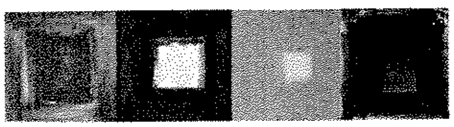

MACROECONOMICS

SIXTH EDITION

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HARVARD UNIVERSITY

WORTH PUBLISHERS

ables. The art in the science of economics is in judging whether a model captures the important economic relationships for the matter at hand. Because no single model can answer all questions, macroeconomists use different models to look at different issues.

3. A key feature of a macroeconomic model is whether it assumes that prices are flexible or sticky. According to most macroeconomists, models with flexible prices describe the economy in the long run, whereas models with sticky prices offer a better description of the economy in the short run.

4. Microeconomics is the study of how firms and individuals make decisions and how these decisionmakers interact. Because macroeconomic events arise from many microeconomic interactions, all macroeconomic models must be consistent with microeconomic foundations, even if those foundations are only implicit.

KEY CONCEPTS

Macroeconomics	Recession	Exogenous variables
Real GDP	Depression	Market clearing
Inflation and deflation	Models	Flexible and sticky prices
Unemployment	Endogenous variables	Microeconomics

QUESTIONS FOR REVIEW

1. Explain the difference between macroeconomics and microeconomics. How are these two fields related?
2. Why do economists build models?
3. What is a market-clearing model? When is it appropriate to assume that markets clear?

PROBLEMS AND APPLICATIONS

1. What macroeconomic issues have been in the news lately?
2. What do you think are the defining characteristics of a science? Does the study of the economy have these characteristics? Do you think macroeconomics should be called a science? Why or why not?
3. Use the model of supply and demand to explain how a fall in the price of frozen yogurt would affect the price of ice cream and the quantity of ice cream sold. In your explanation, identify the exogenous and endogenous variables.
4. How often does the price you pay for a haircut change? What does your answer imply about the usefulness of market-clearing models for analyzing the market for haircuts?

KEY CONCEPTS

Gross domestic product (GDP)
Consumer price index (CPI)
Unemployment rate
National income accounting
Stocks and flows
Value added
Imputed value
Nominal versus real GDP
GDP deflator
National income accounts identity
Consumption
Investment
Government purchases
Net exports
Labor force
Labor-force participation rate

QUESTIONS FOR REVIEW

1. List the two things that GDP measures. How can GDP measure two things at once?
2. What does the consumer price index measure?
3. List the three categories used by the Bureau of Labor Statistics to classify everyone in the economy. How does the Bureau compute the unemployment rate?
4. Explain the two ways the Bureau of Labor Statistics measures total employment.

PROBLEMS AND APPLICATIONS

1. Look at the newspapers for the past few days. What new economic statistics have been released? How do you interpret these statistics?
2. A farmer grows a bushel of wheat and sells it to a miller for \$1.00. The miller turns the wheat into flour and then sells the flour to a baker for \$3.00. The baker uses the flour to make bread and sells the bread to an engineer for \$6.00. The engineer eats the bread. What is the value added by each person? What is GDP?
3. Suppose a woman marries her butler. After they are married, her husband continues to wait on her as before, and she continues to support him as before (but as a husband rather than as an employee). How does the marriage affect GDP? How should it affect GDP?
4. Place each of the following transactions in one of the four components of expenditure: consumption, investment, government purchases, and net exports.
   a. Boeing sells an airplane to the Air Force.
   b. Boeing sells an airplane to American Airlines.
   c. Boeing sells an airplane to Air France.
   d. Boeing sells an airplane to Amelia Earhart.
   e. Boeing builds an airplane to be sold next year.
5. Find data on GDP and its components, and compute the percentage of GDP for the following components for 1950, 1980, and 2005.
   a. Personal consumption expenditures
   b. Gross private domestic investment
   c. Government purchases
   d. Net exports
   e. National defense purchases
   f. State and local purchases
   g. Imports

   Do you see any stable relationships in the data? Do you see any trends? (*Hint:* A good place to look for data is the statistical appendices of the *Economic Report of the President*, which is written each year by the Council of Economic Advisers. Alternatively, you can go to www.bea.doc.gov, which is the Web site of the Bureau of Economic Analysis.)
6. Consider an economy that produces and consumes bread and automobiles. In the following table are data for two different years.

	Year 2000	Year 2010
Price of an automobile	\$50,000	\$60,000
Price of a loaf of bread	\$10	\$20
Number of automobiles produced	100 cars	120 cars
Number of loaves of bread produced	500,000 loaves	400,000 loaves

a. Using the year 2000 as the base year, compute the following statistics for each year: nominal GDP, real GDP, the implicit price deflator for GDP, and a fixed-weight price index such as the CPI.

b. How much have prices risen between year 2000 and year 2010? Compare the answers given by the Laspeyres and Paasche price indices. Explain the difference.

c. Suppose you are a senator writing a bill to index Social Security and federal pensions. That is, your bill will adjust these benefits to offset changes in the cost of living. Will you use the GDP deflator or the CPI? Why?

