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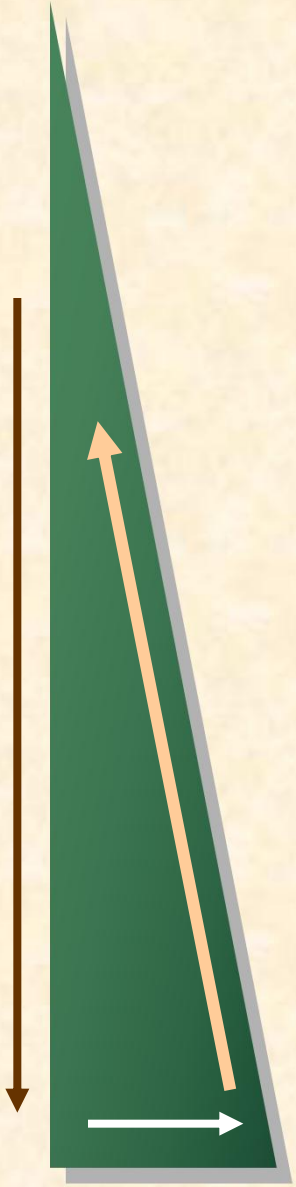

# Chapter 15

# Investment, Time, and Capital Markets

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# Topics to be Discussed

- Stocks Versus Flows
- Present Discounted Value
- The Value of a Bond
- The Net Present Value Criterion for Capital Investment Decisions

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# Topics to be Discussed

- Adjustments for Risk
- Investment Decisions by Consumers
- Intertemporal Production Decisions---Depletable Resources
- How are Interest Rates Determined?

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# Introduction

- Capital
  - Choosing an input that will contribute to output over a long period of time
  - Comparing the future value to current expenditures

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# Stocks Versus Flows

- Stock
  - Capital is a stock measurement.
    - The amount of capital a company owns

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# Stocks Versus Flows

- Flows
  - Variable inputs and outputs are flow measurements.
    - An amount per time period

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# Present Discounted Value (PDV)

- Determining the value today of a future flow of income
  - The value of a future payment must be discounted for the time period and interest rate that could be earned.

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# Present Discounted Value (PDV)

- Future Value (FV)

Future Dollar Value of \$1 invested today $= (1+R)^{n}$

PDV = Present dollar value of \$1 received in the future $= \frac{1}{(1+R)^{n}}$; (how much would you have to invest today to have a dollar in the future)

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# Present Discounted Value (PDV)

- Question
  - What impact does *R* have on the PDV?

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# PDV of $1 Paid in the Future

| Interest Rate | 1 Year | 2 Years | 3 Years | 4 Years | 5 Years | 6 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 |

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# PDV of $1 Paid in the Future

| Interest Rate | 1 Year | 2 Years | 3 Years | 4 Years | 5 Years | 6 Years |
|---|---|---|---|---|---|---|
| 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 |

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# Present Discounted Value (PDV)

- Valuing Payment Streams
  - Choosing a payment stream depends upon the interest rate.

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# Two Payment Streams

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

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# Two Payment Streams

- PDV of Stream $A = \dfrac{100}{(1+R)}$

$$\text{PDV of Stream } B = \frac{100}{(1+R)} + \frac{100}{(1+R)^2}$$

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# PDV of Payment Streams

| | *R* = .05 | *R* = .10 | *R* = .15 | *R* = .20 |
|---|---|---|---|---|
| PDV of Stream *A*: | $195.24 | $190.90 | $186.96 | $183.33 |
| PDV of Stream *B*: | 205.94 | 193.54 | 182.57 | 172.77 |

**Why does the PDV of *A* relative to *B* increase as *R* increases and vice versa for *B*?**

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# The Value of Lost Earnings

- PDV can be used to determine the value of lost income from a disability or death.

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# The Value of Lost Earnings

- Scenario
  - Harold Jennings died in an auto accident January 1, 1986 at 53 years of age.
  - Salary: $85,000
  - Retirement Age: 60

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# The Value of Lost Earnings

- Question
  - What is the PDV of Jennings' lost income to his family?
    - Must adjust salary for predicted increase (*g*)
      - Assume an 8% average increase in salary for the past 10 years

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# The Value of Lost Earnings

- Question
  - What is the PDV of Jennings' lost income to his family?
    - Must adjust for the true probability of death (*m*) from other causes
      - Derived from mortality tables

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# The Value of Lost Earnings

- Question
  - What is the PDV of Jennings' lost income to his family?
    - Assume *R* = 9%
      - Rate on government bonds in 1983

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# The Value of Lost Earnings

- $$PDV = W_0 + \frac{W_0(1+g)(1-m_1)}{(1+R)} + \frac{W_0(1+g)^2(1-m_2)}{(1+R)^2} + \ldots + \frac{W_0(1+g)^7(1-m_7)}{(1+R)^7}$$

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# Calculating Lost Wages

| Year | $W_0(1 + g)^t$ | $(1 - m_t)$ | $1/(1 + R)^t$ | $W_0(1 + g)^t(1 - m_t)/(1 + R)^t$ |
|---|---|---|---|---|
| 1986 | $ 85,000 | .991 | 1.000 | $84,235 |
| 1987 | 91,800 | .990 | .917 | 83,339 |
| 1988 | 99,144 | .989 | .842 | 82,561 |
| 1989 | 107,076 | .988 | .772 | 81,671 |
| 1990 | 115,642 | .987 | .708 | 80,810 |
| 1991 | 124,893 | .986 | .650 | 80,043 |
| 1992 | 134,884 | .985 | .596 | 79,185 |
| 1993 | 145,675 | .984 | .547 | 78,408 |

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# The Value of Lost Earnings

- Finding PDV
  - The summation of column 4 will give the PDV of lost wages ($650,252)
  - Jennings' family could recover this amount as compensation for his death.

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# The Value of a Bond

- Determining the Price of a Bond
  - Coupon Payments = $100/yr. for 10 yrs.
  - Principal Payment = $1,000 in 10 yrs.

$$PDV = \frac{\$100}{(1+R)} + \frac{\$100}{(1+R)^2} + \ldots + \frac{\$100}{(1+R)^{10}} + \frac{\$1000}{(1+R)^{10}}$$

