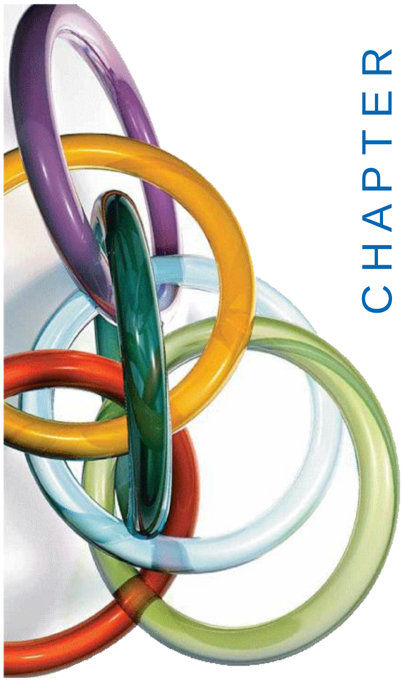

CHAPTER 15

Investment, Time, and Capital Markets

CHAPTER 15 OUTLINE

INVESTMENT, TIME, AND CAPITAL MARKETS

Capital is *durable*: It can last and contribute to production for years after it is purchased.

Time is an important element in the purchase of capital goods. When a firm decides whether to build a factory or purchase machines, it must compare the outlays it would have to make *now* with the additional profit that the new capital will generate *in the future*. To make this comparison, it must address the following question: *How much are future profits worth today?*

Most capital investment decisions involve comparing an outlay today with profits that will be received in the future

15.1 STOCKS VERSUS FLOWS

Chapter 15: Investment, Time, and Capital Markets

Capital is measured as a *stock*. If a firm owns an electric motor factory worth $10 million, we say that it has a *capital stock* worth $10 million.

Suppose the firm sells 8000 motors per month for $52.50 each. Average variable cost is $42.50 per unit. Average profit is
$52.50 – $42.50 = $10 per unit and total profit is $8,000 per month.

To make and sell these motors, a firm needs capital—namely, the factory that it built for $10 million. *The firm's $10 million capital stock allows it to earn a flow of profit of $80,000 per month*. Was the $10 million investment in this factory a sound decision?

If the factory will last 20 years, then we must ask: What is the value today of $80,000 per month for the next 20 years? If that value is greater than $10 million, the investment was a good one.

Is $80,000 five years—or 20 years—from now worth $80,000 today? Money received over time is less than money received today because the money can be invested to yield more money in the future.

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15.2 PRESENT DISCOUNTED VALUE

- **interest rate** Rate at which one can borrow or lend money.
- **present discounted value (PDV)** The current value of an expected future cash flow.

Suppose the annual interest rate is R. Then \$1 today can be invested to yield $(1 + R)$ dollars a year from now. Therefore, $1 + R$ dollars is the *future value* of \$1 today.

Now, what is the value *today*, i.e., the present discounted value (PDV), of \$1 paid one year from now?

\$1 a year from now is worth $\$1/(1 + R)$ today. This is the amount of money that will yield \$1 after one year if invested at the rate R.

\$1 paid n years from now is worth $\$1/(1 + R)^n$ today

We can summarize this as follows:

15.2 PRESENT DISCOUNTED VALUE

TABLE 15.1 PDV of \$1 Paid in the Future

Interest Rate	1 Year	2 Years	5 Years	10 Years	20 Years	30 Years
0.01	\$0.990	\$0.980	\$0.951	\$0.905	\$0.820	\$0.742
0.02	0.980	0.961	0.906	0.820	0.673	0.552
0.03	0.971	0.943	0.863	0.744	0.554	0.412
0.04	0.962	0.925	0.822	0.676	0.456	0.308
0.05	0.952	0.907	0.784	0.614	0.377	0.231
0.06	0.943	0.890	0.747	0.558	0.312	0.174
0.07	0.935	0.873	0.713	0.508	0.258	0.131
0.08	0.926	0.857	0.681	0.463	0.215	0.099
0.09	0.917	0.842	0.650	0.422	0.178	0.075
0.10	0.909	0.826	0.621	0.386	0.149	0.057
0.15	0.870	0.756	0.497	0.247	0.061	0.015
0.20	0.833	0.694	0.402	0.162	0.026	0.004

Table 15.1 shows, for different interest rates, the present value of \$1 paid after 1, 2, 5, 10, 20, and 30 years. Note that for interest rates above 6 or 7 percent, \$1 paid 20 or 30 years from now is worth very little today. But this is not the case for low interest rates. For example, if R is 3 percent, the PDV of \$1 paid 20 years from now is about 55 cents. In other words, if 55 cents were invested now at the rate of 3 percent, it would yield about \$1 after 20 years.

