Application of Game Theory for Strategic Decision Making in Business Firms – A Study

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Abstract: *Game theory is a branch of mathematics that studies strategic decision-making and the interactions between firms. It is a powerful tool that can help you make better business decisions by understanding the behaviours and motivations of your competitors and customers. In the dynamic landscape of business, where competition is fierce and decisions are crucial, companies often seek strategic approaches that can provide them with a competitive edge. One such approach gaining prominence is the application of game theory in crafting business strategies. Game theory, a field rooted in mathematics and economics, involves the study of interactive decision-making among rational entities. In this article, we delve into the practical applications of game theory in the realm of business strategy, exploring how companies can leverage strategic moves to navigate complex scenarios, outmaneuver competitors, and achieve sustainable success.*

Keywords: Payoff Strategy, Zero-Sum Games, Social Situations, Classical Model and Business Dynamics.

Introduction

Game theory, the study of strategic decision-making, brings together elements of mathematics, psychology, and philosophy. In Neumann and Oskar Morgenstern in 1944, it has come a long way since then. Its importance to modern analysis and decision-making can be gauged by the fact that as many as 12 leading economists and scientists have been awarded the Nobel Prize in Economic Sciences for their contributions to game theory since 1970. Game theory is applied in fields including business, finance, economics, political science, and psychology. Understanding its strategies—both the popular ones and some of the relatively lesser-known—is important to enhance one's reasoning and decision-making skills in a complex world.

The goal of game theory is to explain the strategic actions of two or more players in a given situation with set rules and outcomes. Any time a situation with two or more players involves known payouts or quantifiable consequences, we can use game theory to help determine the most likely outcomes. The focus of game theory is the game, which is an interactive situation that involves rational players. The key to game theory is that one player's payoff is contingent on the strategy implemented by the other player. The game identifies the players' identities, preferences, available strategies, and how these strategies affect the outcome. Depending on the model, various other requirements or assumptions may be necessary. Game theory has a wide range of applications, including psychology, evolutionary biology, war, politics, economics, and business. Despite its many advances, game theory is still a young and developing science.

At its core, game theory provides a framework for analyzing and understanding the strategic interactions between decision-makers, whether they are individuals, companies, or nations. It examines the choices each participant makes, considering the potential outcomes and the impact of those choices on the others involved. Game theory encompasses various types of games, ranging from zero-sum games, where one participant's gain is another's loss, to cooperative games, where participants can collaborate for mutual benefit.

Game theory is the theory of independent and interdependent decision making. It is concerned with decision making in organisations where the outcome depends on the decisions of two or more autonomous players, one of which may be nature itself, and where no single decision maker has full control over the outcomes. Obviously, games like chess and bridge fall within the ambit of game theory, but so do many other social situations which are not commonly regarded as games in the everyday sense of the word.

Classical models fail to deal with interdependent decision making because they treat players as inanimate subjects. They are cause and effect models that neglect the fact that people make decisions that are consciously influenced by what others decide. A game theory model, on the other hand, is constructed around the strategic choices available to players, where the preferred outcomes are clearly defined and known.

Strategic Moves in Business Operations:

In the business arena, strategic moves involve making decisions to gain a competitive advantage or achieve specific objectives. Game theory provides a valuable lens through which companies can analyze these strategic moves, taking into account the actions of competitors and the dynamic nature of the market. Here are key areas where game theory plays a pivotal role in shaping business strategies:

Competitive Pricing Strategies: Game theory is particularly relevant in pricing strategies, where companies must consider not only their own pricing decisions but also the potential reactions of competitors. By analyzing the market as a strategic game, businesses can determine optimal pricing points, anticipate competitors' responses, and strategically position themselves to capture market share without triggering damaging price wars.

Strategic Alliances and Collaborations: Collaborations between companies can be modeled as cooperative games. Game theory helps businesses assess the benefits and risks of forming strategic alliances, joint ventures, or partnerships. By understanding the potential outcomes and incentives of each party involved, companies can negotiate more effectively and create alliances that enhance overall industry value.

