

Modules 6 and 7: Markets, Prices, Supply, and Demand practice problems

Practice problems and illustrative test questions for the final exam

(The attached PDF file has better formatting.)

This posting gives sample final exam problems. Other topics from the textbook are asked as well; these problems are just examples. All final exam problems are multiple choice; practice problems are not multiple choice so that the solutions can be better explained.

The following symbols are used in this chapter

- P = price level
- C = real consumption, so PC = nominal consumption
- K = real capital stock, so PK = nominal capital stock
- Π = nominal profit, so Π/P = real profit
- A = technology level
- K^d = demand for capital services; K^s = supply of capital services
- L^d = demand for labor; L^s = supply of labor
- F = the production function, often shown as $A \times F(K^d, L^d)$
- w = nominal wage rate, so w/P is the real wage rate
- R = nominal rental price, so R/P is the real rental price

Some macroeconomics textbooks use *households* for consumers and *business firms* for producers. Barro uses households for both consumers and producers, since people producing goods also consume goods.

**** Exercise 6.1: Equilibrium equations**

- A. What is the formula for household nominal income?
- B. What is the formula for household real income?
- C. What is the household budget constraint in nominal terms?
- D. What is the household budget constraint in real terms?
- E. What is the slope of the household budget constraint?

Part A: Household nominal income includes labor income, return on capital, interest on bonds, and profits.

Labor income is the wage rate times labor.

- Nominal labor income is the nominal wage rate times the labor used, or wL .
- Real labor income is the real wage rate times the labor used, or $(w/P) \times L$.

The return on capital is the rental price times capital minus depreciation. R is the nominal rental price, so PK is a nominal return. The depreciation rate δ does not adjust for inflation, and K is capital in real terms, so $\delta \times K$ is depreciation in real units.

- The nominal return on capital is $RK - \delta \times PK = (R/P - \delta) \times PK$.
- The real return on capital is $RK - \delta \times PK = (R/P - \delta) \times K$.

Bond income is the interest rate times the market value of bonds.

- Nominal bond income is the nominal interest rate i times bonds in nominal terms B , or iB .
- Real bond income is iB/P .

Nominal profit is Π . Real profit is Π/P .

Household nominal income $\Pi + wL + (R/P - \delta) \times PK + iB$

See Barro, Macroeconomics, Chapter 6, market prices supply demand, page 99, column 2, equation 6.5

Question: Is i (the coefficient of B) the real interest rate or the nominal interest rate?

Answer: The i is the real interest rate.

Question: Isn't B always zero, since any bonds owned by one person are issued by another?

Answer: For the economy as a whole, $B = 0$. For any one household, B may be positive or negative.

Question: Isn't economic profit $\Pi = 0$? Shouldn't we drop this variable from household income?

Answer: In the long run for the economy as a whole, economic profit $\Pi = 0$. In the short run for the economy, and for any one business (household) even in the long run, economic profit Π may be positive or negative.

Part B: Dividing by P gives household real income = $\Pi/P + (w/P) \times L + (R/P - \delta) \times K + iB/P$

Part C: The household budget constraint in nominal terms is

$$\text{nominal consumption} + \text{nominal savings} = \text{nominal income}$$

C is real consumption, so nominal consumption is PC .

Savings are used to buy bonds or buy capital.

- Bonds B are in nominal terms, so ΔB is the change in nominal bonds.
- K is capital in real terms, so $P \times \Delta K$ is the change in nominal capital.

In equilibrium, the nominal rental price R/P equals the nominal interest rate i , so nominal income is $\bar{Y} + wL + i \times (B + PK)$.

⇒ The household budget constraint in nominal terms is $PC + \Delta B + P \times \Delta K = \bar{Y} + wL + i \times (B + PK)$.

See Barro, Macroeconomics, Chapter 6, market prices supply demand, page 101, column 2, equation 6.11

Question: Why does the left side of this equation use ΔB and ΔK but the right side uses B and K ?

Answer: The left side is nominal consumption + savings; the right side is nominal income.

- Bond income is the interest rate times all bonds, not the change in bonds.
- The nominal rental price minus depreciation is the nominal interest rate, so the return on capital is $i \times PK$.
- Income is used for consumption, investment, and buying bonds.
- Investment is the change in capital, and the additional bonds are ΔB .

Part D: The household budget constraint in real terms: real consumption + real savings = real income.

Divide each term in the previous equation by P to get $C + (1/P) \times \Delta B + \Delta K = \bar{Y}/P + (w/P) \times L + i \times (B/P + K)$.