15.2 PRESENT DISCOUNTED VALUE

Valuing Payment Streams

TABLE 15.2 Two Payment Streams

	Today	1 Year	2 Years
Payment Stream *A*:	\$100	\$100	\$ 0
Payment Stream *B*:	\$ 20	\$100	\$100

Which payment stream in the table above would you prefer to receive? The answer depends on the interest rate.

TABLE 15.3 PDV of Payment Streams

	R = .05	R = .10	R = .15	R = .20
PDV of Stream *A*:	\$195.24	\$190.91	\$186.96	\$183.33
PDV of Stream *B*:	205.94	193.55	182.57	172.78

For interest rates of 10 percent or less, Stream *B* is worth more; for interest rates of 15 percent or more, Stream *A* is worth more. Why? Because even though less is paid out in Stream *A*, it is paid out sooner.

15.2 PRESENT DISCOUNTED VALUE

EXAMPLE 15.1 The Value of Lost Earnings

In this example, Harold Jennings died in an automobile accident on January 1, 1996, at the age of 53. The PDV of his lost earnings, from 1996 until retirement at the end of 2003 is calculated as follows:

TABLE 15.4 Calculating Lost Wages

Year	$W_0(1 + g)^t$	$(1 - m_t)$	$1/(1 + R)^t$	$W_0(1 + g)^t (1 - m_t)/(1 + R)^t$
1996	\$ 85,000	.991	1.000	\$84,235
1997	91,800	.990	.917	83,339
1998	99,144	.989	.842	82,561
1999	107,076	.988	.772	81,671
2000	115,642	.987	.708	80,810
2001	124,893	.986	.650	80,044
2002	134,884	.985	.596	79,185
2003	145,675	.984	.547	78,409

where W_0 is his salary in 1996, g is the annual percentage rate at which his salary is likely to have grown (so that $W_0(1 + g)$ would be his salary in 1997, $W_0(1 + g)^2$ his salary in 1998, etc.), and $m_1, m_2, \ldots, m_7$ are mortality rates, i.e., the probabilities that he would have died from some other cause by 1997, 1998, . . . , 2003.

By summing the last column, we obtain a PDV of \$650,254.

The Discounted Utility (DU) Model

Paul Samuelson (1937) "A Note on Measurement of Utility.“

- *generalized model of intertemporal Choice applicable to multiple time periods*
- *the discount rate R*
- *intertemporal preferences over consumption profiles* $(c_t,\ldots,c_T)$
- *preferences can be represented by an intertemporal utility function* $U_t(c_t,\ldots,c_T)$

The utility at time t of a flow of goods c_t accruing at times $t, t+1, t+2, \ldots. . T$ is given by:

$$U_t(c_t, \ldots \ldots c_T) = \sum_{k=0}^{T-t} \delta^k u(c_{t+k})$$

where $\delta = \frac{1}{1+R}$

and

$u(c_{t+k})$ *instantaneous utility function*

δ *discount factor*

R *discount rate*

Note that $\mathbf{0 < \delta < 1}$

Useful results

$$\delta = \frac{1}{1+R} \text{ where } R > 0$$

$$\sum_{t=0}^{\infty} \delta^t = \frac{1}{1-\delta} \qquad \sum_{t=0}^{y} \delta^t = \frac{1-\delta^{y+1}}{1-\delta}$$

$$\sum_{t=1}^{\infty} \delta^t = \frac{\delta}{1-\delta} \qquad \sum_{t=1}^{y} \delta^t = \frac{\delta-\delta^{y+1}}{1-\delta}$$

$$\sum_{t=2}^{\infty} \delta^t = \frac{\delta^2}{1-\delta} \qquad \sum_{t=2}^{y} \delta^t = \frac{\delta^2-\delta^{y+1}}{1-\delta}$$

$$\sum_{t=x}^{\infty} \delta^t = \frac{\delta^x}{1-\delta} \qquad \sum_{t=x}^{y} \delta^t = \frac{\delta^x-\delta^{y+1}}{1-\delta}$$

