



UNIVERSITÀ
DEGLI STUDI
DI TERAMO



Economic Growth

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Outline

- Why is long-run economic growth measured as the increase in real GDP per capita? How has real GDP per capita changed over time in different countries?
- Why is productivity the key to long-run economic growth? How is productivity driven by physical capital, human capital, and technological progress?
- Why do long-run growth rates differ so much among countries?
- How does growth vary among several important regions of the world? Why does the convergence hypothesis apply to economically advanced countries?
- How do scarcity of natural resources and environmental degradation pose a challenge to sustainable long-run economic growth?

GROWTH HAS BENEFITS AND COSTS

- Delhi and Beijing have terrible air quality—which is a bad thing. But it's a by-product of a very good thing: the remarkable economic growth.



DOMINIQUE FAGET/Getty Images

COMPARING ECONOMIES ACROSS TIME AND SPACE

The key statistic is real GDP per capita—real GDP divided by population.

- We focus on GDP because GDP measures the income earned in the economy in a given year.
- We use real GDP because we want to separate changes in the quantity of goods and services from the effects of a rising price level.
- We focus on real GDP per capita because we want to isolate the effect of changes in the population.

LEARN BY DOING: PRACTICE QUESTION 1

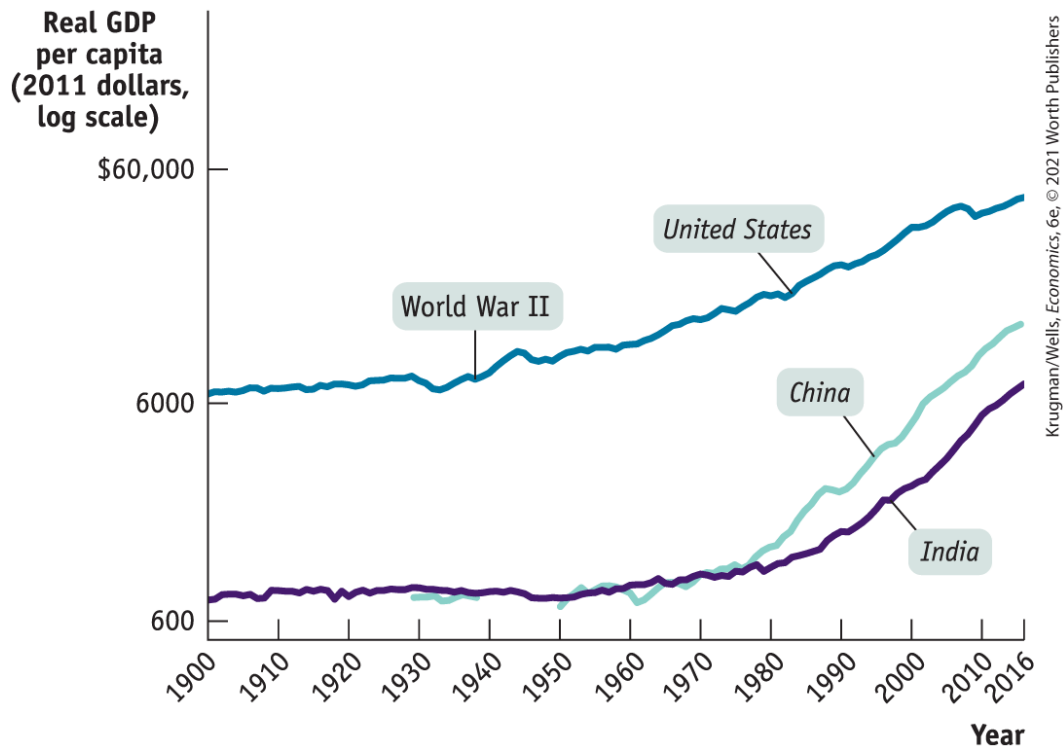
- Suppose the real GDP for Macronesia is \$200 million in 2010. Furthermore, suppose population in Macronesia is 100,000 in 2010. If population increases to 105,000 in 2011 while GDP increases by 5%, then it must be true that real GDP per capita in Macronesia in 2011:
 - a) increased.
 - b) decreased.
 - c) stayed constant.
 - d) may have increased, decreased, or remained constant.

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COMPARING ECONOMIES ACROSS TIME AND SPACE

- Since 1980 India and China had a much higher growth rate than the United States.
- The standard of living achieved in the United States in 1900 was attained by China in 2000 and by India in 2016.



U.S. REAL GDP PER CAPITA

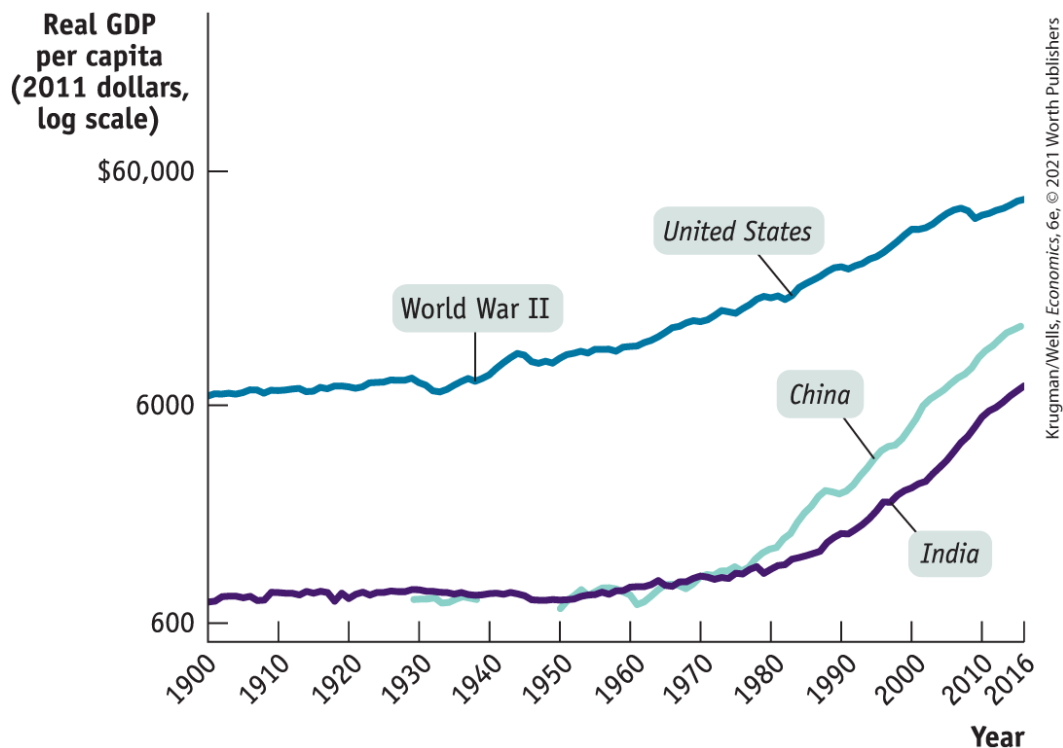
- The U.S. economy produces almost eight times as much per person as in 1900.