See Barro, Macroeconomics, Chapter 6, market prices supply demand, page 102, column 1, equation 6.12

Part E: The household budget constraint shows real saving on the vertical axis and consumption on the horizontal axis. The budget constraint says that consumption + savings = income. If consumption increases one dollar, savings decreases one dollar, so the slope of the budget constraint is -1 .

See Barro, Macroeconomics, Chapter 6, market prices supply demand, page 102, column 1, figure 6.2

**** Exercise 6.2: Equilibrium equations**

- A. What is the nominal economic profit Π received by a household?
- B. What is the real economic profit Π/P received by a household?
- C. At equilibrium, what is the relation of the real wage rate (w/P) and the marginal product of labor (MPL)? (If firms use L^d of labor and K^d of capital, what is the change in real profit from one more unit of labor?)
- D. At equilibrium, what is the relation of the real rental price (R/P) and the marginal product of capital (MPK)? (If firms use L^d of labor and K^d of capital, what is the change in real profit from one more unit of capital?)

Part A: Economic profit Π is output minus labor costs (wages) minus rental payments for capital.

- Nominal output is $A \times F(K^d, L^d)$ = the nominal revenue from labor and capital demanded.
- Nominal labor costs (wages) are wL^d .
- The nominal rental payments for capital are RK^d .

The nominal economic profit Π received by a household is $P \times A \times F(K^d, L^d) - wL^d - RK^d$

- Profit Π is nominal; real profit is Π/P .
- Labor is in units of worker-hours; it is real, not nominal.
 - The wage rate w is dollars per worker-hour, so wL is in units of dollars.
 - The real wage rate is w/P .

See Barro, Macroeconomics, Chapter 6, market prices supply demand, page 103, column 1, equation 6.2

Part B: The real economic profit Π/P is the nominal economic profit divided by $P \Rightarrow$

The real economic profit Π/P received by a household is $A \times F(K^d, L^d) - (w/P) \times L^d - (R/P) \times K^d$

See Barro, Macroeconomics, Chapter 6, market prices supply demand, page 103, column 2, equation 6. 13

Part C: The change in output from one more unit of labor is $\partial \text{output} / \partial L$ = the marginal product of labor.

The production function is in real terms, so this is the change in the real value of output.

The change in real costs is $\partial[(w/P) \times L^d - (R/P) \times K^d] / \partial L = w/P$, the real wage rate.

- If the marginal product of labor were more than the real wage rate, employers would add more workers and increase profits.
- If the marginal product of labor were less than the real wage rate, employers would remove some workers and increase profits.

Since employers maximize profits, the real wage rate must equal the marginal product of labor in equilibrium.

\Rightarrow marginal product of labor = real wage rate (that is, $w/P = \text{MPL}$)

Question: Why is this equation important?

Answer: This relation says that if a worker's marginal product of labor is \$20 an hour, the worker receives \$20 an hour in wages.

Question: This relation seems contradicted by real work experience. Suppose an American worker picks grapes for \$20 an hour. If Mexican workers enter the country and agree to pick grapes for \$10 an hour, the employer will pay the American worker only \$10 an hour, even though the value of his work has not changed.

Answer: The marginal product of labor (the value of the work) has changed even for the American worker. At labor costs of \$20 an hour, the farmer plants only the best land. At labor costs of \$10 an hour, the farmer plants more land, which is profitably only at the lower wage. marginal product of labor is the value of the last hour of labor: that is, the hour of labor on the poorest quality land.

Question: Does this relation of the real wage rate and the marginal product of labor imply that illegal immigration hurts American workers?

Answer: Without Mexican workers, some American workers would be paid more, but goods in the U.S. would cost more. Mexican workers who charge less for their labor increase U.S. real GDP, creating more goods and benefitting U.S. citizens. Native-born U.S. citizens have better education and more human capital (education), so they receive better jobs when real GDP increases. Barro discusses this as the benefits of trade.

Question: Labor markets have a downward sloping labor supply. If the country has an excess of labor (as India and Indonesia and Vietnam have), won't the real wage rate fall below the marginal product of labor?

Answer: The marginal product of labor is the value of the last worker's labor. If the country has many workers and little capital (as India and Indonesia and Vietnam have), the marginal product of labor is lower than the average product of labor. In the long run, businesses add more capital, and the marginal product of labor (= the real wage rate) rises. In the short run, the marginal product of labor is low.

