BUEC 311: Business Economics, Organization and Management
Strategic Behaviour Part I
Game Theory and Business Strategy

Fall 2021

Outline

1. Oligopoly Games
2. Auctions

Strategic Interaction

- Thus far: We have primarily focused on cases where firms are not interacting strategically.
  - But we often need to understand the potential decisions of rivals.
  - We need a toolbox for understanding strategic decision making.

- Game Theory: A set of tools used to analyze strategic decision making.
  - Idea: Model strategic interactions as a game in which players interact according to a set of rules.
    - Players decide strategies based on payoffs, the level of information, and their rationality.
    - Outcome of a game is a Nash Equilibrium; depends on information and rationality.
  - Game theory can be used to understand strategic behaviour by firms, outcomes in bargaining, and auctions.

Outline

Oligopoly Games

- Ex. A duopoly game between American Airlines and United Airlines
  - Players and rules:
    - Two players: American and United, play a static game to decide how many passengers to fly per quarter. Each airline's objective is to maximize profit.
    - Rules: Firms announce output levels simultaneously, but cannot communicate otherwise (no side deals or coordination is allowed).
    - Complete information: Firms know all strategies and payoffs.
  - Strategies:
    - Each firm's strategy is to take one of two available actions: ether choose low output (48k passengers per quarter) or high output (64k passengers per quarter).
    - Both firms know all strategies and the corresponding payoffs for each firm.
    - We can summarize these strategies in a payoff matrix (or profit matrix).

Oligopoly Games

		American Airlines: $q_A = 64$	American Airlines: $q_A = 48$
United Airlines	$q_U = 64$	4.1 / 4.1	3.8 / 5.1
	$q_U = 48$	5.1 / 3.8	4.6 / 4.6

Note: Quantities are in thousands of passengers per quarter; (rounded) profits are in millions of dollars per quarter. The payoff to American Airlines is in the upper-right corner of each cell and the payoff to United Airlines is in the lower left.

Figure: The Payoffs for American and United

Dominant Strategies

- If one is available, a rational player always uses a dominant strategy.

Definition (Dominant Strategy)

A dominant strategy is a strategy that produces a higher payoff (profit) than any other strategy the player can use, no matter what its rivals do.

- In our airline duopoly example, high-output (64k) is the dominant strategy for both firms.
  - High output yields the highest profit *regardless of what the other firm is doing*.
  - Hence, the dominant strategy solution is $q_U = q_A = 64$.

Payoffs

- A dominant strategy solution does not necessarily lead to the best outcome for firms.
  - In our example, United and American choose strategies that do not maximize their joint or combined profit.
    - Each firm could earn $4.6 million if they both chose to produce a low level of output (48k).
  - Game between United and American is an example of a Prisoner's Dilemma.
    - All players have dominant strategies that lead to a profit that is inferior to what they could have achieved if they cooperated.
    - Individual incentives cause players to choose strategies that do not maximize joint profits.

Prisoner's Dilemma Example

- Suppose that United and American are now choosing whether or not to invest in new planes. Currently, each airline earns a profit of $25 billion using their old fleet of planes. If American upgrades to new planes and United does not, then American steals some of United's customers and increases its profits to $35 billion, while United's profits fall to $10 billion. Similarly, if United upgrades and American does not, United's profits increase to $35 billion and American's profits fall to $10 billion. If both airlines upgrade to new planes, then they each will earn $20 billion. What will each firm do? What will they earn in equilibrium?

Best Responses

- Many games do not have a dominant strategy solution. In this case, we can use the approach of best response to determine the outcome of a game.

Definition (Best Response)

A best response is the strategy that maximizes a players payoff (profit) given its beliefs about the strategies of its rivals.

- A dominant strategy is a strategy that is a best response to all possible strategies a rival might use.

- In the absence of a dominant strategy, each firm can determine its best response to any possible strategy chosen by its rivals.

Nash Equilibrium

- Best responses are the basis of a Nash Equilibrium.

Definition (Nash Equilibrium)

A Nash equilibrium is a set of strategies such that if, when all other players use these strategies, no player can obtain a higher profit by choosing a different strategy.