Product Launch and Innovation: Introducing a new product or innovation involves strategic decision-making. Game theory allows businesses to analyze the potential reactions of competitors to a new product, pricing strategy, or technological advancement. This insight helps companies refine their launch strategies, considering the potential competitive landscape and adjusting tactics to gain a favorable position.

Market Entry and Expansion: When entering new markets or expanding existing operations, companies face complex decision-making scenarios. Game theory assists in analyzing the actions of existing competitors and potential new entrants. This analysis guides businesses in making informed decisions about market entry strategies, timing, and resource allocation.

The Airline Industry and Pricing Strategies: The airline industry provides a real-world example of the application of game theory in strategic decision-making. Airlines constantly engage in a dynamic game of pricing, where each carrier's decision influences the outcomes for others. By analyzing the market as a strategic game, airlines can adjust ticket prices based on factors such as demand, competitor pricing, and historical data. This game-theoretic approach allows airlines to maximize revenue while maintaining a competitive position in the market.

Literature review

Game theory is the most popular mathematical tool, the spheres of application of which are Economics, Finance, Management, Politics, and Military Science. It is an economic and mathematical tool for modeling by different persons their optimal performance under competitive (conflict) conditions or cooperation with other persons. The form and applied methods of this theory are mathematical, but by nature of the tasks resolved it refers to the economic analysis. Game theory is a branch of mathematics, but its conclusions have long been applied to economics and business. It studies decision-making processes under conflict conditions, i.e., game theory provides a mathematical prediction of a conflict situation.

In any market situation, there is an opportunity to act differently and get the answer to the question—which option will lead to the desired goal with the lowest cost? If you can simulate the player

companies' actions, you will get an answer. Has the competitor lowered the price of a product that is already sold at cost again? Has the supplier company made shipments to a noncore retail chain, and now they go to the supermarket to buy a hammer and nails instead of to you? Why do competitors and suppliers destroy the market? And what company strategy is appropriate in this situation? These are the questions that game theory answers. Until the mid-twentieth century, all existing models of decision-making in economic systems considered a participant in a vacuum, who was only interested in increasing their own profits and did not take into account the activities of other economic system participants when your steps affect other participants (players), and their actions affect you. It contradicted the market economy realities, because one of the main factors affecting market participants' performance—competition— was not taken into account. In 1944, John von Neumann and O. Morgenstern published the book "Theory of Games and Economic Behavior," which revealed the idea to consider the economic model as a special case of the game, and its participants— as those who compete with each other, the players, and using mathematics scientifically substantiated the behavior of players in any games designed to cause competition between players (noncooperative games). They mathematically described a way to find optimal strategies in such a game.

They saw the main purpose of game theory as an attempt to accurately describe the individual's desire for maximum utility, or, in the case of the entrepreneur, for maximizing possible profit. In the game theory, the tougher decisions call for the use of the more effective approaches such as game trees. Decision trees are important for the optimization of one player without necessarily indigenizing the other players in the market. For instance, when determining the feasibility of entering a new market where only one firm is operational, the issue of market profitability is considered first which also depends on the reaction of the incumbent firm toward the new entrant. On the positive side, the incumbent firm could welcome the new entrant and allow them to take a share in the market or otherwise react negatively through aggression.

A precondition for using game theory and building mathematical models of conflicts is the presence of antagonistic interests between the participants. First of all, this is true for the economic sphere, where the efforts of each participant are aimed at obtaining optimal financial results. Achieving this goal requires effective interaction with other participants (partners, contractors, etc.). That's why, the result of an individual's actions in a business environment depends not only on their own efforts but also on the these persons' actions.

In 1949, John Nash significantly extended the theory of games, allowing situations where players do not compete with each other but cooperate to achieve a common goal (cooperative games). He also introduced the concept of nonzero-sum games, where the payoff was not a constant (zero-sum games), but could change from the players' actions. It was a real breakthrough in the study of game interaction, which clearly showed obsolescence of the classic competition concept (when every man is for himself).

