Economic Growth in Macroeconomic Models

What you will learn in this Module:

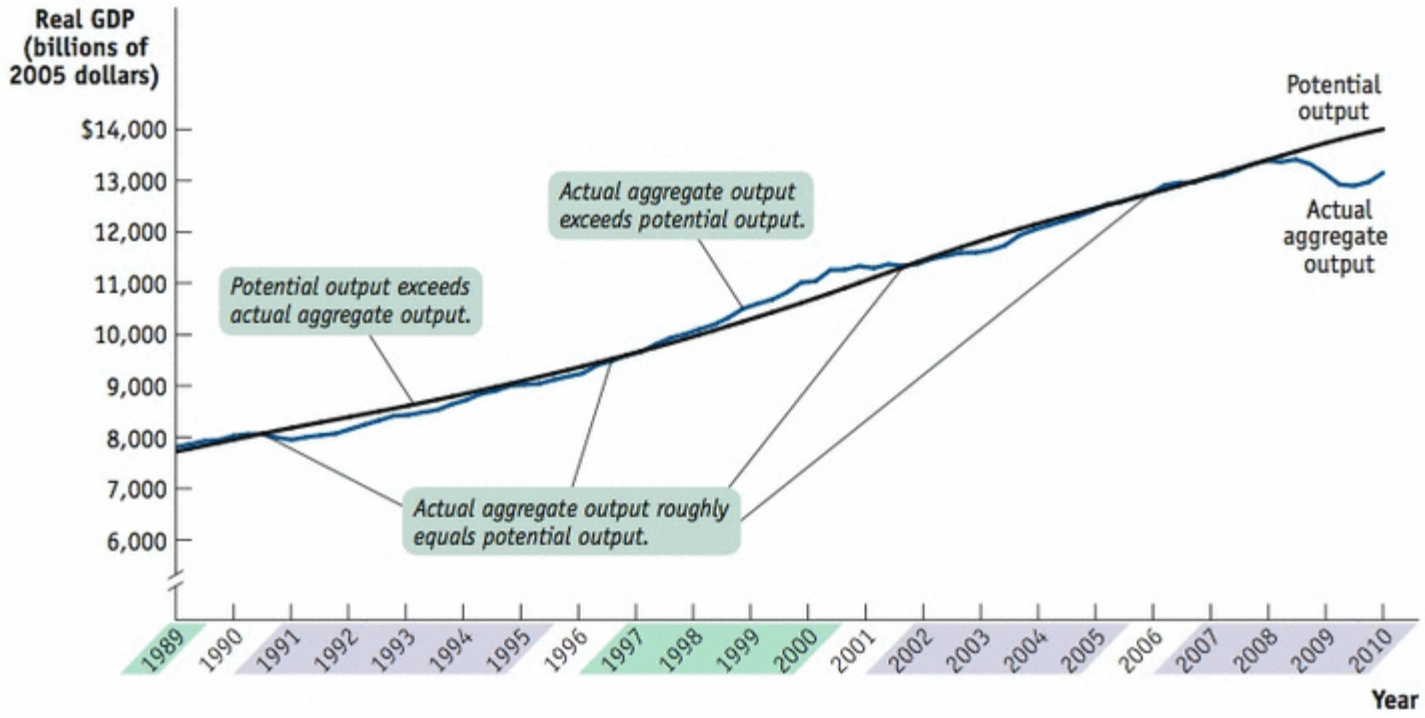
- How long-run economic growth is represented in macroeconomic models
- How to model the effects of economic growth policies

Long-run economic growth is fundamental to solving many of today's most pressing economic problems. It is even more critical in poorer, less developed countries. But the policies we have studied in earlier sections to address short-run fluctuations and the business cycle may not encourage long-run economic growth. For example, an increase in household consumption can help an economy to recover from a recession. However, when households increase consumption, they decrease their savings, which leads to decreased investment spending and slows long-run economic growth.

In addition to understanding short-run stabilization policies, we need to understand the factors that influence economic growth and how choices by governments and individuals can promote or retard that growth in the long-run.

Long-run economic growth is the sustained rise in the quantity of goods and services the economy produces, as opposed to the short-run ups and downs of the business cycle. In **Module 18**, we looked at actual and potential output in the United States from 1989 to 2009. As shown in **Figure 40.1**, increases in potential output during that time represent long-run economic growth in the economy. The fluctuations of actual output compared to potential output are the result of the business cycle.

figure 40.1 Actual and Potential Output from 1989 to 2009



This figure shows the performance of actual and potential output in the United States from 1989 to 2009. The black line shows estimates, produced by the Congressional Budget Office, of U.S. potential output. The blue line shows actual aggregate output. The purple-shaded years are periods in which actual aggregate output fell below potential output, and the green shaded years are periods in which actual aggregate output exceeded potential output. As shown, significant shortfalls occurred in the recessions of the early 1990s and after 2000. Actual aggregate output was significantly above potential output in the boom of the late 1990s.

Sources: Congressional Budget Office, Bureau of Economic Analysis.

As we have seen throughout this section, long-run economic growth depends almost entirely on rising productivity. Good macroeconomic policy strives to foster increases in productivity, which in turn leads to long-run economic growth. In this module, we will learn how to evaluate the effects of long-run growth policies using the production possibilities curve and the aggregate demand and supply model.

