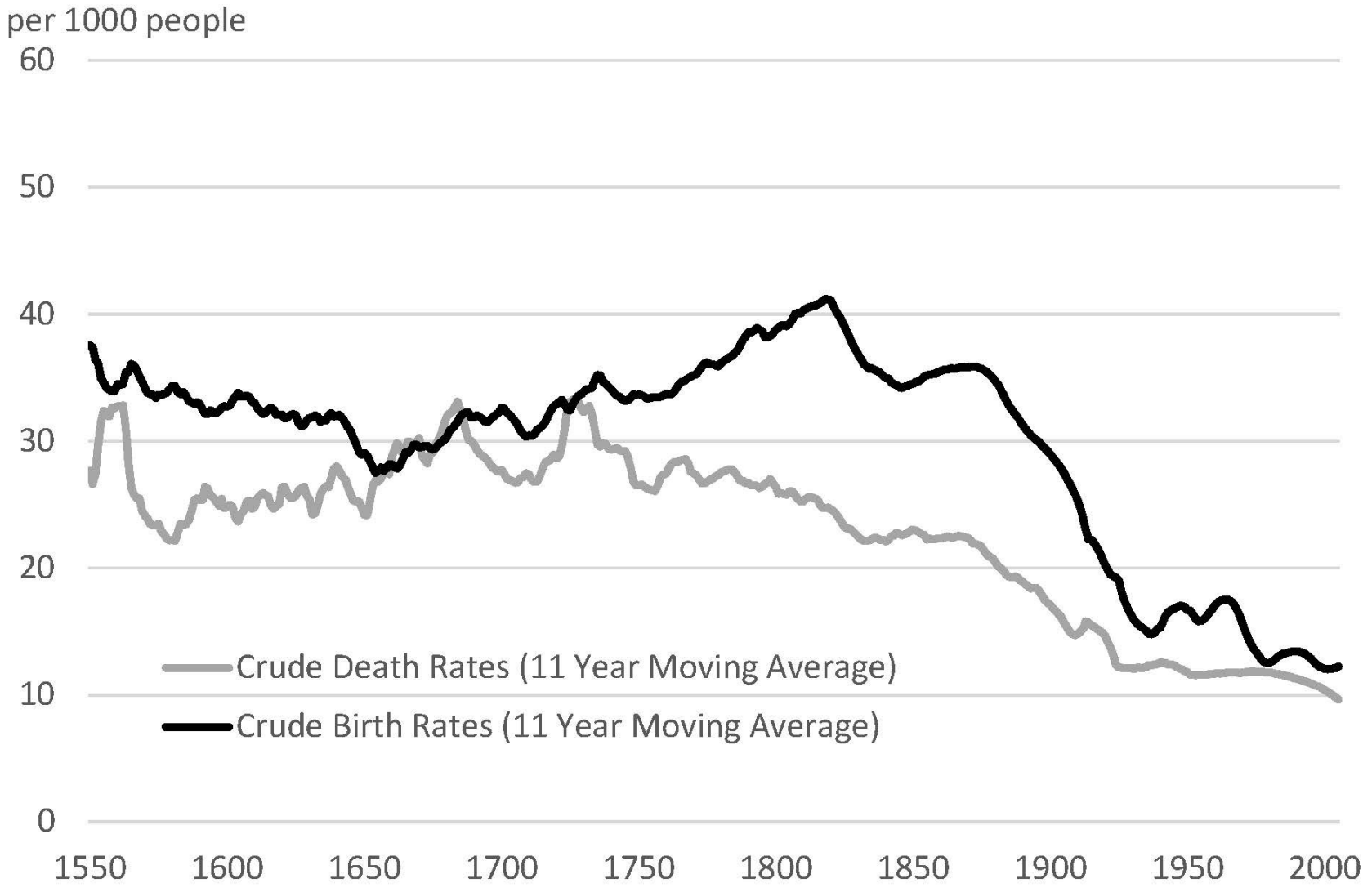
Both population and wage increase in England after 1800. Why?

- A. Industrialization generates fast growth
- B. The demand curve for labor shifts out as workers are more productive
- C. The supply of workers increases as better wages allow the population to grow
- D. All of the above