Table 9-1: U.S. Real GDP per Capita

Year	Percentage of 1900 real GDP per capita	Percentage of 2016 real GDP per capita
1900	100%	12%
1920	136	16
1940	181	21
1980	474	56
2000	734	87
2016	848	100

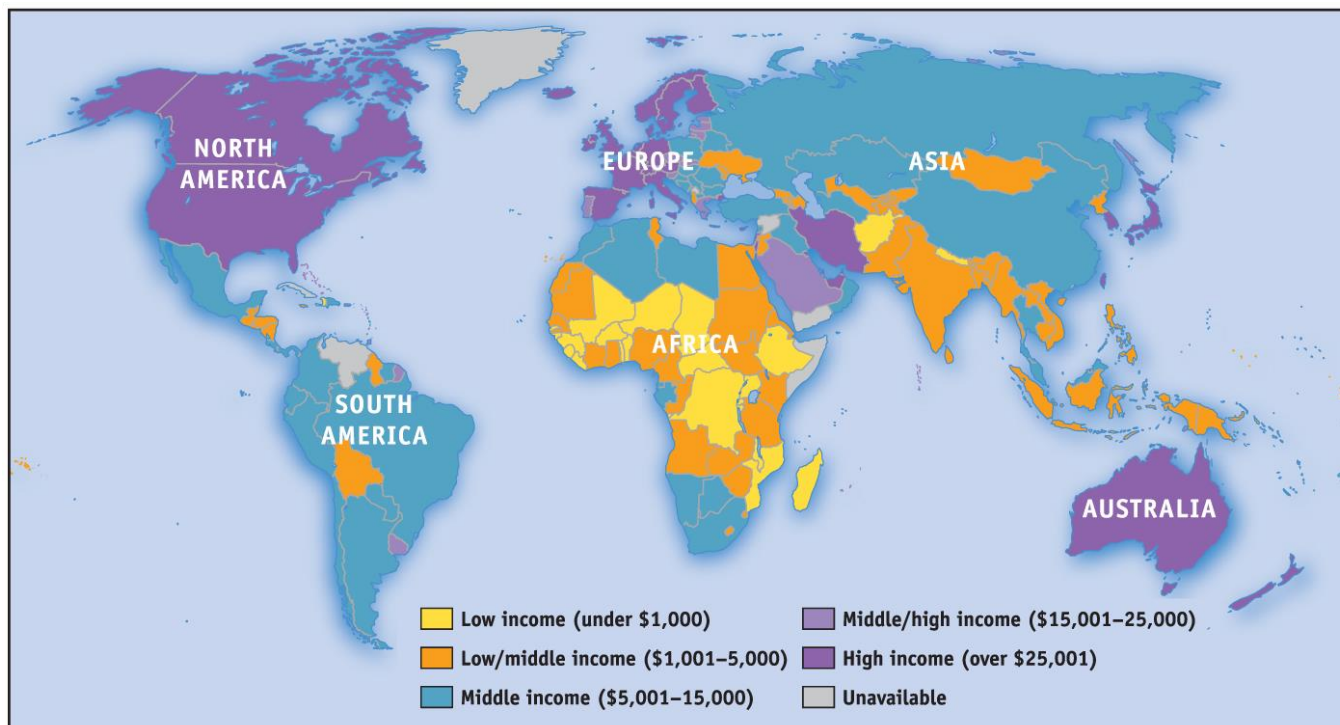
COMPARING ECONOMIES ACROSS TIME AND SPACE

- Despite the dramatic economic growth in China over the last three decades and the less dramatic acceleration of economic growth in India, China has only recently exceeded the standard of living that the US enjoyed in the early twentieth century, while India is still poorer than the US was at that time.



INCOMES AROUND THE WORLD, 2018

- The United States has grown quickly, while some nations have stalled.
- A quarter of the world's population lives in countries where the standard of living is lower than it was in the United States in 1900.



GROWTH RATES

- How did the United States manage to produce over eight times as much real GDP per person in 2019 than in 1900?
- It's a gradual process when real GDP per capita grows a few percent per year.
- It's helpful to use the **Rule of 70** that tells us how long it takes for a variable to double:

$$\text{Number of years for variable } X \text{ to double} = \frac{70}{\text{Annual growth rate of } X}$$

GROWTH RATES

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- Example: If real GDP per capita is growing at an annual growth rate of 3.5%, it will double in $70/3.5 = 20$ years.
- Small improvements in growth add up fast due to the power of compounding.