◀ Module 40: Economic Growth in Macroecono... ▶

Long-run Economic Growth and the Production Possibilities Curve

Recall from **Section 1** that we defined the production possibilities curve as a graph that illustrates the trade-offs facing an economy that produces only two goods. In our example, we developed the production possibilities curve for Tom, a castaway facing a trade-off between producing fish and coconuts. Looking at **Figure 40.2**, we see that economic growth is shown as an outward shift of the production possibilities curve. Now let's return to the production possibilities curve model and use a different example to illustrate how economic growth policies can lead to long-run economic growth.

figure 40.2

Economic Growth

Economic growth results in an *outward shift* of the production possibilities curve because production possibilities are expanded. The economy can now produce more of everything. For example, if production is initially at point *A* (20 fish and 25 coconuts), it could move to point *E* (25 fish and 30 coconuts).

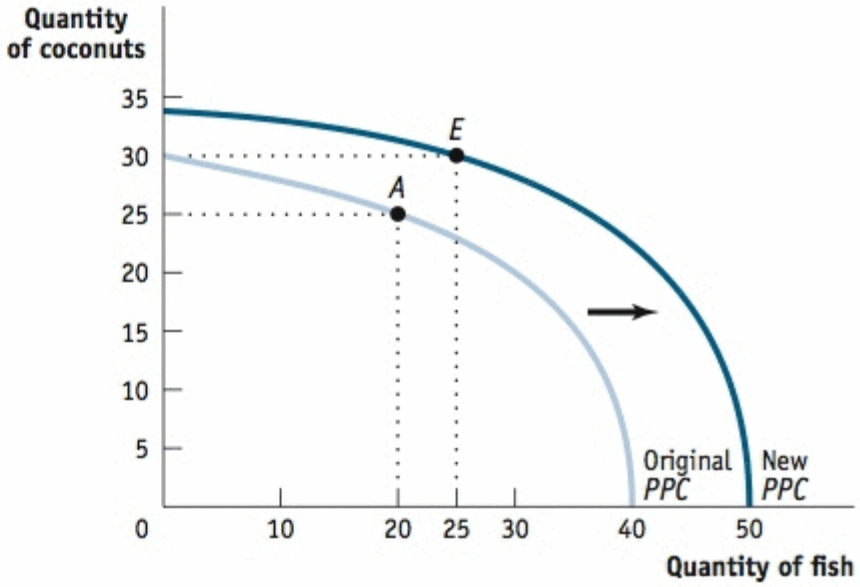
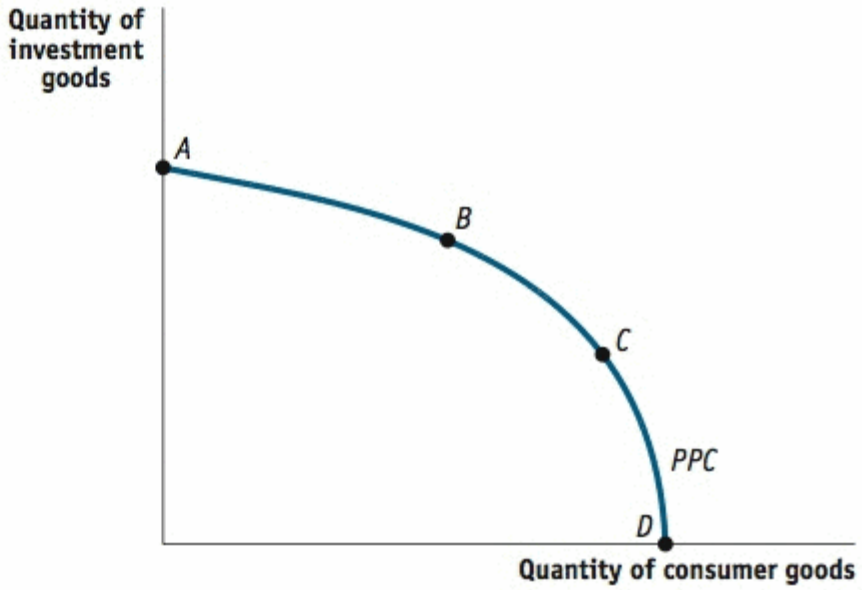


Figure 40.3 shows a hypothetical production possibilities curve for a fictional country we'll call Kyland. In our previous production possibilities examples, the trade-off was between producing quantities of two different goods. In this example, our production possibilities curve illustrates Kyland's trade-off between two different *categories* of goods. The production possibilities curve shows the alternative combinations of investment goods and consumer goods that Kyland can produce. The consumer goods category includes everything purchased for consumption by households, such as food, clothing, and sporting goods. Investment goods include all forms of physical capital. That is, goods that are used to produce other goods. Kyland's production possibilities curve shows the trade-off between the production of consumer goods and the production of investment goods. Recall that the bowed-out shape of the production possibilities curve reflects increasing opportunity cost.

figure 40.3

The Trade-off Between Investment and Consumer Goods

This production possibilities curve illustrates Kyland's trade-off between the production of investment goods and consumer goods. At point *A*, Kyland produces all investment goods and no consumer goods. At point *D*, Kyland produces all consumer goods and no investment goods.



Kyland's production possibilities curve shows all possible combinations of consumer and investment goods that can be produced with full and efficient use of all of Kyland's resources. However, the production possibilities curve model does not tell us which of the possible points Kyland *should* select.