Discounted utility model and PDV

PDV is a specific application of the discounted utility model

In the computation of the PDV the instantaneous utility function $u(x)$ is equal to $x,$ i.e.

$$u(x) = x$$

15.3 THE VALUE OF A BOND

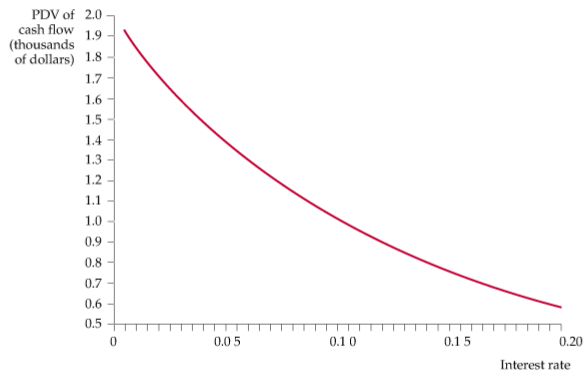
- **bond** Contract in which a borrower agrees to pay the bondholder (the lender) a stream of money.

Figure 15.1

Present Value of the Cash Flow from a Bond

Because most of the bond's payments occur in the future, the present discounted value declines as the interest rate increases.

For example, if the interest rate is 5 percent, the PDV of a 10-year bond paying $100 per year (**from next year)** on a principal of $1000 is $1386. At an interest rate of 15 percent, the PDV is $749.



$$= 100\,\frac{\delta - \delta^{11}}{1-\delta} + 1000 \cdot \delta^{10} \qquad (15.1)$$

Note that

$$\text{PDV} = 100\,\frac{\delta-\delta^{11}}{1-\delta} + 1000\,\delta^{10}$$

is increasing in δ

and δ is decreasing in R

Then PDV is decreasing in R

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15.3 THE VALUE OF A BOND

Perpetuities

- **perpetuity** Bond paying out a fixed amount of money each year, forever.

The present value of the payment stream (starting one year later) is given by the infinite summation:

The summation can be expressed in terms of a simple formula:

$$U_o = PDV = 100\sum_{t=1}^{\infty}\delta^t = \frac{\delta}{1-\delta}100$$

where $\delta = \frac{1}{1+R}$

So if the interest rate is 5 percent, the perpetuity is worth \$100/(.05) = \$2000, but if the interest rate is 20 percent, the perpetuity is worth only \$500.

If the payment stream starts in the current period ($t = 0$)

$$U_o = PDV = 100\sum_{t=0}^{\infty}\delta^t = \frac{100}{1-\delta}$$

If the payment stream starts in a future period $t = x$

$$U_o = PDV = 100\sum_{t=x}^{\infty}\delta^t = \frac{\delta^x}{1-\delta}100$$

The Effective Yield on a Bond

The effective yield is the interest rate that equates the present value of the bond's payment stream with the bond's market price.

Suppose the market price of the perpetuity paying 100 from the next year is *P*. The value of the perpetuity is $U_o = PDV = \frac{\delta}{1-\delta}100$

It can be rewritten as $PDV = \frac{100}{R}$

Thus, if the price of the perpetuity is \$1000, we know that the interest rate is *R* = \$100/\$1000 = 0.10, or 10 percent. This interest rate is called the **effective yield**, or **rate of return**.

- **effective yield (**or **rate of return)** Percentage return that one receives by investing in a bond.

15.3 THE VALUE OF A BOND

The Effective Yield on a Bond

Effective Yield

Figure 15.2

Effective Yield on a Bond

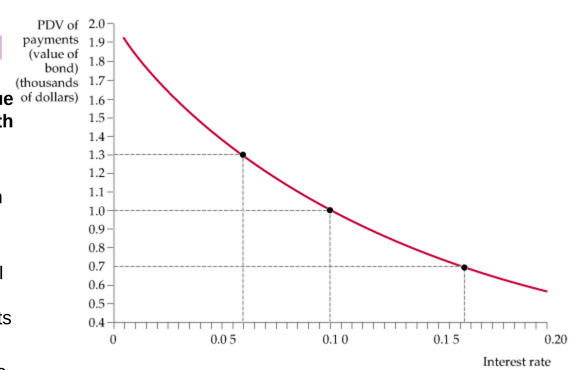
The effective yield is the interest rate that equates the present value of the bond's payment stream with the bond's market price.

