Lecture 12. Game Theory and Capital Markets

BTM210, KAIST

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Topics Covered in This Lecture

Game Theory Continued

Capital Markets

Game Theory Continued

Capital Markets

Sequential Games

- In sequential games, players move in turn.
  - The Stackelberg model is an example of a sequential game: One firm sets output before the other does.
  - Need to think through the possible actions and rational reactions of each player.
- Simultaneous game vs. Sequential game

TABLE 13.9 MODIFIED PRODUCT CHOICE PROBLEM

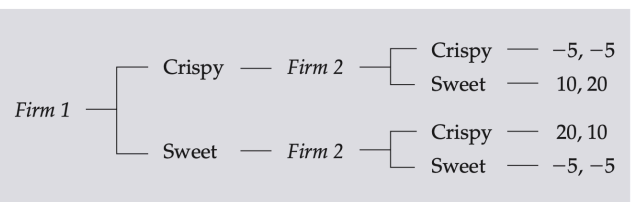
		FIRM 2	
		CRISPY	SWEET
FIRM 1	CRISPY	−5, −5	10, 20
	SWEET	20, 10	−5, −5

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.9

The Extensive Form of a Game

- Sequential games are sometimes easier to visualize if we represent the possible moves in the form of a decision tree.
- This representation is called **the extensive form of a game**.

FIGURE 13.2
PRODUCT CHOICE GAME IN EXTENSIVE FORM



Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Figure 13.2

Threats, Commitments, and Credibility

- In the Stackelberg model, the firm that moved first gained an advantage by **committing itself to a large output**.
- Here, making a commitment - constraining its future behavior - is crucial. Why?
  - Suppose that the first mover (Firm 1) could later change its mind in response to what Firm 2 does.
  - Then, Firm 2 would produce a large output because it knows that Firm 1 will respond by reducing the output that it first announced.
  - The only way that Firm 1 can gain a first-mover advantage is by committing itself.
- Paradoxically, constraining your own behavior can be a key to gain an advantage in a sequential game. What if the first mover in the previous product choice game can't commit?

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Empty Threats

- Firm 1 would prefer the outcome in the upper left-hand corner of the matrix.
- For Firm 2, charging a low price is clearly a dominant strategy.
- Can Firm 1 induce Firm 2 to charge a high price by threatening to charge a low price if Firm 2 charges a low price?
- No. Firm 1's threat is not credible.

TABLE 13.11 PRICING OF COMPUTERS AND WORD PROCESSORS

		FIRM 2	
		HIGH PRICE	LOW PRICE
FIRM 1	HIGH PRICE	100, 80	80, 100
	LOW PRICE	20, 0	10, 20

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.11

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Commitment and Credibility

- Sometimes firms can make threats credible.
- A sequential game in which Race Car Motors is the "leader."
  - The top-left (Small engines, Small cars) is an equilibrium, although (Big engines, Big cars) would be good for Far Out Engines.
- Can Far Out Engines make its threat to produce only big engines credible?

TABLE 13.12(a) PRODUCTION CHOICE PROBLEM

		RACE CAR MOTORS	
		SMALL CARS	BIG CARS
FAR OUT ENGINES	SMALL ENGINES	3, 6	3, 0
	BIG ENGINES	1, 1	8, 3

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.12(a)

- Far Out Engines can make its threat credible by visibly and irreversibly reducing some of its own payoffs in the matrix, thereby constraining its own choices.
  - Far Out Engines can reduce its profits from small engines, the top row.
  - It might do this by shutting down or destroying its small engine production capacity.
  - This would result in the payoff matrix shown in Table 13.12(b).
  - Now, Race Car Motors knows that whatever kind of car it produces, Far Out will produce big engines.

TABLE 13.12(b) MODIFIED PRODUCTION CHOICE PROBLEM

		RACE CAR MOTORS	
		SMALL CARS	BIG CARS
FAR OUT ENGINES	SMALL ENGINES	0, 6	0, 0
	BIG ENGINES	1, 1	8, 3

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.12(b)

The Role of Reputation

- Developing the right kind of reputation can also give one a strategic advantage.
- Suppose that the managers of Far Out Engines develop a reputation for being irrational—perhaps downright crazy.
  - They threaten to produce big engines no matter what Race Car Motors does (refer to Table 13.12(a)).
  - Now the threat might be credible without any further action.
  - You can't be sure that an irrational manager will always make a profit-maximizing decision.
  - In gaming situations, the party that is known (or thought) to be a little crazy can have a significant advantage.
- A firm may find it advantageous to act irrationally over several rounds of the game in order to build a reputation and significantly increase its long-run profits.