# Industrialization

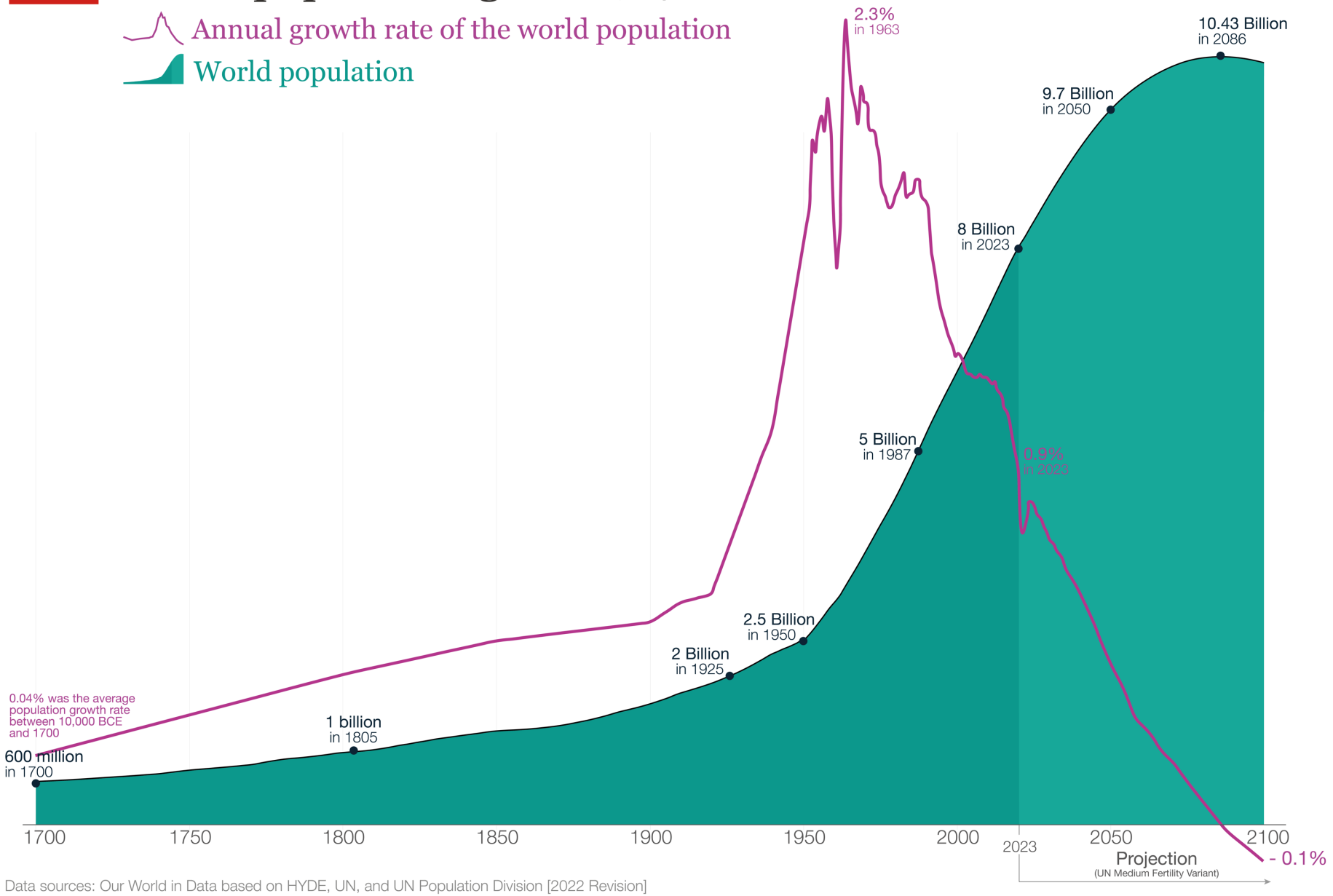
- Agriculture: production is done with workers and fixed land
- Industry: production is done with workers and capital but capital (machines, factories) is not fixed and can expand
- Sustained growth becomes possible: population growth no longer reduces productivity.
- Productivity gains after 1800 large enough to beat (slow) population growth
- Demographic transition in 20$^{th}$ century: higher incomes no longer associated with more children (family planning, women's empowerment)

# Demographic Transition in England



Our World in Data

# World population growth, 1700-2100




Data sources: Our World in Data based on HYDE, UN, and UN Population Division [2022 Revision]
This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.

# III. Modern Economies

# Aggregate Production Function Framework

- The Three Key Determinants of Potential Output:
  - Labor
  - Capital
  - Technology

# Decomposition of Potential Output per Person

$$\frac{Y^*}{POP} = \frac{Y^*}{N^*} \bullet \frac{N^*}{POP}$$

where:

- $Y^*$ is potential output;
- POP is population;
- $N^*$ is normal employment.

- $\frac{N^*}{POP}$ is the normal employment-to-population ratio.
- $\frac{Y^*}{N^*}$ is normal average labor productivity.

# Determinants of Average Labor Productivity

$$\frac{Y^*}{N^*} = f\left(\frac{K^*}{N^*}, T\right)$$

- $\frac{K^*}{N^*}$ is normal capital per worker.
- T is technology.
- Production per worker is an increasing function of capital per worker and technology

# Aggregate Production Function

(1) $$\frac{Y^*}{POP} = \frac{Y^*}{N^*} \bullet \frac{N^*}{POP}$$

(2) $$\frac{Y^*}{N^*} = f\left(\frac{K^*}{N^*}, T\right)$$

(3) $$\frac{Y^*}{POP} = f\left(\frac{K^*}{N^*}, T\right) \bullet \frac{N^*}{POP}$$

# Capital

- Aids to the production process that were created in the past.
- Components of Capital:
  - Conventional physical capital (machines, buildings, computers).
  - Infrastructure (roads, telecommunications systems, dams) is also part of physical capital.
  - Human capital (education, job training)

# Technology

- The methods for producing output (goods and services).
- More broadly: Everything that affects how much output per worker we produce using a given amount of capital per worker.
- Components of Technology:
  - Production techniques
  - Management techniques
  - Economic institutions
  - Local culture