7. Abby consumes only apples. In year 1, red apples cost \$1 each, green apples cost \$2 each, and Abby buys 10 red apples. In year 2, red apples cost \$2, green apples cost \$1, and Abby buys 10 green apples.

a. Compute a consumer price index for apples for each year. Assume that year 1 is the base year in which the consumer basket is fixed. How does your index change from year 1 to year 2?

b. Compute Abby's nominal spending on apples in each year. How does it change from year 1 to year 2?

c. Using year 1 as the base year, compute Abby's real spending on apples in each year. How does it change from year 1 to year 2?

d. Defining the implicit price deflator as nominal spending divided by real spending, compute the deflator for each year. How does the deflator change from year 1 to year 2?

e. Suppose that Abby is equally happy eating red or green apples. How much has the true cost of living increased for Abby? Compare this answer to your answers to parts (a) and (d). What does this example tell you about Laspeyres and Paasche price indices?

8. Consider how each of the following events is likely to affect real GDP. Do you think the change in real GDP reflects a similar change in economic well-being?

a. A hurricane in Florida forces Disney World to shut down for a month.

b. The discovery of a new, easy-to-grow strain of wheat increases farm harvests.

c. Increased hostility between unions and management sparks a rash of strikes.

d. Firms throughout the economy experience falling demand, causing them to lay off workers.

e. Congress passes new environmental laws that prohibit firms from using production methods that emit large quantities of pollution.

f. More high-school students drop out of school to take jobs mowing lawns.

g. Fathers around the country reduce their workweeks to spend more time with their children.

9. In a speech that Senator Robert Kennedy gave when he was running for president in 1968, he said the following about GDP:

> [It] does not allow for the health of our children, the quality of their education, or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages, the intelligence of our public debate or the integrity of our public officials. It measures neither our courage, nor our wisdom, nor our devotion to our country. It measures everything, in short, except that which makes life worthwhile, and it can tell us everything about America except why we are proud that we are Americans.

Was Robert Kennedy right? If so, why do we care about GDP?

technological innovation or a tax incentive for investment, also raises the interest rate. An increase in investment demand increases the quantity of investment only if higher interest rates stimulate additional saving.

KEY CONCEPTS

Factors of production
Production function
Constant returns to scale
Factor prices
Competition
Profit
Marginal product of labor (*MPL*)
Diminishing marginal product
Real wage
Marginal product of capital (*MPK*)
Real rental price of capital
Economic profit versus accounting profit
Cobb-Douglas production function
Disposable income
Consumption function
Marginal propensity to consume (*MPC*)
Interest rate
Nominal interest rate
Real interest rate
National saving (saving)
Private saving
Public saving
Loanable funds
Crowding out

QUESTIONS FOR REVIEW

1. What determines the amount of output an economy produces?
2. Explain how a competitive, profit-maximizing firm decides how much of each factor of production to demand.
3. What is the role of constant returns to scale in the distribution of income?
4. Write down a Cobb-Douglas production function for which capital earns one-fourth of total income.
5. What determines consumption and investment?
6. Explain the difference between government purchases and transfer payments. Give two examples of each.
7. What makes the demand for the economy's output of goods and services equal the supply?
8. Explain what happens to consumption, investment, and the interest rate when the government increases taxes.

PROBLEMS AND APPLICATIONS

1. Use the neoclassical theory of distribution to predict the impact on the real wage and the real rental price of capital of each of the following events:
   a. A wave of immigration increases the labor force.
   b. An earthquake destroys some of the capital stock.
   c. A technological advance improves the production function.
2. If a 10-percent increase in both capital and labor causes output to increase by less than 10 percent, the production function is said to exhibit *decreasing returns to scale*. If it causes output to increase by more than 10 percent, the production function is said to exhibit *increasing returns to scale*. Why might a production function exhibit decreasing or increasing returns to scale?
3. Suppose that an economy's production function is Cobb-Douglas with parameter $\alpha = 0.3$.
   a. What fractions of income do capital and labor receive?

b. Suppose that immigration raises the labor force by 10 percent. What happens to total output (in percent)? The rental price of capital? The real wage?

c. Suppose that a gift of capital from abroad raises the capital stock by 10 percent. What happens to total output (in percent)? The rental price of capital? The real wage?

d. Suppose that a technological advance raises the value of the parameter A by 10 percent. What happens to total output (in percent)? The rental price of capital? The real wage?

4. Figure 3-5 shows that in U.S. data, labor's share of total income is approximately a constant over time. Table 3-1 shows that the trend in the real wage closely tracks the trend in labor productivity. How are these facts related? Could the first fact be true without the second also being true?

5. According to the neoclassical theory of distribution, the real wage earned by any worker equals that worker's marginal productivity. Let's use this insight to examine the incomes of two groups of workers: farmers and barbers.

   a. Over the past century, the productivity of farmers has risen substantially because of technological progress. According to the neoclassical theory, what should have happened to their real wage?

   b. In what units is the real wage discussed in part (a) measured?

   c. Over the same period, the productivity of barbers has remained constant. What should have happened to their real wage?

   d. In what units is the real wage in part (c) measured?

   e. Suppose workers can move freely between being farmers and being barbers. What does this mobility imply for the wages of farmers and barbers?

   f. What do your previous answers imply for the price of haircuts relative to the price of food?

   g. Who benefits from technological progress in farming—farmers or barbers?