Bargaining Strategy

- The outcome of a bargaining situation can depend on the ability of either side to take an action that alters its relative bargaining position.
- A production decision
  - Two firms plan to introduce one of two products which are complementary goods.
  - (A,B) is the only Nash equilibrium.
  - However, Firm 1 would prefer the outcome in the lower left-hand corner, (B,A).

TABLE 13.13 PRODUCTION DECISION

		FIRM 2	
		PRODUCE A	PRODUCE B
FIRM 1	PRODUCE A	40, 5	50, 50
	PRODUCE B	60, 40	5, 45

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.13

- A decision to join consortium
  - Clearly, the dominant strategy is for both firms to enter the consortium, thereby increasing profits to 40.
- Now suppose that Firm 1 links the two bargaining problems by announcing that it will join the consortium only if Firm 2 agrees to produce product A.
  - In this case, it is indeed in Firm 2's interest to produce A (with Firm 1 producing B) in return for Firm 1's participation in the consortium.

TABLE 13.14 DECISION TO JOIN CONSORTIUM

		FIRM 2	
		WORK ALONE	ENTER CONSORTIUM
FIRM 1	WORK ALONE	10, 10	10, 20
	ENTER CONSORTIUM	20, 10	40, 40

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.14

Entry Deterrence

- Firms can deter entry by convincing any potential competitor that entry will be unprofitable.
- Entry Possibilities: Threat is not credible.
  - Once entry has occurred, an incumbent firm chooses to accommodate and maintain a high price. Thus, a prospective entrant's rational move is to enter the market.
  - The outcome will be the upper left-hand corner of the matrix.

TABLE 13.16(a) ENTRY POSSIBILITIES

		POTENTIAL ENTRANT: ENTER	POTENTIAL ENTRANT: STAY OUT
INCUMBENT	HIGH PRICE (ACCOMMODATION)	100, 20	200, 0
	LOW PRICE (WARFARE)	70, −10	130, 0

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.16(a)

- What if you can make an irrevocable commitment that will give you little choice but to charge a low price if entry occurs?
- A new payoff matrix as a result of your decision to invest in additional capacity
  - Your threat to engage in competitive warfare is completely credible.
  - Because the potential competitor now knows that entry will result in warfare, it is rational for it to stay out of the market.

Go to page 528 6(b) **ENTRY DETERRENCE**

		POTENTIAL ENTRANT	
		ENTER	STAY OUT
INCUMBENT	HIGH PRICE (ACCOMMODATION)	50, 20	150, 0
	LOW PRICE (WARFARE)	70, −10	130, 0

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.16(b)

Alternative Solution I: A Reputation for Irrationality

- Suppose the incumbent firm has a reputation for irrationality.
- By means of vicious price-cutting, this firm has eventually driven out every entrant in the past, even though it incurred losses in doing so.
- Its threat might then be credible: The incumbent' s irrationality suggests to the potential competitor that it might be better off staying away.

Alternative Solution II: Infinitely Repeated Game

- The incumbent might have a rational incentive to engage in warfare whenever entry actually occurs.
- Why? Because short-term losses from warfare might be outweighed by longer-term gains from preventing entry.
- Understanding this, the potential competitor might find the incumbent's threat of warfare credible and decide to stay out.
- Now the incumbent relies on its reputation for being rational to provide the credibility needed to deter entry.
- The success of this strategy depends on the time horizon and the relative gains and losses associated with accommodation and warfare.

Strategic Trade Policy and International Competition

- In some situations,
  - A preemptive investment (subsidized or otherwise encouraged by the government) can give a country an advantage in international markets and so be an important instrument of trade policy.
  - A country can benefit by adopting policies that give its domestic industries a competitive advantage.

- To see how this might occur, consider an industry with substantial economies of scale.
  - Suppose that by granting subsidies or tax breaks, the government can encourage domestic firms to expand faster than they would otherwise.
  - This might prevent firms in other countries from entering the world market,
  - So that the domestic industry can enjoy higher prices and greater sales.
  - Such a policy works by creating a credible threat to potential entrants.
  - Large domestic firms, taking advantage of scale economies, would be able to satisfy world demand at a low price.
  - If other firms entered, price would be driven below the point at which they could make a profit.

