COMPETITION ANALYSIS USING GAME THEORY FOR DECISION MAKING

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DECLARATION

I hereby declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all the principles of academic honesty and integrity policies of the University of Exeter and have not fabricated or falsified any ideas or facts in my submission.

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ABSTRACT

In a particular company it is very important to make good pricing decisions not only from a profit point of view but also for paving a way through the competitive environment. These decisions could only be made by considering the market's intuitive responses. As simple as it sounds, it is a very difficult task to estimate the competitors' effective responses with respect to the rate changes. This effective process is triggered by both the company's respective market strength as well as the reactions of its competitors'. Provided the desired acts, Game theory puts forwards a mechanism for anticipating the corresponding actions of the rivals. This research delves into the use of game theory to predict how the opponents will react to cost changes based on certain reasonable moral speculations. While each participant evaluates the expected actions and measures of its rivals, it aims for the best optimal strategic planning possible. It posits that the participants will just make judgements depending on what their opponents are likely to do because they are pragmatic and self-egocentric. This research covers understanding game theory on the basis of the theoretical models to analyse the competition between two or more firms. As we know price is primarily decided by the firm's and its competitors' respective market power, this study also explains how the firm decide on value and/or productive efficiency to maximise the market impact. The research uses both theoretic and numerical demonstrations to examine some game theory concepts with an attention on the ramifications of these techniques to strengthen the planning process.

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1. INTRODUCTION

This Introduction section gives an overview about the research study and its importance in making strategic decisions within the areas of business and economics. A background history of the given research is then provided considering the various strategies involved while analysing the competition among the organizational firms.

1.1 Background and Overview

The research of a duopoly by Antoine Cournot in 1838 marks the origins of a formal game-theoretic analysis. Emile Borel, a mathematician, proposed a formal theory of games in 1921. His recommendation was based on his "Theory of Parlour Games", where in another mathematician, John von Neumann, happened to improve the theory in 1928. Neumann realized it earlier that game theory would be useful to economists. He studied on his thesis with Oskar Morgenstern, an Austrian economist at Princeton. Even though the book was designed with economics in mind, its applicability to psychology, sociology, politics, conflict, leisure sports, and a number of other areas immediately became apparent. John Nash established in 1950 that finite games eventually reach an equilibrium point, where all competitors choose the optimum course of action provided their rivals' preferences. This is known as a non-cooperative game, and it has been a topic of research ever since. Game theory was conceptually generalized and addressed to concerns of war and politics in the 1950s and 1960s. It has acquired popularity in economic principles since the 1970s. It has also been linked to evolution and biology and has applications in sociology and psychology. However, when game theorists John F. Nash, John C. Harsanyi, and Reinhard Selten were conferred with Nobel Prize in Economics in 1994, game theory received considerable attention.

In the corporate sector, a company's pricing decision would be impossible to make without contemplating the market's participatory reactions. Therefore, due to consumers' dynamic responses to price changes, calculating the change in the value to the change in a firm's earnings is difficult. When opponents' reactions are taken into account, it becomes even more difficult. The developing concept of customer pricing power is based on the firm's market strength as well as the reactions of its competitors – how do opponents react to product pricing? As a result, an additional step is required to evaluate rivals' corresponding behaviours in context of the defined tasks. It is indeed a crucial step in the methodology that is frequently overlooked, if not completely neglected, during the decision-making procedure. Inadequate analysis leads to poor selections, resulting in less productive, if not completely pointless solutions. This void is addressed by game theory. It is more about how competitors react to each other in a sequence of strategic exchanges inside a competitive world. It focuses specifically on achieving the best judgements when each player thoroughly evaluates the expected actions and thoughts of its opponents. It also presupposes that the participants are reasonable and self-interested, and that they can always make judgments based on what their opponents are likely to do. Researchers have embarked on an eternal adventure to discover the inconsistency and unpredictability in human nature due to man's varied and unpredictable nature. But since ancient period, economists have preached individual rationality—a utility researcher's argument—to improve their designs and include thoughts adapt into the real-life conception, encouraging the evolution of many sectors of the profession.

1.2 Problem Statement

The purpose of this work is to examine the application of game theory models to discover market equilibrium (quantities sold and market pricing), as well as to assess and compare the effectiveness of businesses in a market. The questions arising in this aspect revolve not only around what are the various ways in which the companies and government make judgements for their organizations with respect to financial matters but also around the following:

- How do the companies in an organization collide or conflict to manage the cost or amount of the organization's product?
- How do rivals proposing less budgets for products are able to make profits?
- How do any two people in a firm justify their actions to own the exorbitant share in an accomplishment with regard to be respected and rise exceptionally over their adversaries. These questions enhanced the need for analysing not to as if it were for exemplification, but also to have good repercussions to the choices that were been made.