# IV. Explaining the Variation in the Level of Potential Output per Person across Countries

# Contribution of the Employment-to-Population Ratio

$$\frac{Y^*}{POP} = f\left(\frac{K^*}{N^*}, T\right) \bullet \frac{N^*}{POP}$$

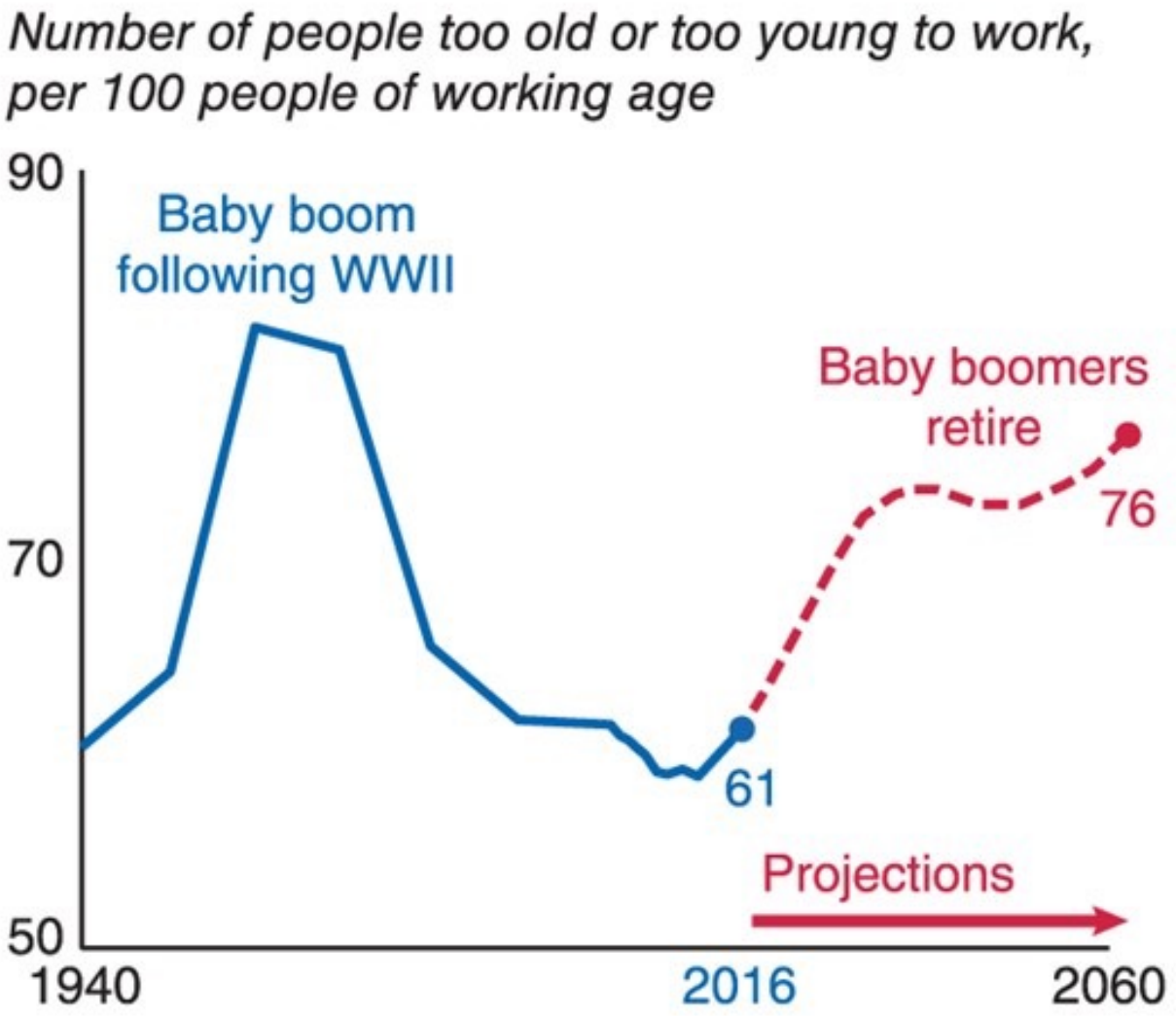
- It can certainly matter, but its effects are inherently limited.
- It doesn't vary that much across countries.
- Main differences due to age structure, gender norms:
  - Elderly people work less (especially in richer countries)
  - Young people work less (due to education surge)

## TABLE 1.1 STATISTICS ON GROWTH AND DEVELOPMENT

| | GDP per capita, 2008 | GDP per worker, 2008 | Labor force participation rate, 2008 | Average annual growth rate, 1960–2008 | Years to double |
|---|---|---|---|---|---|
| "Rich" countries | | | | | |
| United States | $43,326 | $84,771 | 0.51 | 1.6 | 43 |
| Japan | 33,735 | 64,778 | 0.52 | 3.4 | 21 |
| France | 31,980 | 69,910 | 0.46 | 2.2 | 30 |
| United Kingdom | 35,345 | 70,008 | 0.51 | 1.9 | 36 |
| Spain | 28,958 | 57,786 | 0.50 | 2.7 | 26 |
| "Poor" countries | | | | | |
| China | 6,415 | 10,938 | 0.59 | 5.6 | 13 |
| India | 3,078 | 7,801 | 0.39 | 3.0 | 24 |
| Nigeria | 1,963 | 6,106 | 0.32 | 0.6 | 114 |
| Uganda | 1,122 | 2,604 | 0.43 | 1.3 | 52 |
| "Growth miracles" | | | | | |
| Hong Kong | 37,834 | 70,940 | 0.53 | 4.3 | 16 |
| Singapore | 49,987 | 92,634 | 0.54 | 4.1 | 17 |
| Taiwan | 29,645 | 62,610 | 0.47 | 5.1 | 14 |
| South Korea | 25,539 | 50,988 | 0.50 | 4.5 | 16 |
| "Growth disasters" | | | | | |
| Venezuela | 9,762 | 21,439 | 0.46 | −0.1 | −627 |
| Haiti | 1,403 | 3,164 | 0.44 | −0.4 | −168 |
| Madagascar | 810 | 1,656 | 0.49 | −0.1 | −488 |
| Zimbabwe | 135 | 343 | 0.40 | −1.5 | −47 |