- In a Nash equilibrium, players are "best-responding" to each other.
  - This means the Nash equilibrium is self enforcing.

- Two steps to find the Nash Equilibrium:
  1. Determine each player's best response to any given strategy of the other player.
  2. Check whether pairs of strategies are best responses for both firms; these pairs are Nash equilibria.

Oligopoly Games

- As an example, consider a more complicated game between American and United.
  - Now both firms have 3 possible strategies:
    1. High output (96k passengers/quarter).
    2. Medium output (64k passengers/quarter).
    3. Low output (8k passengers/quarter).
  - Otherwise, the rules are the same as before:
    - Static simultaneous move game.
    - Perfect information.

Oligopoly Games

		American Airlines		
		$q_A = 96$	$q_A = 64$	$q_A = 48$
United Airlines	$q_U = 96$	0 0	2.0 3.1	2.3 4.6
	$q_U = 64$	3.1 2.0	4.1 4.1	3.8 5.1
	$q_U = 48$	4.6 2.3	5.1 3.8	4.6 4.6

Note: Quantities are in thousands of passengers per quarter; (rounded) profits are in millions of dollars per quarter.

Oligopoly Games

- Determine equilibrium via two step method:
  1. Determine best responses for United:
     - If United chooses $q_U = 96$, American's best response is $q_A = 48$.
     - If United chooses $q_U = 64$, American's best response is $q_A = 64$.
     - If United chooses $q_U = 48$, American's best response is $q_A = 64$.

     And for American:
     - If American chooses $q_A = 96$, United best response is $q_U = 48$.
     - If American chooses $q_A = 64$, United best response is $q_U = 64$.
     - If American chooses $q_A = 48$, United best response is $q_U = 64$.

  2. Determine the Nash Equilibrium
     - The Nash equilibrium is $q_A = q_U = 64$.
     - This outcome is a Nash equilibrium because neither firm wants to deviate from its strategy *given what the other firm is doing*.
     - Note: The Nash Equilibrium does not maximize joint profits.

Oligopoly Games

- In general, whether or not the Nash equilibrium maximizes the combined payoff to players (i.e. profits for firms) depends on the payoff matrix.
- As an example, consider a static game where firms decide to 'advertise' or 'not advertise'.
- The effects of advertising depend on whether advertising brings new customers into the market.

Oligopoly Games

(a) Advertising Only Takes Customers from Rivals

		Firm 1: Do Not Advertise	Firm 1: Advertise
Firm 2: Do Not Advertise		2, 2	0, 3
Firm 2: Advertise		3, 0	1, 1

(b) Advertising Attracts New Customers to the Market

		Firm 1: Do Not Advertise	Firm 1: Advertise
Firm 2: Do Not Advertise		2, 2	3, 4
Firm 2: Advertise		4, 3	5, 5

Oligopoly Games

- Example highlights a phenomenon often observed in practice:
  - In oligopolistic markets, the effect of firm advertising depends on whether it helps (increases the size of the overall market) or hurts (steals customers) rivals.
- In some industries, advertising primarily steals customers from rivals.
  - E.g. market for cola; market for erectile dysfunction drugs.
- In other industries, advertising by any firm increases the size of the market.
  - E.g. market for beer; market for cigarettes.
- It is possible to observe market size and business stealing effects simultaneously.
  - E.g. Fast food; CPUs.

Outline

Auctions

Definition (Auction)

A sale in which a good or service is sold to the highest bidder.

- Game theory can be used to understand behaviour in auctions.
  - An auction is a game in which players (called bidders) devise bidding strategies without knowing the payoff functions of other players.
  - Bidders need to know the rules of the game:
    - The number of units being sold.
    - The format of bidding.
    - The value that potential bidders place on the good.

Auctions

- Auctions are frequently used in practice:
  - Government auctions:
    - Government procurement, auctions for electricity and transport markets, auctions to concede portions of the airwaves for radio stations, mobile phones and wireless internet access; auctions for oil and gas leases.
  - Market transactions:
    - Goods commonly sold at auction are natural resource such as timber and drilling rights for oil, as well as houses, cars, agricultural products, horses, antiques and art. And of course, goods online in sites like eBay.