Figure 40.3 illustrates four points on Kyland's production possibilities curve. At point *A*, Kyland is producing all investment goods and no consumer goods. Investment in physical capital, one of the economy's factors of production, causes the production possibilities curve to shift outward. Choosing to produce at a point on the production possibilities curve that creates more capital for the economy will result in greater production possibilities in the future. Note that at point *A*, there are no consumer goods being produced, a situation which the economy cannot survive.

Depreciation occurs when the value of an asset is reduced by wear, age, or obsolescence.

At point *D*, Kyland is producing all consumer goods and no investment goods. While this point provides goods and services for consumers in Kyland, it does not include the production of any physical capital. Over time, as an economy produces more goods and services, some of its capital is used up in that production. A loss in the value of physical capital due to wear, age, or obsolescence is called **depreciation**. If Kyland were to produce at point *D* year after year, it would soon find its stock of physical capital depreciating and its production possibilities curve would shift inward over time, indicating a decrease in production possibilities. Points *B* and *C* represent a mix of consumer and investment goods for the economy. While we can see that points *A* and *D* would not be acceptable choices over a long period of time, the choice between points *B* and *C* would depend on the values, politics, and other details related to the economy and people of Kyland. What we do know is that the choice made by Kyland each year will affect the position of the production possibilities curve in the future. An emphasis on the production of consumer goods will make consumers better off in the short run but will prevent the production possibilities curve from moving farther out in the future. An emphasis on investment goods will lead the production possibilities curve to shift out farther in the future but will decrease the quantity of consumer goods available in the short run.

Investments in capital help the economy reach new heights of productivity. © Rosenfeld/Corbis

So what does the production possibilities curve tell us about economic growth? Since long-run economic growth depends almost entirely on rising productivity, a country's decision regarding investment in physical capital, human capital, and technology affects its long-run economic growth.

Governments can promote long-run economic growth, shifting the country's production possibilities curve outward over time, by investing in physical capital such as infrastructure. They can also encourage high rates of private investment in physical capital by promoting a well-functioning financial system, property rights, and political stability.

Long-run Economic Growth and the Product...

Long-run Economic Growth and the Aggregate Demand-Aggregate Supply Model

The aggregate demand and supply model we developed in **Section 4** is another useful tool for understanding long-run economic growth. Recall that in the aggregate demand-aggregate supply model, the long-run aggregate supply curve shows the relationship between the aggregate price level and the quantity of aggregate output supplied when all prices, including nominal wages, are flexible. As shown in **Figure 40.4**, the long-run aggregate supply curve is vertical at the level of potential output. While actual real GDP is almost always above or below potential output, reflecting the current phase of the business cycle, potential output is the level of output around which actual aggregate output fluctuates. Potential output in the United States has risen steadily over time. This corresponds to a rightward shift of the long-run aggregate supply curve, as shown in **Figure 40.5**. Thus, the same government policies that promote an outward shift of the production possibilities curve promote a rightward shift of the long-run aggregate supply curve.

figure 40.4

The Long-run Aggregate Supply Curve

The long run aggregate supply curve shows the quantity of aggregate output supplied when all prices, including nominal wages, are flexible. It is vertical at potential output, Y_P, because in the long run a change in the aggregate price level has no effect on the quantity of aggregate supplied.

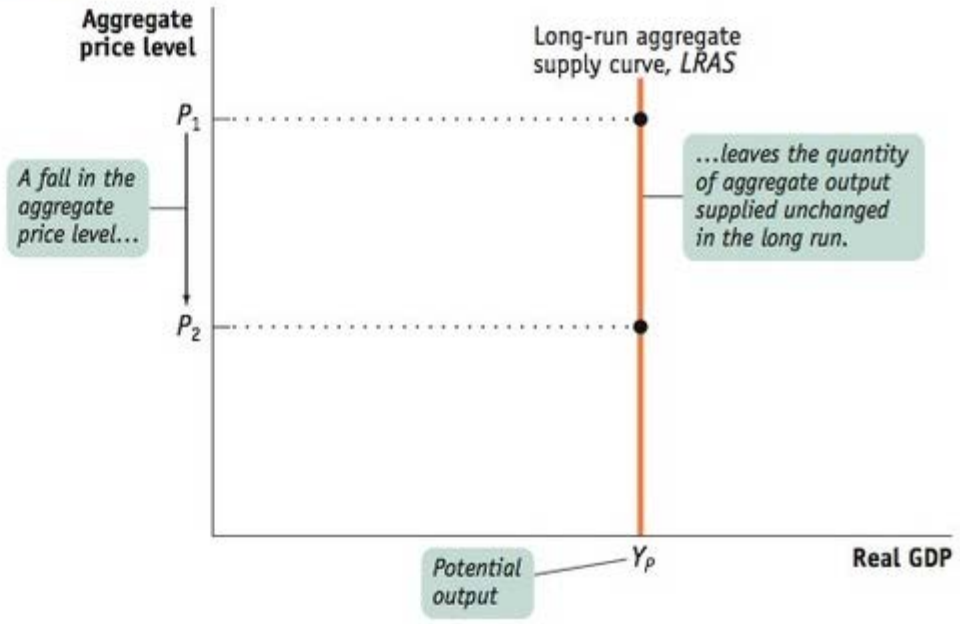
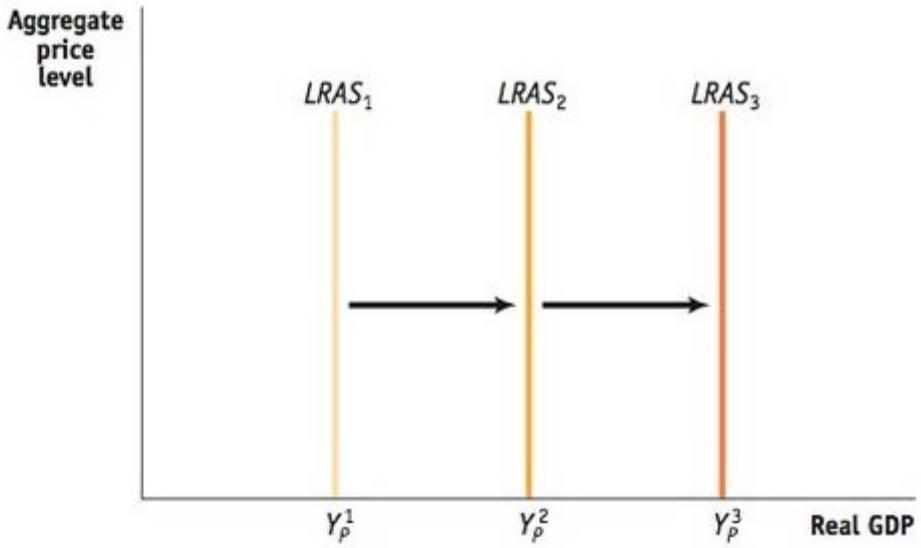


