

CHAPTER 11

ASSET MARKETS

Assets are goods that provide a flow of services over time. Assets can provide a flow of consumption services, like housing services, or can provide a flow of money that can be used to purchase consumption. Assets that provide a monetary flow are called **financial assets**.

The bonds that we discussed in the last chapter are examples of financial assets. The flow of services they provide is the flow of interest payments. Other sorts of financial assets such as corporate stock provide different patterns of cash flows. In this chapter we will examine the functioning of asset markets under conditions of complete certainty about the future flow of services provided by the asset.

11.1 Rates of Return

Under this admittedly extreme hypothesis, we have a simple principle relating asset rates of return: if there is no uncertainty about the cash flow provided by assets, then all assets have to have the same rate of return. The reason is obvious: if one asset had a higher rate of return than another, and both assets were otherwise identical, then no one would want to buy

the asset with the lower rate of return. So in equilibrium, all assets that are actually held must pay the same rate of return.

Let us consider the process by which these rates of return adjust. Consider an asset A that has current price p_0 and is expected to have a price of p_1 tomorrow. Everyone is certain about what today's price of the asset is, and everyone is certain about what tomorrow's price will be. We suppose for simplicity that there are no dividends or other cash payments between periods 0 and 1. Suppose furthermore that there is another investment, B, that one can hold between periods 0 and 1 that will pay an interest rate of r . Now consider two possible investment plans: either invest one dollar in asset A and cash it in next period, or invest one dollar in asset B and earn interest of r dollars over the period.

What are the values of these two investment plans at the end of the first period? We first ask how many units of the asset we must purchase to make a one dollar investment in it. Letting x be this amount we have the equation

$$p_0x = 1$$

or

$$x = \frac{1}{p_0}.$$

It follows that the future value of one dollar's worth of this asset next period will be

$$FV = p_1x = \frac{p_1}{p_0}.$$

On the other hand, if we invest one dollar in asset B, we will have $1 + r$ dollars next period. If assets A and B are both held in equilibrium, then a dollar invested in either one of them must be worth the same amount second period. Thus we have an equilibrium condition:

$$1 + r = \frac{p_1}{p_0}.$$

What happens if this equality is not satisfied? Then there is a sure way to make money. For example, if

$$1 + r > \frac{p_1}{p_0},$$

people who own asset A can sell one unit for p_0 dollars in the first period and invest the money in asset B. Next period their investment in asset B will be worth $p_0(1 + r)$, which is greater than p_1 by the above equation. This will guarantee that second period they will have enough money to repurchase asset A, and be back where they started from, but now with extra money.

This kind of operation—buying some of one asset and selling some of another to realize a sure return—is known as **riskless arbitrage**, or **arbitrage** for short. As long as there are people around looking for “sure things” we would expect that well-functioning markets should quickly eliminate any opportunities for arbitrage. Therefore, another way to state our equilibrium condition is to say that in equilibrium *there should be no opportunities for arbitrage*. We’ll refer to this as the **no arbitrage condition**.

But how does arbitrage actually work to eliminate the inequality? In the example given above, we argued that if $1 + r > p_1/p_0$, then anyone who held asset A would want to sell it first period, since they were guaranteed enough money to repurchase it second period. But who would they sell it to? Who would want to buy it? There would be plenty of people willing to supply asset A at p_0 , but there wouldn’t be anyone foolish enough to demand it at that price.

This means that supply would exceed demand and therefore the price will fall. How far will it fall? Just enough to satisfy the arbitrage condition until $1 + r = p_1/p_0$.

11.2 Arbitrage and Present Value

We can rewrite the arbitrage condition in a useful way by cross multiplying to get

$$p_0 = \frac{p_1}{1 + r}.$$

This says that the current price of an asset must be its present value. Essentially we have converted the future-value comparison in the arbitrage condition to a present-value comparison. So if the no arbitrage condition is satisfied, then we are assured that assets must sell for their present values. Any deviation from present-value pricing leaves a sure way to make money.

