INVESTMENT

Gross investment makes up roughly 17 to 18 percent of gross domestic product. Out of gross investment about half goes to replace capital worn out during the year. This leaves less than 10% of GDP to go for net investment. This 10% represents new additions to the nation's capital stock and is an important source of new productive capacity. In this chapter we study the basic facts and determinants of investment.

Some Measurement Issues

The capital stock of a country consists of physical capital and human capital. Human capital is the talent, training, knowledge, and experience of its citizens. Wages and salaries may be thought of as the return to human capital and since the majority of a country's income is in the form of employee compensation, the stock of human capital is several times the size of its stock of physical capital. Recent estimates find that the stock of human capital is roughly three times as large as the stock of physical capital. Nevertheless, the traditional breakdown of output identifies physical capital separately and we follow this convention by emphasizing investment in physical capital in this chapter. We return briefly to human capital concerns in the extensions section below.

Recall from our discussion of the national income accounts that physical investment is the purchase of new capital and falls into one of four categories. These four are investment in: 1) producer durables, 2) non-residential structures, 3) residential structures, and 4) inventories of goods. The first two categories make up fixed business investment and this is the traditional concept of investment. To begin building a model, it is convenient to adopt the traditional concept and you can picture investment as the purchase of a new machine or the construction of
a new factory. However, the principles that we discuss apply to the broader definition of investment and to investment in human capital.

Another important distinction to keep in mind is the one between gross and net investment. Gross investment refers to the production of new capital goods and it is the appropriate measure of the resources devoted in the current period to investment. A portion of gross investment goes to replace capital that has been worn out. This is called replacement investment, depreciation, or capital consumption. The remaining part of gross investment is called net investment and this part increases the total capital stock available to the economy. Though this distinction can be important, for the sake of simplicity we do not emphasize it here.

The Guiding Facts about Investment

Before we look at the basic determinants of investment, we should examine how investment behaves. Figure 9.1 plots the growth in real investment against the growth in real output. The scatter diagram clearly shows that investment is procyclical. That is, when output growth is high, investment grows rapidly as well.

The second outstanding feature of investment is its volatility. In Figure 9.2 both real investment and real output growth are plotted against

![Figure 9.1 The Cyclical Behavior of Investment](image1)

![Figure 9.2 The Volatility of Investment](image2)
time. The amplitude of the fluctuations in investment exceeds that of real income. In other words, investment is more volatile or variable than output. Furthermore, since we already know that consumption growth is smoother than income growth, it follows that investment is also more volatile than consumption. When we think about investment, we should keep these basic facts in mind since, in large part, these facts are what we hope to understand.

**The Nature of the Investment Decision**

To get a feel for the basic nature of the investment decision, consider the following example. Suppose that you are the manager of a chain of frozen yogurt stores and it comes to your attention that there is a new yogurt machine that is less costly to operate. If you buy these machines for your stores, costs will fall, and profits would thus rise. After some investigation, you discover that the machine has a working life of three years and in those years would increase the real profits from your stores by 1,000 bundles in the first year and 1,500 in the second and third years.

Of course, the makers of the new machine are not giving them away. To buy one machine for each of your stores would cost a million dollars. When you check a recent price index, say the CPI, you find it stands at 320, and this makes the relative price of the machines $1,000,000/320 = 3,125$ bundles. To complicate matters a bit more, you must pay today, but it takes one period to deliver, install, and begin to use the new yogurt machines. In short, you must weigh costs that will be paid today against benefits that will arrive in the future. This is the basic nature of the investment problem and its elements are illustrated in Figure 9.3. In this example

\[
\begin{array}{cccc}
  t & t+1 & t+2 & t+3 \\
  \hline 
  \text{benefits} & 1,000 & 1,500 & 1,500 \\
  \text{costs} & 3,125 & & & \\
\end{array}
\]

*Figure 9.3 The Investment Decision*
The specific question is: are the benefits of the higher profit stream 1,000, 1,500, and 1,500 bundles worth the 3,125 bundle cost of the machine?

To answer this question, we have to make the stream of future profits comparable to the current cost. Fortunately, we have already developed the tool that we need. We just take the present value of the expected profit stream. An interest rate is needed to calculate this present value and suppose you estimate that the current real rate of interest is 5%. This makes the present value of the profit stream

\[ \text{present value of profit stream} = \frac{1,000}{(1+.05)} + \frac{1,500}{(1+.05)^2} + \frac{1,500}{(1+.05)^3} \]

\[ = 3,608.68. \]

This means that the benefit of the higher profit stream is equivalent to 3,608.68 bundles paid today. Since the cost of the machine is 3,125 bundles and the benefit is 3,608.68, the investment in these machines will raise the current value or net worth of your yogurt stores by about 483 bundles. If you like to think in terms of dollars, the 483 bundle increase translates to a dollar increase of (483 bundles)($320/bundle) = $154,560. Since this project will increase the value of your stores, you are well advised to undertake it. We now turn to the general formulation of this problem.