He developed analysis methods according to which all participants either win or lose. These situations are called Nash equilibrium. According to his theory, the participants should use the optimal strategy, which leads to the stable equilibrium creation. It is advantageous for players to maintain this equilibrium, because any change will worsen their situation. These Nash's works made a serious contribution to the development of game theory, and the mathematical tools of economic modeling were revised. John Nash has shown that the classic Adam Smith approach to competition, where every man is for himself, is suboptimal. More optimal strategies are when everyone tries to do better for themselves by doing better for others. In the Nash equilibrium, the egoistic thinking of each player in the long-term (strategic) perspective leads to a general loss. The result is optimal when each member of the group does better for themselves and for other players. A player's decision that contradicts Nash equilibrium results in their loss. Moreover, Nash equilibrium requires each player to trust others in their rational actions regarding gaining their own benefits, and if one of the players receives information about Nash equilibrium, they must inform other players about the strategies to be followed to increase their payoffs.

As a revolutionary and interdisciplinary phenomenon, the game theory utilizes mathematical, philosophical, psychological, and a wide range of knowledge in other fields. In the

business context, the theory is commonly used to conduct economic analysis for the highly competitive market such as the oligopolistic market. As a result, the game theory is a particularly useful tool in identifying high-risk versus high-reward strategic decisions in which strategy games are utilized. The game theory has indeed enables many organizations to grow into veterans in their respective industries and consequently maintain their influence in the long term.

The game theory is an ideal approach where competitive modes can be easily remodeled. In this regard, multiple strategy games will be played for the purposes of averting the different pressures caused by different competitors. The games are aimed at recommending multiple strategic decisions to guide competitive processes and analyzing how the possible strategies can aid in predicting competitive outcomes. The involved strategic decision, number of players, and the available information will hence help to determine the type of game that is best suited for the organization's immediate needs.

The theory is an imminent part of modern decision-making practices. Through the simultaneous strategies, for instance, rivals need not inform their competitors about their decisions before taking them. For example, if two airline companies are required to submit sealed bids for the price of several jet airliners to a foreign national airliner. Both organizations will be free to set either low or high prices, in which case, the lower bidder will be awarded the order. However, should both companies bid the same amount, and then they will share the bid especially if both have the capacity to build all 10 airplanes. The benefits realized for both firms are therefore dependent on the choices of each company. The dominant strategy is also a well-known approach that was developed as part of the game theory. The dominant theory is applicable in situations where the only means of achieving optimization is through a specific strategy regardless of the rival's actions. In such a case, the equilibrium is attained when each player settles for their own dominant strategy.

Indeed, with the dominant strategy, the payoffs could involve profit or loss. According to the preferences and needs of the end user (dimensions of value) can be used as a means of beating

competitors. One form of aggression is a cut-throat price war. To cut down on operational costs, the new entrant can venture into moderns technology or otherwise settle for the high cost case by using existing technologies. In such a case, the game theory dictates that the incumbent would benefit more by accommodating the new entrant. In this regard, the theory discourages indifference and irrationality among firms, as doing so can thwart optimization.

The game theory is a multifaceted phenomenon, which, despite being theoretical in nature, highly affects real-life business situations. The principles thereof account for the different forms and sizes of organizations regardless of the industry in which they operate. For instance, the emphasis the theory puts in the concepts of equilibriums offers a clear-cut depiction of the need for organizations to pay attention to the potential impact of their short-term and long-term decisions. The theory is also rich in perspectives and allows for real-life investigation of decisions before embarking on them. Doubtlessly, the game theory has had a revolutionary effect on the business world since its inception.

Impact of Game theory in different areas

Game theory is present in almost every industry or field of research. Its expansive theory can pertain to many situations, making it a versatile and important theory. Here are several fields of study directly impacted by game theory.

Economics

Game theory brought about a revolution in economics by addressing crucial problems in prior mathematical economic models. For instance, neoclassical economics struggled to explain entrepreneurial anticipation and could not handle the imperfect competition. Game theory turned attention away from steady-state equilibrium toward the market process.

Economists often use game theory to explain oligopoly firm behavior. It helps to predict likely outcomes when firms engage in certain behaviors, such as price-fixing and collusion.

