Notes on Investment

We previously examined the behavior of consumption and saving. That exercise was important for two reasons. First, consumption is the largest component of GDP. Second, saving behavior plays an important role in determining the interest rate required to clear the credit market. We now turn to an examination of investment. Investment is another important component of GDP, and investment demand also exerts an important influence on interest rates and the credit market.

In addition, we have seen how shocks to the production function (which might correspond to unusually favorable or unfavorable weather conditions, changes in the price of imported raw materials, etc.) result in the temporary fluctuations in output that we call business cycles. We will now examine how such productivity shocks affect consumption and investment as well as total output.

Capital enters our model in two ways. First, like labor, capital is a factor of production. Second, unlike labor, capital must be produced, so that additions to the capital stock constitute an important use of output and thus are a major source of aggregate demand. We assume that each unit of newly produced output can be either consumed or designated as investment and added to the capital stock. Once designated as capital, a particular unit of output can never be consumed. There is a market for used capital, however, so that a firm can own a unit of capital for only one period and then sell it.

A. Capital in the Production Function

In Module 2 ("Production and Distribution"), we considered capital’s role as a factor of production. We saw that, with labor held fixed, the marginal product of capital (MPK) is positive but that it decreases as the capital stock increases. We also saw that labor and capital are complements in production, so that an increase in the capital stock raises the entire MPL schedule. In other words, increasing the stock of capital available to each worker makes the worker more productive.

Short-run changes in the capital stock (net investment) are only a fraction of the capital stock itself. While increases in the capital stock raise the MPL, we assume that investment in any period is so small relative to the capital stock that we can ignore the resulting short-run changes in labor productivity.

Empirically, the capital stock is several times as large as annual output. Thus, even if investment is a small fraction of the capital stock, it need not be a small fraction of output. We assume that fluctuations in investment are large enough to cause noticeable short-run variation in aggregate demand. Thus, the only short-run effect of having capital in the model is that investment constitutes a source of aggregate demand in addition to consumption. Investment does not affect the capital stock enough to cause noticeable short-run changes in the aggregate supply of output. (In the long run, of course, capital accumulation can have large effects on an economy’s productive capacity.)
B. Investment Demand

What determines a firm's investment demand? Assume that, like a household, each firm can borrow and lend in the credit market at an interest rate of \( r \). Should a firm borrow funds to acquire additional capital? The answer requires comparing the return on capital with the market interest rate. Because we assume there is a market for used capital, a firm can buy new (or used) capital, employ it for one period, and then sell the undepreciated portion. Thus, we only need to calculate the one-period return on capital.

The return on capital depends on capital's marginal product and the rate of depreciation. Assume that a fraction \( \delta \) of the capital stock wears out each period, regardless of the size of the capital stock. An additional unit of capital acquired today and put in place overnight increases the firm's output tomorrow by \( MPK_{t+1} \). A fraction \( 1 - \delta \) of the capital itself is left over at the end of tomorrow and, if the firm desires, can be sold. Therefore, an additional unit of capital acquired today entitles the firm to \( 1 + MPK_{t+1} - \delta \) units of output next period. \( MPK_{t+1} - \delta \) is sometimes called the net marginal product of capital.

If the net marginal product of capital is greater than the interest rate, it pays the firm to borrow funds and invest in capital. If the interest rate is greater than the net MPK, investing in capital is unwise. Next period's net MPK depends negatively on the size of next period's capital stock. However, next period's capital stock is equal to this period's capital stock (after deducting depreciation) plus this period's investment:

\[
K_{t+1} = (1 - \delta)K_t + I_t.
\]

Because this period's capital stock is given, next period's net MPK is negatively related to this period's investment (Figure 5-3-1).

Suppose that each firm can borrow and lend at a market interest rate of \( r_0 \). The firm will undertake all investment projects up to \( I_0 \), as these projects earn rates of return in excess of the cost of funds. When investment reaches \( I_0 \), the rate of return on additional investment no longer exceeds the cost of funds, so investment ceases. Therefore, the firm's net MPK schedule is its investment demand curve.\(^2\)

With investment in the model, aggregate saving by the household sector no longer needs to equal zero. The household sector can become a net lender to firms. The capital market clears at an interest rate

---

1 Alternatively, the firm might pay for the project with retained earnings. Since retained earnings could also be lent out at the market interest rate \( r \), the opportunity cost of internally generated funds is the same as the cost of borrowed funds. We assume that the Miller-Modigliani dividend irrelevance theorem holds, so that paying earnings out in dividends has the same effect as retaining the earnings and lending them at the going market interest rate. Thus, for simplicity, think of firms as paying out all earnings in dividends and then going to the capital market to raise funds for investment projects.

2 The MPK curves in Figure 5-3-1, with investment rather than the capital stock on the horizontal axis, are sometimes called the marginal efficiency of investment (MEI) curves. We will not bother with this terminological distinction.
If firms retain earnings, then additions to retained earnings are known as business saving, and the aggregate saving curve incorporates both household and business saving. This sum is known as private saving. In terms of national income accounting, the relevant market clearing condition is $Y = C + I$, as there are no government and foreign sectors in this simple model. Because saving equals income minus consumption, this condition is equivalent to the market clearing condition $S = I$ shown in Figure 5-3-2.

C. Responses to Productivity Shocks

We next examine how the economy responds to temporary and permanent shocks.