Elements of Auctions

- Number of units: auctions can be used to sell one or many units of a good.
- Format of bidding:
  - English auction: Ascending-bid auction process where the good is sold to the last bidder for the highest bid. Commonly used to sell art/antiques.
  - Dutch auction: Descending-bid auction process where the seller reduces the price until someone accepts it and buys at that price. Often used in government procurement.
  - Sealed-bid auction: Bidders submit bids simultaneously without seeing anyone else's bid and highest bidder wins. In a 1st price sealed-bid auction, the winner pays its own, highest bid. In a 2nd price sealed-bid auction, the winner pays the amount bid by the 2nd highest bidder.
- Value:
  - Private value: Individual bidders know how much the good is worth to them, but not how much other bidders value it.
  - Common value: The good has the same value to everyone, but no bidder knows exactly what that value is.

Second Price Sealed Bid Auctions

- Rules:
  - Each bidder has a different private value for a single indivisible good.
  - Bidders simultaneously submit sealed bids without knowledge of other bids.
- Design of auction means that amount that you bid affects whether you win, but it does not affect how much you pay if you win (which is equal to the second-highest bid).
- Best strategy: Bid your highest value.
  - This strategy weakly dominates all others.
  - Ex: Suppose that you value a folk art carving at \$100. If you bid \$100 and win, your $CS = 100 - 2\text{nd price}$. If you bid less than \$100, you risk not winning. If you bid more than \$100, you risk ending up with negative CS.
  - Thus, bidding \$100 leaves you *at least as well off* as bidding any other value.

English Auctions

- Rules:
  - Each bidder has a different private value for a single indivisible good.
  - Ascending-bid auction process where the good is sold to the last bidder for the highest bid.
- Design of auction means that amount you bid affects whether you win and how much you pay.
- Best strategy: Raise the current highest bid as long as that value is less than the value you place on the good.
  - Ex: Again suppose that you value a folk art carving at \$100. If you bid an amount b and win, $CS = 100 - b$. CS is positive or zero for $b \leq 100$, but negative if $b > 100$. So it is best to raise bids up to \$100 and stop there.
  - If all participants bid up to their value, the winner will pay slightly more than the value of the second-highest bidder. Thus, the outcome of an English auction is essentially the same is a in a sealed-bid, second-price auction.

Other Auctions

- Two other common private value auctions:
  - Dutch Auction: Descending-bid auction where the seller reduces the price until someone accepts the offered price and buys at that price.
  - First-Price Sealed-Bid Auction: Bidders submit bids simultaneously without seeing other bids. Highest bidder wins and pays amount of bid.
- In both cases, the amount that you bid affects whether you win and pay.
- The best strategy in both auctions is to bid an amount that is equal to, or slightly greater than what you expect will be the second-highest bid, given that your value is the highest.
  - Bidders shade bids to less than their value to balance the effect of decreasing the probability of winning and increasing CS. Bid depends on beliefs about strategies of rivals.

Auctions

- Key point: Expected outcome is the same across private value auctions.
  - Winner is the person with the highest value, and the winner pays roughly the second-highest value.
- Is there any reason that a seller still might choose one format over an alternative?

Auctions

- Key feature of common-value auctions: the Winner's Curse.
  - Winner's bid exceeds the value of item up for bid; winner pays too much.
  - Occurs due to uncertainty about the true value of the good.
    - E.g. Timber land auctions/auctions for oil and gas leases.
- Best strategy to avoid Winner's Curse: Shade/reduce bids to below estimates of value.
  - The amount of reduction depends on number of other bidders; more bidders $\Longrightarrow$ more likely winning bid is an overestimate.
- While Winner's Curse is a well known phenomenon, there is strong empirical evidence it continues to happen in practice (e.g in the corporate acquisition market).
  - One possible explanation: Bounded rationality.

Takeaways

1. Insights from game theory can be used to improve outcomes when making strategic decisions.
2. Bargaining can lead to efficient outcomes.
3. Best strategy in most auctions is to bid your valuation, but it may be useful to shade bids to avoid the Winner's Curse.