Source: Charles Jones and Dietrich Vollrath, *Economic Growth*. Year 2008

# Dependency Ratio in the United States

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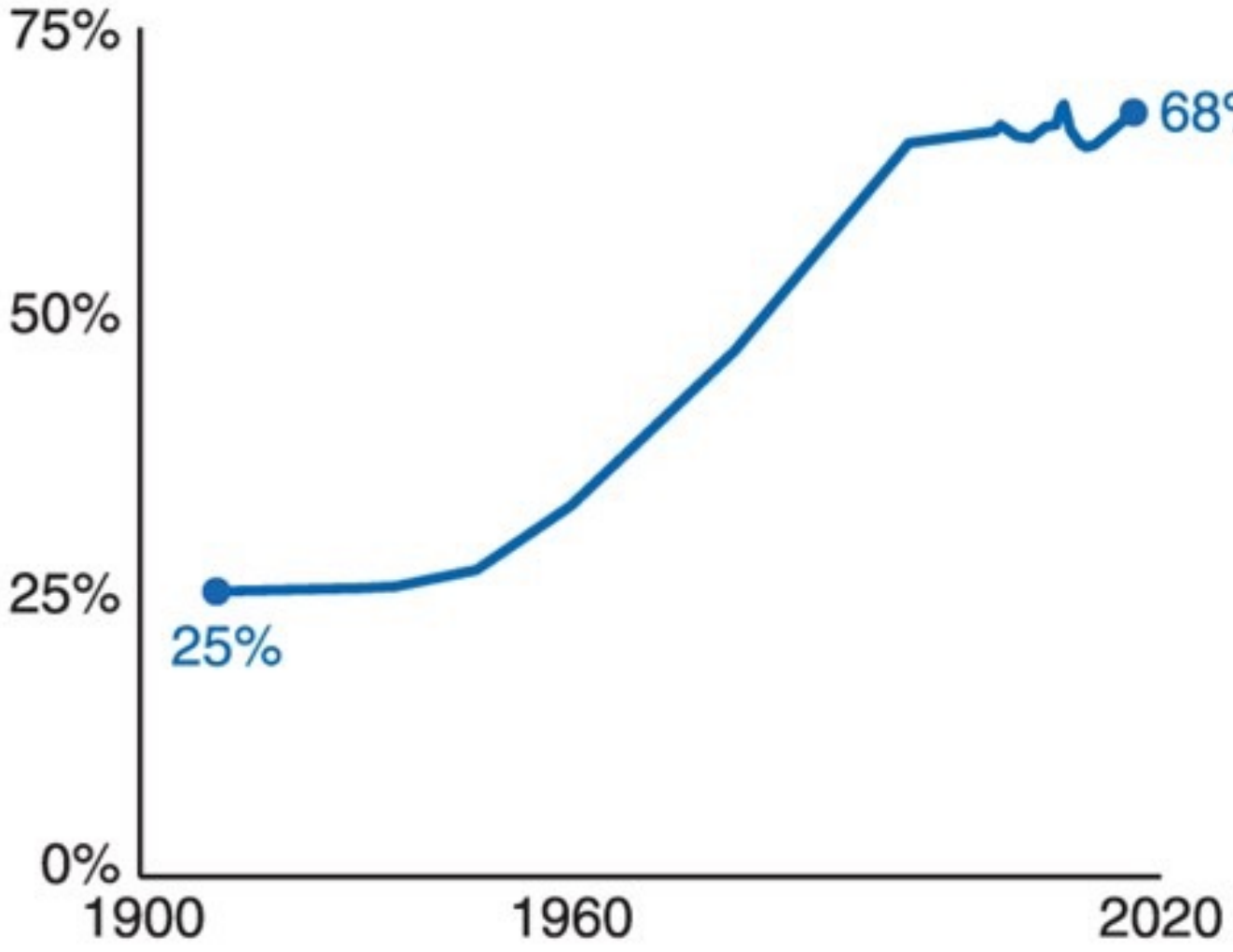
# Share of US Working-Age Women Who are Employed

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# Contribution of Capital per Worker

$$\frac{Y^*}{POP} = f\left(\frac{K^*}{N^*}, T\right) \bullet \frac{N^*}{POP}$$

- Physical and human capital vary a lot across countries.
- Educational attainment grows with development
- Physical capital grows like output in the long-run
  - Generally stock of physical capital (buildings, machines, equipment) is about 3 years of output Y*

# GDP Statistics for Selected Countries (2008)

| | GDP per Capita | Physical Capital per Worker | Average years of Education |
|---|---|---|---|
| "Rich" countries | | | |
| U.S.A | 43,326 | 292,614 | 13.2 |
| Japan | 33,735 | 297,337 | 11.4 |
| France | 31,980 | 327,397 | 10.7 |
| U.K. | 35,345 | 222,377 | 12.8 |
| "Poor" countries | | | |
| China | 6,415 | 57,700 | 7.0 |
| India | 3,078 | 20,373 | 5.2 |
| Nigeria | 1,963 | 8,516 | 5.2 |
| "Growth miracles" | | | |
| Hong Kong | 37,834 | 293,414 | 11.3 |
| Singapore | 49,987 | 309,148 | 10.5 |
| Taiwan | 29,645 | 179,589 | 10.6 |
| Korea | 25,539 | 234,288 | 11.6 |
| "Growth disasters" | | | |
| Venezuela | 9,762 | 91,882 | 8.2 |
| Zimbabwe | 135 | 1,288 | 7.0 |

Sources: Jones and Vollrath, *Economic Growth* ; United Nations; Penn World Tables.