11.3 Adjustments for Differences among Assets

The no arbitrage rule assumes that the asset services provided by the two assets are identical, except for the purely monetary difference. If the services provided by the assets have different characteristics, then we would want to adjust for those differences before we blandly assert that the two assets must have the same equilibrium rate of return.

For example, one asset might be easier to sell than the other. We sometimes express this by saying that one asset is more **liquid** than another. In this case, we might want to adjust the rate of return to take account of the difficulty involved in finding a buyer for the asset. Thus a house that is worth \$100,000 is probably a less liquid asset than \$100,000 in Treasury bills.

Similarly, one asset might be riskier than another. The rate of return on one asset may be guaranteed, while the rate of return on another asset may be highly risky. We'll examine ways to adjust for risk differences in Chapter 13.

Here we want to consider two other types of adjustment we might make. One is adjustment for assets that have some return in consumption value, and the other is for assets that have different tax characteristics.

11.4 Assets with Consumption Returns

Many assets pay off only in money. But there are other assets that pay off in terms of consumption as well. The prime example of this is housing. If you own a house that you live in, then you don't have to rent living quarters; thus part of the "return" to owning the house is the fact that you get to live in the house without paying rent. Or, put another way, you get to pay the rent for your house to yourself. This latter way of putting it sounds peculiar, but it contains an important insight.

It is true that you don't make an *explicit* rental payment to yourself for the privilege of living in your house, but it turns out to be fruitful to think of a homeowner as *implicitly* making such a payment. The **implicit rental rate** on your house is the rate at which you could rent a similar house. Or, equivalently, it is the rate at which you could rent your house to someone else on the open market. By choosing to "rent your house to yourself" you are forgoing the opportunity of earning rental payments from someone else, and thus incurring an opportunity cost.

Suppose that the implicit rental payment on your house would work out to T dollars per year. Then part of the return to owning your house is the fact that it generates for you an implicit income of T dollars per year—the money that you would otherwise have to pay to live in the same circumstances as you do now.

But that is not the entire return on your house. As real estate agents never tire of telling us, a house is also an *investment*. When you buy a house you pay a significant amount of money for it, and you might reasonably expect to earn a monetary return on this investment as well, through an increase in the value of your house. This increase in the value of an asset is known as **appreciation**.

Let us use A to represent the expected appreciation in the dollar value of your house over a year. The total return to owning your house is the sum of the rental return, T , and the investment return, A . If your house initially cost P , then the *total* rate of return on your initial investment in housing is

$$h = \frac{T + A}{P}.$$

This total rate of return is composed of the consumption rate of return, T/P , and the investment rate of return, A/P .

Let us use r to represent the rate of return on other financial assets. Then the total rate of return on housing should, in equilibrium, be equal to r :

$$r = \frac{T + A}{P}.$$

Think about it this way. At the beginning of the year, you can invest P in a bank and earn rP dollars, or you can invest P dollars in a house and save T dollars of rent and earn A dollars by the end of the year. The total return from these two investments has to be the same. If $T + A < rP$ you would be better off investing your money in the bank and paying T dollars in rent. You would then have $rP - T > A$ dollars at the end of the year. If $T + A > rP$, then housing would be the better choice. (Of course, this is ignoring the real estate agent's commission and other transactions costs associated with the purchase and sale.)

Since the total return should rise at the rate of interest, the financial rate of return A/P will generally be less than the rate of interest. Thus in general, assets that pay off in consumption will in equilibrium have a lower financial rate of return than purely financial assets. This means that buying consumption goods such as houses, or paintings, or jewelry *solely* as a financial investment is probably not a good idea since the rate of return on these assets will probably be lower than the rate of return on purely financial assets, because part of the price of the asset reflects the consumption return that people receive from owning such assets. On the other hand, if you place a sufficiently high value on the consumption return on such assets, or you can generate rental income from the assets, it may well make sense to buy them. The *total* return on such assets may well make this a sensible choice.

11.5 Taxation of Asset Returns

The Internal Revenue Service distinguishes two kinds of asset returns for purposes of taxation. The first kind is the **dividend** or **interest** return. These are returns that are paid periodically—each year or each month—over the life of the asset. You pay taxes on interest and dividend income at your ordinary tax rate, the same rate that you pay on your labor income.