The Commercial Aircraft Market

- The development and production of a new line of aircraft are subject to substantial economies of scale.
- Suppose it is only economical for one firm to produce the new aircraft.
- If Boeing has a head start in the development process, the outcome of the game is the upper right-hand corner of the payoff matrix.

TABLE 13.17(a) DEVELOPMENT OF A NEW AIRCRAFT

		AIRBUS	
		PRODUCE	DON'T PRODUCE
BOEING	PRODUCE	−10, −10	100, 0
	DON'T PRODUCE	0, 100	0, 0

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.17(a)

- Suppose European governments commit to subsidizing Airbus and make this commitment before Boeing has committed itself to produce.
- If the European governments commit to a subsidy of 20 to Airbus if it produces the plane regardless of what Boeing does, the payoff matrix would change.
- Airbus will make money from a new aircraft whether or not Boeing produces one.
- 100 is a transfer of profit from the United States to Europe.

TABLE 13.17(b) DEVELOPMENT OF AIRCRAFT AFTER EUROPEAN SUBSIDY

		AIRBUS	
		PRODUCE	DON'T PRODUCE
BOEING	PRODUCE	−10, 10	100, 0
	DON'T PRODUCE	0, 120	0, 0

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 13.17(b)

Game Theory Continued

Capital Markets

Investment, Time, and Capital Markets

- In this chapter, we will learn how to calculate the current value of future flows of money.
  - Capital is durable.
  - Time matters.
  - Intertemporal decisions required.
  - Need to compare an outlay today with profits that will be received in the future
  - Crucial for firm's investment decision
  - Crucial for individual's consumption and saving decision
  - Interest rate

Stocks vs Flows

- Need to be clear about how to measure capital and other factor inputs that firms purchase.
- Capital is measured as a **stock**, i.e., as a quantity of plant and equipment that the firm owns.
  - If a firm owns an electric motor factory worth $10 million, we say that it has a capital stock worth $10 million.
- Inputs of labor, raw materials, or the output of the firm are measured as **flows**.
  - The firm uses 20,000 worker-hours of labor and 20,000 pounds of copper per month to produce 8000 electric motors per month.

Present Discounted Value

- How much is \$1 paid in the future worth today?
  - 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.
  - Similarly, \$1 paid in the future is \$1/(1 + R) worth today.
- What is the value today of \$1 paid two years from now?
  - If \$1 were invested today at the interest rate R, it would be worth (1 + R) dollars after one year, and (1 + R)(1 + R) dollars at the end of two years.
  - Because $(1 + R)^2$ dollars two years from now is worth \$1 today,
  - \$1 two years from now is worth $1/(1 + R)^2$ dollars today.
- **Present discounted value (PDV)** is the current value of an expected future cash flow.

$$\text{PDV of \$1 paid after 1 year} = \frac{\$1}{(1+R)}$$

$$\text{PDV of \$1 paid after 2 years} = \frac{\$1}{(1+R)^2}$$

$$\text{PDV of \$1 paid after 3 years} = \frac{\$1}{(1+R)^3}$$

$$\vdots$$

$$\text{PDV of \$1 paid after } n \text{ years} = \frac{\$1}{(1+R)^n}$$

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018)

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

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Table 15.1

The Value of a Bond

- A **bond** is a contract in which a borrower agrees to pay the bondholder (the lender) a stream of money.
  - A corporate bond (a bond issued by a corporation) might make "coupon" payments of \$100 per year for the next ten years, and then a principal payment of \$1000 at the end of the ten-year period.
  - To find out how much the bond is worth, we simply compute the present value of the payment stream:

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

- A **perpetuity** is a bond that pays out a fixed amount of money each year, forever.

$$PDV = \frac{\$100}{(1+R)} + \frac{\$100}{(1+R)^2} + \cdots = \frac{\$100}{R}$$

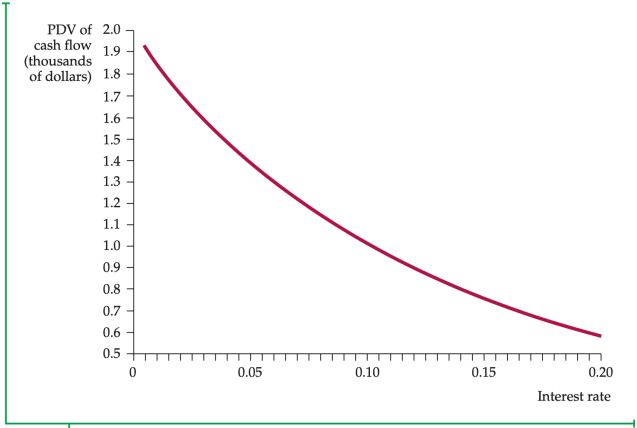


FIGURE 15.1
PRESENT VALUE OF THE CASH FLOW FROM A BOND

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 on a principal of $1000 is $1386. At an interest rate of 15 percent, the PDV is $749.