figure 40.5

Long-run Growth and the LRAS Curve

The growth in potential output over time can be shown as a rightward shift of the long-run aggregate supply curve.



Long-run Economic Growth and the Aggrega...

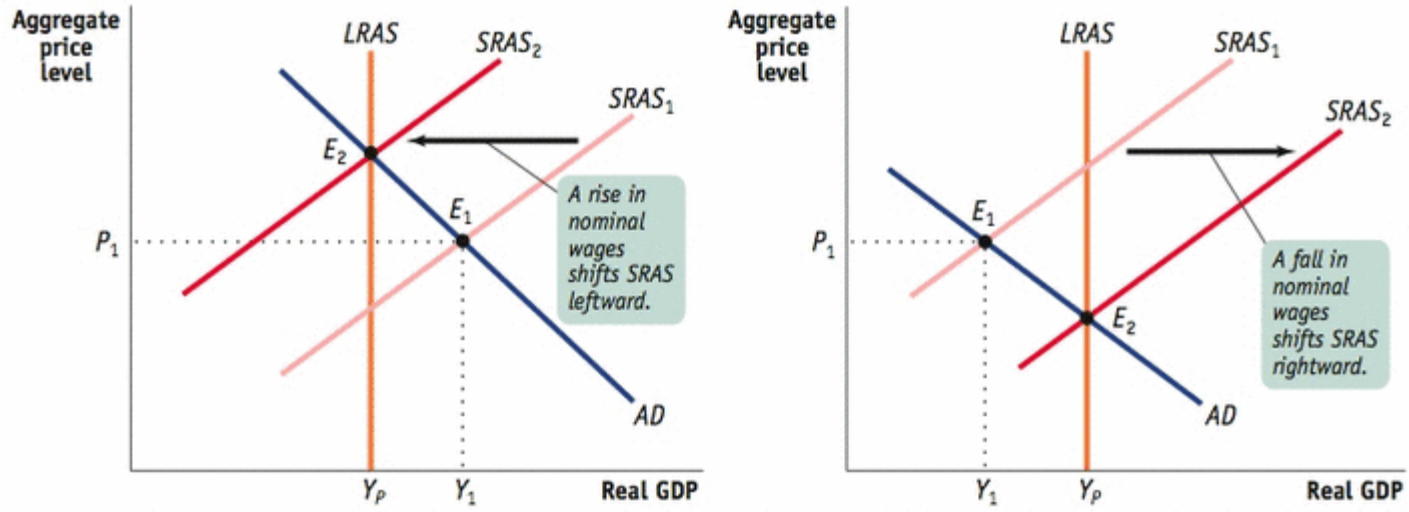
Distinguishing Between Long-run Growth and Short-run Fluctuations

When considering changes in real GDP, it is important to distinguish long-run growth from short-run fluctuations due to the business cycle. Both the production possibilities curve model and the aggregate demand-aggregate supply model can help us do this.

The points along a production possibilities curve are achievable if there is efficient use of the economy's resources. If the economy experiences a macroeconomic fluctuation due to the business cycle, such as unemployment due to a recession, production falls to a point inside the production possibilities curve. On the other hand, long-run growth will appear as an outward shift of the production possibilities curve.

In the aggregate demand-aggregate supply model, fluctuations of actual aggregate output around potential output are illustrated by shifts of aggregate demand or short-run aggregate supply that result in a short-run macroeconomic equilibrium above or below potential output. In both panels of **Figure 40.6**, E_1 indicates a short-run equilibrium that differs from long-run equilibrium due to the business cycle. In the case of short-run fluctuations like these, adjustments in nominal wages will eventually bring the equilibrium level of real GDP back to the potential level. By contrast, we saw in **Figure 40.5** that long-run economic growth is represented by a rightward shift of the long-run aggregate supply curve and corresponds to an increase in the economy's level of potential output.

figure 40.6 From the Short Run to the Long Run



In panel (a), the initial equilibrium is E_1. At the aggregate price level, P_1, the quantity of aggregate output supplied, Y_1, exceeds potential output, Y_P. Eventually, low unemployment will cause nominal wages to rise, leading to a leftward shift of the short-run aggregate supply curve from $SRAS_1$ to $SRAS_2$ and a long-run equilibrium at E_2. In panel (b), the reverse happens: at the short-run equilibrium, E_1, the quantity of aggregate output supplied is less than potential output. High unemployment eventually leads to a fall in nominal wages over time and a rightward shift of the short-run aggregate supply curve. The end result is long-run equilibrium at E_2.