These types of questions enhance the need for analysing not to as if it were for exemplification, but also to have good repercussions to the choices that were been made by the firms.

And a way to answer questions like these is by carrying out competitive analysis, which is a powerful mechanism for identifying the ups and downs in the market and assists in wavering a lasting competitive leverage.

1.3 Structure of the work

The research work is categorized in small sections in order to highlight the insights and give a clear understanding of the completed work. The first subsection comprises of Introduction, which gives us an overview about what is game theory and how vital it is to analyse the market pricing decisions in terms of rivalry between the firms and their competitors. A problem statement section is also included in this segment.

The 'Literature Review' is the second section of the research, in which we learn about some of the published papers that are closely related to our study, assisting us in understanding certain important points as well as some advantages and disadvantages that can be further enhanced or examined using this research. The data in published papers can be extremely informative, and the experiments or observations depicted in the publications are carried out by scholars and specialists in that field.

The methods employed are covered in the third segment of the research. It gives us information about the various methodologies involved while working on the research. The many theoretic models that are used to analyse company's competition are thoroughly explained.

Findings and Analysis form the fourth section of this research. After detailing the methodologies utilised, this section will present the research's outcomes and findings.

Finally, in the final subsection, the study conducted on the research will be summarised, with conclusions and recommendations for the near future.

2. LITERATURE REVIEW

This section provides literature on game theory, competitive analysis, and theoretic models used to derive or illustrate competition between various enterprises and sectors, which will be reviewed to create perspective when conducting various studies required for this project.

2.1 Review Methodology

Particular search keywords such as 'game theory', 'competitive analysis', 'game theory models', 'duopolies and oligopolies', 'models for competition analysis' were used in order to do the research and development of the dissertation. Thereafter, the results were then further refined using the synopsis to retrieve relevant articles from the considerable number of papers, for performing deep research. To complete the needed study, all papers that possess the required context for the research have been utilised.

2.1.1. Game Theory to Model Competition

This particular article (Moorthy, 1985) provides a simplified explanation about the Non cooperative game theory. The theoretical concepts related to non-cooperative game theory and their implications to the field of marketing can be understood from this research. Products and competition in the market, channel coordination, pricing wars, "implicit" collusion, first-mover advantage, price as a quality signal, and the "winner's curse" in competitive bidding are among the implications that are covered. However, the main focus of the article is to provide the reader with a general idea of the wide range of applications that modern game theory has to offer.

As per (Moorthy, 1985), businesses are sensible, if they rely solely on optimizing their perceived predicted "value." When confronted with ambiguity, rational businesses will generate subjective assessments of the likelihood of uncertain occurrences by using these evaluations to determine the estimated value of various options. (Moorthy, 1985) also outlines two situations: first in which both the business and its adversary were aware of the game's rules, and the other one in which both the businesses were unaware of the regulations. It also looks at several methods for decreasing the quantity of feasible equilibria. Fundamentally, a flawless equilibrium would be one in which no business's activities can be validated strictly on the grounds of "logical" assumptions about the items that the business is unclear about. Such conditions, though, do not ensure that there will be just one "good" equilibrium. Since there are many optimal equilibria, the corporation must choose the one that appears to be the most promising. In order to do so, the corporation will have to examine factors which were not part of the formal competition.

2.1.2. Game Theory with Dominance

According to (Turocy & Stengel, 2003) even though all the participants reckon to be logical in game theory, they arrive at a conclusion which they value the most, provided what their competitors do. So, both the participants are said to possess Dominant strategies. A dominant strategy is said to be the only strategy that results in the highest outcome, no matter what choices the opponents desire to take. Dominant strategy is very well described by (Kelly, 2003) he states that given any possible set of choices by the opponents, there is no better strategy than the 'dominant strategy' for a participant. The best way to make how a dominant strategy is important, a game model called 'Prisoner's Dilemma' was put forward by (Tucker, 1983). Prisoner's Dilemma is such a game that develops conflicts between the player and his opponent, and the outcomes are likely to cause a situation that benefits an individual rather than both as a group. (Nalebuff & Dixit, 1993) has explained the 'dominance' in Prisoner's Dilemma in the best way possible. They give an example of two people who have been suspected of committing a crime. They are questioned in two different rooms so that they do not negotiate with each other. They both are given the similar situation,

- if they both happen to confess, each of them will go to prison for a period of 10 years,

- if only one of them confesses, his prison statement will be reduced to 1 year and the other one would be sentenced to 25 years of imprisonment,
- if none of them confess, they would be sentenced prison for 3 years each.