LEARN BY DOING: PRACTICE QUESTION 2

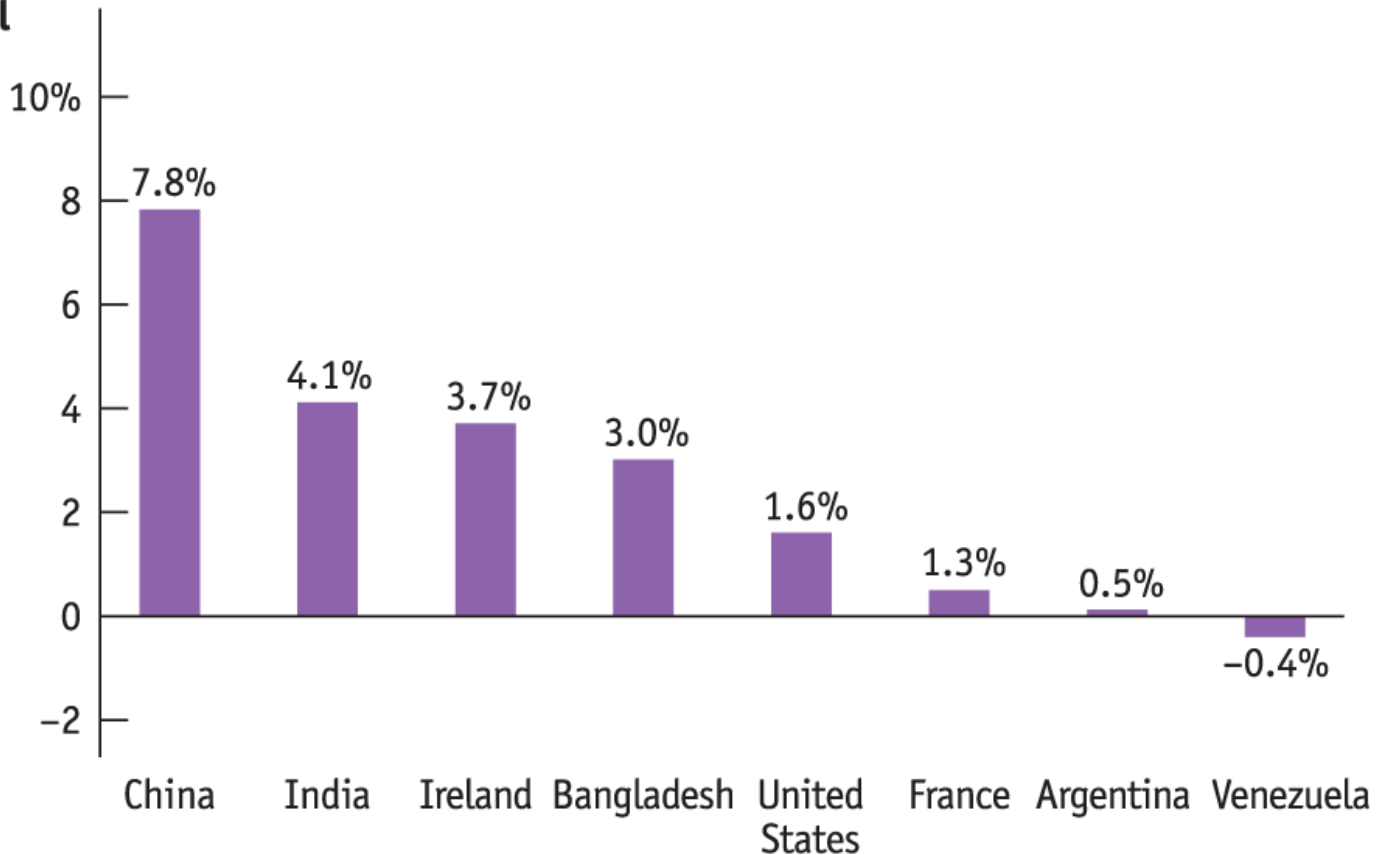
- Let's figure out how long it will take for the average Indian to be as wealthy as the average Western European is today. *Note that all numbers are adjusted for inflation.*
- India's GDP per capita is \$3,000, and let's assume real output per person grows at 5% per year. Using the rule of 70, how many years will it take for India to reach Italy's current level of GDP per capita, about \$24,000 per year?
 - a) 42 years
 - b) 14 years
 - c) 28 years
 - d) 12 years

LEARN BY DOING: PRACTICE QUESTION 2

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 - a) 42 years (correct answer)**
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 - d) 12 years

COMPARING RECENT GROWTH RATES

Average annual growth rate of real GDP per capita, 1980–2018



India Takes off

- India achieved independence from Great Britain in 1947, becoming the world's most populous democracy
- For more than three decades after independence, however, the happy political story was overshadowed by economic disappointment
- In 1980, India's real GDP per capita was only about 50% higher than it had been in 1947
- Since then, India has done much better. From 1980 to 2020 real GDP per capita has grown at an average rate of 4.2% a year
- What went right after 1980?
- Many economists point to policy reforms. For decades after independence, India had a highly regulated economy
- A series of reforms opened the economy to international trade and freed up domestic competition.

THE SOURCES OF LONG-RUN GROWTH

- Long-run economic growth depends on one ingredient: rising productivity.
- Sustained economic growth occurs only when the amount of output produced by the average worker increases steadily.
- **Labor productivity** (often called productivity): output per worker.
- Productivity is simply real GDP divided by the number of people working.
- What leads to higher productivity?

EXPLAINING GROWTH IN PRODUCTIVITY

- Why does the average worker today produce far more a century ago? Modern workers have more physical capital, are better educated, and take advantage of a century's technological progress.
- Three sources of productivity growth:
 1. **Increase in physical capital**
 2. **Increase in human capital**
 3. **Technological progress**

EXPLAINING GROWTH IN PRODUCTIVITY

1. Increase in physical capital

- Economists define physical capital as manufactured resources, such as buildings and machines. Physical capital makes workers more productive. For example, a worker operating a back-hoe can dig a lot more feet of trench per day than one equipped only with a shovel.

2. Increase in human capital

- It is not enough for a worker to have good equipment- he or she must also know what to do with it. **Human capital:** the improvement in labor created by the education and knowledge embodied in the workforce. Analysis based on growth accounting suggest that education – and its effect on productivity – is an even more important determinant of growth than increases in physical capital.

