# Econ 302 Intermediate Macro Handout 11

April 28, 2016

## Chapter 17 - The Theory of Investment

Remember that GDP is made up of consumption, government spending, net exports, and investment spending. Last week we looked at the microeconomic decisions that consumers make to determine consumption. This week, we turn to decisions that firms make. Studying investment spending is particularly important for understanding the business cycle, because investment is far more volatile than consumption. During a recession, investment falls by much more than consumption.

#### Three Types of Investment

1. Business Fixed Investment - Equipment, intellectual property, etc. used in production
2. Residential Investment - New housing
3. Inventory Investment - Goods and materials added to inventory

### Business Fixed Investment

#### Neoclassical Model of Investment

To understand a firm's investment decision, we need to model the costs and benefits of buying and renting capital. For simplicity, we assume there are two types of firms: **production firms** and **rental firms**. Production firms rent capital from the rental firms to produce goods and services. Rental firms buy capital that they rent to production firms. Thus, investment spending is driven by the rental firms, but they make investments in anticipation of renting capital to production firms and making a profit.

#### Production Firms

Let the rental price of a unit of capital be $R$ and the price level be $P$. Then the **real rental price of capital** is $R/P$. The real benefit from renting an

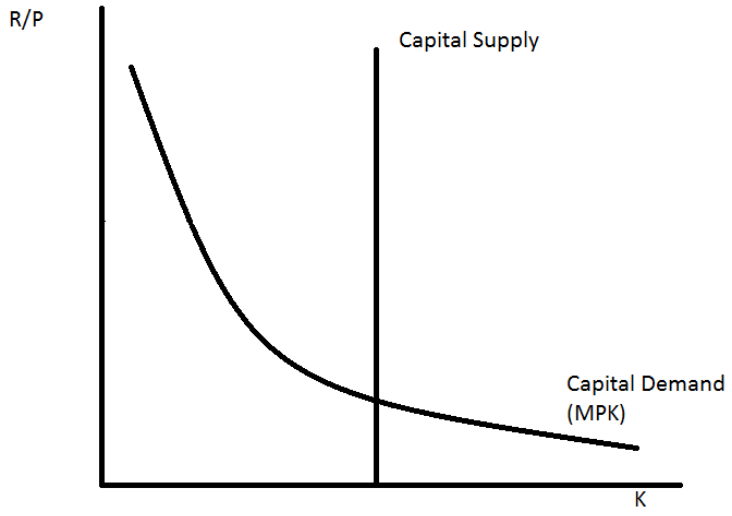
additional unit of capital is the **marginal product of capital**. Thus, in equilibrium:

$$\frac{R}{P} = MPK$$

For a Cobb-Douglas production function, this is

$$R/P = \alpha A(L/K)^{1-\alpha}$$

Notice that, since MPK declines in the level of capital, **demand for capital is downward sloping**. Since at any given point, the supply of capital is inelastic, a supply and demand graph looks like:




The equation $R/P = MPK$ defines the equilibrium rental price at each level of capital, and the supply of capital locks down the level of capital in the economy. Thus equilibrium rental price is where the two curves meet. We notice that

1. The rental price falls as the stock of capital $K$ rises
2. If labor supply $L$ increases, the rental price increases
3. If technology increases ($A$ increases), the rental price increases

### Rental Firms

We now consider the decision of a rental firm. Clearly, **the benefit to owning a unit of capital is the income $R/P$ generated from renting it out**. What is the **cost of capital?**

There are three pars to the **cost of capital**:

1. Borrowing to buy a unit of capital (or foregoing interest earned on investing the cash used to buy a unit of capital) entails **interest cost**:

$$iP_K$$

where $i$ is in the interest rate and $P_K$ is the price of a unit of capital.

2. Capital is an asset to the rental firm. If the price of capital falls, the firm suffers a loss (if the price of capital rises, the firm gains). The cost is:

$$-\Delta P_K$$

or the change in the price of capital (if the change is negative, the cost is positive, etc.).

