

EoE NOTES

INVESTMENT

There are three types of Investment spending:

1. **Business fixed investment:** includes the equipment and structures that businesses buy to use in production
2. **Residential investment:** includes the new housing that people buy to live in and that landlords buy to rent out
3. **Inventory investment:** includes those goods that businesses put aside in storage, including materials and supplies, work in process, and finished goods

Business fixed investment

“Fixed” means that this spending is for capital that will stay put for a while as opposed to inventory investment which will be used or sold shortly. The standard model is called the **neoclassical model of investment** which examines the benefits and costs to firm of owning capital goods. The model shows how the level of investment – the addition to the stock of capital – is related to the marginal product of capital, the interest rate and the tax rules affecting firms.

To develop the model, imagine that there are two kinds of firms in the economy. *Production firms* produce goods and services using capital they rent. *Rental firms* make all the investments in the economy, they buy capital and rent it out to the production forms. Of course, most firms in the actual economy perform both the functions, however, our analysis is simple if we separate these two activities by imagining that they take place in different firms.

a. The Rental Price of Capital

Let's first consider the typical production firm. The firm decides how much capital to rent by comparing the cost and benefit of each unit of capital. The firm rents capital at a rental rate R and sells its output at a price P ; the real cost of unit of capital to the production firm is R/P . The real benefit of a unit of capital is the marginal product of capital MPK – the extra output produced with one more unit of capital. The MPK declines as the amount of capital rises: the more capital the firm has, the less an additional unit of capital will add to its output. To maximize profit, the firm rents capital until the MPK falls to equal the real rental price. The demand for capital curve slopes downward because the MPK is low when the level of capital is high. At any point in time, the amount of capital in the economy is fixed so the capital supply curve is vertical. The real rental price of capital adjusts to equilibrate supply and demand. Many economies consider the Cobb-Douglas production function a good approximation of how the actual economy turns capital and labor into goods and services. The Cobb-Douglas production function is:

$$Y = AK^\alpha L^{1-\alpha}$$

Where Y is output, K capital, L labor, A is parameter measuring the level of technology, α measures capital's share of output (value between zero and one). Hence, the MPK is:

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

Because the real rental price equals the marginal product of capital in equilibrium, we can say

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

This expression identifies the variable that determine the real rental price. It shows the following:

- Lower the stock of capital, higher the real rental price of capital
- Greater the amount of labor employed, higher the real rental price of capital
- Better the technology, higher the real rental price of capital

Events that reduce the capital stock (an earthquake), or raise in employment (an expansion of aggregate demand), or improve the technology (scientific discovery) raise the equilibrium real rental price of capital.

b. The Cost of Capital

Next consider the rental firms. These firms like car-rental companies, merely buy capital goods and rent them out. We begin by considering the benefit and cost of owning capital. The benefit of owning capital is the revenue from renting it to the production firm. The rental firm receives the real rental price of capital R/P for each unit of capital it owns and rents out. The cost of owning capital is more complex. For each period of time that it rents out a unit of capital the rental firm bears three costs:

1. When a rental firm borrows to buy a unit of capital, which it intends to rent out, it must pay interest on the loan. If P_K is the purchase price of a unit of capital and i is the nominal interest rate, then iP_K is the interest cost. Notice that this interest cost would be the same even if the rental firm did not have to borrow: if the rental firm buy a unit of capital using cash on hand, it loses out the interest it could have earned by depositing this cash in the bank. In either case the interest cost is iP_K .
2. When the rental firm is renting out the capital, the price of capital can change. If the price of capital falls, the firm loses because the firm's asset has fallen in value. If the price of capital rises, the firm gains because the firm's asset has risen in value. The cost of this loss or gain is $-\Delta P_K$ (minus sign is due to measuring of cost and not benefit).
3. While the capital is rented out, it suffers wear and tear called **depreciation**. If δ is the rate of depreciation – the fraction of value lost per period because of wear and tear – then the dollar cost of depreciation is δP_K . Total cost of renting out a unit of capital for one period is:

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

The cost of capital depends upon the price of capital, the interest rate, the rate at which capital prices are changing and depreciation rate.

To make the expression of cost of capital simpler and easier to interpret, we assume that the price of capital goods rises with the prices of other goods. In this case, $\Delta P_K / P_K$ equals the overall rate of inflation π . Because $1 - \pi$ equals the real interest rate r , we can write the cost of capital as:

Cost of capital = $P_K (r + \delta)$ i.e., cost of capital depends on the price of capital, real interest rate and depreciation rate.

Real Cost of capital = $P_K / P(r + \delta)$ i.e., cost of capital depends on the relative price of capital good P_K / P , real interest rate r and depreciation rate δ .