EXPLAINING GROWTH IN PRODUCTIVITY

3. Technological progress: an advance in technical means of production of goods and services.

- Workers today are able to produce more than those in the past, even with the same amount of physical and human capital, because technology has advanced over time.
- Historians have noted that past economic growth has been driven not only by major inventions, such as the railroad or the semiconductor chip, but also by thousands of modest innovations, such as the flat-bottomed paper bag or the Post-it
- https://www.ted.com/talks/hans_rosling_the_magic_washing_machine/transcript

THE AGGREGATE PRODUCTION FUNCTION

- Productivity is higher, other things equal, when workers are equipped with more physical capital, human capital, better technology, or any combination of the three.
- But, can we put numbers to these effects? How much does output change when we change inputs?
- **Aggregate production function:** a hypothetical function that shows how productivity (real GDP per worker) depends on the quantities of physical capital per worker, human capital per worker, and technology.

THE AGGREGATE PRODUCTION FUNCTION

- Example of aggregate production function
- Comparative study of Chinese and Indian economic growth by the economists Barry Bosworth and Susan Collins of the Brookings Institution.

$$\text{GDP per worker} = T \times (\text{Physical capital per worker})^{0.4} \times (\text{Human capital per worker})^{0.6}$$

where T is an estimate of the level of technology, and human capital is years of education.

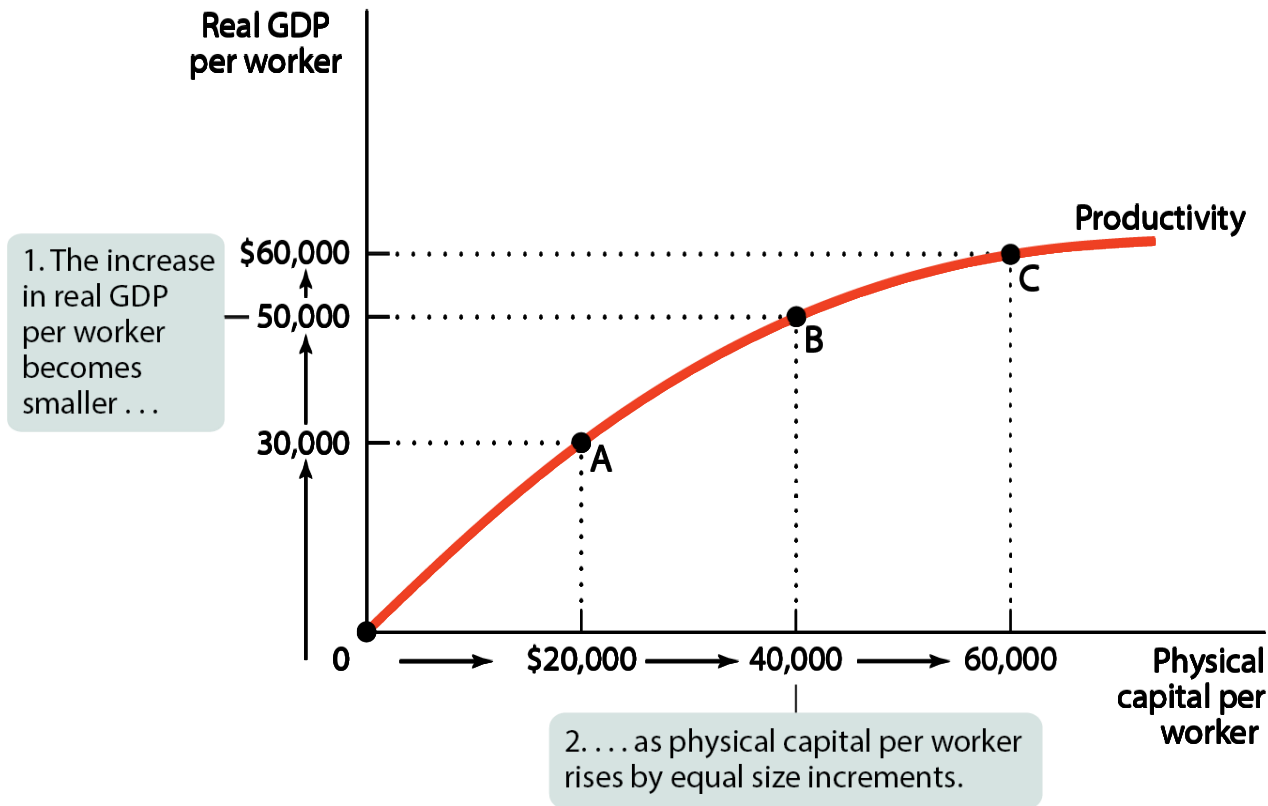
THE AGGREGATE PRODUCTION FUNCTION

- They assumed that each year of education raises workers' human capital by 7%.
- Using this function, they tried to explain why China grew faster than India between 1978 and 2004.
- They found that half of the difference was due to China's higher levels of investment spending, which raised its level of physical capital per worker faster than India's.
- The other half was due to faster Chinese technological progress.

THE AGGREGATE PRODUCTION FUNCTION

- Aggregate production function exhibits **diminishing returns to physical capital**:
 - When the amount of human capital per worker and the state of technology are held fixed, each successive increase in the amount of physical capital per worker leads to a smaller increase in productivity
 - For example, a second computer improves one's productivity, but not by as much as the first computer did.