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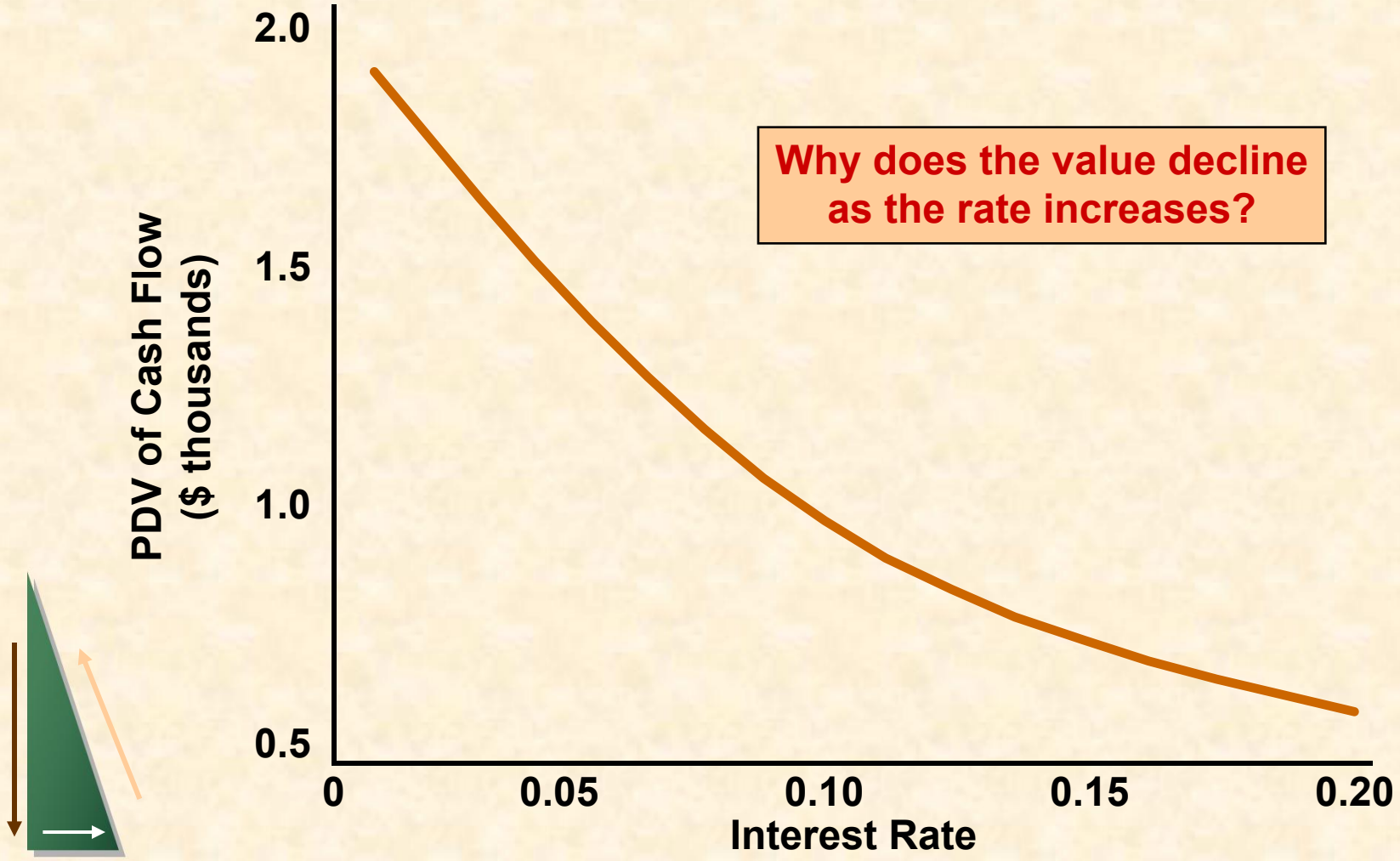
# Present Value of the Cash Flow from a Bond

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# The Value of a Bond

- Perpetuities
  - Perpetuities are bonds that pay out a fixed amount of money each year, *forever.*

$$\text{PDV} = \frac{\text{Payment}}{R}$$

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# Effective Yield on a Bond

- Calculating the Rate of Return From a Bond

$$P = \text{PDV}$$

$$\text{Perpetuity}: P = \frac{\text{Payment}}{R} = \frac{\$100}{R}$$

$$R = \frac{\$100}{P} \qquad P = \$1{,}000$$

$$R = 10\%$$

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# Effective Yield on a Bond

- Calculating the Rate of Return From a Bond

$$\text{Coupon Bond}: \text{PDV} = \frac{\$100}{(1+R)} + \frac{\$100}{(1+R)^2} + \ldots + \frac{\$100}{(1+R)^{10}} + \frac{\$1000}{(1+R)^{10}}$$

Calculate $R$ in terms of $P$

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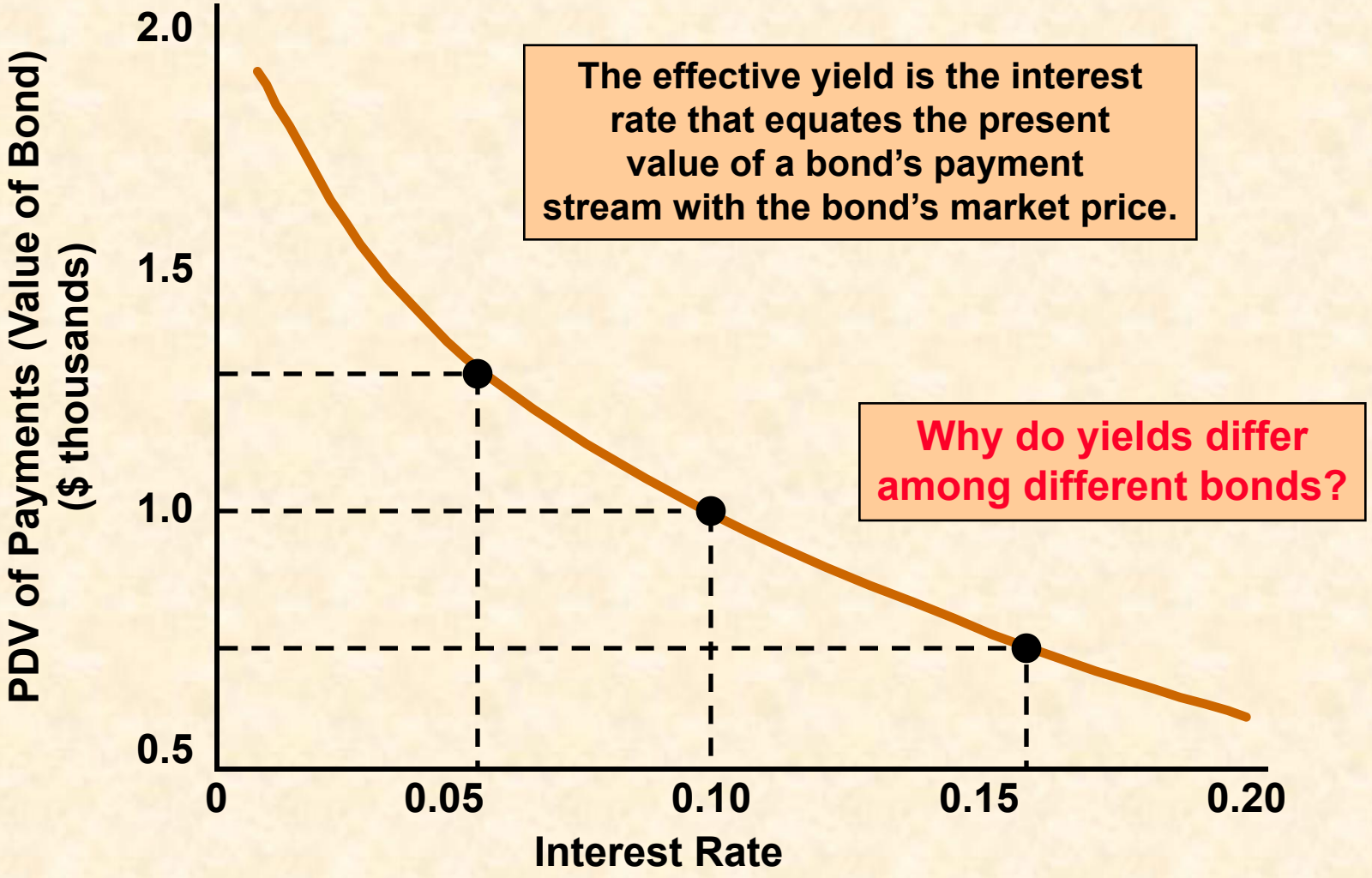
# Effective Yield on a Bond

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# The Yields on Corporate Bonds

- In order to calculate corporate bond yields, the face value of the bond and the amount of the coupon payment must be known.
- Assume
  - IBM and Polaroid both issue bonds with a face value of $100 and make coupon payments every six months.