Check Your Understanding

1. How are long-run economic growth and short-run fluctuations during a business cycle represented using the production possibilities curve model?

[Answer Field]

Show Answer

2. How are long-run economic growth and short-run fluctuations during a business cycle represented using the aggregate demand-aggregate supply model?

[Answer Field]

Show Answer

Tackle the Test: Multiple-Choice Questions

1. Which of the following will shift the production possibilities curve outward?

I. an increase in the production of investment goods
II. an increase in the production of consumer goods
III. technological progress

a. I only
b. II only
c. III only
d. I and III only
e. I, II, and III

[Answer Field]

Show Answer

2. In the production possibilities curve (PPC) model, long-run economic growth is shown by a(n)

a. outward shift of the PPC.
b. inward shift of the PPC.
c. movement from a point below the PPC to a point on the PPC.
d. movement from a point on the PPC to a point below the PPC.
e. movement from a point on the PPC to a point beyond the PPC.

[Answer Field]

Show Answer

3. The reduction in the value of an asset due to wear and tear is known as

a. depreciation.
b. negative investment.
c. economic decline.
d. disinvestment.
e. net investment.

[Answer Field]

Show Answer

4. In the aggregate demand-aggregate supply model, long-run economic growth is shown by a

a. leftward shift of the aggregate demand curve.
b. rightward shift of the aggregate demand curve.
c. rightward shift of the long-run aggregate supply curve.
d. rightward shift of the short-run aggregate supply curve.
e. leftward shift of the short-run aggregate supply curve.

[Answer Field]

Show Answer

5. Which of the following is listed among the key sources of growth in potential output?

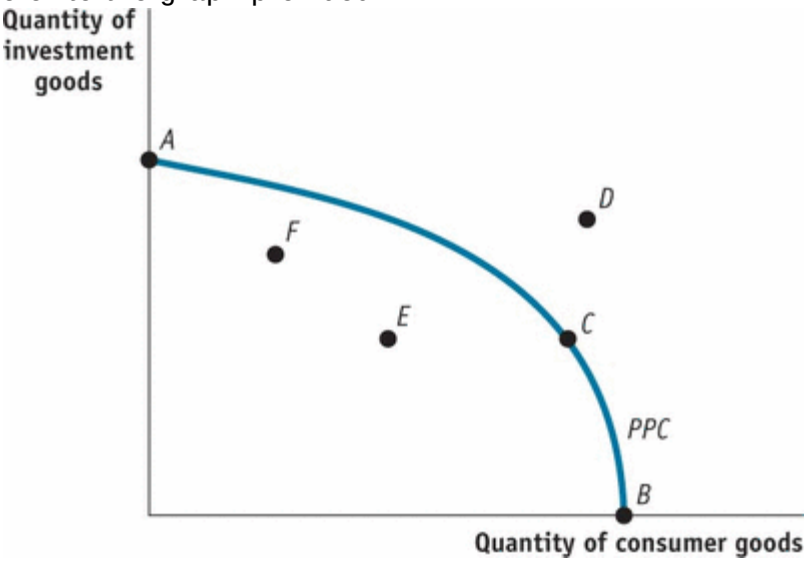
a. expansionary fiscal policy
b. expansionary monetary policy
c. a rightward shift of the short-run aggregate supply curve
d. investment in human capital
e. both a and b

[Answer Field]

Show Answer

Tackle the Test: Free-Response Questions

1. Refer to the graph provided.



a. Which point(s) could represent a downturn in the business cycle?

[Answer Field]

b. Which point(s) represent efficient production?

[Answer Field]

c. Which point(s) are attainable only after long-run economic growth?

[Answer Field]

d. How would long-run economic growth be represented on this graph?

[Answer Field]

e. Policy that results in an increase in the production of consumer goods without reducing the production of investment goods is represented by a movement from point _____ to point _____.

[Answer Field]

f. Producing at which efficient point this year would lead to the most economic growth next year?

[Answer Field]

2. Draw a separate, correctly labeled aggregate demand and supply graph to illustrate each of the following situations. On each of your graphs, include the short-run aggregate supply curve(s), long-run aggregate supply curve(s), and aggregate demand curve(s).

a. Expansionary fiscal policy moves the economy out of a recession.

[Answer Field]

Show Answer

b. Investment in infrastructure by the government leads to long-run economic growth.

[Answer Field]

Show Answer

Answer (9 points)

2points: A downturn could be represented by points *E* or *F*

3points: Points *A*, *B*, and *C* represent efficient production.

1 point: Point *D* is attainable only after long-run economic growth.

1 point: Long-run economic growth would be represented by an outward shift of the curve.

1 point: Consumer goods increase and investment goods remain unchanged when moving from point *E* to point *C*.

1 point: Producing at point *A* would lead to the most economic growth.