PHYSICAL CAPITAL AND PRODUCTIVITY



Physical capital per worker	Real GDP per worker
\$ 0	\$ 0
20,000	30,000
40,000	50,000
60,000	60,000

THE AGGREGATE PRODUCTION FUNCTION

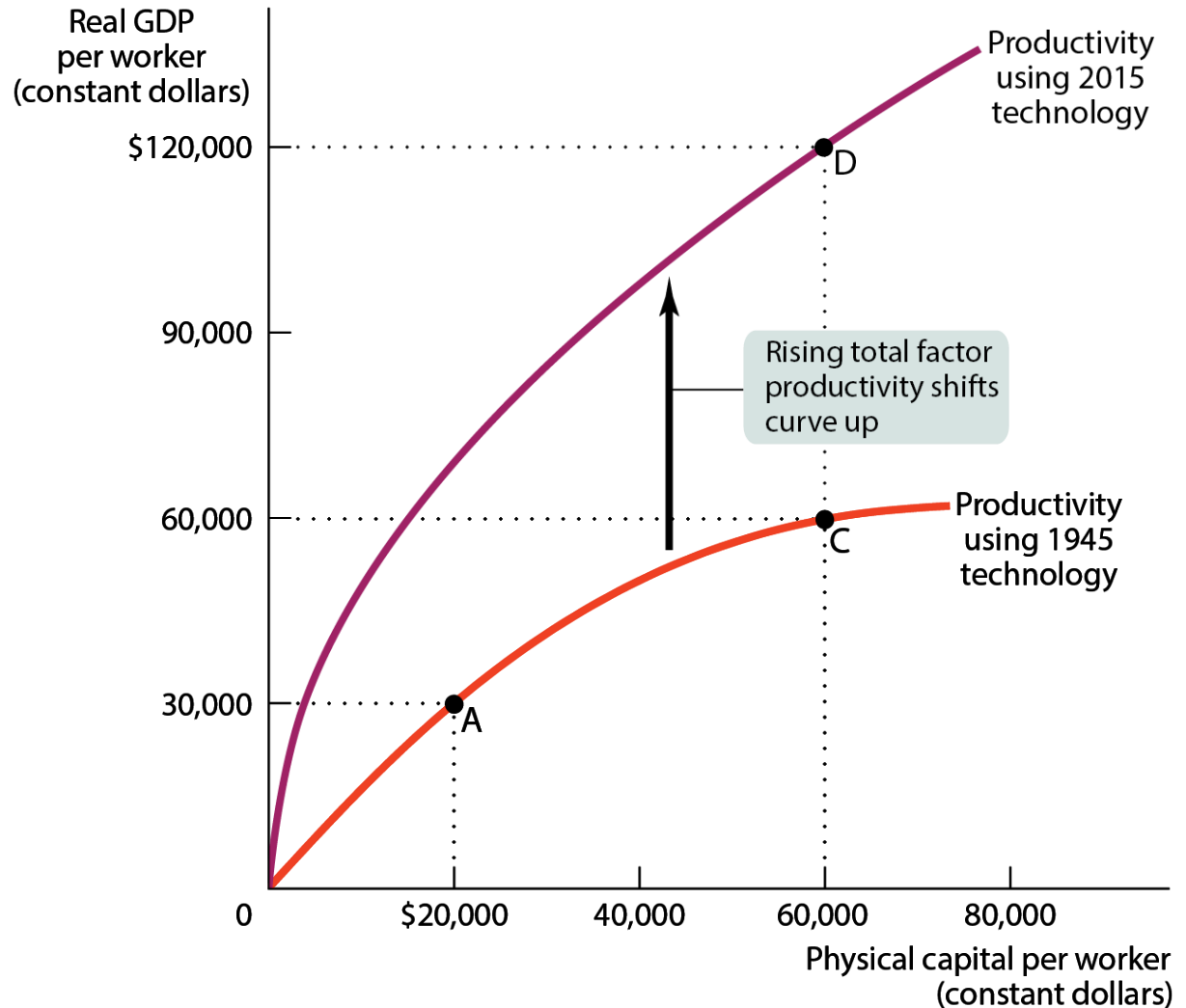
- Diminishing returns is an “other things equal” phenomenon: it holds true **when the amount of human capital per worker and the technology are held fixed.**
- Diminishing returns may disappear if we increase the amount of human capital per worker, or improve the technology, or both.
- In practice, all the factors contributing to higher productivity rise over time: both physical capital and human capital per worker increase, and technology advances as well.

GROWTH ACCOUNTING

- **Growth accounting:** estimates of the contribution of each major factor in the aggregate production function to economic growth
- **Total factor productivity:** the amount of output that can be produced with a given amount of factor inputs
- When total factor productivity increases, the economy can produce more output with the same quantity of physical capital, human capital, and labor.

TECHNOLOGICAL PROGRESS AND PRODUCTIVITY GROWTH

Technological progress raises productivity and shifts the aggregate production function upward.



GROWTH ACCOUNTING

- Increases in total factor productivity are central to economic growth.
- Technological progress drives increases in total factor productivity.
- According to the Bureau of Labor Statistics, over the period from 1948 to 2019 American labor productivity rose 2.1% per year.
- 49% of that rise is explained by increases in physical and human capital per worker; the rest is explained by rising total factor productivity—by technological progress.

WHAT ABOUT NATURAL RESOURCES?

- Natural resources certainly influence productivity, but in the modern world, they are less important than human or physical capital.
- Japan, for example, has very few natural resources but very high real GDP per capita. Nigeria is a resource-rich nation but low real GDP per capita.

WHY GROWTH RATES DIFFER

Rapidly growing economies excel at:

1. savings and investment spending.
2. education.
3. research and development.

