

Homework 2

Intermediate Macroeconomics

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6 Long-Run Economic Growth

6.1 Review Questions

1. According to the growth accounting approach, what are the three sources of economic growth? From what basic economic relationship is the growth accounting approach derived?
2. Of the three sources of growth identified by growth accounting, which one is primarily responsible for the slowdown in U.S. economic growth after 1973? What explanations have been given for the decline in this source of growth?
3. How did technology increase U.S. economic growth in the 1990s?
4. Explain what is meant by a steady state. In the Solow model, which variables are constant in a steady state?

5. What types of government policies can increase long-run living standards?

6. Describe the main ideas of endogenous growth theory. What does it say about the role of government in economic growth?

7. What effect should each of the following have on long-run living standards, according to the Solow model?
 - a. An increase in the saving rate.

 - b. An increase in the population growth rate.

 - c. A one-time improvement in productivity.

8. What two explanations of productivity growth does endogenous growth theory offer? How does the production function in an endogenous growth model differ from the production function in the Solow model?

9. What types of policies are available to a government that wants to promote economic growth? For each type of policy you identify, explain briefly how the policy is supposed to work and list its costs or disadvantages. How does endogenous growth theory possibly change our thinking about the effectiveness of various pro-growth policies, such as increasing the saving rate?

6.2 Numerical Problems

1. Two economies, Hare and Tortoise, each start with a real GDP per person of \$5000 in 1950. Real GDP per person grows 3% per year in Hare and 1% per year in Tortoise. In the year 2020, what will be real GDP per person in each economy? Make a guess first; then use a calculator to get the answer.

2. Over the past 20 years an economy's total output has grown from 1000 to 1300, its capital stock has risen from 2500 to 3250, and its labor force has increased from 500 to 575. All measurements are in real terms. Calculate the contributions to economic growth of growth in capital, labor, and productivity:

a. assuming that $a_K = 0.3$ and $a_N = 0.7$.

b. assuming that $a_K = 0.5$ and $a_N = 0.5$.

3. For a particular economy, the following capital input K and labor input N were reported in four different years:

Year	K	N
1	200	1000
2	250	1000
3	250	1250
4	300	1200

The production function in this economy is $Y = K^{0.3}N^{0.7}$, where Y is total output.

- a. Find total output, the capital–labor ratio, and output per worker in each year. Compare year 1 with year 3 and year 2 with year 4. Can this production function be written in per-worker form? If so, write algebraically the per-worker form of the production function.

- b. Repeat Part (a) but assume now that the production function is $Y = K^{0.3}N^{0.8}$.

4. Use the data from Table 6.1 to calculate annual growth rates of GDP per capita for each country listed over the period 1950–2018. [Note: The annual growth rate z will satisfy the equation $(1 + z)^{68} = \text{GDP}_{2018}/\text{GDP}_{1950}$. To solve this equation for z using a calculator, take logs of both sides of the equation.] You will find that Germany and Japan, two countries that suffered extensive damage in World War II, had the two highest growth rates after 1950. Give a reason, based on the analysis of the Solow model, for these countries' particularly fast growth during this period.

5. An economy has the per-worker production function

$$y_t = 3k_t^{0.5}$$

where y_t is output per worker and k_t is the capital–labor ratio. The depreciation rate is 0.1, and the population growth rate is 0.05. Saving is

$$S_t = 0.3Y_t$$

where S_t is total national saving and Y_t is total output.

- a.** What are the steady-state values of the capital–labor ratio, output per worker, and consumption per worker?

The rest of the problem shows the effects of changes in the three fundamental determinants of long-run living standards.

- b.** Repeat Part (a) for a saving rate of 0.4 instead of 0.3.

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6. Consider a closed economy in which the population grows at the rate of 1% per year. The per-worker production function is $y = 6k^{0.5}$, where y is output per worker and k is capital per worker. The depreciation rate of capital is 14% per year.
- a. Households consume 90% of income and save the remaining 10% of income. There is no government. What are the steady-state values of capital per worker, output per worker, consumption per worker, and investment per worker?
- b. Suppose that the country wants to increase its steady-state value of output per worker. What steady-state value of the capital–labor ratio is needed to double the steady-state value of output per capita? What fraction of income would households have to save to achieve a steady-state level of output per worker that is twice as high as in Part (a)?