# Contribution of Technology

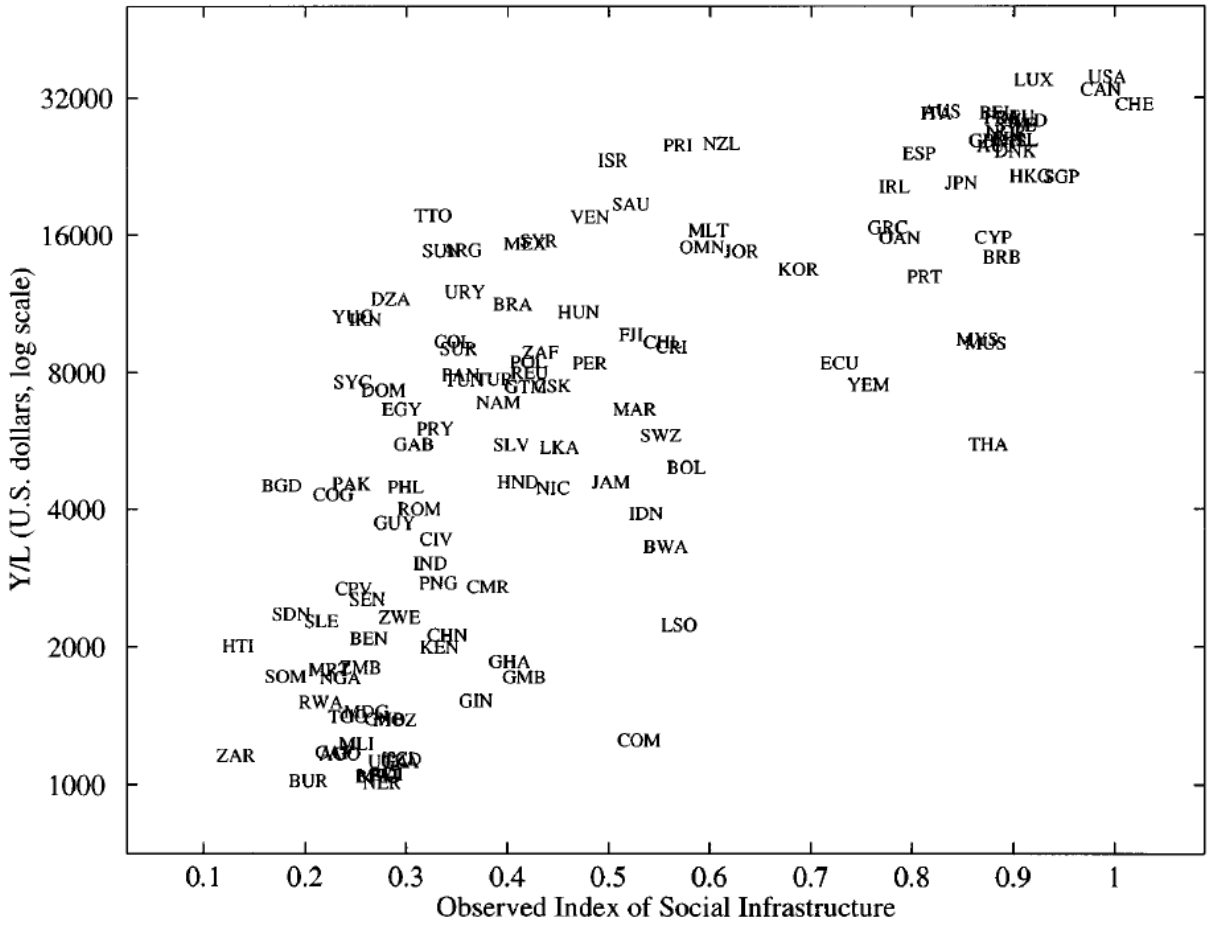
$$\frac{Y^*}{POP} = f\left(\frac{K^*}{N^*}, T\right) \bullet \frac{N^*}{POP}$$

- The types of technology that vary significantly across countries are not so much knowledge, but ability to deploy knowledge, institutions and culture.
- And this variation is an important source of the variation in normal output per capita.

# Economists' View: Three Key Features for Economic Success

- (1) Property rights + (2) Market-based system for producing/allocating resources + (3) government quality (bureaucratic quality, rule of law, low corruption, low risk of expropriation)
  - Market is a powerful decentralized mechanism to reward producers of valuable goods (Friedrich Hayek)
  - Example: North vs. South Korea divergence since 1948
  - Caveat: some countries succeed economically even when government can arbitrarily confiscate (e.g. China)

# Average Labor Productivity and Social Infrastructure




Social infrastructure index: government quality + openness to trade

This is a correlation not necessarily causation.

Source: Hall and Jones (1999), "Why Do Some Countries Produce So Much More Output per Worker than Others?"

# Can Increases in K*/N* Explain Growth? The Case of Physical Capital

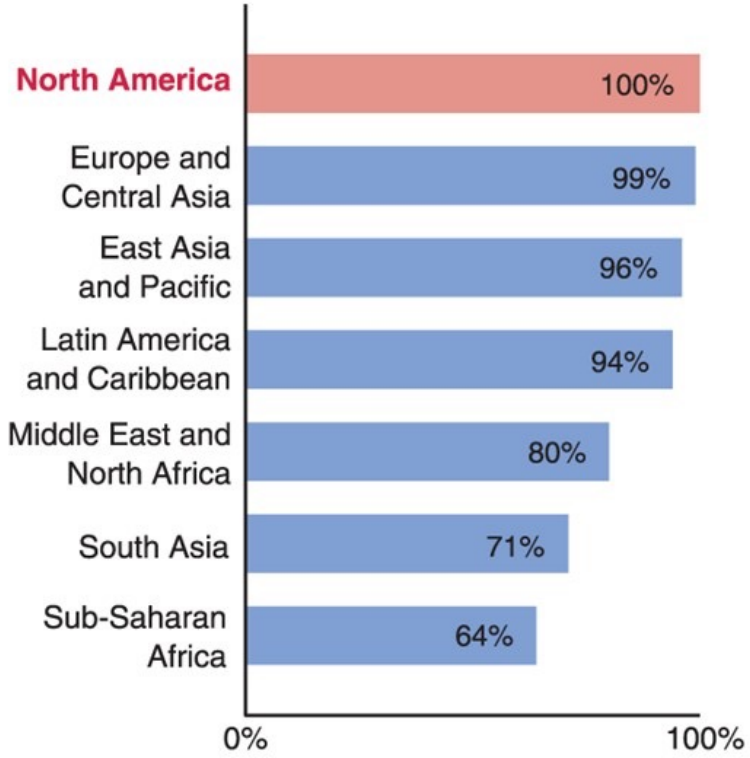
- An increase in K*/N* will raise Y*/POP, and there have been periods when capital accumulation was important to growth.
- But, diminishing returns means that doubling K*/N* less than doubles Y*/POP.
- Observed increases in K*/N* tend to follow Y*/N*, i.e. more valuable production tends to require more valuable capital equipment.