These scenarios can be understood by a tabular format as given below:

		Decision of Prisoner 1	
Decision of Prisoner 2		Confess	Deny
	Confess	10 years	25 years
	Deny	1 year	3 years

Table 1. Prisoner's Dilemma
Source : (Nalebuff & Dixit, 1993)

The above table demonstrates that if Prisoner 1 confesses or denies he will be sentenced to 10 years and 25 years of imprisonment respectively. If at all the other prisoner (prisoner 2) happens to confess, the prisoner 1 will also opt to confess. If the other prisoner (prisoner 2) refuses to confess i.e., denies, the prisoner 1 will be sentenced to 1 year in jail if he confesses, and 3 years if he does not, thus he would like to confess. It is thus claimed that both players have dominant strategies. A dominant strategy comprises payoffs that are so high that no other approach would yield in a larger payoff, irrespective of what other players perform. The conclusion is that if both suspects use their confess, they will not achieve the best result.

2.1.3.Competition and Game Theory

A game-theoretic understanding of competition, according to (Mcafee & Mcmillan, 1996) it is valuable to marketers in a number of different ways. Part of the research involves developing new competitive processes. It means that digital market forces can efficiently manage goods in instances when standard supply curve collapses, such as when items are distinctive and different, numerous goods have efficiencies between themselves, buyers' demands contradict normal theory, or individual customers and sellers must be linked.

They certainly make us realise that rivalry reveals previously undisclosed information. The buyer might have no previous understanding of the asset's value, similar to bidding. The cost, is from the other hand, gives the seller an idea of how much the item is worth after the auction. They also believe that competition is preferable to negotiation because the buyer sometimes doesn't know the net value of the commodity, they are going to deal for bidding in dealing, whereas in competition, the buyer knows precisely the minimal value at which the object must be sold at auction (Mcafee & Mcmillan, 1996)

2.1.4.Concept of Nash Equilibrium

The Nash equilibrium is a game theory decision-making theorem that argues that if a player sticks to the strategy that they were initially dealing with, they will attain the desired result. John Nash claimed that in the presence of the adversary's actions, an equilibrium arises in which individuals form their best decisions. He claims that a player's best option cannot be improved without considering the adversary's best choice, since each participant is making a reasonable choice and it will only select the most suitable. According to (Muthoo, Osborne, & Rubinstein, 1996) there a few theories which argue that Nash equilibrium as a context relates to the strategic actions that the participants in a game would rather choose.

In order to do so, participants need not presume that all other players are reasonable. They like to concentrate their efforts on statistical information from past game play circumstances, if such evidence is accessible and appropriate. (Muthoo, Osborne, & Rubinstein, 1996) also gave an illustration of a situation in which people buy and sell. A buyer normally only accepts payment with a seller once, or engages with them regularly but anonymously. Each player picks her course of action based on her perceptions of the other players' choices.

2.1.5. Mixed Strategies in Game Theory

(Muthoo, Osborne, & Rubinstein, 1996) argues mixed strategy as a perception shared by all other players about a player's actions. According to (Muthoo, Osborne, & Rubinstein, 1996) in a game, the concept of mixed strategy equilibrium doesn't really inspire the player to incorporate unpredictability in their behaviour. Randomization is usually done on purpose to change the behavior of the other player. Under mixed tactics, (Pindyck & Rubinfeld, 2009) pointed out that there is no Nash equilibrium in game theory. (Pindyck & Rubinfeld, 2009) used matching pennies to further describe mixed strategies. Each participant decides between heads or tails in the game, then both players disclose their coins at the same time. Player one wins if both coins are heads or tails, and player two wins if both coins are heads or tails.

2.1.6. Auctions

Competing in auction was viewed by (Pindyck & Rubinfeld, 2009) through auction markets, which are described as markets where commodities are acquired and traded using systematic auction contracts or biddings. One of the successes of game theory, according to (Turocy & Stengel, 2003) is the design and study of auctions. William Vickrey, an economist, coined the term "auction theory" in 1961. It became even more widely used in the early 1990s, when auctions for radio frequency spectrum for mobile communications earned huge amounts of money. One of most common type of auction, as stated by (Turocy & Stengel, 2003) is the open ascending-bid auction. Within that sort of auction, an item is offered for sale when all the buyers are present. So as long as there are at least two prospective bidders, an auctioneer will boost the pricing of the object. If there's only one prospective bidder left, the auction ends. The object is awarded to the interested bidder at the price at which the last surviving opponent withdraws.