7. Both population and the work force grow at the rate of $n = 0.01$ per year in a closed economy. Consumption is $C = 0.5(1 - t)Y$, where t is the tax rate on income and Y is total output. The per-worker production function is $y = 8k^{0.5}$, where y is output per worker and k is the capital-labor ratio. The depreciation rate of capital is $d = 0.09$ per year. Suppose for now that there are no government purchases and the tax rate on income is $t = 0$.
- a. Find expressions for national saving per worker and the steady-state level of investment per worker as functions of the capital-labor ratio, k . In the steady state, what are the values of the capital-labor ratio, output per worker, consumption per worker, and investment per worker?
 - b. Suppose that the government purchases goods each year and pays for these purchases using taxes on income. The government runs a balanced budget in each period and the tax rate on income is $t = 0.5$. Repeat Part (a) and compare your results.

6.3 Analytical Problems

1. According to the Solow model, how would each of the following affect consumption per worker in the long run (that is, in the steady state)? Explain.
 - a. The destruction of a portion of the nation's capital stock in a war.
 - b. A permanent increase in the rate of immigration (which raises the overall population growth rate).

- c. A permanent increase in energy prices.
- d. A temporary rise in the saving rate.
- e. A permanent increase in the fraction of the population in the labor force (the population growth rate is unchanged).

2. An economy is in a steady state with no productivity change. Because of an increase in acid rain, the rate of capital depreciation rises permanently.
 - a. According to the Solow model, what are the effects on steady-state capital per worker, output per worker, consumption per worker, and the long-run growth rate of the total capital stock?
 - b. In an endogenous growth model, what are the effects on the growth rates of output, capital, and consumption of an increase in the depreciation rate of capital?

3. This problem adds the government to the Solow model. Suppose that a government purchases goods in the amount of g per worker every year; with N_t workers in year t , total government purchases are gN_t . The government has a balanced budget so that its tax revenue in year t , T_t , equals total government purchases. Total national saving, S_t , is

$$S_t = s(Y_t - T_t)$$

where Y_t is total output and s is the saving rate.

- a. Graphically show the steady state for the initial level of government purchases per worker.

- b. Suppose that the government permanently increases its purchases per worker. What are the effects on the steady-state levels of capital per worker, output per worker, and consumption per worker? Does your result imply that the optimal level of government purchases is zero?

4. In a Solow-type economy, total national saving, S_t , is

$$S_t = sY_t - hK_t$$

The extra term, $-hK_t$, reflects the idea that when wealth (as measured by the capital stock) is higher, saving is lower. (Wealthier people have less need to save for the future.)

Find the steady-state values of per-worker capital, output, and consumption. What is the effect on the steady state of an increase in h ?

5. Two countries are identical in every way except that one has a much higher capital-labor ratio than the other. According to the Solow model, which country's total output will grow more quickly? Does your answer depend on whether one country or the other is in a steady state? In general terms, how will your answer be affected if the two countries are allowed to trade with each other?

6. Suppose that total capital and labor both increase by the same percentage amount, so that the amount of capital per worker, k , doesn't change. Writing the production function in per-worker terms, $y = f(k)$, requires that this increase in capital and labor must not change the amount of output produced per worker, y . Use the growth accounting equation to show that equal percentage increases in capital and labor will leave output per worker unaffected only if $a_K + a_N = 1$.

7. An economy has a per-capita production function $y = Ak^a h^{1-a}$, where A and a are fixed parameters, y is per-worker output, k is the capital–labor ratio, and h is human capital per worker, a measure of the skills and training of the average worker. The production function implies that, for a given capital–labor ratio, increases in average human capital raise output per worker.