The General Investment Problem

a. the benefits of investment projects

The purchase and installation of new capital will increase a firm's profit over many years. To evaluate a project, a firm must first calculate the profits it expects to reap each period. Let \( A_t \) stand for the profit from the project that the firm expects in period \( t \). Since the profits will be realized during different time periods, the firm must calculate the present value of the expected profit stream. We call the present value of the stream of expected profits \( \text{PVSTREAM} \) and calculate it using the present value formula
PVSTREAM = \frac{A_{t+1}}{(1+r)} + \frac{A_{t+2}}{(1+r)^2} + \frac{A_{t+3}}{(1+r)^3} + ..... + \frac{A_{t+n}}{(1+r)^n}

where \( r \) is still the real rate of interest. The owners of the firm care about real profits because it is real profits that determine their standard of living, so we think of the "A's" as profits in terms of bundles of goods. In short, PVSTREAM is the real benefit to the firm of undertaking the project.

b. the cost of investment projects

The new capital is not free of course. It has a price tag. The important price is, as in our example, a relative price. Let \( P^c \) be the dollar price of capital, and \( P^1 \) still be the price of a bundle of goods. The relative price of capital is just

\[
\text{relative price of capital} = \frac{P^c}{P^1}.
\]

This relative price tells you how many bundles of goods must be given up to buy the capital.

c. investment decision rule

When is it a good idea for the firm to purchase the new capital and when is it a bad idea? The answer depends on whether PVSTREAM is greater than or less than the relative price of capital, \( P^c/P \). If the present value of the expected profits from the investment project is greater than the cost of the project, as it was in our example, then the firm should buy the capital. This is because the new capital adds value to the firm. On the other hand, if the cost of the project exceeds its PVSTREAM, the project is not a good deal; and the firm should pass it up. We can summarize our discussion with the investment decision rule. This rule is

\[
\text{If PVSTREAM} \geq P^c/P, \text{ then accept the project}
\]
If PVSTREAM < P^K/P, then don't accept the project

The investment project may be the purchase of a machine, the building of a new factory, or the acquisition of new technology. The expected profit each period is just the expected profits from the new machine, the new plant, or the new technology; and the appropriate relative price is the relative price of the machine, the plant, or the real value of R and D (research and development) expenditures.

**Some Simple Examples**

Let's look at some simple examples. Suppose we expect the machine in question to yield 100 bundles of profit next year and then, to keep things simple, zero profits afterwards. If the interest rate is 10% and the machine costs 85 bundles, should the firm make the purchase? To find out, we must calculate the PVSTREAM for this project. In this simple case we have

\[
PVSTREAM = \frac{100}{1+.1} = 90.91.
\]

Since the machine produces 90.91 bundles of profit in present value but costs only 85, the firm should buy this machine. It adds 5.91 bundles to the value of the firm.

We now complicate matters just a bit. Assume that the machine yields a profit of 80 bundles the first year and 120 the next. We still assume that the interest rate is 10%. The PVSTREAM for this project is

\[
PVSTREAM = \frac{80}{1+.1} + \frac{120}{(1+.1)^2}
= 72.73 + 99.17
= 171.90
\]

If the machine costs less than 171.90 bundles, the firm is well advised to buy it. If the cost of the machine is greater than 171.90 bundles, the firm should pass.

**Aggregate Investment**
The discussion so far has centered on the investment decision of a firm, but ultimately we will be interested in the behavior of aggregate investment. Aggregate investment is just the sum of all the individual demands by the firms. For example, if there are two firms and the first firm wants to invest in 50 bundles worth of machines and the second firm wants to invest in 80 bundles worth of machines, then aggregate investment demand is 130 bundles.

**The Determinants of Investment Demand**

The interest rate and the stream of expected profits play a crucial role in the investment decision because they both must be used to calculate the PVSTREAM. When either of these two variables changes PVSTREAM changes and we may suspect that this alters the investment decision.

*a. the interest rate*

Let's first look at the effect of a change in the interest rate. Suppose that the interest rate increases. What happens to the PVSTREAM for any given investment project? Because we are now discounting with a larger interest rate, the PVSTREAM will decline for all projects. The PVSTREAM will still be higher than the cost for some projects, but for others the increase in the interest rate will lower the PVSTREAM below its cost. So, some projects that were accepted before the increase in the interest rate are no longer undertaken. Since these projects are no longer accepted, investment will fall. Our conclusion is that an increase in the interest rate lowers investment because it makes PVSTREAM fall. You should check your understanding of this result by convincing yourself that a decline in the rate of interest will increase investment demand.

