

Game Theory and its Application to Oligopolistic market

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Abstract- In the real-world situations, each economic operator faces the rivalries competition by the reaction of his rivals. Hence his decision making depends not only on his own choices but also on the choices of the others. To select an optimal strategy, in the oligopolistic market, decision makers can use game theory. An important contribution in the development of methods for economic analysis has been made by Von Neumann and Oscar Morgenstern which is known as the game theory. Game theory is a mathematical theory that is used for analysis and solving of conflict situations, in which participants have opposite interests. The concepts of game theory provide a tool for formulating, analyzing, and understanding different strategies. It attempts to address the functional relationship between the selected strategies of individual players and their market outcome, which may be either profit or loss. The game theory has been applied to the analysis of market situations in which the outcome depends upon the actions of participants with conflicting interests such as duopoly, bilateral monopoly, and oligopoly. In this paper try to show how the key aspects of game theory can be used to the equilibrium analysis of Oligopolistic market and explain how an individual firm decides to cheat on a cartel agreement.

Key words: Game theory, oligopoly, optimal strategy, decision makers, equilibrium analysis

INTRODUCTION

In the real-world situations, each economic operation faces the rivalrous competition by the reaction of his rivals. Hence his decision making depends not only on his own choices but also on the choices of the others. Reference to such situations is made while discussing the model of imperfect competitions, oligopolistic, in which each firm must anticipate what his rival will do in reaction to his own actions, is remarkably similar to the state of mind of players in any game involving strategy; such as Chess, Checkers and Bridge. In all such games, each player must calculate the response of his opponents and adopt his own strategy, which

seems most advantageous to him under the circumstances.

Game theory is the study of how players should rationally play games. Each player would like the game to end in an outcome which gives him as large as payoff as possible. Game theory is one of the possible ways of interpreting human behavior and choice in conflict and partially conflict situations. These involve all the situations in which the final solution depends not only on one party, i.e. a player who makes the decision, but also the decisions made by other participants, and this where the conflict and cooperation enter. Game theory is the logical analysis of situations of conflict and cooperation.

A basic feature of oligopoly is that each firm must consider of its rival's reactions to its own actions. For example, Pepsi company cannot ignore the effect of an increase in price of its product on the prices and profits of its rival firms and how they will respond to its move of rise in price of its product. Thus, oligopolistic behavior has some of the characteristics of a game where a player must know how his move will affect his rival and he is rational, will react on his move.

Game theory highlights that, in an oligopolistic market, a firm behaves strategically, that is, it adopts strategic decision making which means that while taking decisions regarding price, output, advertising etc. it takes into account how its rivals will react to its decisions and assuming them to be rational it thinks that they will do their best to promote their interests and take this into account while decision making.

The main objectives of this paper are:

1. To give a brief idea of game theory and oligopoly market.
2. Explain the process how the game theory help in decision making by firms operating in oligopolistic market.
3. Try to explain how an individual firm decides to cheat on a cartel agreement.

THE BASIC CONCEPTS OF THE GAME THEORY

Game theory is a mathematical theory that is used for the analysis and resolution of conflict situations in which parties have opposing interests. The theory of games examines the outcome of a situation of interactions between the parties when they have conflicting interest. Basically, the game theory seeks to explain what is the rational course of action for an individual who is faced with an uncertain situation, the outcome of which depends not only upon this his course of actions but also upon the actions of others who too confront the same problem of choosing a rational strategic course of action.

A game is any situation in which players, i.e. participants in the game, make strategic decisions, taking into account actions and reactions of others. A strategy is a rule or plan of action for playing the game. For example, for an oligopoly company which needs to determine the price of its products, a possible strategy is “to maintain a high price as long as that is how my competitors act, but when some of the competitors lower their price, to lower my price even further”.

The main objective of game theory is to determine the optimal strategy for each player. The optimal strategy is defined as a strategy that maximizes the expected return of the player. The mechanisms of game theory allow a study of a large number of possible strategies, from a total agreement to a conflict of interest.