Business

In business, game theory is beneficial for modeling competing behaviors between economic agents. Businesses often have several strategic choices that affect their ability to realize economic gain. For example, businesses may face dilemmas such as whether to retire existing products and develop new ones or employ new marketing strategies.

Businesses can often choose their opponent as well. Some focus on external forces and compete against other market participants. Others set internal goals and strive to be better than their previous versions. Whether external or internal, companies are always competing for resources, attempting to hire the best candidates away from rivals, and dissuade customers from choosing competing goods.

Game theory in business may most resemble a game tree, as shown below. A company may start in position one and must decide on two outcomes. However, there are continually other decisions to be made; the final payoff amount is not known until the final decision has been processed.

Project Management

Project management involves social aspects of game theory, as different participants may have different influences. For example, a project manager may be motivated to successfully complete a building development project. Meanwhile, the construction worker may be motivated to work slower for safety or to delay the project to add more billable hours.

When dealing with an internal team, game theory may be less prevalent as all participants working for the same employer often have a greater shared interest for success. However, third-party consultants or external parties assisting with a project may be motivated by other factors separate from the project's success.

Consumer Product Pricing

The strategy of Black Friday shopping is at the heart of game theory. The concept holds that should companies reduce prices, more consumers will buy more goods. The relationship between a consumer, a good, and the financial exchange that transfers ownership plays a major part in game theory, as each consumer has a different set of expectations.

Other than sweeping sales in advance of the holiday season, companies must utilize game theory when pricing products for launch or in anticipation of competition from rival goods. A balance must be found. Price a good too low and it won't reap profit. Price a good too high and it might push customers toward a substitute.

Classification of Game Theory

Cooperative vs. Non-Cooperative Games

Although there are many types of game theory, such as symmetric/asymmetric, simultaneous/sequential, and so on, cooperative and non-cooperative game theories are the most common.

Cooperative game theory deals with how coalitions, or cooperative groups, interact when only the payoffs are known. It is a game between coalitions of players rather than between individuals, and it questions how groups form and how they allocate the payoff among players.

Non-cooperative game theory deals with how rational economic agents deal with each other to achieve their own goals. The most common non-cooperative game is the strategic game, in which only the available strategies and the outcomes that result from a combination of choices are listed. A simplistic example of a real-world non-cooperative game is rock-paper-scissors.[6]

Zero-Sum vs. Non-Zero-Sum Games

When there is a direct conflict between multiple parties striving for the same outcome, it is often called a zero-sum game. This means that for every winner, there is a loser. Alternatively, it means that the collective net benefit received is equal to the collective net benefit lost. Lots of sporting events are a zero-sum game as one team wins and another team loses.

A non-zero-sum game is one in which all participants can win or lose at the same time. Consider business partnerships that are mutually beneficial and foster value for both entities. Instead of competing and attempting to win at the expense of the other, both parties benefit.

Investing and trading stocks is sometimes considered a zero-sum game. After all, one market participant buys a stock and another participant sells that same stock for the same price. However, because different investors have different risk appetites and investing goals, it may be mutually beneficial for both parties to transact.

Simultaneous Move vs. Sequential Move Games

Simultaneous move situations, which occur frequently in life, mean each participant must continually make decisions at the same time that their opponent is making decisions. As companies devise their marketing, product development, and operational plans, competing companies are doing the same thing at the same time.

In some cases, there is an intentional staggering of decision-making steps, enabling one party to see the other party's moves before making their own. This is usually present in negotiations; one party lists their demands, then the other party has a designated amount of time to respond and list their own.

One Shot vs. Repeated Games

Game theory can begin and end in a single instance. Like much of life, the underlying competition starts, progresses, ends, and cannot be redone. This is often the case with equity traders, who must wisely choose their entry point and exit point, as their decision may not easily be undone or retried.

On the other hand, some repeated games continue on and seemingly never end. These types of games often contain the same participants each time, and each party has the knowledge of what occurred previously.

For example, consider rival companies trying to price their goods. Whenever one makes a price adjustment, so may the other. This circular competition repeats itself across product cycles or sale seasonality.