The second kind of returns are called **capital gains**. Capital gains occur when you sell an asset at a price higher than the price at which you bought it. Capital gains are taxed only when you actually sell the asset. Under the current tax law, capital gains are taxed at the same rate as ordinary income, but there are some proposals to tax them at a more favorable rate.

It is sometimes argued that taxing capital gains at the same rate as ordinary income is a “neutral” policy. However, this claim can be disputed for at least two reasons. The first reason is that the capital gains taxes are only paid when the asset is sold, while taxes on dividends or interest are

paid every year. The fact that the capital gains taxes are deferred until time of sale makes the effective tax rate on capital gains *lower* than the tax rate on ordinary income.

A second reason that equal taxation of capital gains and ordinary income is not neutral is that the capital gains tax is based on the increase in the *dollar* value of an asset. If asset values are increasing just because of inflation, then a consumer may owe taxes on an asset whose *real* value hasn't changed. For example, suppose that a person buys an asset for \$100 and 10 years later it is worth \$200. Suppose that the general price level also doubles in this same ten-year period. Then the person would owe taxes on a \$100 capital gain even though the purchasing power of his asset hadn't changed at all. This tends to make the tax on capital gains *higher* than that on ordinary income. Which of the two effects dominates is a controversial question.

In addition to the differential taxation of dividends and capital gains there are many other aspects of the tax law that treat asset returns differently. For example, in the United States, **municipal bonds**, bonds issued by cities or states, are not taxed by the Federal government. As we indicated earlier, the consumption returns from owner-occupied housing is not taxed. Furthermore, in the United States even part of the capital gains from owner-occupied housing is not taxed.

The fact that different assets are taxed differently means that the arbitrage rule must adjust for the tax differences in comparing rates of return. Suppose that one asset pays a before-tax interest rate, r_b , and another asset pays a return that is tax exempt, r_e . Then if both assets are held by individuals who pay taxes on income at rate t , we must have

$$(1 - t)r_b = r_e.$$

That is, the after-tax return on each asset must be the same. Otherwise, individuals would not want to hold both assets—it would always pay them to switch exclusively to holding the asset that gave them the higher after-tax return. Of course, this discussion ignores other differences in the assets such as liquidity, risk, and so on.

11.6 Applications

The fact that all riskless assets must earn the same return is obvious, but very important. It has surprisingly powerful implications for the functioning of asset markets.

Depletable Resources

Let us study the market equilibrium for a depletable resource like oil. Consider a competitive oil market, with many suppliers, and suppose for sim-

plicity that there are zero costs to extract oil from the ground. Then how will the price of oil change over time?

It turns out that the price of oil must rise at the rate of interest. To see this, simply note that oil in the ground is an asset like any other asset. If it is worthwhile for a producer to hold it from one period to the next, it must provide a return to him equivalent to the financial return he could get elsewhere. If we let p_{t+1} and p_t be the prices at times $t + 1$ and t , then we have

$$p_{t+1} = (1 + r)p_t$$

as our no arbitrage condition in the oil market.

The argument boils down to this simple idea: oil in the ground is like money in the bank. If money in the bank earns a rate of return of r , then oil in the ground must earn the same rate of return. If oil in the ground earned a higher return than money in the bank, then no one would take oil out of the ground, preferring to wait till later to extract it, thus pushing the current price of oil up. If oil in the ground earned a lower return than money in the bank, then the owners of oil wells would try to pump their oil out immediately in order to put the money in the bank, thereby depressing the current price of oil.

This argument tells us how the price of oil changes. But what determines the price level itself? The price level turns out to be determined by the demand for oil. Let us consider a very simple model of the demand side of the market.

Suppose that the demand for oil is constant at D barrels a year and that there is a total world supply of S barrels. Thus we have a total of $T = S/D$ years of oil left. When the oil has been depleted we will have to use an alternative technology, say liquefied coal, which can be produced at a constant cost of C dollars per barrel. We suppose that liquefied coal is a perfect substitute for oil in all applications.