In our simple example the firm purchased the machine that cost 85 bundles when the interest rate was 10%. Now suppose the interest rate rises to 20%. Will the firm still purchase the machine? To find out we must recalculate the PVSTREAM of the project with the new interest rate:
PVSTREAM = 100/(1+.2) = 83.33.

The PVSTREAM is now less than the cost of the machine and undertaking the project no longer adds, on net, to the value of the firm. The increase in r has lowered investment demand.

**b. the expected profit stream**

There are several reasons why expected profits from a project may increase. First, the firm may believe that the relative demand for its product is going to increase in the future and the relative price of its output will therefore be higher. For example, if you expect that people in the future will be more interested in staying healthy by working out, investing in equipment for your health spa becomes more attractive. On the other hand, bar owners may not want to invest in more stools if they believe the same change in tastes will occur. Second, the firm may expect technological changes that will increase the productivity of capital. For example, the prospect of the development of software useful in monitoring inventories may make investment in computers more appealing. Finally, the firm may expect changes in tax rates or government regulations that will make investment projects more profitable in the future.

An increase in expected profits raises PVSTREAM. If the project was unacceptable before it may be acceptable now. For example, suppose the interest rate remains at 20%, but a new technology makes the real profit of the machine rise from 100 to 110 bundles. The new PVSTREAM is

PVSTREAM = 110/(1+.2) = 91.67,

which exceeds its cost of 85 bundles. The increase in $A_{t+1}$ has made this project acceptable again.

**c. the relative price of capital**

Finally, suppose that the relative price of capital increases. Some of the projects that were acceptable will now fall into the unacceptable category. To continue with the simple example,
assume that the price of the machine increases to 100 bundles. The interest rate remains at 20% and $A_{t+1}$ is still 110, so PVSTREAM remains 91.67; but the cost of the machine is no longer justified.

**Investment Demand**

We can now gather together our basic results. The decision to invest depends on: 1) the stream of expected profits $A_{t+1}, A_{t+2}, \ldots$, 2) the interest rate $r$, and 3) the relative price of capital $P_t^k/P_t$. In symbols we can write

$$I^d = I(r_t, A_{t+1}, A_{t+2}, \ldots, P_t^k/P_t)$$

The inverse relationship between investment and the interest rate is graphed in Figure 9.4. In Figure 9.4 aggregate investment is $I^d_1$ when the interest rate is $r_1$. If the interest rate increases to $r_2$, some projects that were accepted when the interest rate was $r_1$ will now be rejected. Aggregate investment will fall to a lower level, say $I^d_2$. The $I^d$ curve traces out the aggregate demand for investment. Along the $I^d$ curve the expected profitability of projects and the relative price of capital are held constant.

A change in the expected profitability of investment shifts the $I^d$ curve. To see how this happens, we redraw $I^d$ in Figure 9.5. Now, suppose the interest rate remains at $r_1$, while
expected profits increase. Some projects now become acceptable that were earlier rejected and additional projects are undertaken at the interest rate $r_1$. This means that the new $I^d$ curve will be to the right of the old $I^d$ curve. In general, an increase in the expected profits from projects will raise investment demand and shift the investment demand curve out and to the right. This is shown in Figure 9.5 by a shift from $I^d$ to $I'^d$.

A change in the relative price of capital will also shift the $I^d$ curve. An increase in $P^k/P$ makes capital goods relatively expensive, and fewer projects will be undertaken at any given rate of interest. This means that the $I^d$ curve shifts down and to the left. However, even though we have gone to the trouble of finding out the effect of a change in $P^k/P$ on investment, we now suppress it. It turns out that allowing this relative price to change greatly increases the complexity of our analysis and our quest for simplicity forbids its inclusion. Instead, we will assume that when prices rise or fall, all prices rise or fall by the same percentage amount, including the price of capital. This means that the relative price of capital will stay the same.

The Volatility of Investment

We pointed out earlier that an important feature of investment is its volatility. We pause now to consider a couple of explanations for this volatility.