Summary

1. Economic growth is a sustained increase in the productive capacity of an economy and can be measured as changes in real GDP per capita. This measurement eliminates the effects of changes in both the price level and population size. Levels of real GDP per capita vary greatly around the world: more than half of the world's population lives in countries that are still poorer than the United States was in 1908.

2. Growth rates of real GDP per capita also vary widely. According to the **Rule of 70**, the number of years it takes for real GDP per capita to double is equal to 70 divided by the annual growth rate of real GDP per capita.

3. The key to long-run economic growth is rising **labor productivity**, or just **productivity**, which is output per worker. Increases in productivity arise from increases in **physical capital** per worker and **human capital** per worker as well as advances in **technology**. The **aggregate production function** shows how real GDP per worker depends on these three factors. Other things equal, there are **diminishing returns to physical capital:** holding human capital per worker and technology fixed, each successive addition to physical capital per worker yields a smaller increase in productivity than the one before. Similarly, there are diminishing returns to human capital among other inputs. With **growth accounting**, which involves estimates of each factor's contribution to economic growth, economists have shown that rising **total factor productivity**, the amount of output produced from a given amount of factor inputs, is key to long-run growth. Rising total factor productivity is usually interpreted as the effect of technological progress. In most countries, natural resources are a less significant source of productivity growth today than in earlier times.

4. The world economy contains examples of success and failure in the effort to achieve long-run economic growth. East Asian economies have done many things right and achieved very high growth rates. In Latin America, where some important conditions are lacking, growth has generally been disappointing. In Africa, real GDP per capita declined for several decades, although there are recent signs of progress. The growth rates of economically advanced countries have converged, but the growth rates of countries across the world have not. This has led economists to believe that the **convergence hypothesis** fits the data only when factors that affect growth, such as education, infrastructure, and favorable policies and institutions, are held equal across countries.

5. The large differences in countries' growth rates are largely due to differences in their rates of accumulation of physical and human capital as well as differences in technological progress. A prime factor is differences in savings and investment rates, since most countries that have high investment in physical capital finance it by high domestic savings. Technological progress is largely a result of **research and development**, or **R&D.**

6. Government actions that contribute to growth include the building of **infrastructure**, particularly for transportation and public health; the creation and regulation of a well-functioning banking system that channels savings into investment spending; and the financing of both education and R&D. Government actions that slow growth are corruption, political instability, excessive government intervention, and the neglect or violation of property rights.

7. In regard to making economic growth **sustainable**, economists generally believe that environmental degradation poses a greater problem than

natural resource scarcity does. Addressing environmental degradation requires effective governmental intervention, but the problem of natural resource scarcity is often well handled by the incentives created by market prices.

8. The emission of greenhouse gases is clearly linked to growth, and limiting emissions will require some reduction in growth. However, the best available estimates suggest that a large reduction in emissions would require only a modest reduction in the growth rate.

9. There is broad consensus that government action to address climate change and greenhouse gases should be in the form of market-based incentives, like a carbon tax or a cap and trade system. It will also require rich and poor countries to come to some agreement on how the cost of emissions reductions will be shared.

10. Long-run economic growth can be analyzed using the production possibilities curve and the aggregate demand-aggregate supply model. In these models, long-run economic growth is represented by an outward shift of the production possibilities curve and a rightward shift of the long-run aggregate supply curve.

11. Physical capital **depreciates** with use. Therefore, over time, the production possibilities curve will shift inward and the long-run aggregate supply curve will shift to the left if the stock of capital is not replaced.

Summary

Problems

[Notes / Highlighting]

1. The accompanying table shows data on real GDP per capita for several countries between 1960 and 2000. (*Source:* The Penn World Table, Version 6.2.)

	Argentina			Ghana			South Korea			United States		
Year	Real GDP per capita (2000 dollars)	Percentage of 1960 real GDP per capita	Percentage of 2000 real GDP per capita	Real GDP per capita (2000 dollars)	Percentage of 1960 real GDP per capita	Percentage of 2000 real GDP per capita	Real GDP per capita (2000 dollars)	Percentage of 1960 real GDP per capita	Percentage of 2000 real GDP per capita	Real GDP per capita (2000 dollars)	Percentage of 1960 real GDP per capita	Percentage of 2000 real GDP per capita
1960	$7,838	?	?	$412	?	?	$1,458	?	?	$12,892	?	?
1970	9,821	?	?	1,052	?	?	2,552	?	?	17,321	?	?
1980	10,921	?	?	1,142	?	?	4,497	?	?	21,606	?	?
1990	8,195	?	?	1,153	?	?	9,593	?	?	27,097	?	?
2000	11,332	?	?	1,392	?	?	15,702	?	?	34,365	?	?

a. Complete the table by expressing each year's real GDP per capita as a percentage of its 1960 and 2000 levels.

[Answer Field]

b. How does the growth in living standards from 1960 to 2000 compare across these four nations? What might account for these differences?

[Answer Field]

2. The accompanying table shows the average annual growth rate in real GDP per capita for several countries between 1960 and 2000. (*Source:* The Penn World Table, Version 6.2)

	Average annual growth rate of real GDP per capita		
Years	Argentina	Ghana	South Korea
1960–1970	2.53%	15.54%	7.50%
1970–1980	1.12	0.85	7.62
1980–1990	–2.50	0.10	11.33
1990–2000	3.83	2.08	6.37

a. For each decade and for each country, use the Rule of 70 where possible to calculate how long it would take for that country's real GDP per capita to double.