Games which firms play can be either cooperative or non-cooperative. A game is cooperative if the firm i.e. players in the game can arrive at an enforceable or binding contract that permits them to adopt a strategy to maximise joint profits. If the two firms can sign a binding contract to share the profits between them from the production and sale of a product, the game is called a cooperative game. On the other hand, a non-cooperative game is one where because of conflict of interests two firms cannot sign a binding contract. In most of the oligopolistic market situation binding contract, that is, contract that are enforceable cannot be negotiated. Therefore, in oligopoly in most cases we find examples of non-cooperative games. In a situation of non-cooperative games while the competing firms take each other's actions into account, but they take decisions independently and adopt strategies regarding pricing, advertising, product variation to promote their interests.

In addition to these games there are repeated games (an infinite number of times - pricing of products) and games that are not repeated (decisions made only once). In the contemporary economic conditions, the most important element of each game is setting strategic objectives, especially in those games that are repeated an infinite number of times, such as, for example, determining the price of a product.

AN OLIGOPOLY AS A MARKET STRUCTURE

Oligopoly is an important form of imperfect competition. Oligopoly is said to prevail when there are few firms or sellers in the market producing or selling a product. The characteristics of oligopoly markets are to harbour a few businesses and that the entry of new companies is limited. Products can be differentiated (as in the automotive industry), but not necessarily so (as in the steel industry). The scope of the monopoly power of companies partially depends on the interaction that exists between them. In some oligopolistic industries, companies cooperate, and in others they implement aggressive competition, and consequently achieve lower profits. In decision making in an oligopolistic market, one must consider possible reactions of the competitors. In addition, we assume that companies, as subjects, act rationally, that is, think about the consequences of their actions.

Game theory is widely applied in oligopolistic market situations research. In fact, many of the central problems of oligopoly depend on strategic reciprocal relations that exist between the market participants. The issue of the strength of the above-mentioned reciprocal connections is especially important, and game theory models provide answers to this question. For this paper purposes, we will simplify the analysis of an oligopoly market and, therefore, consider the case of duopoly, or the existence of only two companies in the market. Each company has only one competitor that must be considered when making its decisions. By an example of duopoly (company A and company B) we will show how companies, by choosing price as a strategic variable, can achieve an advantage in the market.

EQUILIBRIUM IN AN OLIGOPOLY MARKET

A duopoly in an oligopolistic market is comprised of two companies, which may or may not produce differentiated products. Let us assume that there are two companies that produce a homogeneous product.

Then there will be four variables that may be of interest for us. These are the prices (P_1, P_2) which are determined by each company and the quantities (q_1, q_2) produced by each company. The company should first decide on the strategic variables with which it wants to achieve a competitive advantage. If two companies make decisions simultaneously on the amount they need to produce, whereby the market determines the price, then we talk about the Cournot duopoly model. If one company decides on the quantity or price before the other company, it becomes a leader either in quantity or price, which is explained by the Stackelberg duopoly model. When both companies make decisions simultaneously on the price of their product, with the amount determined by the market, we talk about the Bertrand duopoly model. Each company determines the price by which it will maximize profits, according to the given choice (price) of the other company. When the market is in equilibrium, the companies operate as best as they can and have no reason to change prices or production quantities. The competitive market is in equilibrium when the total supply equals total demand. Then each company operates as best as it can because it sells all it produces and maximizes its profits. A monopolist is in equilibrium when marginal revenue equals marginal cost. Then the monopolist achieves the maximum profit. In an oligopolistic market, a company determines the price and quantity taking into account the behaviour of its competitors, whereas the competitors' decisions depend on the decisions of the company. Is there equilibrium in an oligopolistic market at all? When is oligopoly equilibrium achieved? Yes, oligopolistic market equilibrium exists and is known as Nash equilibrium. Nash equilibrium is since every company operates as best as it can, considering the performance of its competitors. When companies are in Nash equilibrium, neither of the companies has incentive to disturb it, because each operates as best as it can, that is, achieves the highest profits (as well as its competitor) with the strategy chosen.