The figure shows the present value of the payment stream as a function of the interest rate.

The effective yield is found by drawing a horizontal line at the level of the bond's price. For example, if the price of this bond were \$1000, its effective yield would be 10 percent.

If the price were \$1300, the effective yield would be about 6 percent.

If the price were \$700, it would be 16.2 percent.



15.3 THE VALUE OF A BOND

EXAMPLE 15.2 The Yields on Corporate Bonds

	General Electric	Ford
Price:	98.77	92.00
Coupon:	5.00	8.875
Maturity Date:	Feb. 1, 2013	Jan. 15, 2022
Yield to Maturity:	5.256	9.925
Current Yield:	5.062	9.647
Rating:	AAA	CCC

The yield on the General Electric bond is given by the following equation

To find the effective yield, we must solve this equation for R. The solution is approximately R^* = 5.256 percent.

The yield on the General Electric bond is given by the following equation

R^* = 9.925 percent.

The yield on the Ford bond was much higher because the Ford bond was much riskier.

15.4 THE NET PRESENT VALUE CRITERION FOR CAPITAL INVESTMENT DECISIONS

- **net present value (NPV) criterion** Rule holding that one should invest if the present value of the expected future cash flow from an investment is larger than the cost of the investment.

Suppose a capital investment costs C and is expected to generate profits over the next 10 years of amounts $\pi_1, \pi_2, \ldots, \pi_{10}$. We then write the net present value as

(15.3)

where R is the **discount rate** that we use to discount the future stream of profits. Equation (15.3) describes the net benefit to the firm from the investment. The firm should make the investment only if that net benefit is positive—i.e., *only if NPV > 0.*

- **discount rate** Rate used to determine the value today of a dollar received in the future.

Determining the Discount Rate

- **opportunity cost of capital** Rate of return that one could earn by investing in an alternate project with similar risk.

15.4 THE NET PRESENT VALUE CRITERION FOR CAPITAL INVESTMENT DECISIONS

The Electric Motor Factory

Initial investment of $10 million. 8000 electric motors per month are produced and sold for $52.50 over the next 20 years. Production cost is $42.50 per unit, for a profit of $80,000 per month. Factory can be sold for scrap (with certainty) for $1 million after it becomes obsolete. Annual profit equals $960,000.

(15.4)

15.4 THE NET PRESENT VALUE CRITERION FOR CAPITAL INVESTMENT DECISIONS

The Electric Motor Factory

Figure 15.3

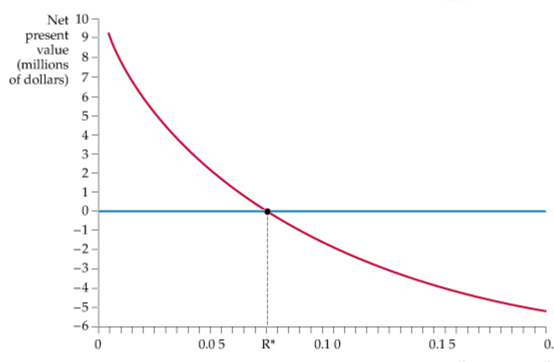
Net Present Value of a Factory

The NPV of a factory is the present discounted value of all the cash flows involved in building and operating it.

Here it is the PDV of the flow of future profits less the current cost of construction.

The NPV declines as the discount rate increases.

At discount rate *R**, the NPV is zero.



For discount rates below 7.5 percent, the NPV is positive, so the firm should invest in the factory. For discount rates above 7.5 percent, the NPV is negative, and the firm should not invest. *R** is sometimes called the *internal rate of return* on the investment.

15.4 THE NET PRESENT VALUE CRITERION FOR CAPITAL INVESTMENT DECISIONS

Real versus Nominal Discount Rates

In our electric motor factory example, we assumed that future cash flows are certain, so that the discount rate *R* should be a risk-free interest rate, such as on government bonds. Suppose that rate is 9%. The discount rate should therefore be the real interest rate on government bonds. The 9% includes inflation.