3. As we have seen before, **capital depreciates**. Every period, $\delta P_K$ of the capital's value is lost to depreciation.

Thus the total cost of capital is all these costs summed:

$$\begin{aligned}\text{Cost of Capital} &= iP_K - \Delta P_K + \delta P_K \\ &= P_K(i - \Delta P_K/P_K + \delta) \\ &= P_K(r + \delta)\end{aligned}$$

where the last equality assumes that the percent change in the price of capital, $\Delta P_K/P_K$, is the same as the rate of inflation $\pi$. By the Fisher Equation

$$i - \Delta P_K/P_K = i - \pi = r$$

As usual, to get the **real cost of capital**, we divide through by the price level $P$:

$$\text{Real Cost of Capital} = \frac{P_K}{P}(r + \delta)$$

**Determining Investment Spending**

We have outlined the costs and benefits for both the production firms and the rental firms. But **what determines the level of investment spending in the economy?** Let's examine the marginal decision of a rental firm. Their profits are:

$$\begin{aligned}\text{Profit} &= \text{Revenue} - \text{Cost} \\ &= R/P - \frac{P_K}{P}(r + \delta) \\ &= MPK - \frac{P_K}{P}(r + \delta)\end{aligned}$$

Thus, it is profitable to add another unit of capital when the MPK is greater than the cost of capital. Note that this result *is the same for a firm that both produces and buys capital.*

We can characterize the change in the capital stock as a function of the profits from buying more capital:

$$\Delta K = I_n[MPK - \frac{P_K}{P}(r + \delta)]$$

where $I_n$ is some function. To get the total level of investment spending, let $K$ be the capital stock today and $K'$ be the capital stock tomorrow. Note that:

$$K' = K + \Delta K$$

Investment spending is the difference between capital tomorrow, $K'$, and the capital that was leftover today after depreciation, $(1 - \delta)K$. The intuition here is that at the end of the day, we were left with $(1 - \delta)K$. To end up with $K'$ tomorrow, we must have purchased the difference. Thus:

$$\begin{aligned} I &= K' - (1 - \delta)K \\ &= K + \Delta K - K + \delta K \\ &= I_n[MPK - \frac{P_K}{P}(r + \delta)] + \delta K \end{aligned}$$

So **business fixed investment depends on the MPK, the cost of capital, and the depreciation rate**.

We can now see why the investment demand curve is downward sloping: as the interest rate rises, the cost of capital increases, and so $I$ decreases. Changes in MPK will shift the curve.

### Steady State

What happens with MPK increases above the cost of capital? Then adding more capital is profitable, and so the stock of capital increases. If MPK falls below the cost of capital, then firms will let their capital depreciate away and the stock of capital will fall. Eventually, these forces cause:

$$MPK = (P_K/P)(r + \delta)$$

and investment spending is just replacement of depreciated capital. We call this a **steady state**, as $K' = K$: the level of capital is not changing.

### Tobin's q

Another measure of the returns to adding an additional unit of capital (beyond the difference between MPK and the cost of capital) is what we call **Tobin's q**,

named after economist James Tobin. It is defined as:

$$q = \frac{\text{Market Value of Installed Capital}}{\text{Replacement Cost of Installed Capital}}$$

A more specific name for this is **Tobin's Average q**. Basically, it measures the market value of the firm due to one unit of capital. One advantage of Tobin's Average q is that it is *easily measured*. The numerator can be measured by the market capitalization of a firm: the stock price multiplied by the number of shares. This is the market's valuation of the firm (remember from your finance classes that market capitalization is the present discounted value of all future profits). The denominator can be measured from a firm's financial statements. Thus, $q$ measures how productive (measured in profits) the market thinks one dollar of capital is at this firm.