The economy's saving rate is s , and all saving is used to create physical capital, which depreciates at rate d . Workers acquire skills on the job by working with capital; the more capital with which they have to work, the more skills they acquire. We capture this idea by assuming that human capital per worker is always proportional to the amount of physical capital per worker, or $h = Bk$, where B is a fixed parameter.

Find the long-run growth rates of physical capital, human capital, and output in this economy.

7 The Asset Market, Money, and Prices

7.1 Review Questions

1. Define money. How does the economist's use of this term differ from its everyday meaning?

2. What are the three functions of money? How does each function contribute to a more smoothly operating economy?
3. Who determines the nation's money supply? Explain how the money supply could be expanded or reduced in an economy in which all money is in the form of currency.
4. What are the four characteristics of assets that are most important to holders of wealth? How does money compare with other assets for each characteristic?

5. Describe what is meant by the expectations theory of the term structure of interest rates. Why isn't the expectations theory sufficient to describe the data on interest rates that we observe? What must be added to the expectations theory to form a more accurate theory?
6. List and discuss the macroeconomic variables that affect the aggregate demand for money.
7. What are the major components of M1? What are the major components of M2? Describe each component.
8. Why is equilibrium in the asset market described by the condition that real money supply equal real money demand? What aggregation assumption is needed to allow ignoring the markets for other assets?

9. What is the relationship between the price level and the nominal money supply? What is the relationship between inflation and the growth rate of the nominal money supply?

10. Give an example of a factor that would increase the public's expected rate of inflation. All else being equal, how would this increase in the expected inflation rate affect interest rates?

7.2 Numerical Problems

1. Suppose the interest rate on a one-year bond today is 6% per year, the interest rate on a one-year bond one year from now is expected to be 4% per year, and the interest rate on a one-year bond two years from now is expected to be 3% per year. The term premium on a two-year bond is 0.5% per year and the term premium on a three-year bond is 1.0% per year. In equilibrium, what is the interest rate today on a two-year bond? On a three-year bond? What is the shape of the yield curve?

2. Money demand in an economy in which no interest is paid on money is

$$\frac{M^d}{P} = 500 + 0.2Y - 1000i$$

- a. Suppose that $P = 100$, $Y = 1000$, and $i = 0.10$. Find real money demand, nominal money demand, and velocity.

- b.** The price level doubles from $P = 100$ to $P = 200$. Find real money demand, nominal money demand, and velocity.
- c.** Starting from the values of the variables given in Part (a) and assuming that the money demand function as written holds, determine how velocity is affected by an increase in real income, by an increase in the nominal interest rate, and by an increase in the price level.

3. Jason has wealth of \$100,000 that he invests entirely in money (a checking account) and government bonds. Jason instructs his broker to invest \$50,000 in bonds, plus \$5000 more in bonds for every percentage point that the interest rate on bonds exceeds the interest rate on his checking account.
- a. Write an algebraic formula that gives Jason's demand for money as a function of bond and checking account interest rates.
 - b. Write an algebraic formula that gives Jason's demand for bonds. What is the sum of his demand for money and his demand for bonds?
 - c. Suppose that all holders of wealth in the economy are identical to Jason. Fixed asset supplies per person are \$80,000 of bonds and \$20,000 of checking accounts. Checking accounts pay no interest. What is the interest rate on bonds in asset market equilibrium?

4. Assume that the quantity theory of money holds and that velocity is constant at
5. Output is fixed at its full-employment value of 10,000, and the price level is 2.
 - a. Determine the real demand for money and the nominal demand for money.
 - b. In this same economy the government fixes the nominal money supply at 5000. With output fixed at its full-employment level and with the assumption that prices are flexible, what will be the new price level? What happens to the price level if the nominal money supply rises to 6000?
5. Consider an economy with a constant nominal money supply, a constant level of real output $Y = 100$, and a constant real interest rate $r = 0.10$. Suppose that the income elasticity of money demand is 0.5 and the interest elasticity of money demand is -0.1 .
 - a. By what percentage does the equilibrium price level differ from its initial value if output increases to $Y = 106$ (and r remains at 0.10)? (Hint: Use Eq. 7.12.)
 - b. By what percentage does the equilibrium price level differ from its initial value if the real interest increases to $r = 0.11$ (and Y remains at 100)?
 - c. Suppose that the real interest rate increases to $r = 0.11$. What would real output have to be for the equilibrium price level to remain at its initial value?