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Figure 15.1

The Effective Yield on a Bond

- Suppose that the market price or the value of the perpetuity is P.
  - Then $P = \$100/R$, and $R = \$100/P$.
  - This interest rate is called the **effective yield, or rate of return**: the percentage return that one receives by investing in a bond.
- Given the market price P, the effective yield of the ten-year coupon bond R can be solved from the following equation.

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

- Note that the price of a bond P is in inverse proportion to its effective yield R.

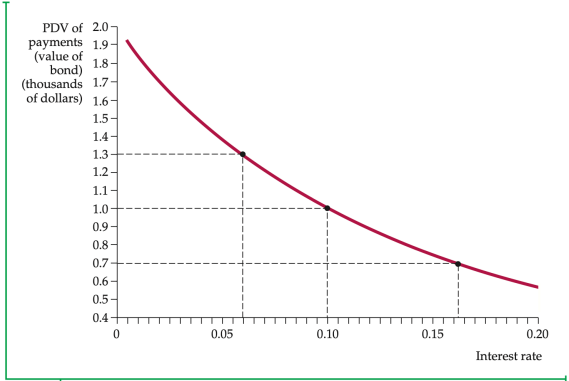


FIGURE 15.2
EFFECTIVE YIELD ON A BOND

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.

Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Figure 15.2

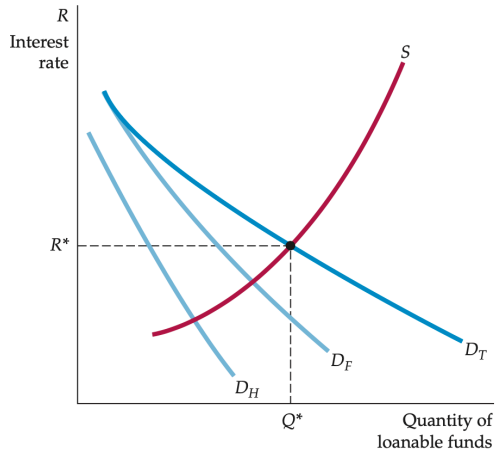
How Are Interest Rates Determined?

- What determines interest rate levels? Why do they fluctuate over time?
- An interest rate is the price that borrowers pay lenders to use their funds.
- Like any market price, interest rates are determined by supply and demand.
  - The supply of loanable funds comes from households that wish to save part of their incomes in order to consume more in the future (or make bequests to their heirs).
  - The higher the interest rate, the greater the incentive to save. $\Rightarrow$ An upward-sloping supply curve
  - The demand for loanable funds has three components: (1) households who want to consume more, (2) firms that want to make capital investment, and (3) the government that needs fiscal financing.
  - The higher the interest rate, the greater the cost of consuming or investing. $\Rightarrow$ A downward-sloping demand curve

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.



Source: *Microeconomics, 9th ed.* (Pindyck and Rubinfeld, 2018), Figure 15.5

A Variety of Interest Rates

- **Treasury bill rate**
  - Treasury bill is a short-term (one year or less) bond issued by the U.S. government.
  - It is a pure discount bond: It makes no coupon payments but instead is sold at a price less than its redemption value at maturity.
- **Treasury bond rate**
  - Treasury bond is a longer-term bond issued by the U.S. government for more than one year and typically for 10 to 30 years.
  - Rates vary, depending on the maturity of the bond.
- **Federal funds rate**
  - This is the interest rate that banks charge one another for overnight loans of federal funds.

- **Commercial paper rate**
  - Commercial paper refers to short-term (six months or less) discount bonds issued by high-quality corporate borrowers.
  - Because commercial paper is only slightly riskier than Treasury bills, the commercial paper rate is usually less than 1 percent higher than the Treasury bill rate.
- **Corporate bond rate**
  - Newspapers and government publications report the average annual yields on long-term (typically 20-year) corporate bonds in different risk categories (e.g., high-grade, medium-grade, etc.).
  - These average yields indicate how much corporations are paying for long-term debt.
  - The yields on corporate bonds can vary considerably, depending on the financial strength of the corporation and the time to maturity for the bond.