2.1.7. Extensive Games

Extensive games are defined by (Pindyck & Rubinfeld, 2009)as a depiction of available alternatives in a game in the manner of a tree structure. In strategically form games, competitors choose their tactics simultaneously without being informed of the plans chosen by other players. However, in large games, participants can learn about the behaviours of other players over time (Turocy & Stengel, 2003). Because every player gets acquainted of the past decisions of other participants that at a certain point, this is also regarded as under adequate knowledge. It is also said that just one participant operates at a time in order to avoid synchronized motion on a large game. According to (Muthoo, Osborne, & Rubinstein, 1996)this framework enables for game monitoring whereby each participant can examine his course of action not just at start of the match but at any moment in time. The analysis of a strategic game, on the other hand, is limited because each participant picks his way to proceed and get it over with. Extensive games can only explore infinite alternatives, whereas a tactical game does not permit a participant to change his mind once some of the game's events have occurred. A tree diagram can be used to display extensive matches with perfect information, which is why it's also known as a game tree with perfect knowledge.

3. RESEARCH METHODOLOGY

3.1 Research Design

The objective of the research is analysing the various existing literatures and performing or constructing models based on real-life scenarios. The techniques that could be used would certainly form answers for the questions highlighted in the Problem Statement section of the research.

3.2 Game Theory

Game theory draws together multiple aspects such as mathematics, psychology, and philosophy to examine strategic decision-making. John von Neumann and Oskar Morgenstern (Copeland, 1945) invented game theory and it has progressed significantly since then. Comprehending the strategies of game theory, which comprises of both the infamous strategies as well as the ones which are hardly known to consumers, can be proved exceptionally crucial in augmenting one's decision-making abilities and logical thinking.

The framework for cooperation provides a structure, a collection of concepts, and a vocabulary that enables us to characterise a competitive scenario in terms of: (Grant, 2018)

- Who are the participants?
- What are the options available to each player?
- What are the benefits of each choice combination?
- What is the order in which decisions are made?

Prisoner's Dilemma:

When we think about game theory, the first strategy which crosses our minds is the Prisoner's Dilemma. This notion explores into the decision-making technique of two people who, by pursuing in their own best interests, eventually wind up with far worse consequences than if they had worked together in the first place. Two suspects captured for an offence are detained in different rooms and are unable to interact with one another in the prisoner's dilemma. Accused 1 and Accused 2 are each told that if they confess and testify against the other, they would be released, but if they do not comply and the other accused does, they will be condemned to 3 years of imprisonment. Both will be condemned to 2 years of imprisonment if they both confess, and one year in prison when none confesses. Although cooperation is the optimal approach for the suspected criminals, research shows that when faced with a choice, most reasonable people would rather confess and testify against the other than remain quiet and risk the other party confessing.

Matching Pennies:

This game basically involves two competitors (XYZ and ABC) who happen to place a coin or a penny on a desk at the same time, the reward being determined by if or not the pennies match. XYZ wins and takes away the pennies of ABC if both the pennies show 'head and head(HH)' or 'tail and tail(TT)'. ABC wins and takes away the pennies of XYZ if they do not match.

Deadlock:

This dilemma is similar to the concept of prisoner's dilemma in terms of cooperating or not cooperating players. But in this scenario, Competitor X and Competitor Y each get a reward of 10, if both cooperate, and get a reward of 20, if they both defect(do not cooperate). However, if Competitor X cooperates and Competitor Y happens to defect, then X receives a reward of 0 and Y receives a reward of 30. Similarly if Competitor X does not cooperate and Y does, then Y receives a reward of 0 and X receives a reward of 30. The below diagram explains the Deadlock in a better way.

		Competitor Y	
		Cooperate	**Defect**
Competitor X	**Cooperate**	(10,10)	(0,30)
	Defect	(30,0)	(20,20)

Table 2. Deadlock Payoff Matrix

Difference between Prisoner's Dilemma and Deadlock – The best decision that would be favourable in this case is when both defect, which is also termed as the dominant strategy.

Dictator Game:

This is a straightforward game in which Player A must select how to split a $1,000 prize with Player B, who has no say in the matter. While this isn't really a game theory approach, it does offer some fascinating insights on human behaviour. According to studies, around half of the participants keep all of the wealth to themselves, 5% share it evenly, and the remaining 45 percent give the other person a smaller piece. The dictator game is similar to the determined goals and objective, in which Player A is handed a fixed sum of money, a portion of which must be delivered to Player B, who can accept or decline the sum.

Cournot Competition:

This model is like the Prisoner's dilemma as well. It is known as Cournot Model because it was established in 1838 by a French Mathematician named 'Augustin Cournot'.
Let us understand the model with the help of an example.