6. Suppose that the real money demand function is

$$L(Y, r + \pi^e) = \frac{0.01Y}{r + \pi^e}$$

where Y is real output, r is the real interest rate, and π^e is the expected rate of inflation. Real output is constant over time at $Y = 150$. The real interest rate is fixed in the goods market at $r = 0.05$ per year.

- a. Suppose that the nominal money supply is growing at the rate of 10% per year and that this growth rate is expected to persist forever. Currently, the nominal money supply is $M = 300$. What are the values of the real money supply and the current price level? (Hint: What is the value of the expected inflation rate that enters the money demand function?)

- b. Suppose that the nominal money supply is $M = 300$. The central bank announces that from now on the nominal money supply will grow at the rate of 5% per year. If everyone believes this announcement, and if all markets are in equilibrium, what are the values of the real money supply and the current price level? Explain the effects on the real money supply and the current price level of a slowdown in the rate of money growth.

7. The income elasticity of money demand is $2/3$ and the interest elasticity of money demand is -0.1 . Real income is expected to grow by 4.5% over the next year, and the real interest rate is expected to remain constant over the next year. The rate of inflation has been zero for several years.
- a. If the central bank wants zero inflation over the next year, what growth rate of the nominal money supply should it choose?
 - b. By how much will velocity change over the next year if the central bank follows the policy that achieves zero inflation?

7.3 Analytical Problems

1. What happens to M1 and M2 due to each of the following changes?
 - a. You take \$500 out of your checking account and put it into a passbook savings account.
 - b. You take \$1000 out of your checking account and buy traveler's checks.
 - c. You take \$1500 out of your money-market mutual fund and deposit it into your checking account.

- d. You cash in \$2000 in savings bonds and invest the money in a certificate of deposit.

2. Figure 7.2 shows that, before the 1990s, M2 velocity generally rose over time. Suggest some explanations for this upward trend.

3. The prisoner-of-war camp described by Radford (“In Touch with Data and Research: Money in a Prisoner-of-War Camp”) periodically received large shipments of cigarettes from the Red Cross or other sources.
 - a. How did cigarette shipments affect the price level (the prices of goods in terms of cigarettes) in the POW camp?

 - b. (More difficult) On some occasions the prisoners knew in advance when the cigarette shipments were to arrive. What happened to the demand for cigarette money and the price level in the camp in the days just before an anticipated shipment?

4. Assume that prices and wages adjust rapidly so that the markets for labor, goods, and assets are always in equilibrium. What are the effects of each of the following on output, the real interest rate, and the current price level?
- a. A temporary increase in government purchases.
 - b. A reduction in expected inflation.
 - c. A temporary increase in labor supply.
 - d. An increase in the interest rate paid on money.

9 The IS–LM/AD–AS Model: A General Framework for Macroeconomic Analysis

9.1 Review Questions

1. What determines the position of the FE line? Give two examples of changes in the economy that would shift the FE line to the right.

2. What relationship does the IS curve capture? Derive the IS curve graphically and show why it slopes as it does. Give two examples of changes in the economy that would cause the IS curve to shift down and to the left.

3. What relationship does the LM curve capture? Derive the LM curve graphically and show why it slopes as it does. Give two examples of changes in the economy that would cause the LM curve to shift down and to the right.

4. For constant output, if the real money supply exceeds the real quantity of money demanded, what will happen to the real interest rate that clears the asset market? In describing the adjustment of the real interest rate, use the relationship that exists between the price of a nonmonetary asset and the interest rate that it pays.

5. Define general equilibrium and show the general equilibrium point in the IS–LM diagram. If the economy isn't in general equilibrium, what determines output and the real interest rate? What economic forces act to bring the economy back to general equilibrium?

6. Define monetary neutrality. Show that, after prices adjust completely, money is neutral in the IS–LM model. What are the classical and Keynesian views about whether money is neutral in the short run? In the long run?