APPLICATION OF GAME THEORY IN AN OLIGOPOLY MARKET

According to the theory of demand and supply, the notion of a market equilibrium in which demand equals supply is central. The theoretical attraction of the concept arises because in such a situation, there is

no tendency or necessity for anyone's behaviour to change. These regularities in behaviour form the basis for making prediction. With a view toward making predictions, we wish to describe potential regularities in behaviour that might arise in a strategic setting. At the same time, we wish to incorporate the idea that the players are rational, both in the sense they act in their own self-interest and that they are fully aware of regularities in the behaviour of others. In the strategic setting, just as in the demand and supply setting, regularities in behaviour that can be rationally sustained will be called equilibria. In this case we can be encountered the notion of a Nash equilibrium in the strategic context of Cournot duopoly. This concept generalizes to arbitrary form games. Indeed, Nash equilibrium, introduced in Nash (1951), is the single most important equilibrium concept in all of game theory. Informally, a joint strategy constitutes a Nash equilibrium if everyone, while fully aware of the others' behaviour, has no incentive to change his own. Thus, Nash equilibrium describes behaviour that can be rationally sustained.

Let us illustrate the Nash equilibrium with dominant strategy in case of duopoly in the choice of whether to 'Advertise' or not. In this case, deciding in favour of advertising by a firm to promote its sales and hence profits or deciding not to advertise are the two strategies. Thus, 'Advertising' or 'Not Advertising' are the two strategies between which each firm must make a choice. We assume there are two firms, A and B which must make a choice between the two strategies. The outcome (or profits made) from the various combinations of two strategies chosen by the two firms are presented in the following Table-1 in the form of payoff matrix. It should be noted that outcome or profits made by a firm by adopting a strategy is influenced by the choice of a strategy by the rival firm.

Table 1: Payoff Matrix for Advertising Game

	FIRM B	
Advertising	A:10 B: 5	A:15 B: 0
Not Advertising	A: 6 B:8	A:10 B: 2

The payoff matrix shows us that if the two firm adopt the strategy of 'Advertising', the firm A will make a profits of 10 crores and B will earn profits of 5 crores. If Firm A decides to advertise and firm B decides not

to advertise, profits of firm A are 15 crores and firm B are zero. Similarly, if firm a decides not to advertise but firm B decides in favour of advertising, firm A makes profits of 6 crores and B of 8 crores. Further, if both firms go in for not advertising profits of A are 10 crores and B are 2 crores.

It is clear from the Payoff matrix, choice of strategy of ‘Advertising’ by firm A is better or optimal since it ensures more profits whether firm B adopts strategy firm B adopts strategy of ‘Advertising’ or the strategy of ‘Not Advertising’. Thus, in the above payoff matrix, whatever strategy firm B adopts, for firm A strategy of ‘Advertising’ is optimal. When payoff matrix of a game is such that a choice of one strategy is better regardless of what ever strategy the other firm chooses, the strategy is known as dominant strategy. In the present case choice of strategy of ‘Advertising’ is a dominant for Firm A. The similar conclusion can be drawn for the optimal strategy to be adopted by firm B from the payoff matrix for advertising game given above. In this case too, choice strategy of ‘Advertising’ by firm B is optimal whatever strategy the firm adopts. Thus, strategy of ‘Advertising’ is a dominant strategy for firm B. Since it is assumed that both firms behave rationally each of them will choose the strategy of Advertising and the outcome will be profits of Rs 10 crores for firm A and for Rs 5 crores for firm B. It is important to note that all games do not have a dominant strategy for each player. The concept of equilibrium of Nash equilibrium is quite relevant here. Let us take another payoff matrix table 2

Table 2: Payoff Matrix for Advertising Game

	FIRM B	
Advertising	Not Advertising	
Advertising	A:10	A:15
	B: 5	B: 0
	FIRM A	
Not Advertising	A: 6	A:20
	B:8	B: 2

It is cleared from above table 2, optimal strategy for firm A depends on which strategy B adopts. Choice of strategy of ‘Advertising’ is optimal for firm A, given that the firm B adopts the strategy of ‘Advertising’. On the other hand, choice of strategy of ‘Not advertising’ by a Firm A is better, given that the B adopts strategy of ‘Not Advertising’. Thus, in this case there is no dominant strategy for firm A. the choice of an optimal strategy by firm A in the present case, that is, when dominant strategy does not exist, will be easier if firm