WHY GROWTH RATES DIFFER

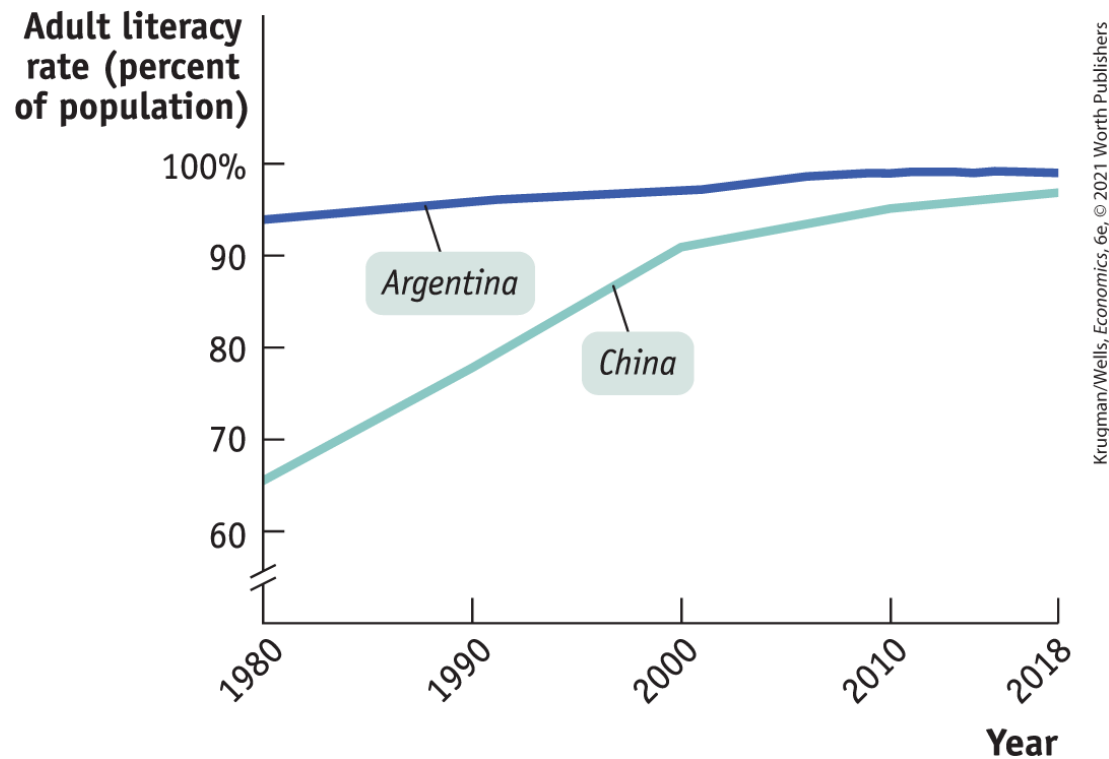
Saving and Investment Spending

- In 2019, investment spending was 43% of China's GDP, compared with only 21% in the United States.
- Money for investment spending comes from savings. Countries that have high investment spending do so because they have high domestic savings.

WHY GROWTH RATES DIFFER

Education

- China's success at adding human capital is one key to its spectacular long-run growth.



WHY GROWTH RATES DIFFER

Research and development (R&D): spending to create and implement new technologies

- Scientific advances make new technologies possible. R&D translates scientific knowledge into useful products and processes.
- U.S. businesses were among the first to adopt R&D: in 1875, Thomas Edison created the first modern industrial research laboratory.

Endogenous Economic Growth Model

- Until the 1990s, economic models of technological progress assumed that what drove innovation was a mystery – unknown and unpredictable.
- Starting with the work of Robert Solow (nobel price in Economics in 1987), many economists believed that the sources of technological progress were exogenous.
- Then, in a series of influential papers written in the 1980s and 1990s, Paul Romer (nobel price in Economics in 2018) founded what we now call “the New Growth Theory”.
- In Romer’s model, technological progress was explainable because it was in fact endogenous – the outcome of economic variables and incentives.
- Because technological progress was endogenous, **policies could be adopted to foster its growth.**

Endogenous Economic Growth Model

- At any point in time, an economy has a stock of knowledge capital – the accumulated knowledge generated by past investments in research and development, education, and skill enhancement, as well as knowledge acquired from other economies.
- That stock of capital is spread throughout the economy, so all firms benefit from it.
- According to the New Growth Theory, a rising stock of knowledge capital, creates the foundation for further technological progress as innovation, shared by firms throughout the economy, and makes further innovation possible.

Endogenous Economic Growth Model

- As Romer pointed out, there is a severe wrinkle in this story: because knowledge is shared throughout the economy, it may be very difficult for an innovator to capture the rewards of his or her innovation as others exploit the innovation for their own interests.
- In the New Growth Theory, **government protection of intellectual property rights is critical to furthering technological progress.**
- In addition, governments, institutions, and firms can enhance technological progress by subsidizing investments in education and research and development, which in turn, can increase the stock of knowledge capital.
- The New Growth Theory makes clear how important the policies of government, institutions and firms are in fostering technological progress.

THE ROLE OF GOVERNMENT IN PROMOTING ECONOMIC GROWTH

- Government policies can increase the economy's growth rate through the following six channels:
 1. Government subsidies to infrastructure
 - **Infrastructure:** roads, power lines, ports, information networks, and other underpinnings for economic activity
 - China spends more on infrastructure than Western Europe and North America combined.
 2. Government subsidies to education
 - Literacy in China has been increasing more rapidly than in Argentina. This isn't because China is richer than Argentina; it's because the Chinese government has made education a priority.

THE ROLE OF GOVERNMENT IN PROMOTING ECONOMIC GROWTH

3. Government subsidies to R&D

- For example, the internet grew out of the Advanced Research Projects Agency Network (ARPANET), created by the U.S. Department of Defense.

4. Maintaining a well-functioning financial system

- If people distrust banks, they'll keep gold or cash in safe deposit boxes or under the mattress, where it cannot be turned into productive investment spending.

THE ROLE OF GOVERNMENT IN PROMOTING ECONOMIC GROWTH

5. Protection of property rights

- **Property rights** are the legal rights held by owners of valuable items to dispose of those items as they choose.
- **Intellectual property rights** are the rights of innovators to accrue the rewards of their innovations.
- Generally, governments protect intellectual property rights by giving **patents** (government-created temporary monopolies given to innovators for the use or sale of their innovations).

THE ROLE OF GOVERNMENT IN PROMOTING ECONOMIC GROWTH

6. Political stability and good governance

- There's not much point in investing in a business if rioting mobs are likely to destroy it.
- Economic success of the United States has been possible because there are good laws, institutions that enforce those laws, and a stable political system that maintains those institutions.