The firm's decision regarding its capital stock – i.e., whether to add to it or let it depreciate – depends on whether owning and renting out capital is profitable. The change in the capital stock, called the **net investment** depends on the difference between the MPK and the Cost of Capital.

If the $MPK > \text{Cost of Capital}$ firms find it profitable to add to their capital stock.

If the $MPK < \text{Cost of Capital}$ then firms let their capital stock shrink.

For the firm that both uses and owns capital, the benefit of an extra unit of capital is the MPK and the cost is the Cost of Capital. Like a firm that owns and rents out capital, this firm adds to its capital stock if the MPK exceeds the cost of capital. This we can write:

$\Delta K = I_n [MPK - (P_K / P)(r + \delta)]$ where I_n is the function showing how much net investment responds to the incentive to invest.

We can now derive Investment function. Total spending on business fixed investment is the sum of net investment and the replacement of depreciated capital. The investment function is:

$$I = I_n [MPK - (P_K / P)(r + \delta)] + \delta K$$

This model shows why investment depends on the interest rate. A decrease in the real interest rate lowers the cost of capital. It therefore raises the amount of profit from owning capital and increases the incentive to accumulate more capital. Similarly, an increase in the real interest rate raises the cost of capital and leads firms to reduce their investment. For this reason, the investment schedule relating investment to the interest rate slopes downward.

The model also shows what causes investment schedule to shift. Any event that raises the MPK increases the profitability of investment and causes the investment schedule to shift outward. For example, a technological innovation that increases the production function parameter A raises the MPK and for any given interest rate increases the amount of capital goods that rental firm wish to buy.

Finally, consider what happens as this adjustment of the capital stock continues over time. If the MPK begins above the Cost of capital, the capital stock will rise and the MPK will fall. If the MPK begins below the Cost of capital, the capital stock will fall and the MPK will rise. Eventually, as the capital stock adjusts the MPK approaches the cost of capital.

Thus in the long run the MPK equals the real cost of capital. The speed of adjustment toward the steady state depends on how quickly firms adjust their capital stock, which in turn depends on how costly it is to build, deliver and install new capital.

Inventory investment

In recessions, firms stop replenishing their inventory as goods are sold and inventory investment becomes negative. In a typical recession, more than half the fall in spending comes from a decline in inventory investment.

Reasons for Holding Inventories

1. One use of inventories is for **production smoothing** over time. Consider a firm that experiences temporary booms and busts in sales. Rather than adjusting production to match the

fluctuations in sales the firm may find it cheaper to produce goods at a steady rate. When sales are low, the firm produces more than it sells and puts the extra goods into inventory. When sales are high the firm produces less than it sells and takes goods out of inventory.

2. It may allow the firm to operate more efficiently. Retail stores, for example, can sell merchandise more effectively if they have goods on hand to show to customers. Manufacturing firms keep inventories of spare parts to reduce the time that the assembly line is shut down when a machine breaks. In some ways, we can view **inventories as a factor of production**: the larger the stock of inventories a firm holds, the more output it can produce.
3. It helps to avoid running out of goods when sales are unexpectedly high. Firms often have to make production decisions before knowing the level of customer demand. If demand exceeds production and there are no inventories, the good will be out of stock for a period and the firms will lose sales and profit. Inventories can prevent this from happening. This motive for holding inventories is called **stock-out avoidance**.
4. Many goods require a number of steps in production and therefore, take time to produce. When a product is only partly completed, its components are counted as part of a firm's inventory. These inventories are called **work in process**.

The Accelerator Model of Inventories

One simple model, without endorsing a particular motive is the **accelerator model**. This assumes that firms hold a stock of inventories that is proportional to the firms' level of output. When output is high manufacturing firms need more materials and supplies on hand and they have more goods in the process of being completed. When the economy is booming retail firms want to have more merchandise on the shelves to show customers. Thus, if N is the economy's stock of inventories and Y is output then,

$N = \beta Y$ where β is the parameter reflecting how much inventory firms wish to hold as a proportion of output.

Inventory investment I is the change in the stock of inventories ΔN .

$$I = \Delta N = \beta \Delta Y$$

The accelerator model predicts that inventory investment is proportional to the change in output. When output rises firms want to hold larger stock of inventory so inventory investment is high. When output falls firms want to hold smaller stock of inventory so they allow their inventory to run down and inventory investment is negative.

We can now see how the model earned its name. Because the variable Y is the rate at which firms are producing goods, ΔY is the "acceleration" of production. The model says that inventory investment depends on whether the economy is speeding up or slowing down.