A factory or new machine may have a long productive life stretching out over decades and today’s investment decision may depend on our expectations of events that occur in the distant future. Our ability to forecast long into the future is limited at best. This observation led John Maynard Keynes to suggest that investment is likely to be a volatile component of total spending. In his *General Theory of Employment, Interest, and Money* he wrote:

Most, probably, of our decisions to do something positive, the full consequences of which will be drawn out over many days to come, can only be taken as a result of animal spirits--of a spontaneous urge to action rather than inaction, and not as the outcome of a weighted average of quantitative benefits multiplied by quantitative probabilities.....Thus if the animal spirits are dimmed and the spontaneous optimism falters, leaving us to depend on nothing but a mathematical expectation, enterprise will fade and die;-- though the fears of loss may have a basis no more reasonable than the hopes of profit had before.
Keynes believed that the investment decision was an emotional one. Furthermore, emotions are unstable. A wave of optimism crashes into a shore of pessimism. In his view there is no rational anchor to tie down the investment decision, and as a result investment demand is volatile.

This explanation has been criticized on the grounds that difficulty predicting the future does not imply whimsy in decision-making. Predicting a young child's future is as precarious as evaluating investment projects, but if your child can't seem to grasp the subtleties of finger-painting in kindergarten, you don't cash in the college fund.

A different explanation for the volatility of investment focuses on the size of investment relative to the capital stock. Investment is typically a very small percentage of the total capital stock. In the U.S. it is something like 4% of the capital stock on average. This means that a very small change in the desired capital stock can have a large impact on current investment.

A numerical example helps bring out the main point. Suppose that there is initially 1000 units of capital. In a normal year investment will be 4% of this stock. That is, investment will be 40 units. Ignoring depreciation this will make the capital stock 1040 units in the following year. If another normal year follows, investment will be 41.6 units, which is 4% of 1040, and the capital stock increases to 1081.6. But suppose another normal year does not follow, and instead there is a small fall-off in the desired capital stock to say 1076.4. This is a decline of less than 1% in the desired capital stock, and means that investment will be 36.4 units as compared to the 40 units the year before. This 3.6 unit decline in investment is a 9% drop-off from the previous year's investment. So, a very small change in the desired capital stock changes a 4% increase in investment.

![Figure 9.6: Volatility and the Small I/K Ratio](image)

<table>
<thead>
<tr>
<th>Normal Years</th>
<th>K = 1,000</th>
<th>K = 1,040</th>
<th>K = 1,081.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>I = 40</td>
<td>I = 41.6</td>
<td>I = 36.4</td>
<td></td>
</tr>
<tr>
<td>%change I = 4%</td>
<td>%change I = -9%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 9.6: Volatility and the Small I/K Ratio
nvestment into a 9% decline. When the capital stock sneezes, investment catches pneumonia. Some economists believe that this is the source of the large fluctuations in investment spending. This argument is summarized in Figure 9.6.

Extensions

a. housing and human capital

In our discussion above, we ignored the housing component of investment, but the general ideas apply to this decision as well. For the housing decision we would have to reinterpret the meaning of the $A_t$s. Instead of real profits, $A_t$ would stand for the real value of the shelter services that the home provides in period $t$. It could be measured by the rent on an equivalent rental home. The interest rate would be the mortgage rate. The decision rule would be the same: if the present value of the stream of shelter services from the home exceeds its relative price, then buy it. Otherwise keep looking, rent, or stay at home with mom and dad.

The human capital decision can also be studied in the above framework. In this case the $A_t$s would represent the increase in expected earnings from, say, an additional year of schooling. The present value of this stream of additional earnings would be the PVSTREAM. The relative price of the additional year of education would be the books, tuition, and, don't forget, the income you could be earning if you weren't in school.

It is important to observe that investment in housing and human capital respond to changes in the interest rate, "expected profits," and their relative prices in the same way that fixed business investment does. Higher interest rates discourage home buyers and the college bound. If the return to education goes up, college becomes more attractive, but, when tuition or the relative price of homes increases, less investment in these types of capital occurs.

b. inventories

Inventories can be final goods waiting for sale or inputs waiting to be transformed in the production process. Changes in inventory holdings, called inventory investment, typically represent less than 10% of aggregate gross investment. They offer firms some protection against lost
sales that may result from stock outs, and protection from production slowdowns or shutdowns caused by delays in the deliveries of inputs.

Inventories must be stored and the rental value of the space to hold inventories makes up part of their cost. Interest opportunity costs makes up the other part. The firm has already purchased the inputs, raw material, fuels, labor, and so forth to produce the final good, or has paid the supplier for the inventory of inputs. For example, suppose a furniture manufacturer has a lumber inventory worth $40,000. This is $40,000 that could have been earning interest. If the interest rate is 5%, the annual interest opportunity cost of holding this inventory is $2,000. When the interest rate rises this part of the cost rises as well and we expect the firm to do less of it; they reduce their holdings and engage in negative inventory investment. Similarly, if the interest rate falls, firms will likely increase inventory investment. The interest rate is therefore inversely related to this type of investment also.