EAST ASIA'S MIRACLE

- It took South Korea only 35 years to achieve growth that required centuries elsewhere.
- Since 1975, the East Asian region has increased real GDP per capita by 6% per year, more than three times America's historical rate of growth.
- How have the Asian countries achieved such high growth rates?
 - **Very high savings rates** allow businesses to borrow and add more physical capital per worker.
 - **Very good basic education** has permitted a rapid improvement in human capital.
 - **Substantial technological progress**

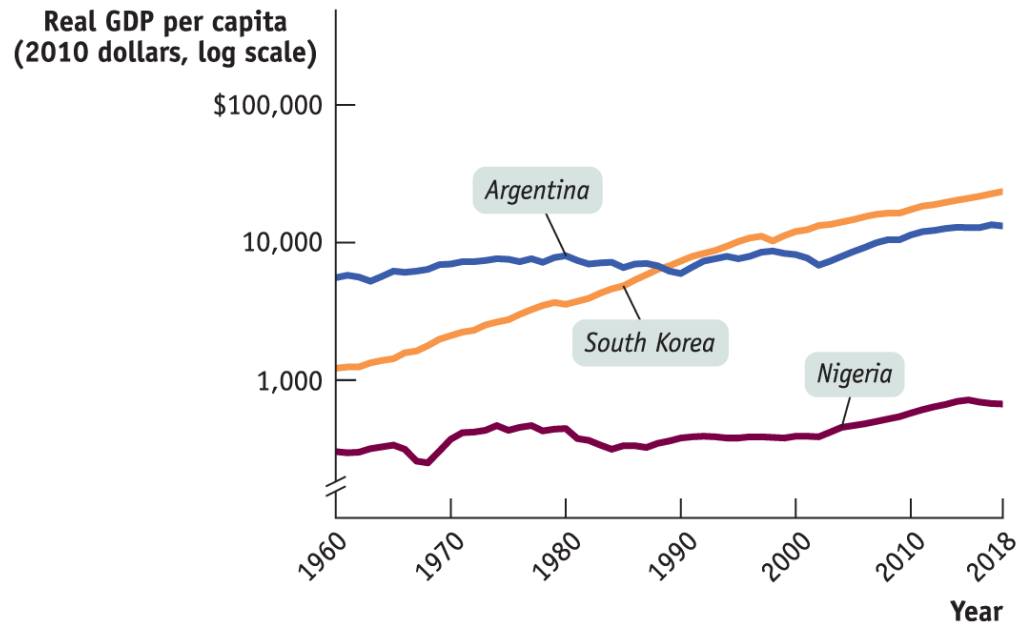
EAST ASIA'S MIRACLE

- Economic growth can be especially fast in countries that are playing catch-up to countries with higher GDP per capita.
- East Asian economies grew fast because they adopted the technologies that already existed.
- **The convergence hypothesis:** differences in real GDP per capita among countries tend to narrow over time
- But having a low real GDP per capita is no guarantee of rapid growth, as the examples of Latin America and Africa demonstrate.

LATIN AMERICA'S DISAPPOINTMENT

What's holding Argentina (and other Latin American nations) back?

- Irresponsible government action that eroded savings through high inflation
- Lack of emphasis on education
- Political instability

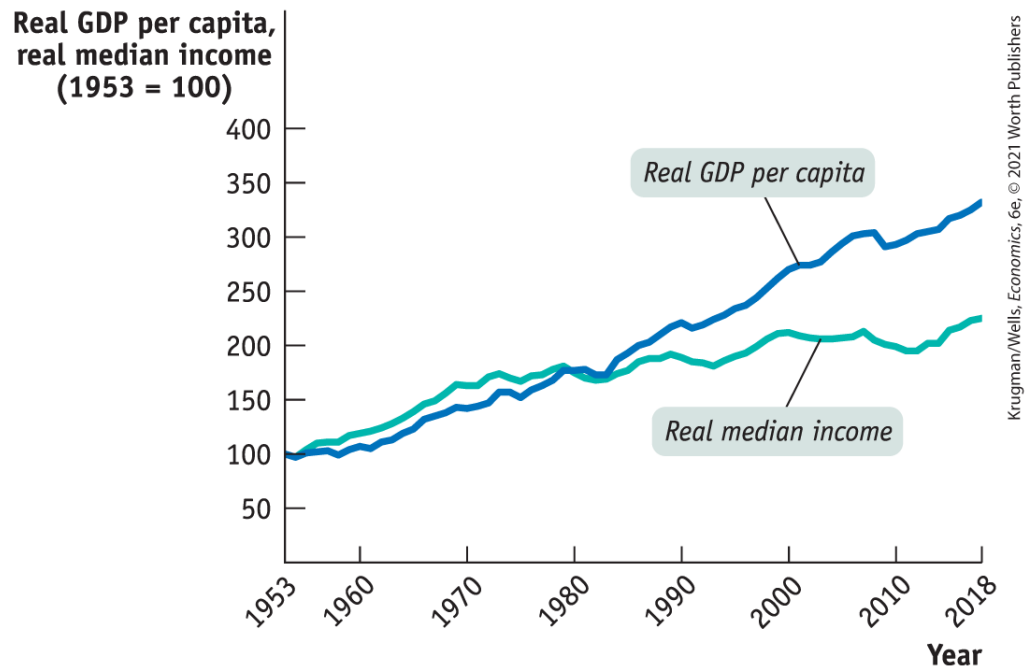


AFRICA'S TROUBLES AND PROMISE

- What's holding much of Africa back?
 - Government corruption
 - Civil wars and political instability
 - Unfavorable geography
- Is Africa poor because it's politically unstable or unstable because it's poor?
- *Good news: Growth rates are up in sub-Saharan African nations since 2011.*

LEFT BEHIND BY GROWTH?

- Historically, rising real GDP per capita has translated into real income for most people. This is less and less true in the United States.
- A growing share of income went to a few people at the top.
- Two qualifications: economic growth still raises the standard of living of the great majority of the population and gives rise to a global middle class.