The real interest rate is the nominal rate minus the expected rate of inflation. If we expect inflation to be 5 percent per year on average, the real interest rate would be 9 − 5 = 4 percent. This is the discount rate that should be used to calculate the NPV of the investment in the electric motor factory. Note from Figure 15.3 that at this rate the NPV is clearly positive, so the investment should be undertaken.

15.4 THE NET PRESENT VALUE CRITERION FOR CAPITAL INVESTMENT DECISIONS

Negative Future Cash Flows

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Negative future cash flows create no problem for the NPV rule; they are simply discounted, just like positive cash flows.

Suppose that our electric motor factory will take a year to build: $5 million is spent right away, and another $5 million is spent next year. Also, suppose the factory is expected to lose $1 million in its first year of operation and $0.5 million in its second year. Afterward, it will earn $0.96 million a year until year 20, when it will be scrapped for $1 million, as before. (All these cash flows are in real terms.) Now the net present value is

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15.5 ADJUSTMENTS FOR RISK

- **risk premium** Amount of money that a risk-averse individual will pay to avoid taking a risk.

Diversifiable versus Nondiversifiable Risk

- **diversifiable risk** Risk that can be eliminated either by investing in many projects or by holding the stocks of many companies.

  Because investors can eliminate diversifiable risk, assets that have only diversifiable risk tend on average to earn a return close to the risk-free rate. If the project's only risk is diversifiable, the opportunity cost is the risk-free rate. *No risk premium should be added to the discount rate*.

- **nondiversifiable risk** Risk that cannot be eliminated by investing in many projects or by holding the stocks of many companies.

  For capital investments, nondiversifiable risk arises because a firm's profits tend to depend on the overall economy. To the extent that a project has nondiversifiable risk, the opportunity cost of investing in that project is higher than the risk-free rate. Thus a risk premium must be included in the discount rate.

15.5 ADJUSTMENTS FOR RISK

The Capital Asset Pricing Model

- **Capital Asset Pricing Model (CAPM)** Model in which the risk premium for a capital investment depends on the correlation of the investment's return with the return on the entire stock market.

The expected return on the stock market is higher than the risk-free rate. Denoting the expected return on the stock market by r_m and the risk-free rate by r_f , the risk premium on the market is $r_m - r_f$. This is the additional expected return you get for bearing the nondiversifiable risk associated with the stock market.

The CAPM summarizes the relationship between expected returns and the risk premium by the following equation:

(15.6)

where r_i is the expected return on an asset. The equation says that the risk premium on the asset (its expected return less the risk-free rate) is proportional to the risk premium on the market.

15.5 ADJUSTMENTS FOR RISK

The Capital Asset Pricing Model

- **asset beta** A constant that measures the sensitivity of an asset's return to market movements and, therefore, the asset's nondiversifiable risk.

If a 1-percent rise in the market tends to result in a 2-percent rise in the asset price, the beta is 2.

The Risk-Adjusted Discount Rate Given beta, we can determine the correct discount rate to use in computing an asset's net present value. That discount rate is the expected return on the asset or on another asset with the same risk. It is therefore the risk-free rate plus a risk premium to reflect nondiversifiable risk:

(15.7)

- **company cost of capital** Weighted average of the expected return on a company's stock and the interest rate that it pays for debt.

15.5 ADJUSTMENTS FOR RISK

EXAMPLE 15.3 Capital Investment in the Disposable Diaper Industry

TABLE 15.5 Data for NPV Calculation ($ millions)

	Pre-2010	2010	2011	2012	. . .	2025
Sales		133.3	266.7	400.0	. . .	400.0
LESS						
Variable cost		96.7	193.3	290.0	. . .	290.0
Ongoing R&D		20.0	20.0	20.0	. . .	20.0
Sales force, ads, and marketing		50.0	50.0	50.0	. . .	50.0
Operating profit		−33.4	3.4	40.0	. . .	40.0
LESS						
Construction cost	60.0	60.0	60.0			
Initial R&D	60.0					
NET CASH FLOW	−120.0	−93.4	−56.6	40.0	. . .	40.0
	Discount Rate:	0.05	0.10	0.15		
	NPV:	80.5	−16.9	−75.1		

15.5 ADJUSTMENTS FOR RISK

EXAMPLE 15.3 Capital Investment in the Disposable Diaper Industry (continued)

Some of this risk is nondiversifiable. To calculate the risk premium, we will use a beta of 1, which is typical for a producer of consumer products of this sort. Using 4 percent for the real risk-free interest rate and 8 percent for the risk premium on the stock market, our discount rate should be

At this discount rate, the NPV is clearly negative, so the investment does not make sense.