6. (This problem requires the use of calculus.) Consider a Cobb-Douglas production function with three inputs. K is capital (the number of machines), L is labor (the number of workers), and H is human capital (the number of college degrees among the workers). The production function is

$$Y = K^{1/3}L^{1/3}H^{1/3}.$$

   a. Derive an expression for the marginal product of labor. How does an increase in the amount of human capital affect the marginal product of labor?

   b. Derive an expression for the marginal product of human capital. How does an increase in the amount of human capital affect the marginal product of human capital?

   c. What is the income share paid to labor? What is the income share paid to human capital? In the national income accounts of this economy, what share of total income do you think workers would appear to receive? (*Hint:* Consider where the return to human capital shows up.)

   d. An unskilled worker earns the marginal product of labor, whereas a skilled worker earns the marginal product of labor plus the marginal product of human capital. Using your answers to (a) and (b), find the ratio of the skilled wage to the unskilled wage. How does an increase in the amount of human capital affect this ratio? Explain.

   e. Some people advocate government funding of college scholarships as a way of creating a more egalitarian society. Others argue that scholarships help only those who are able to go to college. Do your answers to the preceding questions shed light on this debate?

7. The government raises taxes by \$100 billion. If the marginal propensity to consume is 0.6, what happens to the following? Do they rise or fall? By what amounts?

   a. Public saving.

   b. Private saving.

   c. National saving.

   d. Investment.

8. Suppose that an increase in consumer confidence raises consumers' expectations about their future income and thus increases the amount they want to consume today. This might be interpreted as an upward shift in the consumption function.

How does this shift affect investment and the interest rate?

9. Consider an economy described by the following equations:

$$Y = C + I + G$$
$$Y = 5{,}000$$
$$G = 1{,}000$$
$$T = 1{,}000$$
$$C = 250 + 0.75(Y - T)$$
$$I = 1{,}000 - 50\,r.$$

   a. In this economy, compute private saving, public saving, and national saving.

   b. Find the equilibrium interest rate.

   c. Now suppose that G rises to 1,250. Compute private saving, public saving, and national saving.

   d. Find the new equilibrium interest rate.

10. Suppose that the government increases taxes and government purchases by equal amounts. What happens to the interest rate and investment in response to this balanced budget change? Does your answer depend on the marginal propensity to consume?

11. When the government subsidizes investment, such as with an investment tax credit, the subsidy often applies to only some types of investment. This question asks you to consider the effect of such a change. Suppose there are two types of investment in the economy: business investment and residential investment. And suppose that the government institutes an investment tax credit only for business investment.

   a. How does this policy affect the demand curve for business investment? The demand curve for residential investment?

   b. Draw the economy's supply and demand for loanable funds. How does this policy affect the supply and demand for loanable funds? What happens to the equilibrium interest rate?

   c. Compare the old and the new equilibrium. How does this policy affect the total quantity of investment? The quantity of business investment? The quantity of residential investment?

12. If consumption depended on the interest rate, how would that affect the conclusions reached in this chapter about the effects of fiscal policy?

13. Macroeconomic data do not show a strong correlation between investment and interest rates. Let's examine why this might be so. Use our model in which the interest rate adjusts to equilibrate the supply of loanable funds (which is upward sloping) and the demand for loanable funds (which is downward sloping).

   a. Suppose the demand for loanable funds were stable but the supply fluctuated from year to year. What might cause these fluctuations in supply? In this case, what correlation between investment and interest rates would you find?

   b. Suppose the supply of loanable funds were stable but the demand fluctuated from year to year. What might cause these fluctuations in demand? In this case, what correlation between investment and interest rates would you find now?

   c. Suppose that both supply and demand in this market fluctuated over time. If you were to construct a scatterplot of investment and the interest rate, what would you find?

   d. Which of the above three cases seems most empirically realistic to you?

PROBLEMS AND APPLICATIONS

1. What are the three functions of money? Which of the functions do the following items satisfy? Which do they not satisfy?
   a. A credit card
   b. A painting by Rembrandt
   c. A subway token
2. In the country of Wiknam, the velocity of money is constant. Real GDP grows by 5 percent per year, the money stock grows by 14 percent per year, and the nominal interest rate is 11 percent. What is the real interest rate?
3. A newspaper article once reported that the U.S. economy was experiencing a low rate of inflation. It said that "low inflation has a downside: 45 million recipients of Social Security and other benefits will see their checks go up by just 2.8 percent next year."
   a. Why does inflation affect the increase in Social Security and other benefits?
   b. Is this effect a cost of inflation as the article suggests? Why or why not?
4. Suppose you are advising a small country (such as Bermuda) on whether to print its own money or to use the money of its larger neighbor (such as the United States). What are the costs and benefits of a national money? Does the relative political stability of the two countries have any role in this decision?
5. During World War II, both Germany and England had plans for a paper weapon: they each printed the other's currency, with the intention of dropping large quantities by airplane. Why might this have been an effective weapon?
6. Calvin Coolidge once said that "inflation is repudiation." What might he have meant by this? Do you agree? Why or why not? Does it matter whether the inflation is expected or unexpected?
7. Some economic historians have noted that during the period of the gold standard, gold discoveries were most likely to occur after a long deflation. (The discoveries of 1896 are an example.) Why might this be true?
8. Suppose that consumption depends on the level of real money balances (on the grounds that real money balances are part of wealth). Show that if real money balances depend on the nominal interest rate, then an increase in the rate of money growth affects consumption, investment, and the real interest rate. Does the nominal interest rate adjust more than one-for-one or less than one-for-one to expected inflation?