B adopts a strategy before the firm A has to make its choice. But how an optimal decision regarding choice of strategy if both firms must choose their simultaneously, that is, at the same time. Here, the application of the concept of Nash equilibrium is quite relevant. Nash equilibrium is a more general concept of equilibrium that is widely applicable and highly appealing. In Table -2, the firm A has no dominant strategy we reached the conclusion that the equilibrium state is reached when firm A adopts strategy ‘Advertising’ given that the firm B will choose the strategy of ‘Advertising’. That is, firm A is making the best choice, given the choice by its rival firm B is choosing the best strategy, given the strategy of firm A. Therefore, they have no incentive to change their strategies. Hence, exist of Nash equilibrium, called Nash equilibrium. In the above table -2, where firm A has no dominant strategy, each firm promotes its own interests and makes a best choice of strategy, given the other firm’s strategy, both firm A and Firm B adopt strategy of ‘Advertising’ which is optimal strategy for them. Since, each doing the best, given other’s strategy and no one has a tendency to change it unilaterally, there exists Nash equilibrium. As no one has a tendency to deviate from the Nash equilibrium state, strategies chosen by them are stable.

GAME THEORY AND INSTABILITY OF A CARTEL:

The game of prisoner dilemma is of important relevance to the oligopoly theory. The incentive to cheat by a manner of a cartel and eventual collapse of cartel agreement is better explained with the model of ‘Prisoners dilemma’. Instead of the prisoners we take the two firms A and B which have entered into a cartel agreement and fixed the price and output each has to produce and sell. The choice problem facing each member firm of the cartel is whether to cooperate and abide by the agreement and thus sharing the joint monopoly profits or to cheat the other and try to make higher individual profits. But if both cheat and violate the agreement, the cartel would break down and profit would fall to the competitive level. The profit matrix to be made by them is presented in table 3

Table 3: Payoff Matrix for cartel members

	FIRM A	
Cheat	Cooperate	
Cheat	A: 5 lakhs	A: 2 lakhs
	B: 5 Lakhs	B: 25 Lakhs

		FIRM B	
Cooperate	A: 25 Lakhs	A: 15 Lakhs	
	B: 2 Lakhs	B: 15 lakhs	

It is seen from this table that if both firms cooperate and abide by the cartel agreement, they share monopoly profit; Rs 15 lakhs to each of them. If both firms cheat, they violate the agreement and profit to each firm will fall to the competitive level, Rs 5 lakhs each firm. If firm A cheats, while firm B abides by agreement, firm B's profit drop to low level of Rs 2 lakhs and A's profit rise to Rs 25 lakhs. On the other hand, if the firm b cheats and the firm A adheres to the agreement, profit of A decline to 2 lakhs and b's profit shoot up to Rs 25 lakhs. It is evidence from the profit matrix table-3 that from the different choices made by the firms that each firm has a strong incentive to cheat. Under the prevailing circumstances, A's best strategy is to cheat rather than cooperate. The same is true for firm b whose best strategy is also to cheat. Again, it is pursuit of self- interest rather than common interest that prompts the firms to cheat other. Thus, both firms will cheat, and this will bring about the breakdown of the cartel.

CONCLUSION

Game theory is a mathematical theory that is used for the analysis and resolution of conflict situations in which parties have opposing interests. The theory of games examines the outcome of a situation of interactions between the parties when they have conflicting interest. The game played by companies in oligopolistic markets, in order to achieve monopoly profits, is similar to that played in the "prisoner's dilemma" by prisoners. If oligopolists make decisions individually about the price of their products they will be guided by Nash equilibrium, which means charging lower prices and lower profit generation. If they cooperate, or passively compete by charging high prices, higher profits will be realized. The "prisoner's dilemma" describes many real-life situations and shows that cooperation is sometimes difficult to achieve, even when for both players it is better to play together.

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