Temporary Shocks. Suppose for now that there is a temporary, adverse supply shock that shifts today's production function downward but does not affect next period's marginal product of capital. The adverse productivity shock reduces output, causing a recession. Wealth decreases, but only slightly, because

---

3 If firms retain earnings, then additions to retained earnings are known as business saving, and the aggregate saving curve incorporates both household and business saving. This sum is known as private saving. In terms of national income accounting, the relevant market clearing condition is $Y = C + I$, as there are no government and foreign sectors in this simple model. Because saving equals income minus consumption, this condition is equivalent to the market clearing condition $S = I$ shown in Figure 5-3-2.
the supply shock is temporary. The decrease in wealth causes a slight reduction in the quantity of consumption goods demanded. Because consumption demand falls by less than current income, saving decreases (Figure 5-3-3). Because next period's MPK is unchanged, the investment demand schedule does not shift. The interest rate rises to clear the capital market, and the actual quantity of saving and investment falls. In the model without investment, consumption had to equal production \( Y = C \) and so had to absorb the full brunt of adverse supply shocks. Now, however, \( Y = C + I \), so the reduction in investment absorbs part of the shock to output, helping to stabilize consumption. Empirical evidence indicates that investment demand is more sensitive than consumption to changes in the interest rate. Thus, there is a larger proportionate reduction in investment spending than in consumption.

This example illustrates one of the more important facts about business cycles: investment is more volatile over the cycle than is consumption. The reason is that consumers attempt to spread any temporary variations in consumption over many periods of life, so they save less (or borrow more) when their income temporarily declines. The reduction in saving drives up interest rates, leading to a reduction in investment, which is sensitive to variations in the interest rate.

**Permanent Shocks.** Now assume the adverse production function shift is permanent, so that income declines by the same amount today and in all future periods. Also continue to assume the marginal product of capital is unchanged. Wealth effects are now large. Because income declines by the same amount in all periods, current saving is unaffected. The investment demand schedule is also unchanged, so the credit market clears at the original interest rate and there is no change in actual investment spending. Consumption falls by the full amount of the reduction in output. Changes in investment spending cannot shield consumption from permanent productivity shocks.
In fact, the direction of the change in consumption is unclear. The decline in wealth due to the adverse supply shock tends to reduce consumption demand slightly, thus reinforcing the decline in aggregate demand due to the reduction in investment. The lower real interest rate tends to increase consumption (a movement along the consumption demand curve), so the net effect on consumption is uncertain. If there is any decline in consumption at all, it is proportionately smaller than the

Shifts in the Marginal Product of Capital. Now consider a future adverse supply shock that lowers next period's MPK schedule but does not change this period's production technology. Because the shock is temporary, the resulting wealth effects are small. Saving is approximately unaffected (Figure 5-3-4). (In fact, current saving should increase slightly, but this shift is not shown so as to keep the diagram as simple as possible.) The immediate effect of the future decline in the MPK is to reduce this period's investment demand, causing the capital market to clear at a lower real interest rate.

What happens to output? The aggregate demand for output declines because of the decline in investment demand. If the aggregate supply of output is not fixed in the short run, but responds to changes in aggregate demand, then output declines. There are several reasons why this might occur. In some macroeconomic models, aggregate supply is positively related to the interest rate because of intertemporal substitution in labor supply. (Mankiw discusses this assumption in Chapter 14, which is not part of your assigned reading.) A decline in the interest rate reduces work effort and output. Some economists find this assumption implausible, and there is no consensus on any of the alternative models of short-run aggregate supply behavior. Most economists would agree that aggregate output falls, however, even if they do not agree on the reasons. Thus, investment is procyclical. As with the temporary productivity shocks considered above, investment falls proportionately more than output, while consumption falls proportionately less than output.4

---

4 In fact, the direction of the change in consumption is unclear. The decline in wealth due to the adverse supply shock tends to reduce consumption demand slightly, thus reinforcing the decline in aggregate demand due to the reduction in investment. The lower real interest rate tends to increase consumption (a movement along the consumption demand curve), so the net effect on consumption is uncertain. If there is any decline in consumption at all, it is proportionately smaller than the
Some people believe shocks that affect investment demand are an important cause of business cycles. This sort of shock causes the interest rate to fall during a recession, whereas the shocks considered earlier caused the interest rate to rise. If actual shocks combine characteristics of these two pure cases, then we have no clear prediction about how the interest rate should behave over the business cycle. Empirically, there is no clear pattern either.

Thus far, we have attributed recessions to temporary, negative technology shocks. Frequently cited examples are adverse weather conditions and increases in the prices of imported raw materials. Some economists doubt that the resulting temporary declines in production technology are large or frequent enough to account for observed business cycles. With investment in the model, however, it is possible to have recessions without actual declines in production technology. Recessions can result just from below-average rates of technological improvement. For example, suppose that production technology typically improves by one percent per year, so that the MPK schedule typically shifts upward by this amount from year to year. These shifts result in a "normal" level of investment demand. If technology improves at only half the normal rate during a given year, investment demand will be lower than normal. (Remember that a small percentage decline in the demand for capital can translate into a large reduction in investment demand, because each year's new investment is only a fraction of the existing capital stock.) If the resulting decline in investment demand is large enough, it might
set off a recession. Likewise, investment will be above normal during periods when technological progress is more rapid than usual, possibly leading to an economic boom.