[Answer Field]

b. Suppose that the average annual growth rate that each country achieved over the period 1990–2000 continues in definitely into the future. Starting from 2000, use the Rule of 70 to calculate, where possible, the year in which a country will have doubled its real GDP per capita.

[Answer Field]

3. The accompanying table provides approximate statistics on per capita income levels and growth rates for regions defined by income levels. According to the Rule of 70, the high-income countries are projected to

double their per capita GDP in approximately 37 years, in 2042. Throughout this question, assume constant growth rates for each of the regions that are fixed at their average value between 2000 and 2005.

Region	GDP per capita (2005)	Average GDP per capita growth (2000–2005)
High-income countries	$28,612	1.9%
Middle-income countries	2,196	5.7
Low-income countries	494	3.6

Source: World Bank.

a. Calculate the ratio of per capita GDP in 2005 for each of the following:

I.

middle-income to high-income countries

II. low-income to high-income countries

III. low-income to middle-income countries

[Answer Field]

b. Calculate the number of years it will take the low-income and middle-income countries to double their per capita GDP.

[Answer Field]

c. Calculate the per capita GDP of each of the regions in 2042.(*Hint:* How many times does their per capita GDP double in 37 years?)

[Answer Field]

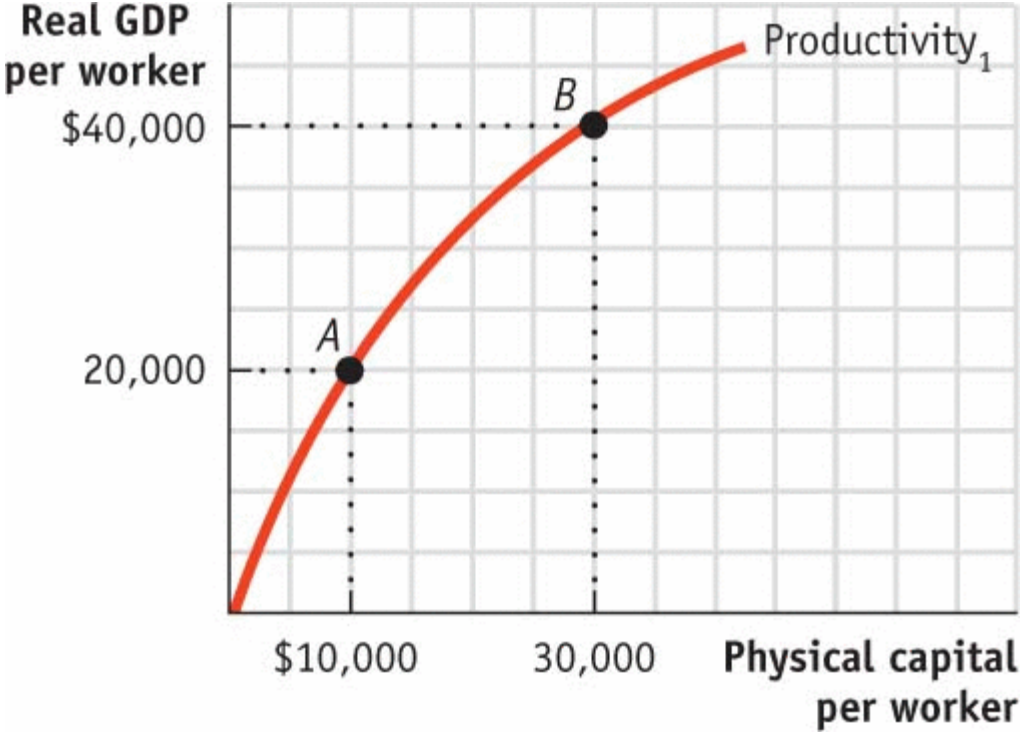
d. Repeat part a with the projected per capita GDP in 2042.

[Answer Field]

e. Compare your answers to parts a and d. Comment on the change in economic inequality between the regions.

[Answer Field]

4. You are hired as an economic consultant to the countries of Albernia and Brittania. Each country's current relationship between physical capital per worker and output per worker is given by the curve labeled Productivity_1 in the accompanying diagram. Albernia is at point *A* and Brittania is at point *B*.



a. In the relationship depicted by the curve Productivity$_1$, what factors are held fixed? Do these countries experience diminishing returns to physical capital per worker?

[Answer Field]

b. Assuming that the amount of human capital per worker and the technology are held fixed in each country, can you recommend a policy to generate a doubling of real GDP per capita in Albernia?

[Answer Field]

c. How would your policy recommendation change if the amount of human capital per worker and the technology were not fixed? Draw a curve on the diagram that represents this policy for Albernia.

[Answer Field]

5. The country of Androde is currently using Method 1 for its production function. By chance, scientists stumble on a technological breakthrough that will enhance Androde's productivity. This technological breakthrough is reflected in another production function, Method 2. The accompanying table shows combinations of physical capital per worker and output per worker for both methods, assuming that human capital per worker is fixed.

Method 1		Method 2	
Physical capital per worker	Real GDP per worker	Physical capital per worker	Real GDP per worker
0	0.00	0	0.00
50	35.36	50	70.71
100	50.00	100	100.00
150	61.24	150	122.47
200	70.71	200	141.42
250	79.06	250	158.11
300	86.60	300	173.21
350	93.54	350	187.08
400	100.00	400	200.00
450	106.07	450	212.13
500	111.80	500	223.61

a. Using the data in the accompanying table, draw the two production functions in one diagram. Androde's current amount of physical capital per worker is 100 using Method 1. In your figure, label that point *A*.