   This deviation from the classical dichotomy and the Fisher effect is called the *Mundell-Tobin effect*. How might you decide whether the Mundell-Tobin effect is important in practice?
9. Use the Internet to identify a country that has had high inflation over the past year and another country that has had low inflation. (*Hint*: One useful website is http://www.economist.com/markets/indicators/) For these two countries, find the rate of money growth and the current level of the nominal interest rate. Relate your findings to the theories presented in this chapter.

Some economists use this model to argue that *credibility* is important for ending hyperinflation. Because the price level depends on both current and expected future money, inflation depends on both current and expected future money growth. Therefore, to end high inflation, both money growth and expected money growth must fall. Expectations, in turn, depend on credibility—the perception that the central bank is committed to a new, more stable policy.

How can a central bank achieve credibility in the midst of hyperinflation? Credibility is often achieved by removing the underlying cause of the hyperinflation—the need for seigniorage. Thus, a credible fiscal reform is often necessary for a credible change in monetary policy. This fiscal reform might take the form of reducing government spending and making the central bank more independent from the government. Reduced spending decreases the need for seigniorage, while increased independence allows the central bank to resist government demands for seigniorage.

MORE PROBLEMS AND APPLICATIONS

1. In the Cagan model, if the money supply is expected to grow at some constant rate μ (so that $Em_{t+s} = m_t + s\mu$), then Equation A9 can be shown to imply that $p_t = m_t + \gamma\mu$.
   a. Interpret this result.
   b. What happens to the price level p_t when the money supply m_t changes, holding the money growth rate μ constant?
   c. What happens to the price level p_t when the money growth rate μ changes, holding the current money supply m_t constant?
   d. If a central bank is about to reduce the rate of money growth μ but wants to hold the price level p_t constant, what should it do with m_t? Can you see any practical problems that might arise in following such a policy?
   e. How do your previous answers change in the special case where money demand does not depend on the expected rate of inflation (so that $\gamma = 0$)?

QUESTIONS FOR REVIEW

1. What are the net capital outflow and the trade balance? Explain how they are related.

2. Define the nominal exchange rate and the real exchange rate.

3. If a small open economy cuts defense spending, what happens to saving, investment, the trade balance, the interest rate, and the exchange rate?

4. If a small open economy bans the import of Japanese VCRs, what happens to saving, investment, the trade balance, the interest rate, and the exchange rate?

5. If Japan has low inflation and Mexico has high inflation, what will happen to the exchange rate between the Japanese yen and the Mexican peso?

PROBLEMS AND APPLICATIONS

1. Use the model of the small open economy to predict what would happen to the trade balance, the real exchange rate, and the nominal exchange rate in response to each of the following events.

   a. A fall in consumer confidence about the future induces consumers to spend less and save more.

   b. The introduction of a stylish line of Toyotas makes some consumers prefer foreign cars over domestic cars.

   c. The introduction of automatic teller machines reduces the demand for money.

2. Consider an economy described by the following equations:

$$Y = C + I + G + NX,$$
$$Y = 5{,}000,$$
$$G = 1{,}000,$$
$$T = 1{,}000,$$
$$C = 250 + 0.75(Y - T),$$
$$I = 1{,}000 - 50r,$$
$$NX = 500 - 500\epsilon,$$
$$r = r^* = 5.$$

   a. In this economy, solve for national saving, investment, the trade balance, and the equilibrium exchange rate.

   b. Suppose now that G rises to 1,250. Solve for national saving, investment, the trade balance, and the equilibrium exchange rate. Explain what you find.

   c. Now suppose that the world interest rate rises from 5 to 10 percent. (G is again 1,000). Solve for national saving, investment, the trade balance, and the equilibrium exchange rate. Explain what you find.

3. The country of Leverett is a small open economy. Suddenly, a change in world fashions makes the exports of Leverett unpopular.

   a. What happens in Leverett to saving, investment, net exports, the interest rate, and the exchange rate?

   b. The citizens of Leverett like to travel abroad. How will this change in the exchange rate affect them?

   c. The fiscal policymakers of Leverett want to adjust taxes to maintain the exchange rate at its previous level. What should they do? If they do this, what are the overall effects on saving, investment, net exports, and the interest rate?

4. In 2005, Federal Reserve Governor Ben Bernanke said in a speech: "Over the past decade a combination of diverse forces has created a significant increase in the global supply of saving—a global saving glut—which helps to explain both the increase in the U.S. current account deficit [a broad measure of the trade deficit] and the relatively low level of long-term real interest rates in the world today." Is this statement consistent with the models you have learned? Explain.

