Game Theory Strategies for Decision Making – A Case Study

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Abstract: Game theory, the study of strategic decision-making, brings together disparate disciplines such as mathematics, psychology and philosophy. Game theory was invented by John von Neumann and Oskar Morgenstern in 1944 and has come a long way since then. The importance of game theory to modern analysis and decision-making can be gauged by the fact that since 1970, as many as 12 leading economists and scientists have been awarded the Nobel Prize in Economic Sciences for their contributions to game theory. Game theory is applied in a number of fields including business, finance, economics, political science, psychology, mathematics, computer science, military, sports, and biology. In this case, we explore the foundations of game theory and analyze the game theory strategies for the decision making in business firms.

Keywords*:* Strategy, Payoff Matrix, Behavior Model, Decision Making, Zero-Sum Games.

Introduction

In game theory, the term *game* means a particular sort of conflict in which *n* of individuals or groups participate. A list of rules stipulates the conditions under which the game begins, the possible legal "moves" at each stage of play, the total number of moves constituting the entirety of the game, and the terms of the outcome at the end of play. *Payoff*, or *outcome*, is a game-theory term referring to what happens at the end of a game. In such games as chess or checkers, payoff may be as simple as declaring a winner or a loser. In poker or other gambling situations the payoff is usually money; its amount is predetermined by antes and bets amassed during the course of play, by percentages or by other fixed amounts calculated on the odds of winning, and so on.

A game is said to be a zero-sum game if the total amount of payoffs at the end of the game is zero. Thus, in a zero-sum game the total amount won is exactly equal to the amount lost. In economic contexts, zero-sum games are equivalent to saying that no production or destruction of goods takes place within the "game economy" in question. Von Neumann and Oskar Morgenstern showed in 1944 that any *n*-person non-zero-sum game can be reduced to an $n + 1$ zero-sum game, and that such $n + 1$ person games can be generalized from the special case of the two-person zero-sum game. Consequently, such games constitute a major part of mathematical game theory. One of the most important theorems in this field establishes that the various aspects of maximal-minimal strategy apply to all two-person zero-sum games. Known as the minimax theorem, it was first proven by von Neumann in 1928; others later succeeded in proving the theorem with a variety of methods in more general terms.

Applications of Game theory

Applications of game theory are wide-ranging and account for steadily growing interest in the subject. Von Neumann and Morgenstern indicated the immediate utility of their work on mathematical game theory by linking it with economic behavior. Models can be developed, in fact, for markets of various commodities with differing numbers of buyers and sellers, fluctuating values of supply and demand, and seasonal and cyclical variations, as well as significant structural differences in the economies concerned. Here game theory is especially relevant to the analysis of conflicts of interest in maximizing profits and promoting the widest distribution of goods and services. Equitable division of property and of inheritance is another area of legal and economic concern that can be studied with the techniques of game theory.

In the social sciences, *n*-person game theory has interesting uses in studying, for example, the distribution of power in legislative procedures. This problem can be interpreted as a three-person game at the congressional level involving vetoes of the president and votes of representatives and senators, analyzed in terms of successful or failed coalitions to pass a given bill. Problems of majority rule and individual decision making are also amenable to such study.

Sociologists have developed an entire branch of game theory devoted to the study of issues involving group decision making. Epidemiologists also make use of game theory, especially with respect to immunization procedures and methods of testing a vaccine or other medication. Military strategists turn to game theory to study conflicts of interest resolved through "battles" where the outcome or payoff of a given war game is either victory or defeat. Usually, such games are not examples of zero-sum games, for what one player loses in terms of lives and injuries is not won by the victor. Some uses of game theory in analyses of political and military events have been criticized as a dehumanizing and potentially dangerous oversimplification of necessarily complicating factors. Analysis of economic situations is also usually more complicated than zero-sum games because of the production of goods and services within the play of a given "game."

Types of games

a) Symmetric and asymmetric

A symmetric game is a game where the payoffs for playing a particular strategy depend only on the other strategies employed, not on who is playing them. If the identities of the players can be changed without changing the payoff to the strategies, then a game is symmetric. Many of the commonly studied 2×2 games are symmetric. The standard representations of chicken, the prisoner's dilemma, and the stag hunt are all symmetric games.

Most commonly studied asymmetric games are games where there are not identical strategy sets for both players. For instance, the ultimatum game and similarly the dictator game have different strategies for each player. It is possible, however, for a game to have identical strategies for both players, yet be asymmetric. For example, the game pictured to the right is asymmetric despite having identical strategy sets for both players.

b) Zero-sum

Zero-sum games are a special case of constant-sum games, in which choices by players can neither increase nor decrease the available resources. In zero-sum games the total benefit to all players in the game, for every combination of strategies, always adds to zero (more informally, a player benefits only at the equal expense of others). Poker exemplifies a zero-sum game (ignoring the possibility of the house's cut), because one wins exactly the amount one's opponents lose. Other zero-sum games include matching pennies and most classical board games including Go and chess.