Now, T years from now, when the oil is just being exhausted, how much must it sell for? Clearly it must sell for C dollars a barrel, the price of its perfect substitute, liquefied coal. This means that the price today of a barrel of oil, p_0 , must grow at the rate of interest r over the next T years to be equal to C . This gives us the equation

$$p_0(1 + r)^T = C$$

or

$$p_0 = \frac{C}{(1 + r)^T}.$$

This expression gives us the current price of oil as a function of the other variables in the problem. We can now ask interesting comparative statics questions. For example, what happens if there is an unforeseen new discovery of oil? This means that T , the number of years remaining of oil,

will increase, and thus $(1 + r)^T$ will increase, thereby decreasing p_0 . So an increase in the supply of oil will, not surprisingly, decrease its current price.

What if there is a technological breakthrough that decreases the value of C ? Then the above equation shows that p_0 must decrease. The price of oil has to be equal to the price of its perfect substitute, liquefied coal, when liquefied coal is the only alternative.

When to Cut a Forest

Suppose that the size of a forest—measured in terms of the lumber that you can get from it—is some function of time, $F(t)$. Suppose further that the price of lumber is constant and that the rate of growth of the tree starts high and gradually declines. If there is a competitive market for lumber, when should the forest be cut for timber?

Answer: when the rate of growth of the forest equals the interest rate. Before that, the forest is earning a higher rate of return than money in the bank, and after that point it is earning less than money in the bank. The optimal time to cut a forest is when its growth rate just equals the interest rate.

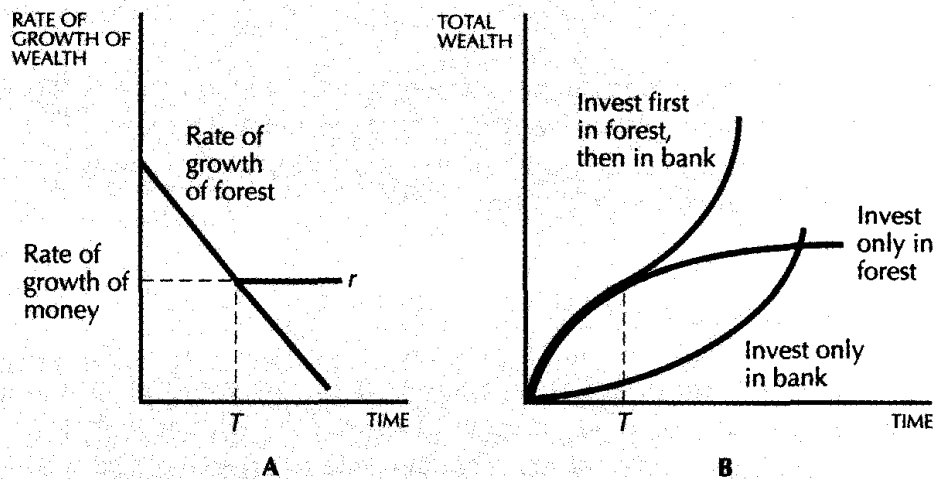
We can express this more formally by looking at the present value of cutting the forest at time T . This will be

$$PV = \frac{F(T)}{(1 + r)^T}.$$

We want to find the choice of T that maximizes the present value—that is, that makes the value of the forest as large as possible. If we choose a very small value of T , the rate of growth of the forest will exceed the interest rate, which means that the PV would be increasing so it would pay to wait a little longer. On the other hand, if we consider a very large value of T , the forest would be growing more slowly than the interest rate, so the PV would be decreasing. The choice of T that maximizes present value occurs when the rate of growth of the forest just equals the interest rate.

This argument is illustrated in Figure 11.1. In Figure 11.1A we have plotted the *rate* of growth of the forest and the *rate* of growth of a dollar invested in a bank. If we want to have the largest amount of money at some unspecified point in the future, we should always invest our money in the asset with the highest return available at each point in time. When the forest is young, it is the asset with the highest return. As it matures, its rate of growth declines, and eventually the bank offers a higher return.