7. What two variables are related by the aggregate demand (AD) curve? Why does the AD curve slope downward? Give two examples of changes in the economy that shift the AD curve up and to the right and explain why the shifts occur.

8. Describe the short-run aggregate supply (SRAS) curve and the long-run aggregate supply (LRAS) curve. Why is one of these curves horizontal and the other vertical?

9. Use the AD–AS framework to analyze whether money is neutral in the short run and whether it is neutral in the long run.

9.2 Numerical Problems

1. Desired consumption and investment are

$$C^d = 4000 - 4000r + 0.20Y;$$

$$I^d = 2400 - 4000r.$$

As usual, Y is output and r is the real interest rate. Government purchases, G , are 2000.

- a. Find an equation relating desired national saving, S^d , to r and Y .
- b. What value of the real interest rate clears the goods market when $Y = 10,000$? Use both forms of the goods market equilibrium condition. What value of the real interest rate clears the goods market when $Y = 10,200$? Graph the IS curve.
- c. Government purchases rise to 2400. How does this increase change the equation for national saving in part (a)? What value of the real interest rate clears the goods market when $Y = 10,000$? Use both forms of the goods market equilibrium condition. How is the IS curve affected by the increase in G ?

2. In a particular economy the real money demand function is

$$\frac{M^d}{P} = 3000 + 0.1Y - 10,000i.$$

Assume that $M = 6000$, $P = 2.0$, and $\pi^e = 0.02$.

a. What is the real interest rate, r , that clears the asset market when $Y = 8000$?
When $Y = 9000$? Graph the LM curve.

b. Repeat part (a) for $M = 6600$. How does the LM curve in this case compare with the LM curve in part (a)?

c. Use $M = 6000$ again and repeat part (a) for $\pi^e = 0.03$. Compare the LM curve in this case with the one in part (a).

4. The production function in an economy is

$$Y = A(5N - 0.0025N^2),$$

where A is productivity. With this production function, the marginal product of labor is

$$MPN = A(5 - 0.005N).$$

Suppose that $A = 2$. The labor supply curve is

$$NS = 55 + 10(1 - t)w,$$

where NS is the amount of labor supplied, w is the real wage, and t is the tax rate on wage income, which is 0.5.

Desired consumption and investment are

$$C^d = 300 + 0.8(Y - T) - 200r;$$

$$I^d = 258.5 - 250r.$$

Taxes and government purchases are

$$T = 20 + 0.5Y; \quad G = 50.$$

Money demand is

$$\frac{M^d}{P} = 0.5Y - 250(r + \pi^e).$$

The expected rate of inflation, π^e , is 0.02, and the nominal money supply M is 9150.

- a. What are the general equilibrium levels of the real wage, employment, and output?

- b. For any level of output, Y , find an equation that gives the real interest rate, r , that clears the goods market; this equation describes the IS curve. (Hint: Write the goods market equilibrium condition and solve for r in terms of Y and other variables.) What are the general equilibrium values of the real interest rate, consumption, and investment?

- c. For any level of output, Y , find an equation that gives the real interest rate that clears the asset market; this equation describes the LM curve. [Hint: As in part (b), write the appropriate equilibrium condition and solve for r in terms of Y and other variables.] What is the general equilibrium value of the price level?
- d. Suppose that government purchases increase to $G = 72.5$. Now what are the general equilibrium values of the real wage, employment, output, the real interest rate, consumption, investment, and price level?