5. What will happen to the trade balance and the real exchange rate of a small open economy when government purchases increase, such as during a

war? Does your answer depend on whether this is a local war or a world war?

6. A case study in this chapter concludes that if poor nations offered better production efficiency and legal protections, the trade balance in rich nations such as the United States would move toward surplus. Let's consider why this might be the case.

a. If the world's poor nations offer better production efficiency and legal protection, what would happen to the investment demand function in those countries?

b. How would the change you describe in part (a) affect the demand for loanable funds in world financial markets?

c. How would the change you describe in part (b) affect the world interest rate?

d. How would the change in the world interest rate you describe in part (c) affect the trade balance in rich nations?

7. The president is considering placing a tariff on the import of Japanese luxury cars. Discuss the economics and politics of such a policy. In particular, how would the policy affect the U.S. trade deficit? How would it affect the exchange rate? Who would be hurt by such a policy? Who would benefit?

8. Suppose that some foreign countries begin to subsidize investment by instituting an investment tax credit.

a. What happens to world investment demand as a function of the world interest rate?

b. What happens to the world interest rate?

c. What happens to investment in our small open economy?

d. What happens to our trade balance?

e. What happens to our real exchange rate?

9. "Traveling in Mexico is much cheaper now than it was ten years ago," says a friend. "Ten years ago, a dollar bought 10 pesos; this year, a dollar buys 15 pesos."

Is your friend right or wrong? Given that total inflation over this period was 25 percent in the United States and 100 percent in Mexico, has it become more or less expensive to travel in Mexico? Write your answer using a concrete example—such as an American hot dog versus a Mexican taco—that will convince your friend.

10. You read in a newspaper that the nominal interest rate is 12 percent per year in Canada and 8 percent per year in the United States. Suppose that the real interest rates are equalized in the two countries and that purchasing-power parity holds.

a. Using the Fisher equation (discussed in Chapter 4), what can you infer about expected inflation in Canada and in the United States?

b. What can you infer about the expected change in the exchange rate between the Canadian dollar and the U.S. dollar?

c. A friend proposes a get-rich-quick scheme: borrow from a U.S. bank at 8 percent, deposit the money in a Canadian bank at 12 percent, and make a 4 percent profit. What's wrong with this scheme?

MORE PROBLEMS AND APPLICATIONS

1. If a war broke out abroad, it would affect the U.S. economy in many ways. Use the model of the large open economy to examine each of the following effects of such a war. What happens in the United States to saving, investment, the trade balance, the interest rate, and the exchange rate? (To keep things simple, consider each of the following effects separately.)
   a. The U.S. government, fearing it may need to enter the war, increases its purchases of military equipment.
   b. Other countries raise their demand for high-tech weapons, a major export of the United States.
   c. The war makes U.S. firms uncertain about the future, and the firms delay some investment projects.
   d. The war makes U.S. consumers uncertain about the future, and the consumers save more in response.
   e. Americans become apprehensive about traveling abroad, so more of them spend their vacations in the United States.
   f. Foreign investors seek a safe haven for their portfolios in the United States.
2. On September 21, 1995, "House Speaker Newt Gingrich threatened to send the United States into default on its debt for the first time in the nation's history, to force the Clinton Administration to balance the budget on Republican terms" (*New York Times,* September 22, 1995, A1). That same day, the interest rate on 30-year U.S. government bonds rose from 6.46 to 6.55 percent, and the dollar fell in value from 102.7 to 99.0 yen. Use the model of the large open economy to explain this event.

explanations have been proposed, including the changing demographic composition of the labor force, changes in the prevalence of sectoral shifts, and changes in the rate of productivity growth.

7. Individuals who have recently entered the labor force, including both new entrants and reentrants, make up about one-third of the unemployed. Transitions into and out of the labor force make unemployment statistics more difficult to interpret.

8. American and European labor markets exhibit some significant differences. In recent years, Europe has experienced significantly more unemployment than the United States, and employed Europeans work fewer hours than employed Americans.

KEY CONCEPTS

Natural rate of unemployment
Frictional unemployment
Sectoral shift
Unemployment insurance
Wage rigidity
Structural unemployment
Insiders versus outsiders
Efficiency wages
Discouraged workers

QUESTIONS FOR REVIEW

1. What determines the natural rate of unemployment?
2. Describe the difference between frictional unemployment and structural unemployment.
3. Give three explanations why the real wage may remain above the level that equilibrates labor supply and labor demand.
4. Is most unemployment long-term or short-term? Explain your answer.
5. How do economists explain the high natural rate of unemployment in the 1970s and 1980s? How do they explain the fall in the natural rate in the 1990s and early 2000s?