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# The Yields on Corporate Bonds

- Closing prices for each July 23, 1999:

| | *a* | *b* | *c* | *d* | *e* | *f* |
|---|---|---|---|---|---|---|
| IBM | 5 3/8 | 09 | 5.8 | 30 | 92 | -1 1/2 |
| Polaroid | 11 1/2 | 06 | 10.8 | 80 | 106 | -5/8 |

*a:* coupon payments for one year ($5.375)
*b:* maturity date of bond (2009)
*c:* annual coupon/closing price ($5.375/92)
*d:* number traded that day (30)
*e:* closing price (92)
*f:* change in price from previous day (-1 1/2)

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# The Yields on Corporate Bonds

- The IBM bond yield:
  - Assume annual payments
  - 2009 - 1999 = 10 years

$$92 = \frac{5.375}{(1+R)} + \frac{5.375}{(1+R)^2} + \ldots + \frac{5.375}{(1+R)^{10}} + \frac{100}{(1+R)^{10}}$$

$$R^* = 6.5\%$$

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# The Yields on Corporate Bonds

- The Polaroid bond yield:

$$106 = \frac{11.5}{(1+R)} + \frac{11.5}{(1+R)^2} + \ldots + \frac{11.5}{(1+R)^7} + \frac{11.50}{(1+R)^7}$$

**Why was Polaroid *R** greater?**

$$R^* = 10.2\%$$

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# The Net Present Value Criterion for Capital Investment Decisions

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- In order to decide whether a particular capital investment is worthwhile a firm should compare the present value (*PV*) of the cash flows from the investment to the cost of the investment.

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- NPV Criterion
  - Firms should invest if the *PV* exceeds the cost of the investment.

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- $C =$ capital cost

  $\pi_n =$ profits for $n$ years $(n = 10)$

$$NPV = -C + \frac{\pi_1}{(1+R)} + \frac{\pi_2}{(1+R)^2} + \frac{\pi_{10}}{(1+R)^{10}}$$

$R =$ discount rate or opportunity cost of capital with a similar risk

Invest if $NPV > 0$

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# The Net Present Value Criterion for Capital Investment Decisions

- The Electric Motor Factory (choosing to build a $10 million factory)
  - 8,000 motors/ month for 20 yrs
    - Cost = $42.50 each
    - Price = $52.50
    - Profit = $10/motor or $80,000/month
    - Factory life is 20 years with a scrap value of $1 million
  - Should the company invest?

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# The Net Present Value Criterion for Capital Investment Decisions

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- Assume all information is certain (no risk)
  - *R* = government bond rate

$$NPV = -10 + \frac{.96}{(1+R)} + \frac{.96}{(1+R)^2} + \ldots + \frac{.96}{(1+R)^{20}} + \frac{1}{(1+R)^{20}}$$

$$R^* = 7.5\%$$

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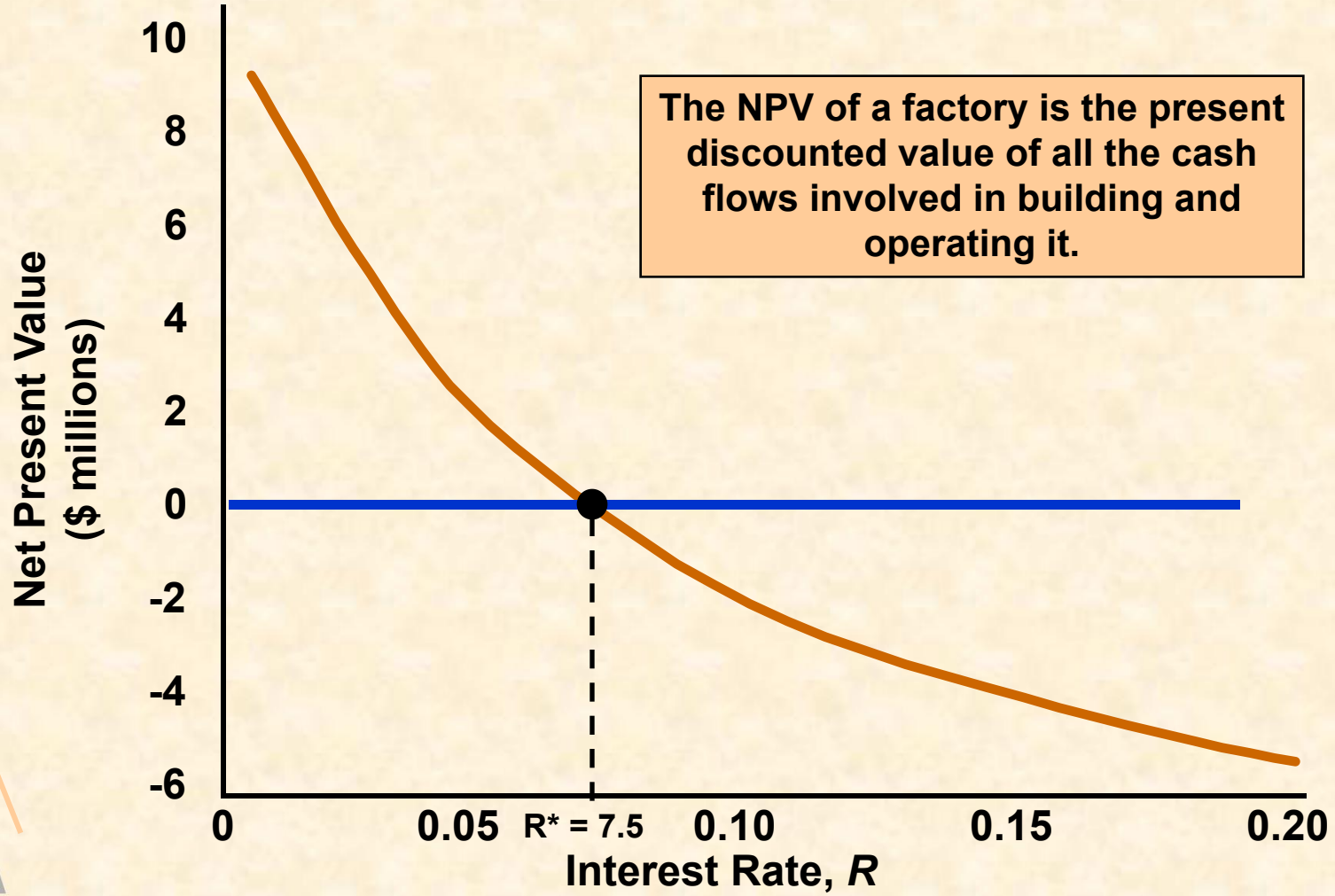
# Net Present Value of a Factory