# Can Increases in K*/N* Explain Growth? The Case of Human Capital

- Human capital has increased substantially over the past 100+ years.
- The increases account for a substantial amount of the observed rise in Y*/POP over time.
- Gethin (2024) is a brand new study looking at the impact of education on growth worldwide.

# Adult Literacy and Graduation Rates

Adult Literacy Rates Vary Across Regions

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U.S. High School and College Graduation Rates

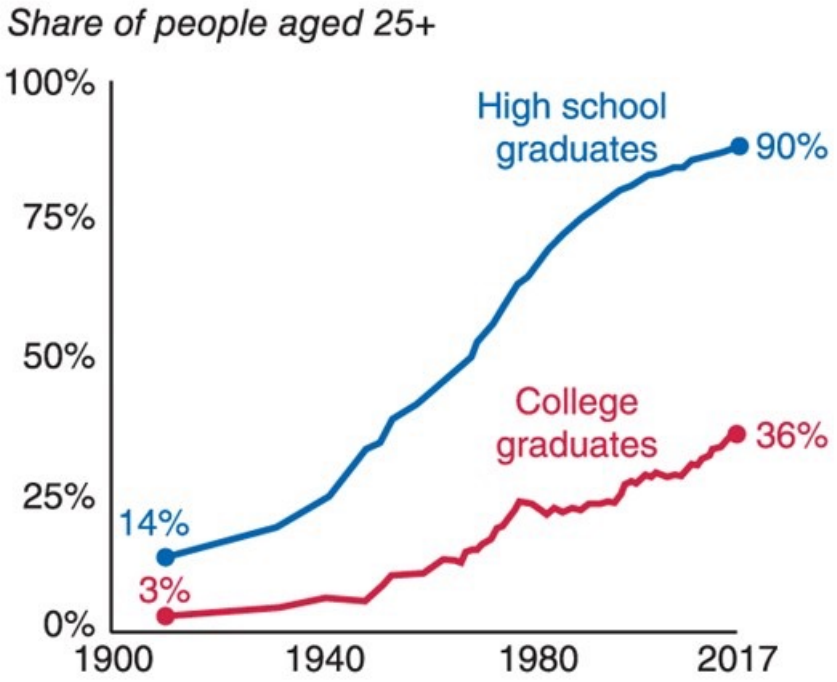


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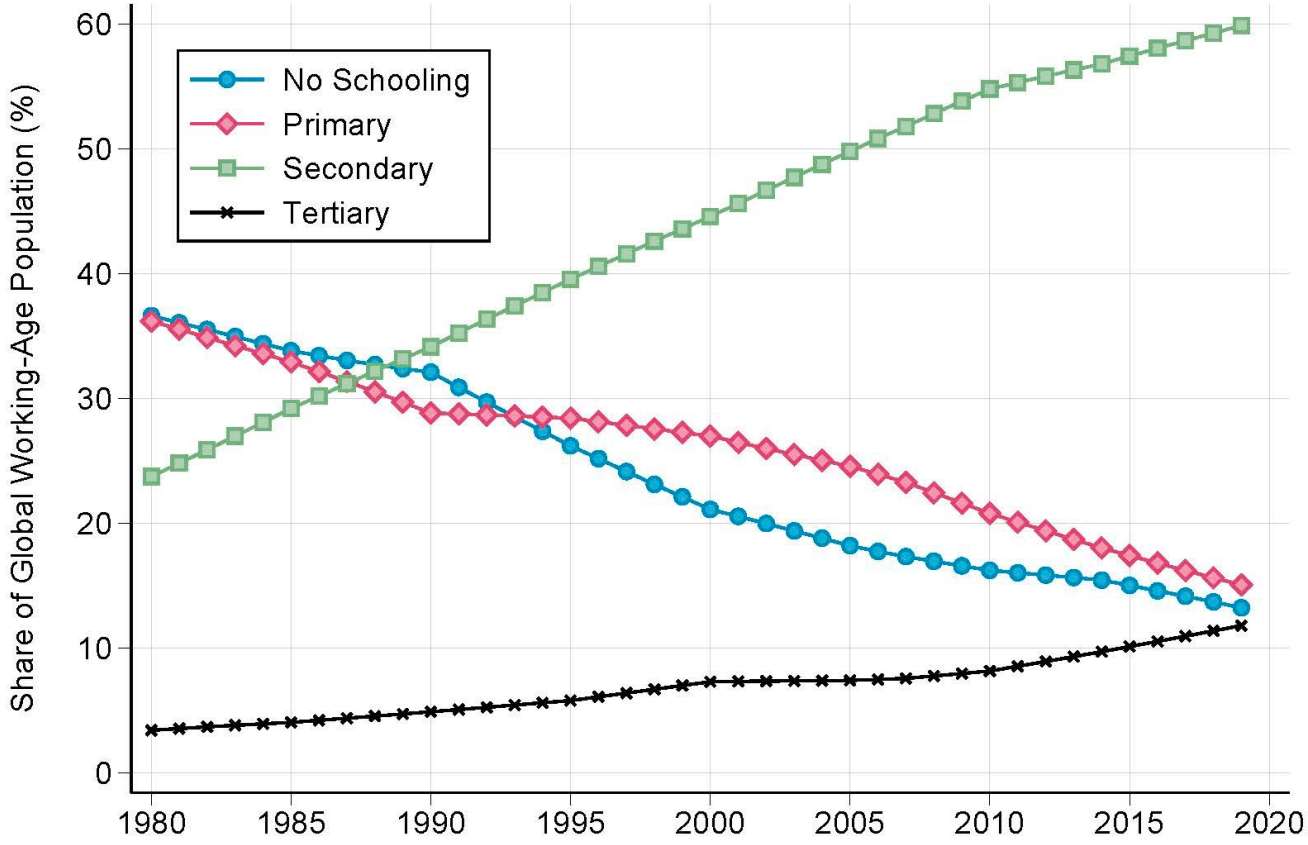
Figure 3 – Educational Attainment of the World's Working-Age Population, 1980-2019