PROBLEMS AND APPLICATIONS

1. Answer the following questions about your own experience in the labor force:
   a. When you or one of your friends is looking for a part-time job, how many weeks does it typically take? After you find a job, how many weeks does it typically last?
   b. From your estimates, calculate (in a rate per week) your rate of job finding f and your rate of job separation s. (*Hint:* If f is the rate of job finding, then the average spell of unemployment is $1/f$.)
   c. What is the natural rate of unemployment for the population you represent?
2. In this chapter we saw that the steady-state rate of unemployment is $U/L = s/(s + f)$. Suppose that the unemployment rate does not begin at this level. Show that unemployment will evolve over time and reach this steady state. (*Hint:* Express the change in the number of unemployed as a function of s, f, and U. Then show that if unemployment is above the natural rate, unemployment falls, and if unemployment is below the natural rate, unemployment rises.)

3. The residents of a certain dormitory have collected the following data: People who live in the dorm can be classified as either involved in a relationship or uninvolved. Among involved people, 10 percent experience a breakup of their relationship every month. Among uninvolved people, 5 percent will enter into a relationship every month. What is the steady-state fraction of residents who are uninvolved?

4. Suppose that Congress passes legislation making it more difficult for firms to fire workers. (An example is a law requiring severance pay for fired workers.) If this legislation reduces the rate of job separation without affecting the rate of job finding, how would the natural rate of unemployment change? Do you think that it is plausible that the legislation would not affect the rate of job finding? Why or why not?

5. Consider an economy with the following Cobb-Douglas production function:

$$Y = K^{1/3}L^{2/3}.$$

The economy has 1,000 units of capital and a labor force of 1,000 workers.

a. Derive the equation describing labor demand in this economy as a function of the real wage and the capital stock. (*Hint*: Review Chapter 3.)

b. If the real wage can adjust to equilibrate labor supply and labor demand, what is the real wage? In this equilibrium, what is employment, output, and the total amount earned by workers?

c. Now suppose that Congress, concerned about the welfare of the working class, passes a law requiring firms to pay workers a real wage of 1 unit of output. How does this wage compare to the equilibrium wage?

d. Congress cannot dictate how many workers firms hire at the mandated wage. Given this fact, what are the effects of this law? Specifically, what happens to employment, output, and the total amount earned by workers?

e. Will Congress succeed in its goal of helping the working class? Explain.

f. Do you think that this analysis provides a good way of thinking about a minimum-wage law? Why or why not?

6. Suppose that a country experiences a reduction in productivity—that is, an adverse shock to the production function.

a. What happens to the labor demand curve?

b. How would this change in productivity affect the labor market—that is, employment, unemployment, and real wages—if the labor market were always in equilibrium?

c. How would this change in productivity affect the labor market if unions prevented real wages from falling?

7. When workers' wages rise, their decision on how much time to spend working is affected in two conflicting ways—as you may have learned in courses in microeconomics. The *income effect* is the impulse to work less, because greater incomes mean workers can afford to consume more leisure. The *substitution effect* is the impulse to work more, because the reward to working an additional hour has risen (equivalently, the opportunity cost of leisure has gone up). Apply these concepts to Blanchard's hypothesis about American and European tastes for leisure. On which side of the Atlantic do income effects appear larger than substitution effects? On which side do the two effects approximately cancel? Do you think it is a reasonable hypothesis that tastes for leisure vary by geography? Why or why not?

8. In any city at any time, some of the stock of usable office space is vacant. This vacant office space is unemployed capital. How would you explain this phenomenon? Is it a social problem?

PROBLEMS AND APPLICATIONS

1. Country A and country B both have the production function

$$Y = F(K, L) = K^{1/2}L^{1/2}.$$

   a. Does this production function have constant returns to scale? Explain.

   b. What is the per-worker production function, $y = f(k)$?

   c. Assume that neither country experiences population growth or technological progress and that 5 percent of capital depreciates each year. Assume further that country A saves 10 percent of output each year and country B saves 20 percent of output each year. Using your answer from part (b) and the steady-state condition that investment equals depreciation, find the steady-state level of capital per worker for each country. Then find the steady-state levels of income per worker and consumption per worker.

   d. Suppose that both countries start off with a capital stock per worker of 2. What are the levels of income per worker and consumption per worker? Remembering that the change in the capital stock is investment less depreciation, use a calculator or a computer spreadsheet to show how the capital stock per worker will evolve over time in both countries. For each year, calculate income per worker and consumption per worker. How many years will it be before the consumption in country B is higher than the consumption in country A?

2. In the discussion of German and Japanese postwar growth, the text describes what happens when part of the capital stock is destroyed in a war. By contrast, suppose that a war does not directly affect the capital stock, but that casualties reduce the labor force.

   a. What is the immediate impact on total output and on output per person?

   b. Assuming that the saving rate is unchanged and that the economy was in a steady state before the war, what happens subsequently to output per worker in the postwar economy? Is the growth rate of output per worker after the war smaller or greater than normal?

3. Consider an economy described by the production function: $Y = F(K, L) = K^{0.3}L^{0.7}$.

   a. What is the per-worker production function?

   b. Assuming no population growth or technological progress, find the steady-state capital stock per worker, output per worker, and consumption per worker as a function of the saving rate and the depreciation rate.

   c. Assume that the depreciation rate is 10 percent per year. Make a table showing steady-state capital per worker, output per worker, and consumption per worker for saving rates of 0 percent, 10 percent, 20 percent, 30 percent, and so on. (You will need a calculator with an exponent key for this.) What saving rate maximizes output per worker? What saving rate maximizes consumption per worker?

   d. (Harder) Use calculus to find the marginal product of capital. Add to your table the marginal product of capital net of depreciation for each of the saving rates. What does your table show?