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# The Net Present Value Criterion for Capital Investment Decisions

- Real versus Nominal Discount Rates
  - Adjusting for the impact of inflation
  - Assume price, cost, and profits are in real terms
    - Inflation = 5%

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# The Net Present Value Criterion for Capital Investment Decisions

- Real versus Nominal Discount Rates
  - Assume price, cost, and profits are in real terms
    - Therefore,
      - $P$ = (1.05)(52.50) = 55.13, Year 2 $P$ = (1.05)(55.13) = 57.88….
      - C = (1.05)(42.50) = 44.63, Year 2 C =….
      - Profit remains $960,000/year

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# The Net Present Value Criterion for Capital Investment Decisions

- Real versus Nominal Discount Rates
  - Real *R* = *nominal R* - inflation = 9 - 5 = 4

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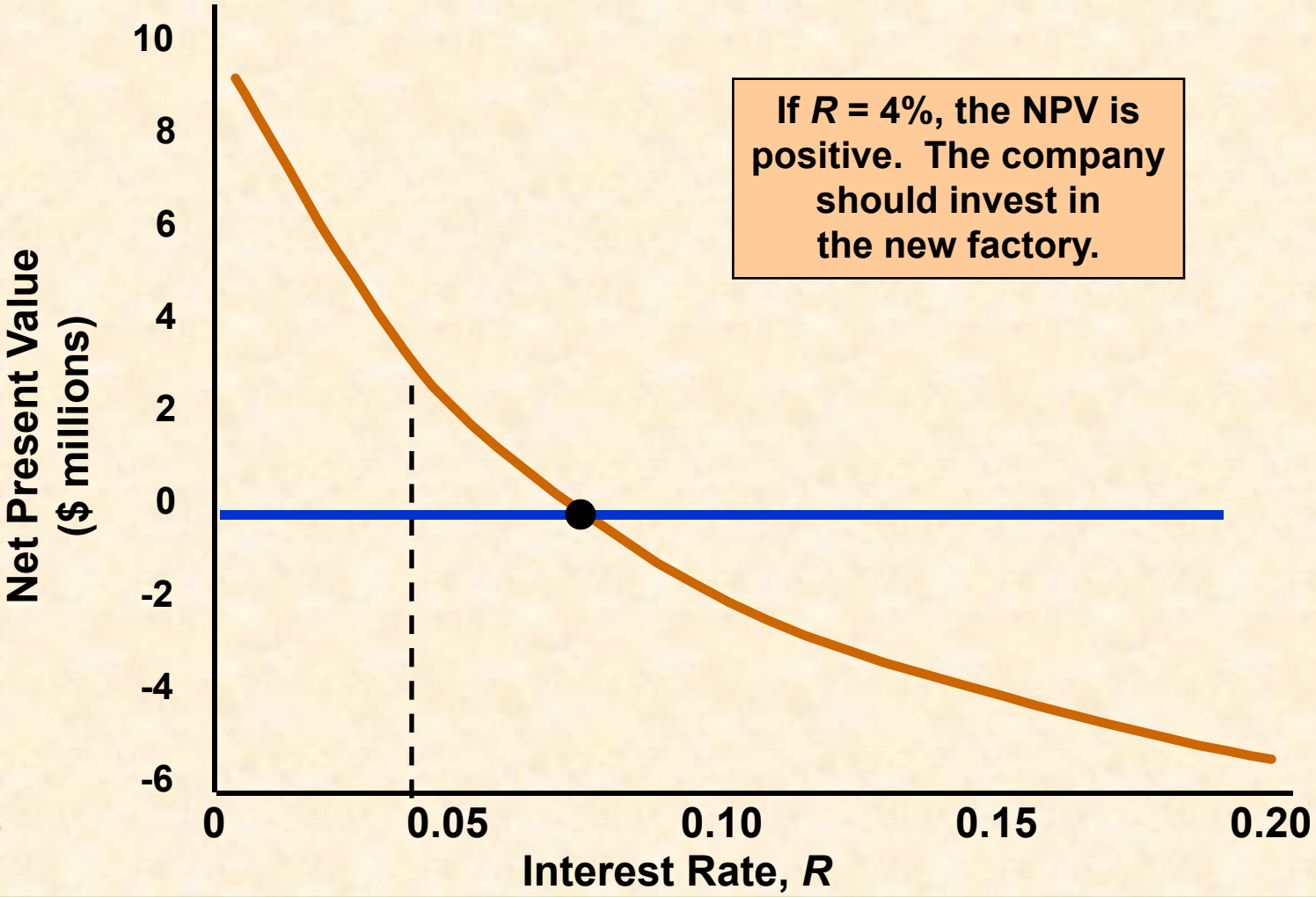
# Net Present Value of a Factory

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# The Net Present Value Criterion for Capital Investment Decisions

- Negative Future Cash Flows
  - Investment should be adjusted for construction time and losses.

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# The Net Present Value Criterion for Capital Investment Decisions

- Electric Motor Factory
  - Construction time is 1 year
    - $5 million expenditure today
    - $5 million expenditure next year
  - Expected to lose $1 million the first year and $0.5 million the second year
  - Profit is $0.96 million/yr. until year 20
  - Scrap value is $1 million

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# The Net Present Value Criterion for Capital Investment Decisions

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- $$NPV = -5 - \frac{5}{(1+R)} - \frac{1}{(1+R)^2} - \frac{.5}{(1+R)^3} + \frac{.96}{(1+R)^4} + \frac{.96}{(1+R)^5} + \ldots + \frac{.96}{(1+R)^{20}} + \frac{1}{(1+R)^{20}}$$

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# Adjustments for Risk

- Determining the discount rate for an uncertain environment:
  - This can be done by increasing the discount rate by adding a *risk-premium* to the risk-free rate.
    - Owners are risk averse, thus risky future cash flows are worth less than those that are certain.

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# Adjustments for Risk

- Diversifiable Versus Nondiversifiable Risk
  - Diversifiable risk can be eliminated by investing in many projects or by holding the stocks of many companies.
  - Nondiversifiable risk cannot be eliminated and should be entered into the risk premium.

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# Adjustments for Risk

- Measuring the Nondiversifiable Risk Using the Capital Asset Pricing Model (CAPM)
  - Suppose you invest in the entire stock market (mutual fund)
    - $r_m$ = expected return of the stock market
    - $r_f$ = risk free rate
    - $r_m - r_f$ = risk premium for nondiversifiable risk

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# Adjustments for Risk

- Measuring the Nondiversifiable Risk Using the Capital Asset Pricing Model (CAPM)
  - Calculating Risk Premium for One Stock

$$r_1 - r_f = \beta(r_m - r_f)$$

$r_1$ = expected return

$\beta$ = asset beta = measures the sensitivity of the asset's return to market movements

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# Adjustments for Risk

- Question
  - What is the relationship between the nondiversifiable risk and the value of the *asset beta*?