Consider two firms X and Y which manufacture a similar product and they can produce it in both large or small amounts. Now if both of the firms cooperate and decide to produce in small quantities, the supply will result in a high market price for the product and both the enterprises would yield significant profits. Whereas if they both happen to defect and produce in large quantities, it would result in overburdening of the markets and would yield in a low product price thus making less earnings for both the parties. However, if one of them cooperates (i.e. produces in small amounts) and the another one defects(i.e. strongly produces in large amounts), the first one barely breaks even whereas the latter gets a bigger profit than if they both cooperate.

The profit matrix for both the firms, Firm X and Firm Y is illustrated below. The table depict profit in billions of dollars. If Firm X cooperates and manufactures in small amounts, while Firm Y defects and manufactures in large amounts, the profits would be (0, 9) which breaks even for Firm X and Firm Y receives a profit of $9 billion.

		Firm Y	
		Cooperate	**Defect**
Firm X	**Cooperate**	(7,7)	(0,9)
	Defect	(9,0)	(5,5)

Table 3. Cournot Payoff Matrix

3.2.1. Is game theory useful

The realism of game theory is its greatest asset: it uses good theoretical underpinnings to analyse competition. Nevertheless, theoretical rigour comes at the cost of practical relevance in real-world settings. In idealised settings with few various factors and limited assumptions, game theory delivers thinking. When implemented to more complicated (and realistic) settings, game theory usually produces no or several equilibria, as well as results that are highly susceptible to adverse changes in underlying assumptions. Therefore, game theory has made only modest progress in simulating real-world commercial scenarios in a way that generates actionable strategy recommendations. Game theory is better at understanding what happened in the past than it is at forecasting what will happen in the future. (Grant, 2018)

3.2.2. What are the limitations of game theory?

Even though there are many positive aspects of game theory, it does have limitations as well. Below are some of the limitations of game theory.

1. It is not necessary for players or participants to make strategic decisions at the same time
2. Zero-sum environments are rarely found in strategic decision-making. To put it another way, in many scenarios, each of the actors or participants may benefit in different ways. For example, if India organises an Olympics but does not win a tournament, the country must have obtained other financial benefits such as increased product sales and money from hotel stays and related services.
3. A two-person scenario does not adequately portray the context under which tactical decisions are taken. In most circumstances, the administration or community, at the very least, is a third or fourth party or relevant body that must be taken into account while making strategic decisions.

3.3 Competition Analysis

The monitoring of existing and prospective competitors is part of a continuous process called competition analysis. The idea allows for continuous surveillance of market rivals' behaviour in all essential parts of their operations.

The goal of competition analysis is to gather detailed information on key competitors. That understanding should be as broad as feasible. It should, at the very least, include all significant components of corporate operations. The presenting of findings and incorporation of collected results into the process of gaining competitive advantage is the final aspect of competition analysis. Outcomes can be used to design market entrance strategies, marketing and business strategies, or supply plans, among other things.

What are considered as the most important features while performing Competition analysis? (Competition analysis – definition, scope, common mistakes, n.d.)

Proposal - Prices and product names, descriptions, functions, client feedback, and other details are included in the proposal.

Target Audience - Consumers, partners, and viewers, as well as their qualities, and needs, are all part of the target audience.

Business Models - Expansion strategy, marketing plan, and value proposition are all examples of business models.

Market research and revenue - It encompasses the target group's strategic plan, resources, and platforms.

Financials - financial efficiency model, new investments etc..

Strengths and limitations – In terms of both the business as a whole and every one of its goods and services individually.

Competitive advantages - Unique properties of given products and services are competitive advantages.

4. FINDINGS AND ANALYSIS

4.1 The analysis by Cournot Model

The Cournot Model is used for the Market-based strategy interactions between several firms. The firms are said to be producing two goods which are closely related to each other.
The hypotheses that underpin this model are as follows:

i. There are more than one firm and all of which manufacture and sell a homogeneous product.
ii. Each firm produces the maximum amount while being unaware of its competitors' production decisions.
iii. Each firm's cost of production is zero.
iv. The market forces itself determine the price. There is no such thing as an arbitrary price set by a company.
v. Each firm's goods attract a large number of buyers.
vi. There are fixed number of firms.

We will now analyse the Cournot Duopoly Model. The Cournot Duopoly has two firms controlling a large share of market, and they compete by simultaneously setting their output. Then, the price is determined by the demand.

Question:

Let's look at two chocolate-making companies that are competitors in today's globe. Let's look at some real-life examples. Cadbury and Nestle own a significant portion of the chocolate production sector. The products of each of these companies are identical. $P = 30 – Q$ is the Inverse Market Demand for chocolates (in dollars). Nestle's production cost per unit is $18. Cadbury's production cost per unit is also $18. Let's say Nestle's CEO decides on chocolate output a few hours before Cadbury, but Cadbury is unaware of Nestle's output until they decide on their own. (Choosing at the same time)
How many chocolates does Nestle's CEO need to make? (A Duopoly Example, n.d.)