4. "Devoting a larger share of national output to investment would help restore rapid productivity growth and rising living standards." Do you agree with this claim? Explain.

5. One view of the consumption function is that workers have high propensities to consume and capitalists have low propensities to consume. To explore the implications of this view, suppose that an economy consumes all wage income and saves all capital income. Show that if the factors of production earn their marginal product, this economy reaches the Golden Rule level of capital. (*Hint:* Begin with the identity that saving equals investment. Then use the steady-state condition that investment is just enough to keep up with depreciation and population growth, and the fact that saving equals capital income in this economy.)

6. Many demographers predict that the United States will have zero population growth in the twenty-first century, in contrast to average population growth of about 1 percent per year in the twentieth century. Use the Solow model to forecast the effect of this slowdown in population growth on the growth of total output and the

growth of output per person. Consider the effects both in the steady state and in the transition between steady states.

7. In the Solow model, population growth leads to steady-state growth in total output, but not in output per worker. Do you think this would still be true if the production function exhibited increasing or decreasing returns to scale? Explain. (For the definitions of increasing and decreasing returns to scale, see Chapter 3, "Problems and Applications," Problem 2.)

8. Consider how unemployment would affect the Solow growth model. Suppose that output is produced according to the production function $Y = K^{\alpha}[(1 - u)L]^{1-\alpha}$, where K is capital, L is the labor force, and u is the natural rate of unemployment. The national saving rate is s, the labor force grows at rate n, and capital depreciates at rate δ.

   a. Express output per worker ($y = Y/L$) as a function of capital per worker ($k = K/L$) and the natural rate of unemployment. Describe the steady state of this economy.

   b. Suppose that some change in government policy reduces the natural rate of unemployment. Describe how this change affects output both immediately and over time. Is the steady-state effect on output larger or smaller than the immediate effect? Explain.

9. Choose two countries that interest you—one rich and one poor. What is the income per person in each country? Find some data on country characteristics that might help explain the difference in income: investment rates, population growth rates, educational attainment, and so on. (*Hint:* The Web site of the World Bank, www.worldbank.org, is one place to find such data.) How might you figure out which of these factors is most responsible for the observed income difference?

PROBLEMS AND APPLICATIONS

1. An economy described by the Solow growth model has the following production function:

$$y = \sqrt{k}.$$

   a. Solve for the steady-state value of y as a function of s, n, g, and δ.

   b. A developed country has a saving rate of 28 percent and a population growth rate of 1 percent per year. A less-developed country has a saving rate of 10 percent and a population growth rate of 4 percent per year. In both countries, $g = 0.02$ and $\delta = 0.04$. Find the steady-state value of y for each country.

   c. What policies might the less-developed country pursue to raise its level of income?

2. In the United States, the capital share of GDP is about 30 percent; the average growth in output is about 3 percent per year; the depreciation rate is about 4 percent per year; and the capital-output ratio is about 2.5. Suppose that the production function is Cobb-Douglas, so that the capital share in output is constant, and that the United States has been in a steady state. (For a discussion of the Cobb-Douglas production function, see Chapter 3.)

   a. What must the saving rate be in the initial steady state? [*Hint:* Use the steady-state relationship, $sy = (\delta + n + g)k$.]

   b. What is the marginal product of capital in the initial steady state?

   c. Suppose that public policy raises the saving rate so that the economy reaches the Golden Rule level of capital. What will the marginal product of capital be at the Golden Rule steady state? Compare the marginal product at the Golden Rule steady state to the marginal product in the initial steady state. Explain.

   d. What will the capital-output ratio be at the Golden Rule steady state? (*Hint:* For the Cobb-Douglas production function, the capital-output ratio is related to the marginal product of capital.)

   e. What must the saving rate be to reach the Golden Rule steady state?

3. Prove each of the following statements about the steady state of the Solow model with population growth and technological progress.

   a. The capital-output ratio is constant.

   b. Capital and labor each earn a constant share of an economy's income. [*Hint:* Recall the definition $MPK = f(k + 1) - f(k)$.]

   c. Total capital income and total labor income both grow at the rate of population growth plus the rate of technological progress, $n + g$.

   d. The real rental price of capital is constant, and the real wage grows at the rate of technological progress g. (*Hint:* The real rental price of capital equals total capital income divided by the capital stock, and the real wage equals total labor income divided by the labor force.)