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# Adjustments for Risk

- Given beta, we can determine the correct discount rate to use in computing an asset's net present value:

$$\text{Discount Rate} = r_f + \beta(r_m - r_f)$$

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# Adjustments for Risk

- Determining beta
  - Stock
    - Estimated statistically for each company

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# Adjustments for Risk

- Determining beta
  - Factory
    - Weighted average of expected return on the company's stock and the interest on the debt
      - Expected return depends on beta
    - *Caution:* The investment should be typical for the company

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# Investment Decisions by Consumers

- Consumers face similar investment decisions when they purchase a durable good.
  - Compare *future* benefits with the *current* purchase cost

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# Investment Decisions by Consumers

- Benefits and Cost of Buying a Car
  - *S* = value of transportation services in dollars
  - *E* = total operating cost/yr
  - Price of car is $20,000
  - Resale value of car is $4,000 in 6 years

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# Investment Decisions by Consumers

- Benefits and Cost

$$\text{NPV} = -20{,}000 + (S-E) + \frac{(S-E)}{(1+R)} + \frac{(S-E)}{(1+R)^2} + \ldots + \frac{(S-E)}{(1+R)^6} + \frac{4000}{(1+R)^6}$$

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# Choosing an Air Conditioner

- Buying a new air conditioner involves making a trade-off.
  - Air Conditioner *A*
    - Low price and less efficient (high operating cost)

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# Choosing an Air Conditioner

- Buying a new air conditioner involves making a trade-off.
  - Air Conditioner *B*
    - High price and more efficient
  - Both have the same cooling power
  - Assume an 8 year life

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# Choosing an Air Conditioner

- $$PDV = C_i + OC_i + \frac{OC_i}{(1+R)} + \frac{OC_i}{(1+R)^2} + \ldots \frac{OC_i}{(1+R)^8}$$

$C_i$ is the purchase price of $i$

$OC_i$ is the averge operating cost of $i$

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# Choosing an Air Conditioner

- Should you choose *A* or *B*?
  - Depends on the discount rate
    - If you borrow, the discount rate would be high
      - Probably choose a less expensive and inefficient unit
    - If you have plentiful cash, the discount rate would be low.
      - Probably choose the more expensive unit

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# Intertemporal Production Decisions---Depletable Resources

- Firms' production decisions often have *intertemporal* aspects---production today affects sales or costs in the future.

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# Intertemporal Production Decisions---Depletable Resources

- Scenario
  - You are given an oil well containing 1000 barrels of oil.
  - *MC* and *AC* = $10/barrel
  - Should you produce the oil or save it?

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# Intertemporal Production Decisions---Depletable Resources

- Scenario
  - $P_t$ = price of oil this year
  - $P_{t+1}$ = price of oil next year
  - $C$ = extraction costs
  - $R$ = interest rate
- If $(P_{t+1} - c) > (1+R)(P_t - c)$: Keep the oil in the ground

  If $(P_{t+1} - c) < (1+R)(P_t - c)$: Sell all the oil now

  If $(P_{t+1} - c) = (1+R)(P_t - c)$: Indifferent

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# Intertemporal Production Decisions---Depletable Resources

- Do not produce 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.
- What will happen to the price of oil?

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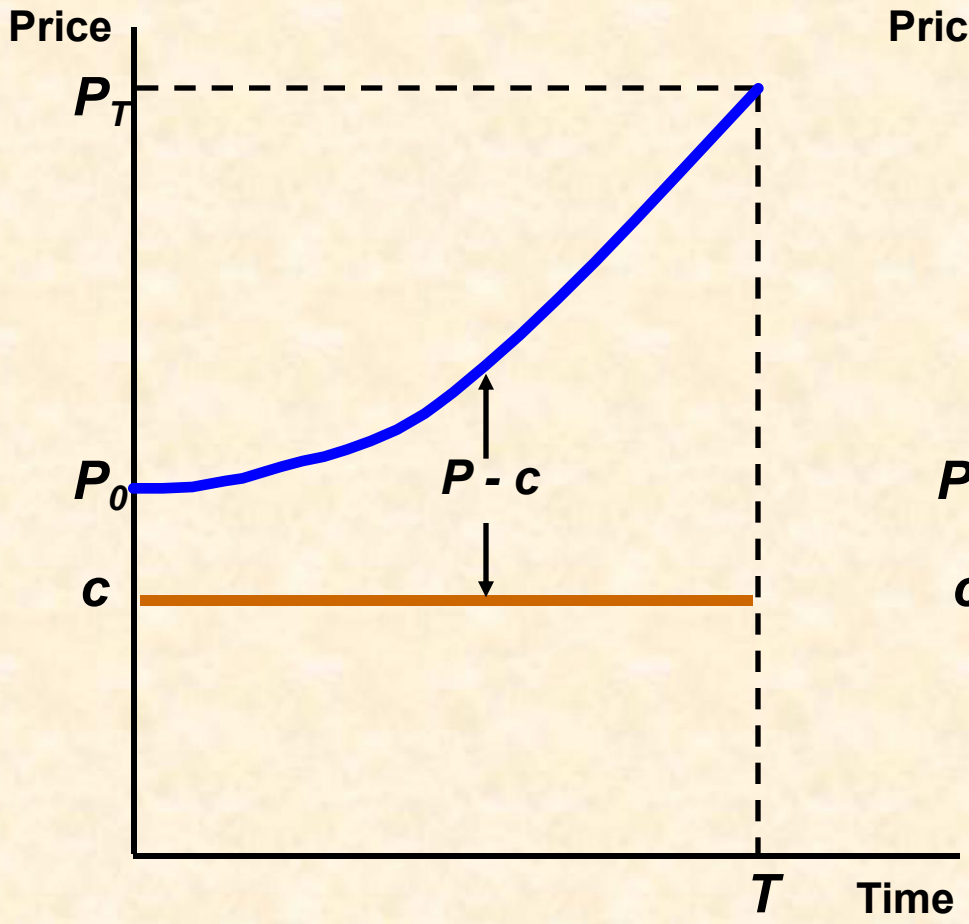
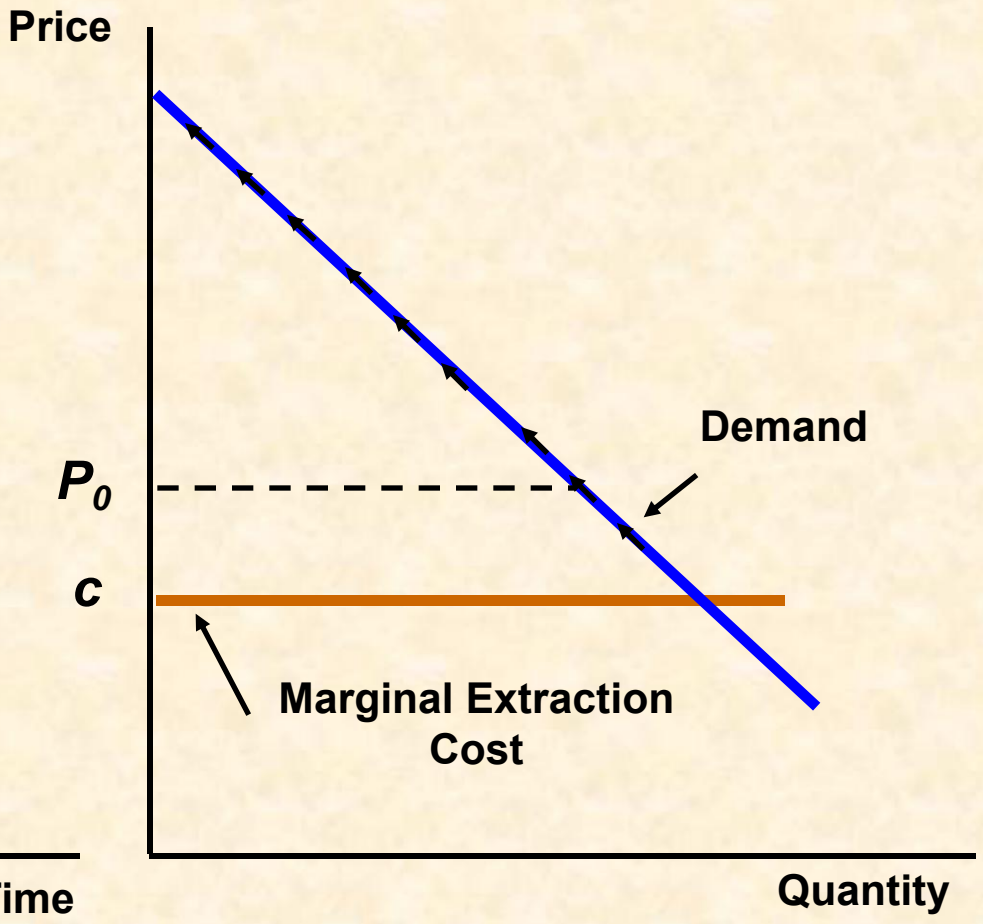
# Price of an Exhaustible Resource