In the example below, a depiction of the Prisoner's Dilemma (discussed in the next section) is shown. In this depiction, after the first iteration occurs, there is no payoff. Instead, a second iteration of the game occurs, bringing with it a new set of outcomes not possible under one-shot games.

Examples of Game Theory

There are several games, or situations, that game theory analyzes. Here are a few:

The Prisoner's Dilemma

The prisoner's dilemma is the most well-known example of game theory. Consider the example of two criminals arrested for a crime. Prosecutors have no hard evidence to convict them. However, to gain a confession, officials remove the prisoners from their solitary cells and question each one in separate chambers. Neither prisoner has the means to communicate with the other. Officials present four deals, often displayed as a 2 x 2 box.

1. If both confess, they will each receive a three-year prison sentence.

2. If Prisoner 1 confesses, but Prisoner 2 does not, Prisoner 1 will get one year and Prisoner 2 will get five years.

3. If Prisoner 2 confesses, but Prisoner 1 does not, Prisoner 1 will get five years, and Prisoner 2 will get one year.

4. If neither confesses, each will serve two years in prison.

The most favorable strategy is to not confess. However, neither is aware of the other's strategy and, without certainty that one will not confess, both will likely confess and receive a three-year prison sentence. The Nash equilibrium suggests that in a prisoner's dilemma, both players will make the move that is best for them individually but worse for them collectively.

"Tit for tat" is said to be the optimal strategy in a prisoner's dilemma. Tit for tat was introduced by Anatol Rapoport, who developed a strategy in which each participant in an iterated prisoner's dilemma follows a course of action consistent with their opponent's previous turn. For example, if provoked, a player subsequently responds with retaliation; if unprovoked, the player cooperates.

The image below depicts the dilemma where the choice of the participant in the column and the choice of the participant in the row may clash. For example, both parties may receive the most favorable outcome if both choose row/column 1. However, each faces the risk of strong adverse

outcomes should the other party not choose the same outcome.

		Columns' Choice	
		C_1	C_2
Rows' Choice	R_1	(2,2)	(0,1)
	R_2	(1,0)	(1,1)

Fig 1: Example of Static Two-Person Game.

Dictator Game

This is a simple game in which Player A must decide how to split a cash prize with Player B, who has no input into Player A's decision. While this is not a game theory strategy per se, it does provide some interesting insights into people's behavior. Experiments reveal about 50% keep all the money to themselves, 5% split it equally, and the other 45% give the other participant a smaller share.

The dictator game is closely related to the ultimatum game, in which Player A is given a set amount of money, part of which has to be given to Player B, who can accept or reject the amount given. The catch is if the second player rejects the amount offered, both A and B get nothing. The dictator and ultimatum games hold important lessons for charitable giving and philanthropy.

Volunteer's Dilemma

In a volunteer's dilemma, someone has to undertake a chore or job for the common good. The worst possible outcome is realized if nobody volunteers. For example, consider a company in which accounting fraud is rampant, though top management is unaware of it.

Some junior employees in the accounting department are aware of the fraud but hesitate to tell top management because it would result in the employees involved in the fraud being fired and most likely prosecuted.

Being labeled as a whistleblower may also have some repercussions down the line. But if nobody volunteers, the large-scale fraud may result in the company's eventual bankruptcy and the loss of everyone's jobs.

The Centipede Game

The centipede game is an extensive-form game in which two players alternately get a chance to take the larger share of a slowly increasing money stash.

It is arranged so that if a player passes the stash to their opponent who then takes it, the player receives a smaller amount than if they had taken the pot.

The centipede game concludes as soon as a player takes the stash, with that player getting the larger portion and the other player getting the smaller portion. The game has a pre-defined total number of rounds, which are known to each player in advance.

Applications of Game Theory in Business Firms

Now, let's look at some real-world applications of game theory in business. One classic example is price competition between two firms. This is a game that can be represented in strategic form as a matrix with the strategies of each firm listed in rows and columns, and the profits for each firm listed in the cells.