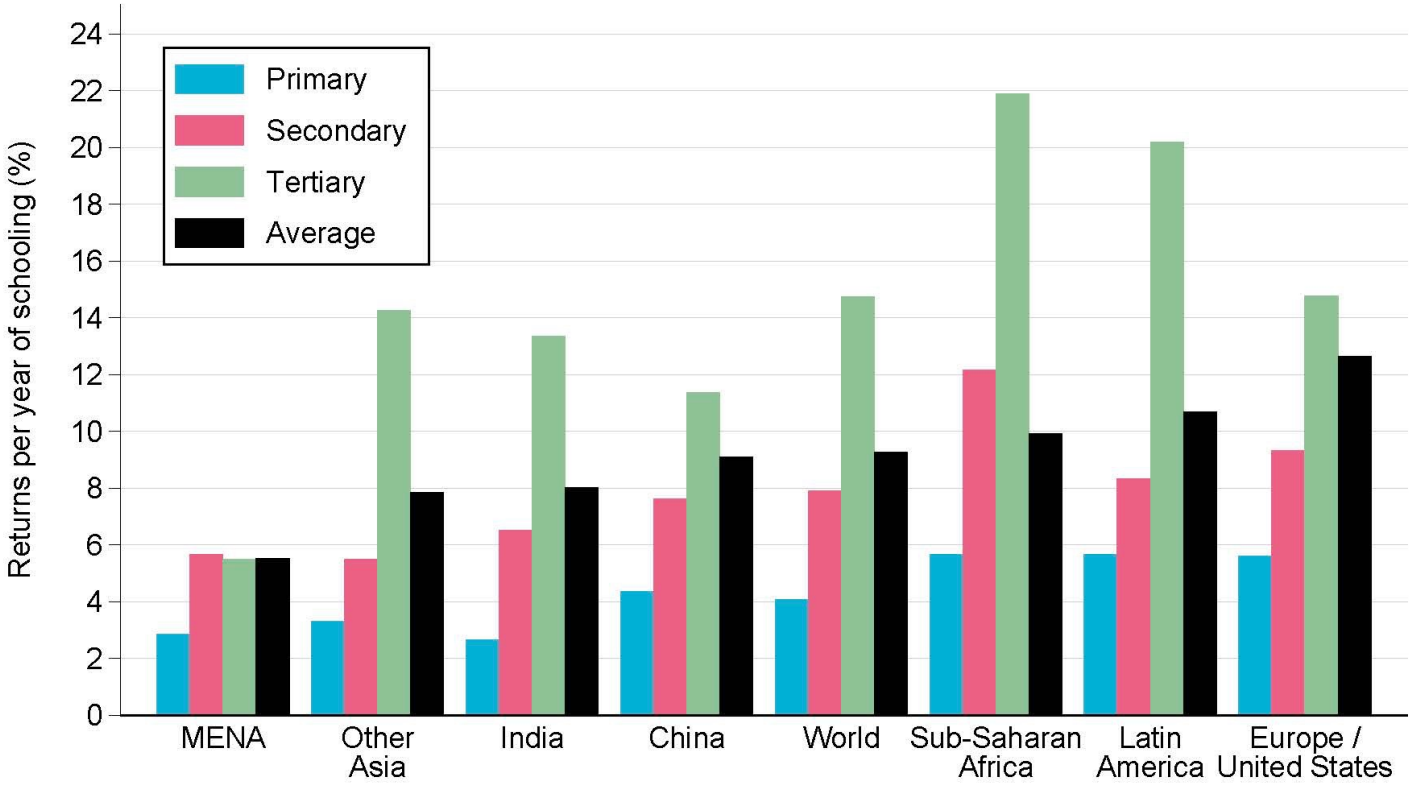



*Notes.* The figure plots the distribution of educational attainment of the working-age population in the world as a whole. From 1980 to 2019, the share of the world's working-age population having reached secondary education grew from about 25% to 60%.



Source: *Gethin (2024).* Primary=elementary school (age 6-12), Secondary=high-school (age 12-18), Tertiary=university (age 18+)