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# Price of an Exhaustible Resource

- In a competitive market, *Price - MC* must rise at exactly the rate of interest.
- Why?
  - How would producers react if:
    - *P - C* increases faster than *R*?
    - *P - C* increases slower than *R*?

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# Price of an Exhaustible Resource

- Notice
  - $P > MC$
    - Is this a contradiction to the competitive rule that $P = MC$?
      - *Hint:* What happens to the opportunity cost of producing an exhaustible resource?

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# Price of an Exhaustible Resource

- $P = MC$
  - $MC$ = extraction cost + user cost
  - User cost = $P$ - marginal extraction cost

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# Price of an Exhaustible Resource

- How would a monopolist choose their rate of production?
  - They will produce so that marginal revenue revenue less marginal cost rises at exactly the rate of interest, or
  - $(MR_{t+1} - c) = (1 + R)(MR_t - c)$

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# Price of an Exhaustible Resource

## Resource Production by a Monopolist

- The monopolist is *more conservationist* than a competitive industry.
  - They start out charging a higher price and deplete the resources more slowly.

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# How Depletable Are Depletable Resources?

| 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 .2 |
| Iron Ore | .1 to .2 |
| Gold | .05 to .1 |

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# How Depletable Are Depletable Resources?

- The market structure and changes in market demand have had a very dramatic impact on resource prices over the past few decades.
- Question
  - Why would oil and natural gas have such a high user cost ratio compared to the other resources?

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# How Are Interest Rates Determined?

- The interest rate is the price that borrowers pay lenders to use their funds.
  - Determined by supply and demand for loanable funds.

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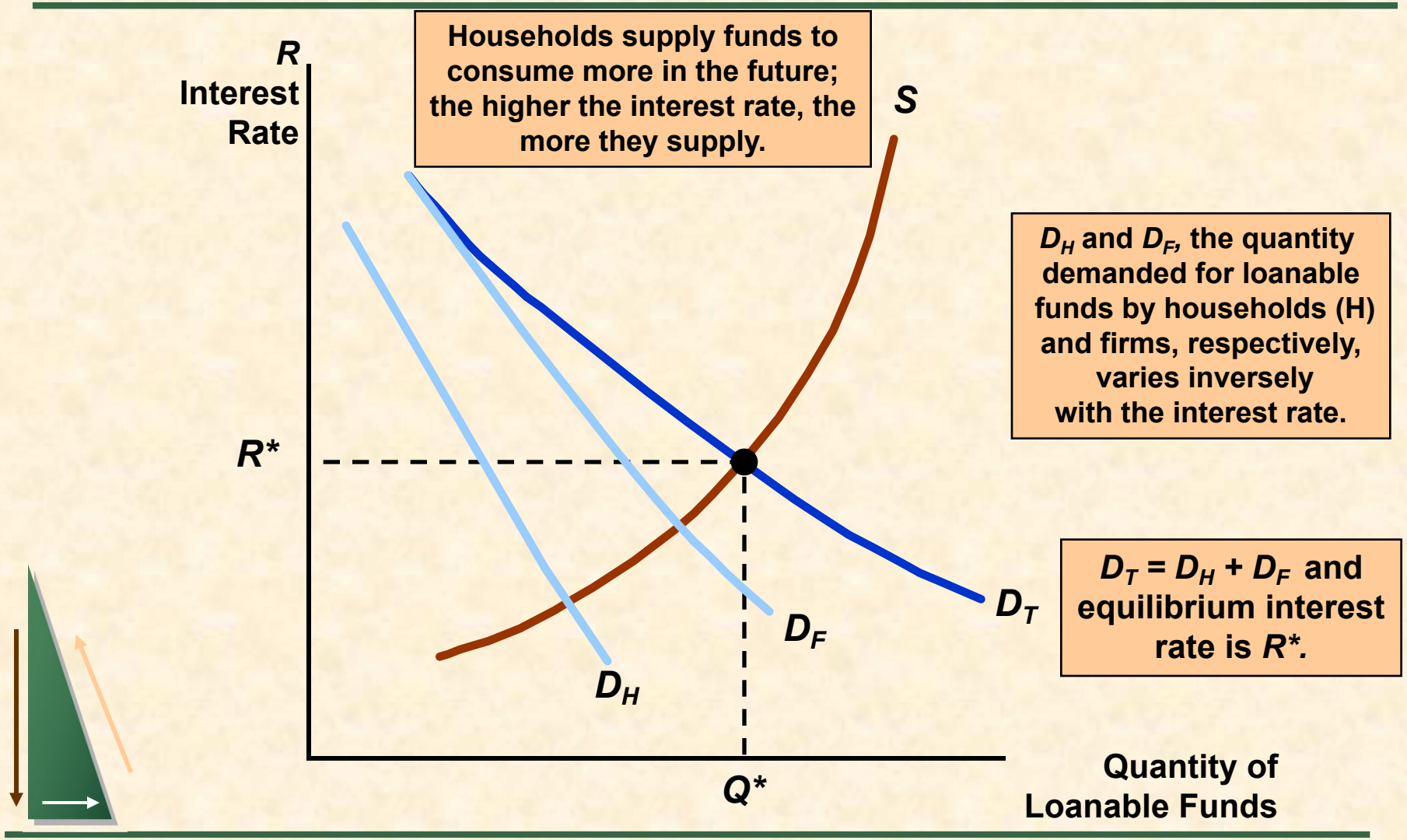
# Supply and Demand for Loanable Funds