4. Two countries, Richland and Poorland, are described by the Solow growth model. They have the same Cobb-Douglas production function, $F(K,L) = A\ K^{\alpha}L^{1-\alpha}$, but with different quantities of capital and labor. Richland saves 32 percent of its income, while Poorland saves 10 percent. Richland has population growth of 1 percent per year, while Poorland has population growth of 3 percent. (The numbers in this problem are chosen to be approximately realistic descriptions of rich and poor nations.) Both nations have technological progress at a rate of 2 percent per year and depreciation at a rate of 5 percent per year.

   a. What is the per worker production function $f(k)$?

   b. Solve for the ratio of Richland's steady-state income per worker to Poorland's. (*Hint:* The parameter α will play a role in your answer.)

   c. If the Cobb-Douglas parameter α takes the conventional value of about 1/3, how much higher should income per worker be in Richland compared to Poorland?

   d. Income per worker in Richland is actually 16 times income per worker in Poorland. Can you explain this fact by changing the value of the parameter α? What must it be? Can you think of any way of justifying such a value for this parameter? How else might you explain the large difference in income between Richland and Poorland?

5. The amount of education the typical person receives varies substantially among countries. Suppose you were to compare a country with a highly educated labor force and a country with a less educated labor force. Assume that education affects only the level of the efficiency of labor. Also assume that the countries are otherwise the same: they have the same saving rate, the same depreciation rate, the same population growth rate, and the same rate of technological progress. Both countries are described by the Solow model and are in their steady states. What would you predict for the following variables?

   a. The rate of growth of total income.

   b. The level of income per worker.

   c. The real rental price of capital.

   d. The real wage.

6. This question asks you to analyze in more detail the two-sector endogenous growth model presented in the text.

   a. Rewrite the production function for manufactured goods in terms of output per effective worker and capital per effective worker.

   b. In this economy, what is break-even investment (the amount of investment needed to keep capital per effective worker constant)?

   c. Write down the equation of motion for k, which shows Δk as saving minus break-even investment. Use this equation to draw a graph showing the determination of steady-state k. (*Hint:* This graph will look much like those we used to analyze the Solow model.)

   d. In this economy, what is the steady-state growth rate of output per worker Y/L? How do the saving rate s and the fraction of the labor force in universities u affect this steady-state growth rate?

   e. Using your graph, show the impact of an increase in u. (*Hint:* This change affects both curves.) Describe both the immediate and the steady-state effects.

   f. Based on your analysis, is an increase in u an unambiguously good thing for the economy? Explain.

to reversing the spectacular long-run growth performance that the Asian Tigers have experienced.)

What accounts for these growth miracles? Some commentators have argued that the success of these four countries is hard to reconcile with basic growth theory, such as the Solow growth model, which takes technology as growing at a constant, exogenous rate. They have suggested that these countries' rapid growth is explained by their ability to imitate foreign technologies. By adopting technology developed abroad, the argument goes, these countries managed to improve their production functions substantially in a relatively short period of time. If this argument is correct, these countries should have experienced unusually rapid growth in total factor productivity.

One recent study shed light on this issue by examining in detail the data from these four countries. The study found that their exceptional growth can be traced to large increases in measured factor inputs: increases in labor-force participation, increases in the capital stock, and increases in educational attainment. In South Korea, for example, the investment-GDP ratio rose from about 5 percent in the 1950s to about 30 percent in the 1980s; the percentage of the working population with at least a high-school education went from 26 percent in 1966 to 75 percent in 1991.

Once we account for growth in labor, capital, and human capital, little of the growth in output is left to explain. None of these four countries experienced unusually rapid growth in total factor productivity. Indeed, the average growth in total factor productivity in the East Asian Tigers was almost exactly the same as in the United States. Thus, although these countries' rapid growth has been truly impressive, it is easy to explain using the tools of basic growth theory.[21]

MORE PROBLEMS AND APPLICATIONS

1. In the economy of Solovia, the owners of capital get two-thirds of national income, and the workers receive one-third.
   a. The men of Solovia stay at home performing household chores, while the women work in factories. If some of the men started working outside the home so that the labor force increased by 5 percent, what would happen to the measured output of the economy? Does labor productivity—defined as output per worker—increase, decrease, or stay the same? Does total factor productivity increase, decrease, or stay the same?
   b. In year 1, the capital stock was 6, the labor input was 3, and output was 12. In year 2, the capital stock was 7, the labor input was 4, and output was 14. What happened to total factor productivity between the two years?
2. Labor productivity is defined as Y/L, the amount of output divided by the amount of labor input. Start with the growth-accounting equation and show that the growth in labor productivity

[21] Alwyn Young, "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience," *Quarterly Journal of Economics* 101 (August 1995): 641–680.

depends on growth in total factor productivity and growth in the capital-labor ratio. In particular, show that

$$\frac{\Delta(Y/L)}{Y/L} = \frac{\Delta A}{A} + \alpha \frac{\Delta(K/L)}{K/L}.$$

Hint: You may find the following mathematical trick helpful. If $z = wx$, then the growth rate of z is approximately the growth rate of w plus the growth rate of x. That is,

$$\Delta z/z \approx \Delta w/w + \Delta x/x.$$

3. Suppose an economy described by the Solow model is in a steady state with population growth n of 1.8 percent per year and technological progress g of 1.8 percent per year. Total output and total capital grow at 3.6 percent per year. Suppose further that the capital share of output is 1/3. If you used the growth-accounting equation to divide output growth into three sources—capital, labor, and total factor productivity—how much would you attribute to each source? Compare your results to the figures we found for the United States in Table 8-3.