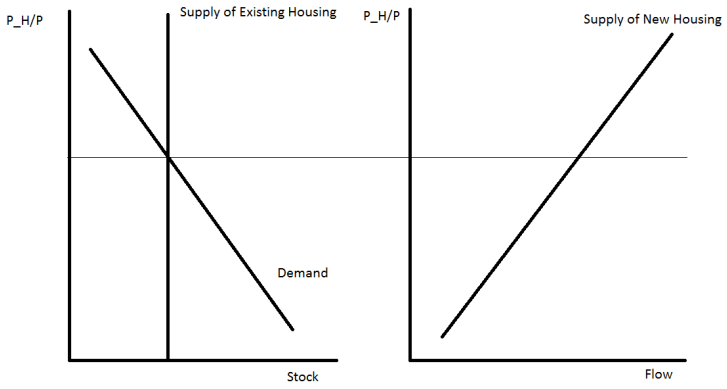
If $q > 1$, then the market thinks each dollar invested in capital creates more than one dollar of profits. Thus the firm should add another unit of capital. If $q < 1$, then the market thinks capital creates less value than it costs, so the firm should not invest.

**Exercise:** Why might Tobin's Average q not accurately give a firm information about the profitability of the next unit of capital it is thinking about installing?

## Residential Investment

### Stock versus Flow

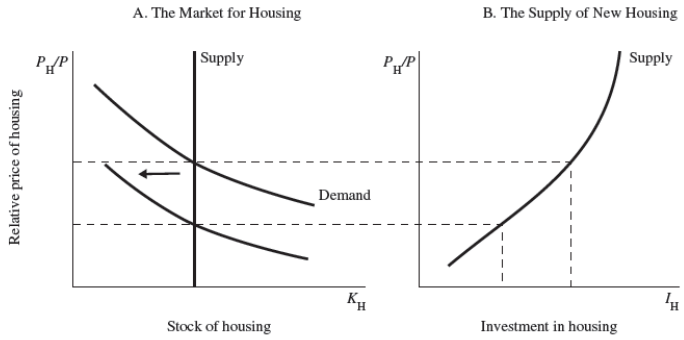
It takes time to build new houses, so getting clear on the difference between the stock and flow of housing is important.




In the short term, the stock of housing is fixed, thus the supply curve is vertical. The intersection of supply and demand determines the relative price of housing,

and the relative price of housing affects the supply of new housing.

What happens when the interest rate rises? It is costlier to get a mortgage, and so demand for housing falls. This lowers the price of housing and thus reduces investment spending on new housing:




# Exercises

**Mankiw 17.1** Use the neoclassical model of investment to explain the impact of each of the following on the rental price of capital, the cost of capital, and investment.

1. Anti-inflationary monetary policy raises the interest rate.
2. An earthquake destroys part of the capital stock.
3. Immigration of foreign workers increases the size of the labor force.
4. Advances in computer technology make production more efficient.

**Mankiw 17.2** Suppose that the government levies a tax on oil companies equal to a proportion of the value of the company's oil reserves. (The government assures the firms that the tax is for one time only.) According to the neoclassical model, what effect will the tax have on business fixed investment by these firms? What if these firms face financing constraints?

**Mankiw 17.3** The IS-LM model assumes that investment depends only on the interest rate. Yet our theories of investment suggest that investment might also depend on national income: higher income might induce firms to invest more.

1. Explain why investment might depend on national income.

2. Suppose that investment is determined by

$$I = \bar{I} + aY$$

where $a$ is a parameter between zero and one, which measures the influence of national income on investment. With investment set this way, what are the fiscal-policy multipliers in the Keynsian-cross model? Explain.

3. Suppose that investment depends on both income and the interest rate:

$$I = \bar{I} + aY - br$$

with $b > 0$. Use the IS-LM model to consider the short-run impact of an increase in government purchases on national income $Y$, the interest rate $r$, consumption $C$, and investment $I$. How might this investment function alter the conclusions implied by the basic IS-LM model?

**Mankiw 17.7** U.S. tax laws encourage investment in housing (such as through the deductibility of mortgage interest for purposes of computing taxable income) and discourage investment in business capital (such as through the corporate income tax). What are the long-run effects of this policy? (Hint: Think about the labor market.)