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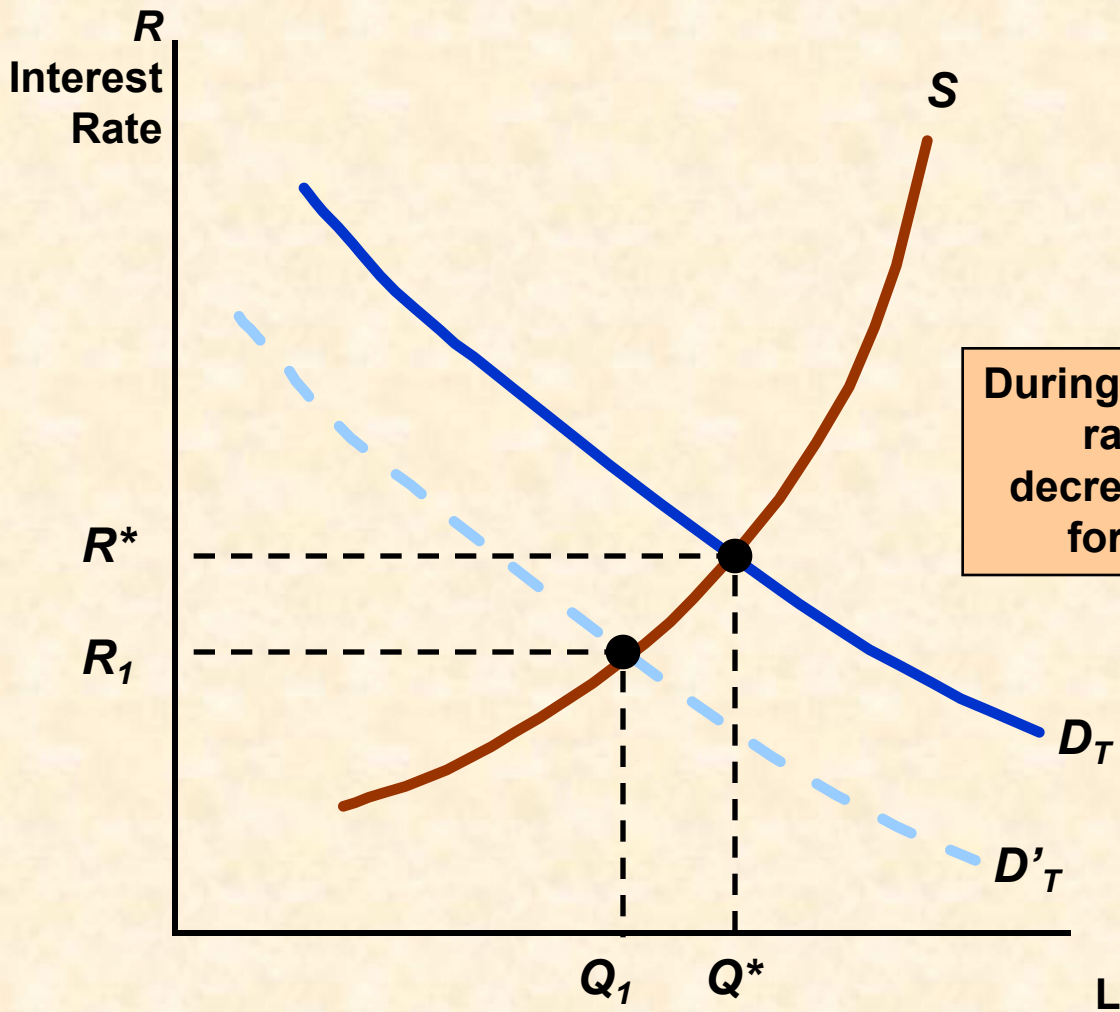
# Changes In The Equilibrium




During a recession interest rates fall due to a decrease in the demand for loanable funds.

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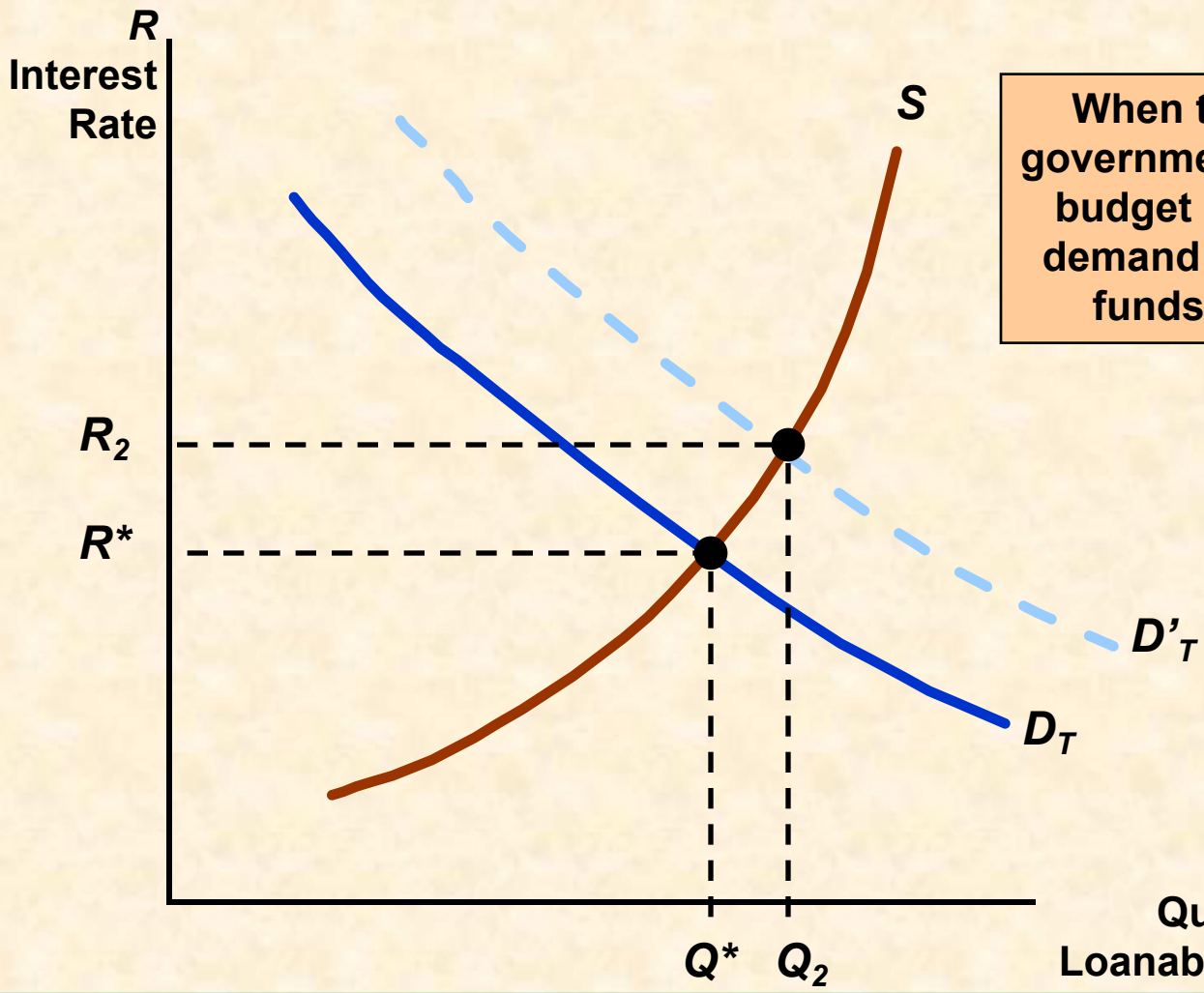
# Changes In The Equilibrium




When the federal government runs large budget deficits the demand for loanable funds increase.