Solution:

First let us formulate the problem,

Let Nestle be the Firm 1 and Cadbury be Firm 2.
Let strategic substitutes or the quantities produced by Firm 1 and Firm 2 be q_1 and q_2.
The Inverse Demand Function is $P = 30 – Q$, where Q is the total industry output.
Now since this is a Duopoly, $Q = q_1 + q_2$
The Inverse Demand Function becomes,

$$P = 30 – (q_1 + q_2)$$

The Total Costs for Firm 1 and Firm 2 are TC_1 and TC_2

$$TC_1 = 18q_1 \text{ and } TC_2 = 18q_2$$

Compute the Marginal Revenues for both the firms:

The Total revenue of Firm 1, TR_1

$$TR_1 = P.q_1 = (30 – (q_1 + q_2))q_1 = 30 – q_1^2 – q_1q_2$$

The Marginal Revenue of Firm 1, MR_1 is just the partial derivative of the Total Revenue(TR_1) with respect to q_1. Hence,

$MR_1 = 30 - 2\,q_1 - q_2$ (Marginal Revenue of Firm 1)

The Total revenue of Firm 2, TR_2

$TR_2 = P.q_2 = (30 - (q_1 + q_2))q_2 = 30 - q_2^2 - q_1q_2$

The Marginal Revenue of Firm 2, MR_2 is just the partial derivative of the Total Revenue(TR_2) with respect to q_2. Hence,

$MR_2 = 30 - 2\,q_2 - q_1$ (Marginal Revenue of Firm 2)

Compute the profit maximization for both the firms:

Marginal Cost MC_1 of Firm 1 is the derivative of Total Cost of Firm 1 with respect to q_1.

$MC_1 = 18$ (Marginal Cost of Firm 1)

Marginal Cost MC_2 of Firm 2 is the derivative of Total Cost of Firm 2 with respect to q_2.

$MC_2 = 18$ (Marginal Revenue of Firm 2)

Now as we know Profit maximization for both firms requires selecting an output at which the marginal revenue equates the marginal cost,
So $MC_1 = MR_1$, we get,

$18 = 30 - 2\,q_1 - q_2$

$q_1 = (12 - q_2)/\,2$ ……(1) (Reaction function of Firm 1, RF_1)

$2q_1 + q_2 = 12$ ……(2)

$MC_2 = MR_2$, we get,

$18 = 30 - 2\,q_2 - q_1$

$q_2 = (12 - q_1)/\,2$ ……(3) (Reaction function of Firm 2, RF_2)

$q_1 + 2q_2 = 12$ ……(4)

Thus by solving equations (2) and (4) simultaneously, in order to determine the output of Nestle, we get,

$q_1 = 0$

Here we understand that the CEO of Nestle must not produce any chocolates.

As a result, given the rivals' decisions, both businesses utilise their reaction functions to determine profit-maximizing output volumes. However, because the game is played simultaneously, firms are not aware of the competitor's actions. So, how are they going to predict the productivity of their competitors? Each firm is aware that everyone in the market is attempting to maximise profits, or, to put it another way, that each firm will employ its own reaction function. Computing the solution (q_1*, q_2*) of both the firms

Firm 1 will maximise its profit by selecting q_1*, given the value q_2* and firm 2 will maximise its profit by selecting q_2* , given q_1*. Therefore, the pair (q_1*, q_2*) is a Nash equilibrium, which means that no firm has an option to unilaterally deviate. Solve equations (1) and (3) in order to compute the pair (q_1*, q_1*).

In order to make the calculations much easier, let's consider a very simple observation. Because the two companies are identical, q_1* = q_2* must be the case.
Hence we substitute q_1* = q_2* into equation 1 (or 3) we get:

q_1* = (12 - q_1*) / 2 …….. (since q_1* = q_2*)

It thus implies that q_1* = q_2* = 4

By substituting q_1* = q_2* = 4 in the Inverse Demand Equation [(P = 30 – (q_1 + q_2))], we get,

P* = 30 – (q_1* + q_2*) = 30 – (4 + 4) = 22

Therefore the profits are,

PR_1* = P* q_1* - 18 q_1* = 22 * 4 – 18 * 4 = 16
PR_2* = P* q_2* - 18 q_2* = 22 * 4 – 18 * 4 = 16

The profits made by Nestle and Cadbury both are $16.
Further we can perform some modifications in the question and observe the results.