5. Consider the following economy:

$$\text{Desired consumption} \quad C^d = 1275 + 0.5(Y - T) - 200r.$$

$$\text{Desired investment} \quad I^d = 900 - 200r.$$

$$\text{Real money demand} \quad L = 0.5Y - 200i.$$

$$\text{Full-employment output} \quad Y = 4600.$$

$$\text{Expected inflation} \quad \pi^e = 0.$$

- a.** Suppose that $T = G = 450$ and that $M = 9000$. Find an equation describing the IS curve. (Hint: Set desired national saving and desired investment equal, and solve for the relationship between r and Y .) Find an equation describing the LM curve. (Hint: Set real money supply and real money demand equal, and again solve for the relationship between r and Y , given P .) Finally, find an equation for the aggregate demand curve. (Hint: Use the IS and LM equations to find a relationship between Y and P .) What are the general equilibrium values of output, consumption, investment, the real interest rate, and price level?
- b.** Suppose that $T = G = 450$ and that $M = 4500$. What is the equation for the aggregate demand curve now? What are the general equilibrium values of output, consumption, investment, the real interest rate, and price level? Assume that full-employment output Y is fixed.
- c.** Repeat part (b) for $T = G = 330$ and $M = 9000$.

6. (Appendix 9.B) This question asks you to use the formulas in Appendix 9.B to find the general equilibrium values of variables for the economy described in Numerical Problem 4. Assume that $G = 50$.
 - a. Use the data from Numerical Problem 4 to find the numerical values of the parameters $A, f_1, f_2, n_0, n_w, c_0, c_Y, c_r, t_0, t, i_0, i_r, \ell_0, \ell_Y, \ell_r$, and ℓ_i defined in Appendix 9.B.
 - b. Substitute the values of these behavioral parameters into the relevant equations in Appendix 9.B to compute the general equilibrium values of the real wage, employment, output, the real interest rate, and the price level.
 - c. Assume that government purchases, G , increase to 72.5, and repeat part (b).

9.3 Analytical Problems

1. For each of the following changes, what happens to the real interest rate and output in the very short run, before the price level has adjusted to restore general equilibrium?
 - a. Wealth declines.

- b.** The money supply declines.
- c.** The future marginal productivity of capital declines.
- d.** Expected inflation rises.
- e.** Future income rises.

2. Use the IS–LM model to analyze the general equilibrium effects of a permanent increase in the price of oil (a permanent adverse supply shock) on current output, employment, the real wage, national saving, consumption, investment, the real interest rate, and the price level. Assume that, besides reducing the current productivity of capital and labor, the permanent supply shock lowers both the expected future MPK and households' expected future incomes. (Assume that the rightward shift in labor supply is smaller than the leftward shift in labor demand.) Show that, if the real interest rate rises at all, it will rise less than in the case of a temporary supply shock that has an equal effect on current output.

3. Suppose that the price level is fixed in the short run so that the economy doesn't reach general equilibrium immediately after a change in the economy. For each of the following changes, what are the short-run effects on the real interest rate and output? Assume that, when the economy is in disequilibrium, only the labor market is out of equilibrium; assume also that for a short period firms are willing to produce enough output to meet the aggregate demand for output.
- a. A decrease in the expected rate of inflation.
 - b. An increase in consumer optimism that increases desired consumption at each level of income and the real interest rate.
 - c. A temporary increase in government purchases.
 - d. An increase in lump-sum taxes, with no change in government purchases (consider both the case in which Ricardian equivalence holds and the case in which it doesn't).
 - e. A scientific breakthrough that increases the expected future MPK .

4. (Appendix 9.B) In some macroeconomic models, desired investment depends on both the current level of output and the real interest rate. One possible reason that desired investment may depend on output is that, when current production and sales are high, firms may expect continued strong demand for their products in the future, which leads them to want to expand capacity. Algebraically, we can allow for a link between desired investment and current output by replacing Eq. (9.B.10) with

$$I^d = i_0 - i_r r + i_Y Y$$

where i_Y is a positive number. Use this alternative equation for desired investment to derive the algebraic expressions for the general equilibrium values of employment, the real wage, output, the real interest rate, and the price level.

5. (Appendix 9.B) Recall from Chapter 7 that an increase in i_m , the nominal interest rate on money, increases the demand for money. To capture that effect, let's replace Eq. (9.B.17) with

$$\frac{M^d}{P} = \ell_0 + \ell_Y Y - \ell_r (r + \pi^e - i_m)$$

How does this modification change the solutions for the general equilibrium values of the variables discussed in Appendix 9.B, including employment, the real wage, output, the real interest rate, and the price level?