The effect on total wealth is illustrated in Figure 11.1B. Before T wealth grows most rapidly when invested in the forest. After T it grows most



Harvesting a forest. The optimal time to cut a forest is when the rate of growth of the forest equals the interest rate.

rapidly when invested in the bank. Therefore, the optimal strategy is to invest in the forest up until time T , then harvest the forest, and invest the proceeds in the bank.

EXAMPLE: Gasoline Prices during the Gulf War

In the Summer of 1990 Iraq invaded Kuwait. As a response to this, the United Nations imposed a blockade on oil imports from Iraq. Immediately after the blockade was announced the price of oil jumped up on world markets. At the same time price of gasoline at U.S. pumps increased significantly. This in turn led to cries of “war profiteering” and several segments about the oil industry on the evening news broadcasts.

Those who felt the price increase was unjustified argued that it would take at least 6 weeks for the new, higher-priced oil to wend its way across to the Atlantic and to be refined into gasoline. The oil companies, they argued, were making “excessive” profits by raising the price of gasoline that had already been produced using cheap oil.

Let’s think about this argument as economists. Suppose that you own an asset—say gasoline in a storage tank—that is currently worth \$1 a gallon. Six weeks from now, you know that it will be worth \$1.50 a gallon. What price will you sell it for now? Certainly you would be foolish to sell it for much less than \$1.50 a gallon—at any price much lower than that you would be better off letting the gasoline sit in the storage tank for 6 weeks. The same intertemporal arbitrage reasoning about extracting oil from the ground applies to gasoline in a storage tank. The (appropriate discounted)

price of gasoline tomorrow has to equal the price of gasoline today if you want firms to supply gasoline today.

This makes perfect sense from a welfare point of view as well: if gasoline is going to be more expensive in the near future, doesn't it make sense to consume less of it today? The increased price of gasoline encourages immediate conservation measures and reflects the true scarcity price of gasoline.

Ironically, the same phenomenon occurred two years later in Russia. During the transition to a market economy, Russian oil sold for about \$3 a barrel at a time when the world price was about \$19 a barrel. The oil producers anticipated that the price of oil would soon be allowed to rise—so they tried to hold back as much oil as possible from current production. As one Russian producer put it, "Have you seen anyone in New York selling one dollar for 10 cents?" The result was long lines in front of the gasoline pumps for Russian consumers.¹

11.7 Financial Institutions

Asset markets allow people to change their pattern of consumption over time. Consider, for example, two people A and B who have different endowments of wealth. A might have \$100 today and nothing tomorrow, while B might have \$100 tomorrow and nothing today. It might well happen that each would rather have \$50 today and \$50 tomorrow. But they can reach this pattern of consumption simply by trading: A gives B \$50 today, and B gives A \$50 tomorrow.

In this particular case, the interest rate is zero: A lends B \$50 and only gets \$50 in return the next day. If people have convex preferences over consumption today and tomorrow, they would like to smooth their consumption over time, rather than consume everything in one period, even if the interest rate were zero.

We can repeat the same kind of story for other patterns of asset endowments. One individual might have an endowment that provides a steady stream of payments and prefer to have a lump sum, while another might have a lump sum and prefer a steady stream. For example, a twenty-year-old individual might want to have a lump sum of money now to buy a house, while a sixty-year-old might want to have a steady stream of money to finance his retirement. It is clear that both of these individuals could gain by trading their endowments with each other.

In a modern economy financial institutions exist to facilitate these trades. In the case described above, the sixty-year-old can put his lump sum of money in the bank, and the bank can then lend it to the twenty-year-old.

¹ See Louis Uchitelle, "Russians Line Up for Gas as Refineries Sit on Cheap Oil," *New York Times*, July 12, 1992, page 4.

The twenty-year-old then makes mortgage payments to the bank, which are, in turn, transferred to the sixty-year-old as interest payments. Of course, the bank takes its cut for arranging the trade, but if the banking industry is sufficiently competitive, this cut should end up pretty close to the actual costs of doing business.