In this game, each firm has to decide whether to charge a high price or a low price for their product. If both firms charge a high price, they both make a high profit. If one firm charges a high price and the other charges a low price, the firm that charges the low price captures a larger market share and makes a higher profit, while the other firm makes a lower profit. If both firms charge a low price, they both make a lower profit. The Nash equilibrium in this game is for both firms to charge a high price, as neither firm has an incentive to change its strategy given the other firm's strategy. However, if one firm decides to charge a low price in an attempt to capture a larger market share, it may be able to achieve a higher profit in the short run, even though it may not be an equilibrium outcome.

Another application of game theory in business is in oligopoly, which is a market structure in which a small number of firms dominate the industry. In an oligopoly, firms have to take into account the actions of their competitors when making decisions. For example, consider the game of price competition between two firms in an oligopoly. In this game, each firm has to decide whether to charge a high price or a low price for their product.

If both firms charge a high price, they both make a high profit. If one firm charges a high price and the other charges a low price, the firm that charges the low price captures a larger market share and makes a higher profit, while the other firm makes a lower

profit. If both firms charge a low price, they both make a lower profit. The Nash equilibrium in this game is for both firms to charge a high price, as neither firm has an incentive to change its strategy given the other firm's strategy. However, if one firm decides to charge a low price in an attempt to capture a larger market share, it may be able to achieve a higher profit in the short run, even though it may not be an equilibrium outcome.

Another application of game theory in business is in auctions, which are used to sell goods or services to the highest bidder. There are several different types of auctions, including English auctions, Dutch auctions, and sealed-bid auctions. Game theory can be used to analyze the behavior of bidders in auctions and to understand how the design of the auction can affect the outcome. Finally, game theory can also be applied to the negotiation process between two or more parties. Negotiation is a common occurrence in business, and game theory can be used to understand how to negotiate effectively and to reach mutually beneficial agreements.

Real-World examples of Companies using Game Theory

Game theory is not just a theoretical concept; it is also used by real companies to make strategic decisions and understand the behaviour of their competitors.

Here are a few examples of real companies using game theory: Apple and Samsung use game theory to analyze the smartphone market and predict each other's actions; Amazon and eBay are two major online retailers competing for customers. They may use game theory to analyze the market and predict each other's actions, such as how the other firm will respond to a price change or a new product listing. They may also use game theory to determine their products and services' optimal pricing and marketing strategy. Or how to encourage more merchants to join their platforms to sell merchandise like t-shirts, phone accessories, or other goods, such as electronics.

1. **Apple and Samsung:** Apple and Samsung are two major competitors in the smartphone market. In order to understand each other's behavior and make strategic decisions, they may use game theory to analyze the market and predict each

other's actions. For example, they may use game theory to predict how the other firm will respond to a price change or a new product launch and to determine the optimal pricing and marketing strategy for their own products.

2. **Amazon and eBay:** Amazon and eBay are two major online retailers that compete with each other for customers. They may use game theory to analyze the market and predict each other's actions, such as how the other firm will respond to a price change or a new product listing. They may also use game theory to determine the optimal pricing and marketing strategy for their own products and services.

3. **Uber and Lyft:** Uber and Lyft are two major ride-hailing companies that compete with each other for riders. They may use game theory to analyze the market and predict each other's actions, such as how the other firm will respond to a price change or a new service offering. They may also use game theory to determine the optimal pricing and marketing strategy for their own services.

Conclusion

In conclusion, game theory is a powerful tool for understanding strategic decision-making and the interactions between firms. By mastering the basic concepts and applying them to real-world business situations, you can make better decisions and achieve better outcomes.

In the complex and ever-evolving landscape of business, strategic decision-making is paramount. The integration of game theory into business strategy offers companies a powerful tool for analyzing, anticipating, and responding to the actions of competitors. By understanding the dynamics of strategic interactions, businesses can make more informed decisions, mitigate risks, and position themselves for success in an increasingly competitive environment. As companies continue to face challenges and opportunities, the strategic application of game theory will likely remain a key element in shaping the future of business strategy.

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