15.6 INVESTMENT DECISIONS BY CONSUMERS

The decision to buy a durable good involves comparing a flow of *future* benefits with the *current* purchase cost

Let's assume a car buyer values the service at *S* dollars per year. Let's also assume that the total operating expense (insurance, maintenance, and gasoline) is *E* dollars per year, that the car costs $20,000, and that after six years, its resale value will be $4000. The decision to buy the car can then be framed in terms of net present value:

+.....

....

What discount rate *R* should the consumer use? The consumer should apply the same principle that a firm does: The discount rate is the opportunity cost of money, the return that could be earned by investing the money in another asset.

15.6 INVESTMENT DECISIONS BY CONSUMERS

EXAMPLE 15.4 Choosing an Air Conditioner and a New Car

Assuming an eight-year lifetime and no resale, the PDV of the cost of buying and operating air conditioner *i* is

where C_i is the purchase price of air conditioner *i* and OC_i is its average annual operating cost.

The preferred air conditioner depends on your discount rate. A high discount rate would make the present value of the future operating costs smaller. In this case, you would probably choose a less expensive but relatively inefficient unit.

As with air conditioners, a consumer can compare two or more cars by calculating and comparing the PDV of the purchase price and expected average annual operating cost for each.

15.7 INVESTMENTS IN HUMAN CAPITAL

- **human capital** Knowledge, skills, and experience that make an individual more productive and thereby able to earn a higher income over a lifetime.

1.The NPV of a College Education Let's assume that the total economic cost of attending college to be $40,000 per year for each of four years. A college graduate will on average earn about $20,000 per year more than a high school graduate. For simplicity we will assume that this $20,000 salary differential persists for 20 years. In that case, the NPV (in $1000s) of investing in a college education is

A reasonable real discount rate would be about 5 percent. This rate would reflect the opportunity cost of money for many households. The NPV is then about $66,000.

A college education is an investment with close to free entry. In markets with free entry, we should expect to see zero economic profits, which implies that investments will earn a competitive return.

*15.8 INTERTEMPORAL PRODUCTION DECISIONS—DEPLETABLE RESOURCES

Production decisions often have *intertemporal* aspects—production today affects sales or costs in the future. Intertemporal production decisions involve comparisons between costs and benefits today with costs and benefits in the future.

The Production Decision of an Individual Resource Producer

How fast must the price rise for you to keep the oil in the ground?

Your production decision rule is: *Keep all your oil if you expect its price less its extraction cost to rise faster than the rate of interest. Extract and sell all of it if you expect price less cost to rise at less than the rate of interest*.

Letting P_t be the price of oil this year, P_{t+1} the price next year, and c the cost of extraction, we can write this production rule as follows:

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*15.8 INTERTEMPORAL PRODUCTION DECISIONS—DEPLETABLE RESOURCES

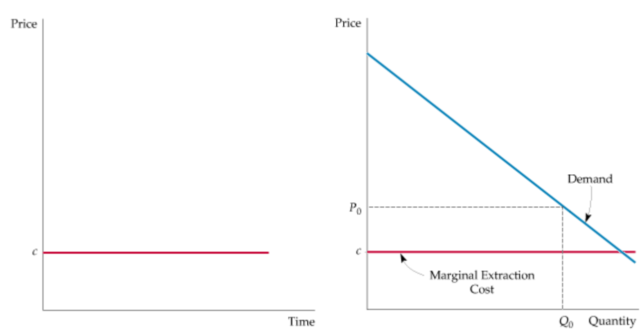
The Behavior of Market Price

Figure 15.4

Price of an Exhaustible Resource (Part I)

Price less marginal cost must rise at exactly the rate of interest.

The marginal cost of extraction is c, and the price and total quantity produced are initially P_0 and Q_0.