LEARN BY DOING: PRACTICE QUESTION 3

- Economic growth can be especially fast:
 - a) for countries playing catch-up with countries that already have high real GDP per capita.
 - b) for relatively poor countries if the convergence hypothesis holds true.
 - c) if the country is able to benefit from adopting the technological advances already used in advanced countries.
 - d) Answers (a), (b), and (c) are all true.

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IS WORLD GROWTH SUSTAINABLE?

- **Sustainable long-run economic growth:** long-run growth that can continue in the face of the limited supply of natural resources and the impact of growth on the environment

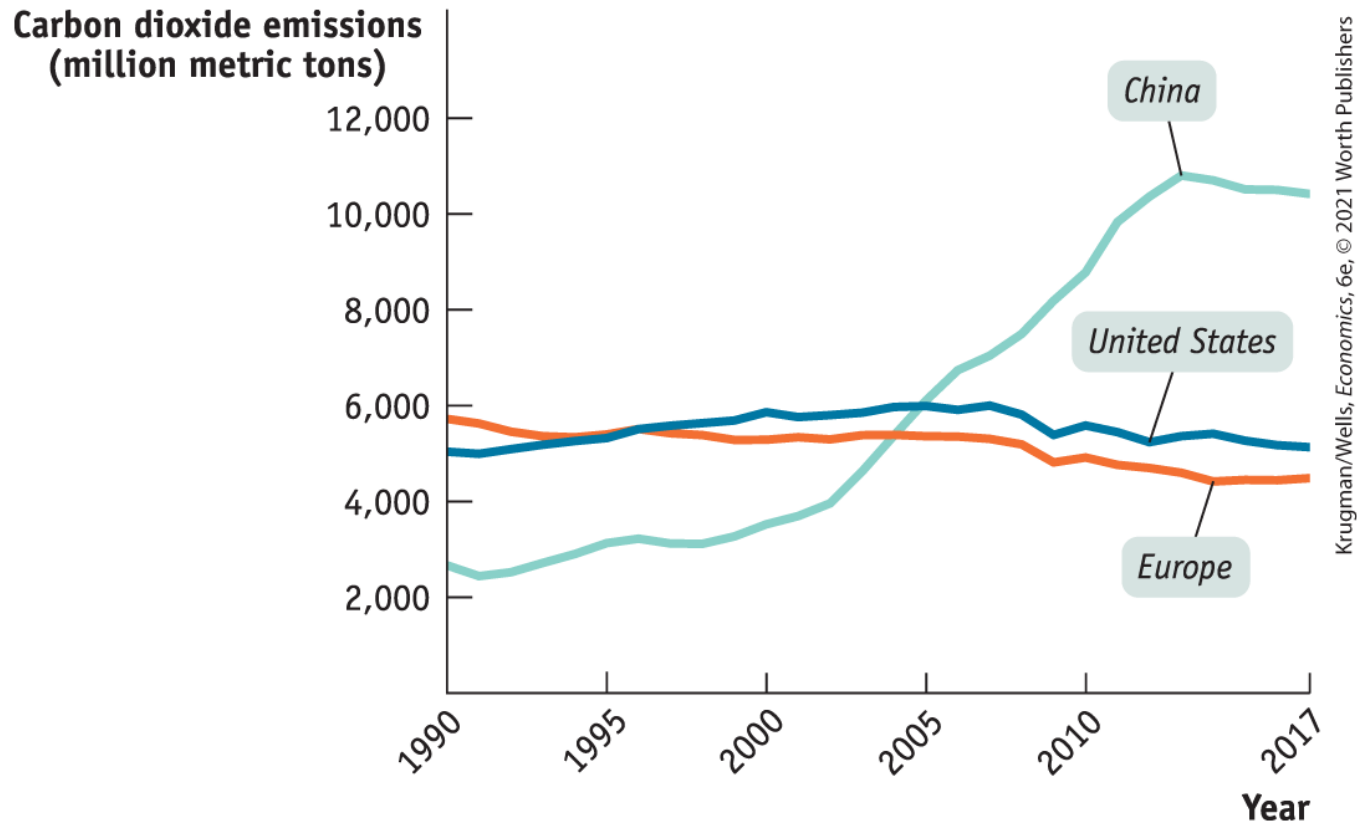
NATURAL RESOURCES AND GROWTH, REVISITED

- “Neo-Malthusian” theories claim that economic growth will be severely limited by lack of resources.
- Economists believe that modern economies handle scarcity fairly well.
- Resource scarcity leads to high prices, and these high prices provide strong incentives to conserve the resource and find alternatives.
 - For example, after the sharp oil price increases of the 1970s, U.S. consumers turned to smaller, more fuel-efficient cars.

ECONOMIC GROWTH AND THE ENVIRONMENT

- Economic growth tends to have the adverse impact on the environment: pollution, loss of wildlife habitats, extinction of species, and reduced biodiversity.
- There's **local environmental degradation** and **global environmental degradation**.
- It's easier to reduce local environmental harm and it's more difficult to address global environmental degradation, in particular, the problem of **climate change**.

CLIMATE CHANGE AND GROWTH



- The United States and Europe have historically been responsible for the great bulk of carbon dioxide emissions.
- As China and other emerging economies have grown, they began to emit much more carbon dioxide.

ECONOMIC GROWTH AND THE ENVIRONMENT

- **Climate change:** changes in Earth's climate brought about by human activity
- Unmitigated climate change will cost 20% of world gross domestic product by 2100. Moreover, these costs tend to fall more heavily on poor countries.
- Climate change is been a hard problem to solve because it requires the cooperation of many countries.
- **Paris Agreement of 2015:** 196 countries agreed to reduce their greenhouse gas emissions in an effort to limit the rise in Earth's temperature to no more than 2 degrees Celsius.
- China and India agreed to limit their emissions, and the rich countries committed to help poorer countries pay the cost.
- The Trump administration announced plans for the United States to withdraw from the agreement in November 2020.
- The Biden administration re-entered the agreement in 2021.



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