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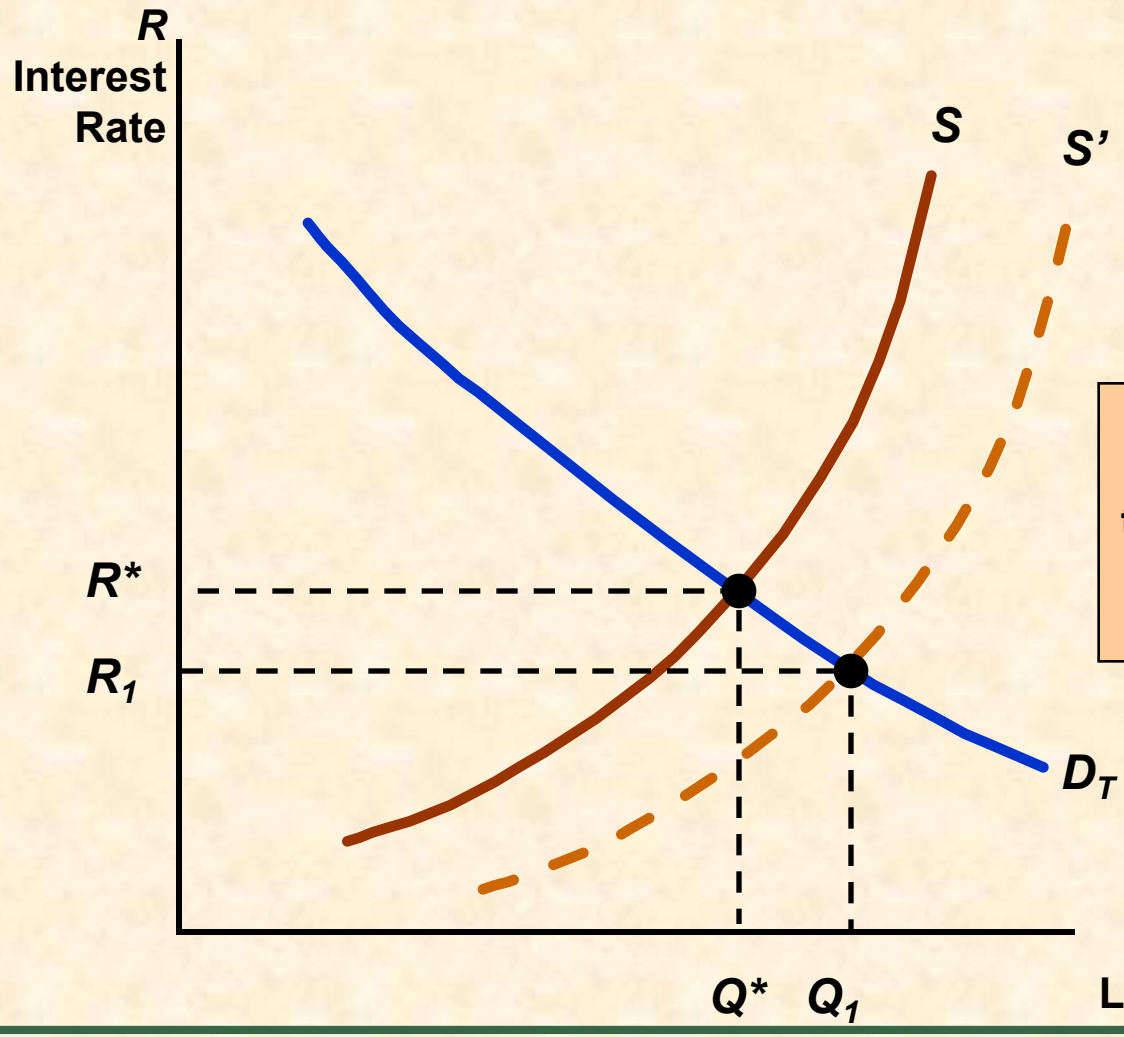
# Changes In The Equilibrium




When the Federal Reserve increases the money supply, the supply of loanable funds increases.

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# How Are Interest Rates Determined?

- A Variety of Interest Rates
  1) Treasury Bill Rate
  2) Treasury Bond Rate
  3) Discount Rate

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# How Are Interest Rates Determined?

- A Variety of Interest Rates

  4) Commercial Paper Rate

  5) Prime Rate

  6) Corporate Bond Rate

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# Summary

- A firm's holding of capital is measured as a stock, but inputs of labor and raw materials are flows.
- When a firm makes a capital investment, it spends money now, so that it can earn profits in the future.

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# Summary

- The present discounted value (PDV) of \$1 paid *n* years from now is $\$1/(1 + R)^n$.
- A bond is a contract in which a lender agrees to pay the bondholder a stream of money.

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# Summary

- Firms can decide whether to undertake a capital investment by applying the NPV criterion.
- The discount rate that a firm uses to calculate the NPV for an investment should be the opportunity cost of capital.

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# Summary

- An adjustment for risk can be made by adding a risk premium to the discount rate.
- Consumers are also faced with investment decisions that require the same kind of analysis as those of firms.

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# Summary

- An exhaustible resource in the ground is like money in the bank and must earn a comparable return.
- Market interest rates are determined by the demand and supply of loanable funds.

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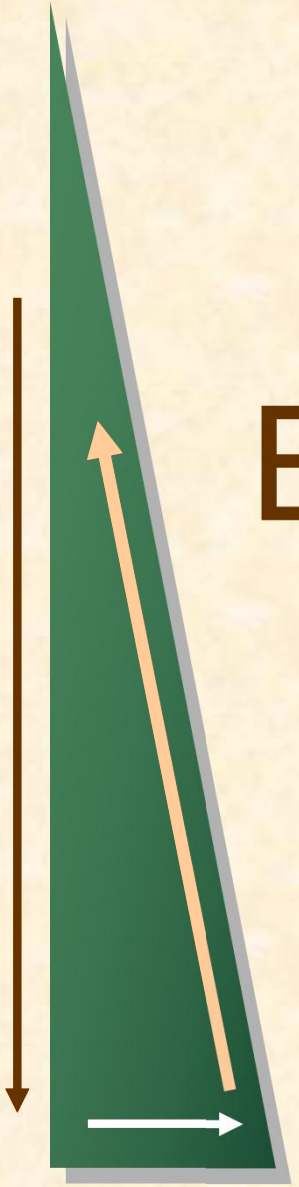

# End of Chapter 15

# Investment, Time, and Capital Markets

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