Reconstructing the Question,
Let's take a look at two chocolate-making companies that are competitors in today's globe. Let's look at some real-life examples. Cadbury and Nestle own a significant portion of the chocolate production sector. The products of each of these companies are identical. P = 30 – Q is the Inverse Market Demand for chocolates (in dollars). Let's say Nestle's CEO decides on chocolate output a few hours before Cadbury, but Cadbury is unaware of Nestle's output until they decide on their own. The Marginal Cost of both of the firms used to be $18. But some of the managers in Cadbury depict that if they go through an upgrade, they can lessen their own marginal cost to $10. What should Cadbury do in this case, should they undergo an upgrade or no?

Solution:

Let us formulate the given question,
Let Nestle be the Firm 1 and Cadbury be Firm 2.
Let strategic substitutes or the quantities produced by Firm 1 and Firm 2 be q_1 and q_2.
The Inverse Demand Function is P = 30 – Q, where Q is the total industry output.
Now since this is a Duopoly, Q = q_1 + q_2
The Inverse Demand Function becomes,
P = 30 – (q_1 + q_2)

Let us Find the Nash Equilibrium both when
a) Opting for the upgrade, so the Marginal Costs are MC_1 = 18 and MC_2 = 10
b) Not opting for the upgrade, so the Marginal Costs are MC_1 = 18 and MC_2 = 18

a) To find the Nash Equilibrium while going through the upgrade,
The Inverse Demand Function is P = 30 – (q_1 + q_2)

The Marginal Costs are $MC_1 = 18$ and $MC_2 = 10$

Given q_1, Equating Marginal Cost to Marginal Revenue of Firm 2,

$MC_2 = MR_2$

$10 = 30 - 2q_2 - q_1$

$q_1 = (20 - q_2)/2$ …….(5)

$q_1 + 2q_2 = 20$ …….(6)

Given q_2, Equating Marginal Cost to Marginal Revenue of Firm 2,

$MC_1 = MR_1$

$18 = 30 - 2q_1 - q_2$

$q_2 = (12 - q_1)/2$ …….(7)

$2q_1 + q_2 = 12$ …….(8)

Solving equations (6) and (8) simultaneously, we get,

$q_1 = 0$ we get $q_1 = -8$ but since quantities cannot be negative let us consider it as 0

$q_2 = 8$

Substituting the values of q1 and q2 in the Inverse Demand Function, we get

$P = 30 - q_1 - q_2 = 30 - 0 - 8 = 22$

Considering the Profit Formulas,

$AC_1 = MC_1 = 18$

$AC_2 = MC_2 = 10$

$\pi_1 = (P - AC_1)\, q_1 = (22 - 18)(0) = 0$

$\pi_2 = (P - AC_2)\, q_2 = (22 - 10)(8) = 112$

Thus we understand that Firm 1 makes a profit of 0, where as Firm 2 makes a profit of $112

b) To find the Nash Equilibrium while it does not go through an upgrade,

The Inverse Demand Function is $P = 30 - (q_1 + q_2)$

The Marginal Costs are $MC_1 = 18$ and $MC_2 = 18$

Given q_1, Equating Marginal Cost to Marginal Revenue of Firm 2,

$MC_2 = MR_2$

$18 = 30 - 2q_2 - q_1$

$q_1 = (12 - q_2)/2$ …….(5)

$q_1 + 2q_2 = 12$ …….(6)

Given q_2, Equating Marginal Cost to Marginal Revenue of Firm 2,

$MC_1 = MR_1$
$18 = 30 - 2q_1 - q_2$

$q_2 = (12 - q_1)/2$ …….(7)

$2q_1 + q_2 = 12$ …….(8)

Thus we get q_1 and $q_2 = 0$

Therefore the Profits made by the two firms are 0 respectively,
$\pi_1 = 0$
$\pi_2 = 0$

Thus with the help of the computed profits in both the cases, we can help Firm 2 i.e. Cadbury to decide if it should go under an upgradation or not?

If it undergoes upgrade, the profits of Cadbury are $\pi_2 = 112$
If it does not undergo upgrade, the profits of Cadbury are $\pi_2 = 0$

So the upgradation increased the profits by $112, which is greater than the cost of $18, so Cadbury ***should undergo the upgradation.***

4.2 The analysis by Cartel Model

Let us say both companies unite to join a cartel. The cartel's purpose is to set business output at a level that maximises profit margins. A cartel rule outlines how the business's output and earnings must be distributed among the cartel members. Things are quite straightforward in our scenario. As a result, we can confidently assume that enterprises share earnings and production equally. (A Duopoly Example, n.d.)