c) Simultaneous and sequential

Simultaneous games are games where both players move simultaneously, or if they do not move simultaneously, the later players are unaware of the earlier players' actions (making them *effectively* simultaneous). Sequential game (or dynamic games) are games where later players have some knowledge about earlier actions. This need not be perfect information about every action of earlier players; it might be very little knowledge. For instance, a player may know that an earlier player did not perform one particular action, while he does not know which of the other available actions the first player actually performed. The difference between simultaneous and sequential games is captured in the different representations discussed above. Often, normal form is used to represent simultaneous games, and extensive form is used to represent sequential ones; although this isn't a strict rule in a technical sense.

d) Perfect information and imperfect information

An important subset of sequential games consists of games of perfect information. A game is one of perfect information if all players know the moves previously made by all other players. Thus, only sequential games can be games of perfect information, since in simultaneous games not every player knows the actions of the others. Most games studied in game theory are imperfect-information games. Perfect-information games include chess. Perfect information is often confused with complete information, which is a similar concept.

Complete information requires that every player know the strategies and payoffs of the other players but not necessarily the actions.

e) Infinitely long games

Games, as studied by economists and real-world game players, are generally finished in finitely many moves. Pure mathematicians are not so constrained, and set theorists in particular study games that last for infinitely many moves, with the winner (or other payoff) not known until *after* all those moves are completed.

f) Discrete and continuous games

Much of game theory is concerned with finite, discrete games, that have a finite number of players, moves, events, outcomes, etc. Many concepts can be extended, however. Continuous games allow players to choose a strategy from a continuous strategy set. For instance, Cournot competition is typically modeled with players' strategies being any non-negative quantities, including fractional quantities (this is a game for duopolies).

Game Theory Strategies for Decision Making

Assume that two Business Firms in Srikakulam are competing for Market Share for a particular product. Each firm is considering what promotional strategy to employ for the coming period. Assume that the following payoff matrix describes the increase in market share for firm A and decrease in market share for firm B. Determine the optional strategy for each firm.

Firm	**B**			
A		**Low advt.**	**Medium advt.**	**High advt.**
	Low advt.	10	12	15
	Medium advt.	14	13	16
	High advt.	11	09	12

Applying saddle point approach in game theory strategy

Firm	**B**				**Row Minimum**
A		**Low advt.**	**Medium advt.**	**High advt.**	
	Low advt.	10	12	15	10
	Medium advt.	14	**13**	16	**13**
	High advt.	11	09	12	09
Column Maximum		14	**13**	16	

From the above table it is observed that the maximum value of row minimum was equals to minimum value of column maximum ad both equals to the corresponding value i.e. **13**

Hence we can conclude that the value of the game is **13**

Also applying the dominance rule in game theory strategy

Firm	**B**			
A		**Low advt.**	**Medium advt.**	**High advt.**
	Low advt.	10	12	15
	Medium advt.	14	13	16
	High advt.	11	09	12

All the elements of Low advt. row were dominated by corresponding elements of Medium advt. hence the inferior low advt. row to be deleted.

Firm	**B**			
A		**Low advt.**	**Medium advt.**	**High advt.**
	Medium advt.	14	13	16
	High advt.	11	09	12

Similarly all the elements of High advt. row were dominated by corresponding elements of Medium advt. hence the inferior high advt. row to be deleted.

Firm	**B**			
A		**Low advt.**	**Medium advt.**	**High advt.**
	Medium advt.	14	13	16

Also the column wise, all the elements of Medium advt. column were dominated by corresponding elements of Low advt. hence the superior Low advt. column to be deleted.

Firm	B		
		Medium advt.	**High advt.**
A	**Medium advt.**	13	16

Similarly all the elements of Medium advt. column were dominated by corresponding elements of High advt. hence the superior High advt. column to be deleted.

Firm	B	
		Medium advt.
A	**Medium advt.**	13

Hence the selected strategy to be implemented was **Medium Advertisement** is needed for the promotion of market share.

Conclusions

Game theory has many applications. It can be applied to multiple fields of study and many different situations. It is used in both everyday life and in mathematical analysis. We can use payoff matrices and game trees to represent games. There are two main types of games: zero-sum games and non-zero-sum games. We can use the minimax theorem to analyze zero-sum games, and we can use the Nash equilibrium to analyze both zero-sum and non-zero-sum games.

Game theory is the study of rational behavior in situations involving interdependence. It is a formal way to analyze interaction among a group of rational individuals who behave strategically. A game consists of a set of players, a set of moves (or strategies) available to those players, and a specification of payoffs for each combination of strategies. Most cooperative games are presented in the characteristic function form, while the extensive and the normal forms are used to define non-cooperative games.

Game theory is a study of strategic decision making. Specifically, it is "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers". An alternative term suggested "as a more descriptive name for the discipline" is *interactive decision theory*. Game theory is mainly used in economics, political science, and psychology, as well as logic and biology. The subject first addressed zero-sum games, such that one person's gains exactly equal net losses of the other participant(s). Today, however, game theory applies to a wide range of behavioral relations, and has developed into an umbrella term for the logical side of decision science, including both humans and non-humans.

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