See Barro, Macroeconomics, Chapter 6, market prices supply demand, page 102, column 2, and page 104, column 1, demand for labor

Part D: The change in output from one more unit of capital is $\partial \text{output} / \partial K =$ the marginal product of capital.

The production function is in real terms, so this is the change in the real value of output.

The change in real rental costs is $\partial [(w/P) \times L^d - (R/P) \times K^d] / \partial K = R/P$, the real rental price.

- If the marginal product of capital were more than the real rental price, employers would add capital and increase profits.
- If the marginal product of capital were less than the real rental price, employers would remove capital and increase profits.

Since employers maximize profits, the real rental price equals the marginal product of capital in equilibrium.

⇒ marginal product of capital = real rental price (that is, $R/P = MPK$)

See Barro, Macroeconomics, Chapter 6, market prices supply demand, page 106

**** Exercise 6.3: Equilibrium equations**

Suppose business firms use L^d of labor and K^d of capital, and the labor market is not in equilibrium.

- A. What is the change in real profit from one more unit of labor?
- B. What is the change in real profit from one more unit of capital?
- C. Real profits are (equation 6.13) $\Pi/P = A \times F(K^d, L^d) - (w/P) \times L^d - (R/P) \times K^d$. To maximize profits, firms use labor and capital so that $\partial(\Pi/P)/\partial K^d = 0$ and $\partial(\Pi/P)/\partial L^d = 0$. What is the resulting relation?

Part A: The increase in output from one more unit of labor is the marginal product of labor (MPL). The increase in costs is the real wage rate (w/P). The increase in profit is $MPL - w/P$.

See Barro, *Macroeconomics*, Chapter 6, page 104: the change in real profit = the marginal product of labor – the real wage rate: $\Pi/P = A \times F(K^d, L^d) - (w/P) \times L^d - (R/P) \times K^d$, so

$$\partial(\Pi/P)/\partial L = \partial[A \times F(K^d, L^d)]/\partial L - \partial[(w/P) \times L^d - (R/P) \times K^d]/\partial L = MPL - w/P.$$

Part B: The increase in output from one more unit of capital is the marginal product of capital (MPK). The increase in costs is the real rental price (R/P). The increase in profit is $MPK - R/P$.

$$\partial(\Pi/P)/\partial K = \partial[A \times F(K^d, L^d)]/\partial K - \partial[(w/P) \times L^d - (R/P) \times K^d]/\partial K = MPK - R/P.$$

Part C: To maximize profits, households use labor and capital so that $\partial(\Pi/P)/\partial K^d = 0$ and $\partial(\Pi/P)/\partial L^d = 0$.

We infer that $MPL = w/P$ and $MPK = R/P$ in equilibrium, so $\Pi/P = A \times F(K, L) - MPL \times L - MPK \times K$.

See Barro, *Macroeconomics*, Chapter 6, page 108, equation 6.18.

Question: Why did you drop the superscript “d” on L and K?

Answer: K and L are now the equilibrium amounts of capital and labor, not the demand for capital and labor.

**** Exercise 6.4: Market for capital**

The supply of capital $K^s = 15$, the real rental price $R/P = 5\%$, and capital \times the marginal product of capital = 1. The capital utilization rate (κ) = 100% and the depreciation rate of capital $\delta = \text{zero}$. Assume that both capital and the capital utilization rate are fixed.

- A. What is the marginal product of capital?
- B. Why is the market for capital not in equilibrium (the market does not clear)?
- C. What happens to clear the market for capital?

What happens in the short run as the market for capital clears? Assume the capital utilization rate (κ) does not change.

Part A: The supply of capital K^s is 15, so the marginal product of capital = $1 / 15 = 6.667\%$.

Part B: Business firms demand more capital than is being supplied, since the marginal product of capital is more than the real rental price of 5%.

Part C: The capital stock and the capital utilization rate are fixed, so the marginal product of capital does not change. To clear the market, the real rental price increases to 6.667%.

Question: What might cause this scenario?

Answer: Developing countries have low marginal products of capital, since people do not use advanced machinery efficiently. As the technology level rises (perhaps because people learn of the new machines from international trade), the marginal product of capital rises. It becomes worth while to use more capital, but it takes time until the new capital is produced. In the short run, the capital stock is fixed. The real rental price increases, and capital is used by those willing to pay more for it.

See Barro, *Macroeconomics*, Chapter 6, Markets, prices, supply, and demand, page 107, Figure 6.7