There are many other extensions of the basic model. The interest rate could vary over time, the machine, or home may have some scrap value after its useful lifetime is over, or we could examine projects of differing degrees of risk. However, all of these complications would not change the principles embodied in the investment decision rule and the investment demand curve.

Summary

In this chapter we have discussed the fundamentals of investment. Investment is procyclical and more volatile than income. The basic determinants of investment are the interest rate, the stream of expected profits from projects, and the relative price of capital. The analysis focused on fixed business investment, but the same general results will hold if we extend the analysis to housing investment, investment in inventories, or investment in human capital.

Review Questions
1. Suppose a firm has three possible projects with the expected profit streams given below.

<table>
<thead>
<tr>
<th>period</th>
<th>project 1</th>
<th>project 2</th>
<th>project 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>t+1</td>
<td>500</td>
<td>800</td>
<td>325</td>
</tr>
<tr>
<td>t+2</td>
<td>500</td>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>t+3</td>
<td>400</td>
<td>250</td>
<td>600</td>
</tr>
<tr>
<td>cost</td>
<td>1240</td>
<td>1240</td>
<td>1240</td>
</tr>
</tbody>
</table>

a) If the interest rate is 12% which of the projects should the firm accept?

b) If the interest rate is 6% which of the projects should the firm accept?

c) Which is the highest PV project when the interest rate is 12%, and which is the highest PV when the interest rate is 6%? Explain any "switching" that might take place.

d) Now suppose a design change is discovered that raises the expected profit stream of project 2 to:

<table>
<thead>
<tr>
<th>period</th>
<th>project 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>t+1</td>
<td>850</td>
</tr>
<tr>
<td>t+2</td>
<td>350</td>
</tr>
<tr>
<td>t+3</td>
<td>350</td>
</tr>
</tbody>
</table>

What happens to the acceptability of this project at two rates of interest used earlier?

2) Suppose that an economy has two industries, the airline industry and the publishing industry. Engineers in the airline industry have designed three innovations: a new method to load and unload baggage at the terminal, a new way to store and heat the food on the planes, and a more rapid way to handle ticketing and reservations. For simplicity assume that each of these innovations would last three years with the first profit coming one year from the time it was accepted. The dollar payoffs and costs for the three projects are given below. All figures are in millions of dollars.

<table>
<thead>
<tr>
<th>year</th>
<th>baggage proj</th>
<th>cater proj</th>
<th>ticketing proj</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>2.2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>$cost</td>
<td>9</td>
<td>8.75</td>
<td>12.5</td>
</tr>
</tbody>
</table>
The publishing industry also has 3 possible innovations: a new computerized method of typesetting, a new way to bind books, and a new method to pack books for shipping. The dollar payoffs and costs are:

<table>
<thead>
<tr>
<th></th>
<th>typesetting proj</th>
<th>binding proj</th>
<th>packing proj</th>
</tr>
</thead>
<tbody>
<tr>
<td>year 1</td>
<td>3.5</td>
<td>1.8</td>
<td>5</td>
</tr>
<tr>
<td>year 2</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>year 3</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>$cost</td>
<td>12.1</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

a) For the interest rates 8%, 7%, and 5% find the aggregate demand for investment in dollar amounts.

b) Suppose the price level is $60 per bundle. What is the aggregate demand for real investment?

c) Plot real investment demand at the three rates of interest. Interpolate (connect the dots) to get a negatively sloped investment demand curve.

d) Suppose that engineers in the publishing industry develop software that helps them better design machines. As a result the payoffs in publishing become:

<table>
<thead>
<tr>
<th></th>
<th>typesetting proj</th>
<th>binding proj</th>
<th>packing proj</th>
</tr>
</thead>
<tbody>
<tr>
<td>year 1</td>
<td>4</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>year 2</td>
<td>5.2</td>
<td>2.1</td>
<td>6</td>
</tr>
<tr>
<td>year 3</td>
<td>5.2</td>
<td>2.1</td>
<td>6</td>
</tr>
<tr>
<td>$cost</td>
<td>12.1</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

Recalculate real investment demand at each rate of interest, and draw the new investment demand curve.

3) In the mid 1800s it is highly likely that the ratio of investment to the capital stock was higher than it is today. How would this observation affect your prediction of the volatility of investment during this period. (For the sake of argument assume all the other determinants of investment were the same as they are today.)

4) Can you think of an example of events that would switch a Keynesian type wave of optimism into a wave of pessimism?