Banks aren't the only kind of financial institution that allow one to reallocate consumption over time. Another important example is the stock market. Suppose that an entrepreneur starts a company that becomes successful. In order to start the company, the entrepreneur probably had some financial backers who put up money to help him get started—to pay the bills until the revenues started rolling in. Once the company has been established, the owners of the company have a claim to the profits that the company will generate in the future: they have a claim to a stream of payments.

But it may well be that they prefer a lump-sum reward for their efforts now. In this case, the owners can decide to sell the firm to other people via the stock market. They issue shares in the company that entitle the shareholders to a cut of the future profits of the firm in exchange for a lump-sum payment now. People who want to purchase part of the stream of profits of the firm pay the original owners for these shares. In this way, both sides of the market can reallocate their wealth over time.

There are a variety of other institutions and markets that help facilitate intertemporal trade. But what happens when the buyers and sellers aren't evenly matched? What happens if more people want to sell consumption tomorrow than want to buy it? Just as in any market, if the supply of something exceeds the demand, the price will fall. In this case, the price of consumption tomorrow will fall. We saw earlier that the price of consumption tomorrow was given by

$$p = \frac{1}{1+r},$$

so this means that the interest rate must rise. The increase in the interest rate induces people to save more and to demand less consumption now, and thus tends to equate demand and supply.

Summary

1. In equilibrium, all assets with certain payoffs must earn the same rate of return. Otherwise there would be a riskless arbitrage opportunity.
2. The fact that all assets must earn the same return implies that all assets will sell for their present value.
3. If assets are taxed differently, or have different risk characteristics, then we must compare their after-tax rates of return or their risk-adjusted rates of return.

REVIEW QUESTIONS

1. Suppose asset A can be sold for \$11 next period. If assets similar to A are paying a rate of return of 10%, what must be asset A's current price?
2. A house, which you could rent for \$10,000 a year and sell for \$110,000 a year from now, can be purchased for \$100,000. What is the rate of return on this house?
3. The payments of certain types of bonds (e.g., municipal bonds) are not taxable. If similar taxable bonds are paying 10% and everyone faces a marginal tax rate of 40%, what rate of return must the nontaxable bonds pay?
4. Suppose that a scarce resource, facing a constant demand, will be exhausted in 10 years. If an alternative resource will be available at a price of \$40 and if the interest rate is 10%, what must the price of the scarce resource be today?

APPENDIX

Suppose that you invest \$1 in an asset yielding an interest rate r where the interest is paid once a year. Then after T years you will have $(1 + r)^T$ dollars. Suppose now that the interest is paid monthly. This means that the monthly interest rate will be $r/12$, and there will be $12T$ payments, so that after T years you will have $(1 + r/12)^{12T}$ dollars. If the interest rate is paid daily, you will have $(1 + r/365)^{365T}$ and so on.

In general, if the interest is paid n times a year, you will have $(1 + r/n)^{nT}$ dollars after T years. It is natural to ask how much money you will have if the interest is paid *continuously*. That is, we ask what is the limit of this expression as n goes to infinity. It turns out that this is given by the following expression:

$$e^{rT} = \lim_{n \rightarrow \infty} (1 + r/n)^{nT},$$

where e is 2.7183..., the base of natural logarithms.

This expression for continuous compounding is very convenient for calculations. For example, let us verify the claim in the text that the optimal time to harvest the forest is when the rate of growth of the forest equals the interest rate. Since the forest will be worth $F(T)$ at time T , the present value of the forest harvested at time T is

$$V(T) = \frac{F(T)}{e^{rT}} = e^{-rT} F(T).$$

In order to maximize the present value, we differentiate this with respect to T and set the resulting expression equal to zero. This yields

$$V'(T) = e^{-rT} F'(T) - re^{-rT} F(T) = 0$$

or

$$F'(T) - rF(T) = 0.$$

This can be rearranged to establish the result:

$$r = \frac{F'(T)}{F(T)}.$$

This equation says that the optimal value of T satisfies the condition rate of interest equals the rate of growth of the value of the forest.