*15.8 INTERTEMPORAL PRODUCTION DECISIONS—DEPLETABLE RESOURCES

The Behavior of Market Price

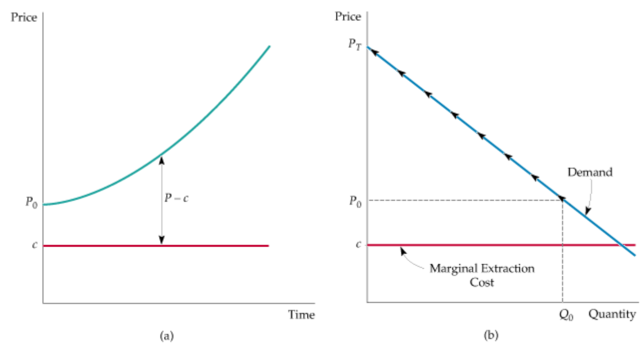
Figure 15.4

Price of an Exhaustible Resource (Part II)

Part (a) shows the net price, $P - c$, rising over time at the rate of interest.

In a competitive market, price less marginal production cost will rise at the rate of interest.

Part (b) shows the movement up the demand curve as price rises and the quantity demanded falls. This continues until time T, when all the oil has been used up and the price P_T is such that demand is just zero.



*15.8 INTERTEMPORAL PRODUCTION DECISIONS—DEPLETABLE RESOURCES

User Cost

- **user cost of production** Opportunity cost of producing and selling a unit today and so making it unavailable for production and sale in the future.

In Figure 15.4, user cost is the difference between price and marginal production cost. It rises over time because as the resource remaining in the ground becomes scarcer, the opportunity cost of depleting another unit becomes higher.

*15.8 INTERTEMPORAL PRODUCTION DECISIONS—DEPLETABLE RESOURCES

Resource Production by a Monopolist

Since the monopolist controls total output, it will produce so that marginal revenue less marginal cost—i.e., the value of an incremental unit of resource—rises at exactly the rate of interest:

If marginal revenue less marginal cost rises at the rate of interest, *price* less marginal cost will rise at less than the rate of interest. We thus have the interesting result that a monopolist is *more conservationist* than a competitive industry. In exercising monopoly power, the monopolist starts out charging a higher price and depletes the resource more slowly.

*15.8 INTERTEMPORAL PRODUCTION DECISIONS—DEPLETABLE RESOURCES

EXAMPLE 15.6 How Depletable Are Depletable Resources?

For resources that are more depleatable, the user cost of production can be a significant component of the market price. If the market is competitive, user cost can be determined from the economic rent earned by the owners of resource bearing lands.

For crude oil and natural gas, the user cost is a substantial component of price. For the other resources, it is small and in some cases almost negligible.

Although most of these resources have experienced sharp price fluctuations, user cost had almost nothing to do with those fluctuations.

TABLE 15.7 User Cost as a Fraction of Competitive Price

Resource	User Cost/Competitive Price
Crude oil	.4 to .5
Natural gas	.4 to .5
Uranium	.1 to .2
Copper	.2 to .3
Bauxite	.05 to .2
Nickel	.1 to .3
Iron ore	.1 to .2
Gold	.05 to .1

15.9 HOW ARE INTEREST RATES DETERMINED?

An interest rate is the price that borrowers pay lenders to use their funds.

Figure 15.5

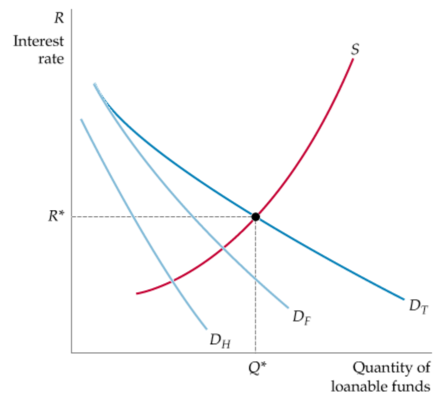
Supply and Demand for Loanable Funds

Market interest rates are determined by the demand and supply of loanable funds.

Households supply funds in order to consume more in the future; the higher the interest rate, the more they supply.

Households and firms both demand funds, but the higher the interest rate, the less they demand.

Shifts in demand or supply cause changes in interest rates.



15.9 HOW ARE INTEREST RATES DETERMINED?

A Variety of Interest Rates

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- **Treasury Bill Rate**
- **Treasury Bond Rate**
- **Discount Rate**
- **Federal Funds Rate**
- **Commercial Paper Rate**
- **Prime Rate**
- **Corporate Bond Rate**

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