[Answer Field]

b. Starting from point *A*, over a period of 70 years, the amount of physical capital per worker in Androde rises to 400. Assuming Androde still uses Method 1, in your diagram, label the resulting point of production *B*. Using the Rule of 70, calculate by how many percent per year output per worker has grown.

[Answer Field]

c. Now assume that, starting from point *A*, over the same 70 years, the amount of physical capital per worker in Androde rises to 400, but that during that time, Androde switches to Method 2. In your diagram, label the resulting point of production *C*. Using the Rule of 70, calculate by how many percent per year output per worker has grown now.

[Answer Field]

d. As the economy of Androde moves from point *A* to point *C*, which percentage of the annual productivity growth is due to higher total factor productivity?

[Answer Field]

6. The Bureau of Labor Statistics regularly releases the "Productivity and Costs" report for the previous month. Go to www.bls.gov and find the latest report. (On the Bureau of Labor Statistics home page, under Latest Numbers, find "Productivity" and click on "News Release.") What were the percent changes in business and nonfarm business productivity for the previous quarter (on the basis of annualized rates for output per hour of all persons)? How does the percent change in that quarter's productivity compare to data from the previous quarter?

[Answer Field]

7. How have U.S. policies and institutions influenced the country's long-run economic growth?

[Answer Field]

8. Over the next 100 years, real GDP per capita in Groland is expected to grow at an average annual rate of 2.0%. In Sloland, however, growth is expected to be somewhat slower, at an average annual growth rate of 1.5%. If both countries have a real GDP per capita today of $20,000, how will their real GDP per capita differ in 100 years? *[**Hint**:* A country that has a real GDP today of *$x* and grows at *y*% per year will achieve a real GDP of $\$x \times (1 + 0.0y)^z$ in *z* years. We assume that $0 \leq y < 10$.]

[Answer Field]

9. The accompanying table shows data on real GDP per capita in 2000 U.S. dollars for several countries in 1950 and 2004. *(Source:* The Penn World Table, Version 6.2) Complete the table. Have these countries converged economically?

	1950		2004	
	Real GDP per capita (2000 dollars)	Percentage of U.S. real GDP per capita	Real GDP per capita (2000 dollars)	Percentage of U.S. real GDP per capita
France	$5,921	?	$26,168	?
Japan	2,188	?	24,661	?
United Kingdom	8,082	?	26,762	?
United States	11,233	?	36,098	?

[Answer Field]

10. The accompanying table shows data on real GDP per capita in 2000 U.S. dollars for several countries in 1960 and 2003. (*Source:* The Penn World Table, Version 6.2.) Complete the table. Have these countries converged economically?

	1960		2003	
	Real GDP per capita (2000 dollars)	Percentage of U.S. real GDP per capita	Real GDP per capita (2000 dollars)	Percentage of U.S. real GDP per capita
Argentina	$7,838	?	$10,170	?
Ghana	412	?	1,440	?
South Korea	1,458	?	17,597	?
United States	12,892	?	34,875	?

[Answer Field]

11. Why would you expect real GDP per capita in California and Pennsylvania to exhibit convergence but not in California and Baja California, a state of Mexico that borders the United States? What changes would allow California and Baja California to converge?

[Answer Field]

12. According to the *Oil & Gas Journal*, the proven oil reserves of the top 12 oil producers was 1,137 billion barrels of oil in 2007. In that year, the U.S. Energy Information Administration reported that the daily oil production from these nations was 48.2 million barrels a day.

a. At this rate, how many years will the proven oil reserves of the top 12 oil producers last? Discuss the Malthusian view in the context of the number you just calculated.

[Answer Field]

b. What are some important assumptions implicit in your calculations that challenge the Malthusian view on this issue?

[Answer Field]

c. Discuss how market forces may affect the amount of time the proven oil reserves will last, assuming that no new oil reserves are discovered and that the demand curve for oil remains unchanged.

[Answer Field]

13. The accompanying table shows the percent change in verified emissions of carbon dioxide (CO_2) and the percent change in real GDP per capita for selected EU countries.

Country	Percent change in real GDP per capita 2005–2007	Percent change in CO_2 emissions 2005–2007
Austria	6.30%	–4.90%
Belgium	4.19	–4.60
Cyprus	5.56	6.20
Finland	9.23	28.50
France	2.76	–3.50
Germany	5.79	2.50
Greece	8.09	2.00
Ireland	6.56	–5.30
Italy	2.28	0.20
Luxembourg	8.55	–1.40
Netherlands	4.61	–0.60
Portugal	2.67	–14.40
Slovenia	11.79	3.80
Spain	4.28	1.60

Sources: European Commission Press Release, May 23, 2008; International Monetary Fund, *World Factbook* 2008.

a. Rank the countries in terms of percentage increase in CO_2 emissions, from highest to lowest. What five countries have the highest percentage increase in emissions? What five countries have the lowest percentage increase in emissions?

[Answer Field]

b. Now rank the countries in terms of the percentage increase in real GDP per person, from highest to lowest. What five countries have the highest percentage increase? What five countries have the lowest percentage increase?

[Answer Field]

c. Would you infer from your results that CO_2 emissions are linked to growth in output per person?

[Answer Field]

d. Do high growth rates necessarily lead to high CO_2 emissions?

[Answer Field]