Figure 4 – Returns to Schooling by World Region

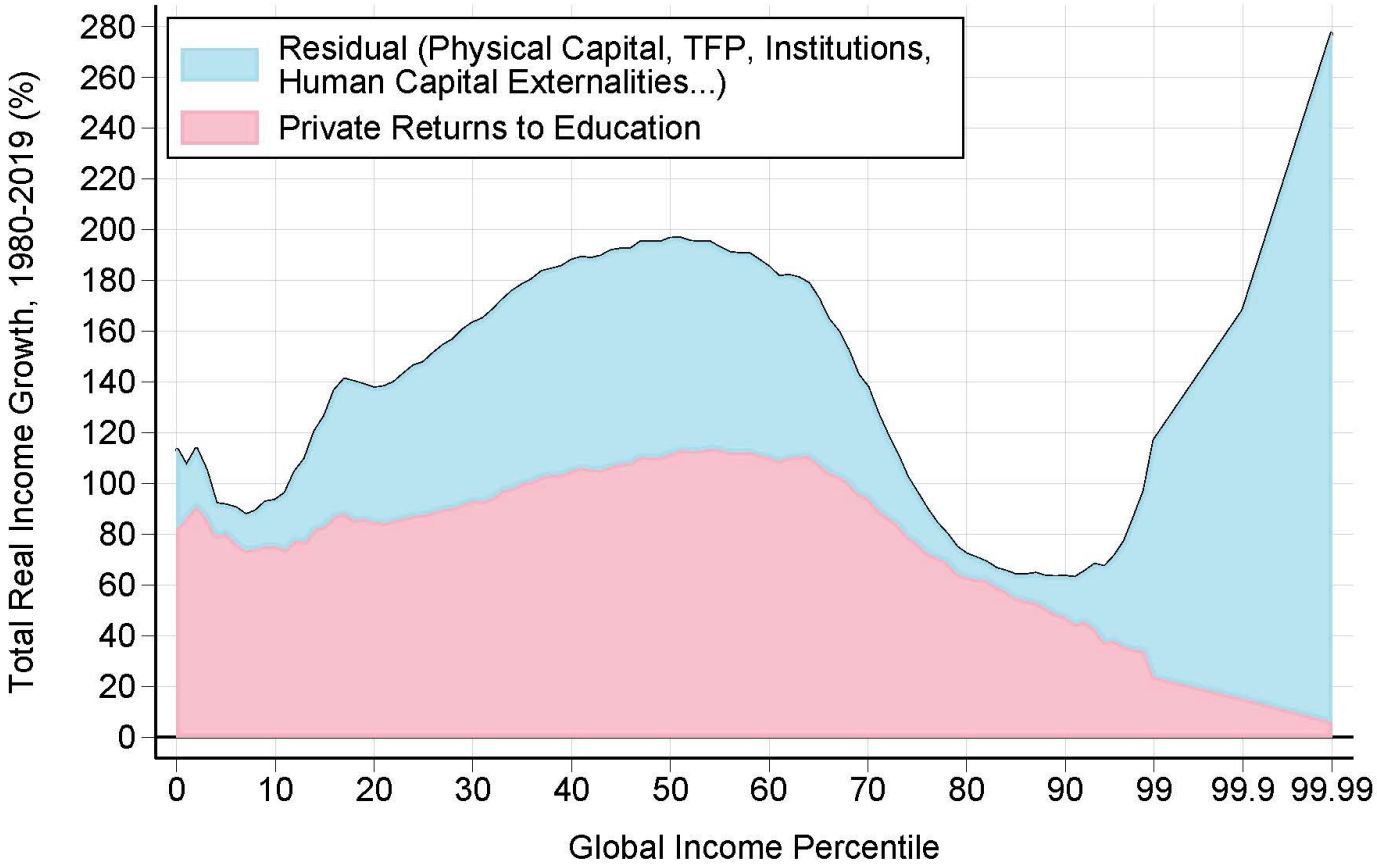



*Notes.* The figure plots returns to a year of schooling by education level and world region. Estimates correspond to the effect of an additional year of schooling on the log of personal income, estimated using modified Mincerian equations that control for an experience quartic, gender, and interactions between the experience quartic and gender. Primary: return to an additional year of primary education. Secondary: return to an additional year of secondary education. Tertiary: return to an additional year of tertiary education. Population-weighted averages of coefficients estimated in each country.



The graph displays the extra-earnings in % for having 1 extra year of education in the primary range (blue), secondary (red), tertiary (green), and average (black). Source: *Gethin (2024).*

Figure 1 – Education and the Distribution of Global Economic Growth, 1980-2019




*Notes.* The figure plots total real income growth by global income percentile from 1980 to 2019, decomposing it into a part that can be explained by private returns to schooling and an unexplained component. The upper shaded area represents the growth rates that would have prevailed absent any improvement in the education of the world's working-age population since 1980. The lower shaded area represents the corresponding contribution of education to economic growth. From 1980 to 2019, the average income of the $20^{th}$ percentile of the world distribution of income grew by 140%, 80 percentage points of which can be rationalized by private returns to education. Education thus accounts for about 60% of growth among this group since 1980.



Source: *Gethin (2024).*

# Technological change is a key determinant of economic growth

$$\frac{Y^*}{POP} = f\left(\frac{K^*}{N^*}, T\right) \bullet \frac{N^*}{POP}$$

- Argument by elimination: What is not explained by N*/POP or K*/N*, must be explained by T.

# IV. Sources of Technological Progress

# Many Factors Are Likely to Affect The Amount of Invention and Innovative Activity

- The strength of inventors' property rights.
- Government subsidies or direct funding of research and innovation.
- Greater competition; lower barriers to entry.
- National emergencies.
- The scale of the market (explains why international trade helps growth)
- Education.
- Consumer tastes for novelty.
- Cultural attitudes toward innovation.
- …

# Does the Free Market Produce the Socially Optimal Amount of Inventive Activity?

- Almost certainly not: Inventions appear to have large positive externalities
- This is especially true for basic science.

# Policies to Encourage Technological Progress

- Increase education.
- Subsidize research and development, particularly for basic science.
- And remember that better institutions are a form of technological progress—which is especially relevant to poor countries.

# Messages about Cross-Country Income Differences

- Differences in the normal employment-to-population ratio are not very important.
- Variations in normal capital per worker (both physical and human) and in technology are both very important.
- A reasonable approximation is that normal capital per worker and technology are each responsible for half of cross-country income differences.
- The most important type of variation in technology is not variation in knowledge or know-how, but variation in institutions.

# References

- CORE-The Economy, Chapter 16.
- Principles of Economics, Chapter 19.