The Inverse Demand Function is $P = 30 - Q$
Where Q is the business's total output

Let us calculate the Total Business revenue of both the firms,
$TR = P.Q = (30 - Q)\,Q = 30Q - Q^2$

Now the Business Marginal Revenue is the partial derivative of the Total Business Revenue(TR) with respect to Q, Thus,
$MR = 30 - 2Q$

As we know both the firms have the same Marginal costs (MC = 18). Therefore equating both MC and MR we get,
$MC = MR$
$30 - 2Q = 18$

Thus the profit maximizing business output Q^C is,
$Q^C = 6$

Substituting $Q^C = 6$ in the Inverse Demand Function, we get,

$$P^C = 30 - Q^C = 30 - 6 = 24$$

Hence each of the firm will produce ($Q_1^C = Q_2^C = 3$), thus the profits would be,

$$\pi_1 = P^C Q_1^C - 18 Q_1^C = 24 * 3 - 18 * 3 = 18$$
$$\pi_2 = P^C Q_2^C - 18 Q_2^C = 24 * 3 - 18 * 3 = 18$$

Companies who operate in accordance with the Cournot - Nash prediction make $16 in profit. They both make $18 in earnings when they create a cartel. Is Cartel formation the only reason that the businesses have had profits maximized more than before? No, certainly not. The cartel is inherently unstable since both firms have a strong motive to produce more than what is required by the cartel agreement (i.e., more than 3). To put it another way, the cartel agreement is not a Nash equilibrium and is hence open to unilateral deviations.

To better understand this argument, imagine that Firm 2 makes a credible commitment to create an output $Q_2^C = 3$ in accordance with the Cartel. Given Firm 2's output decision, what is firm 1's profit-maximizing output? We know from the prior research that firm 1 uses its own reaction function to compute the profit-maximizing output. As a result, by putting $Q_2^C = 3$ into firm 1's reaction function, the profit-maximizing output, Q_1', is obtained.

$$Q_1' = (12 - Q_2^C)/2 = (12 - 3)/2 = 4.5$$

Let us substitute the value of Q_1' in the Inverse Demand Equation ($P = 30 - (q_1 + q_2)$),
where $q_1 = Q_1'$ and $q_2 = Q_2^C$
we get,

$$P' = 30 - (4.5 + 3) = 22.5$$

Therefore, the profits made would be,

$$\pi_1' = P'.Q_1' - 18 Q_1' = 22.5 * 4.5 - 18 * 4.5 = 20.25$$
$$\pi_2' = P'.Q_2^C - 18 Q_2^C = 22.5 * 3 - 18 * 3 = 13.5$$

As a result, we may deduce that by manufacturing 4.5 instead of 3, Firm 1 obtains a profit of $20.25 if the cartel is broken, compared to $18 if the cartel is not broken. This demonstrates Firm 1's unilateral incentive to disrupt the cartel. This is true for Firm 2 as well. As a result, cartel would not be the game's payout.

This game can also be illustrated in the form of a table as shown below:

		Firm 2 (Cadbury)	
Firm 1 (Nestle)		**RF2**	**Cartel**
	RF1	(16,16)	(20.25,13.5)
	Cartel	(13.5,20.25)	(18, 18)

Table 4. Payoff Matrix

In the above table, the first number reflects profit for firm 1 and the second, profit for firm 2. Firm 1 chooses rows, while firm 2 chooses columns. It is clear that RF is the prevailing approach for both companies. As a result, (RF1, RF2) is the game's only Nash equilibrium. This is a game similar to Prisoners Dilemma. Higher

payoffs are provided by the pair of actions (Cartel, Cartel) (relative to the Nash equilibrium payoffs). Both players, on the other hand, have an incentive to unilaterally diverge by playing their dominant strategy.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In this research we can conclude that theoretical and numerical illustrations were utilised to illustrate game theory tactics and their applicability to decision-making. The research was successfully able to explain and make one understand the following terms right from the basis of game theory, classification of game or competitive environment, overview and background of game theory, and limitations of game theory. The many types of strategies in game theory, as well as some of their application in decision making, have been demonstrated using suitable ideas and examples.

We can make use of Stackelberg where Cournot lacks behind. The Stackelberg equilibrium is not the same as the Cournot equilibrium. In a Stackelberg equilibrium, one firm, the Stackelberg leader, gets to determine its quantity first, while the other players are Stackelberg followers. Stackelberg equilibrium is distinguished by the fact that one player gets to commit him first.

The Cournot Duopoly model is criticized on the following points:

- Firm X believes that if it changes the quantities produced, qX, Firm Y will not respond by changing its quantity, qY, in Nash Equilibrium.
- The strategy set is specified as quantities, which is a topic of controversy.
- The Nash equilibrium is very different if strategies are prices rather than quantities.
- What happens when one firm's costs are positive but data is lacking?

We've seen how the game theoretic approach can be applied to nearly all dynamic economic decisions at this point. And what of the flaws, though? To begin with, game theory necessitates clearly defined game rules, and there is a tendency to take these rules for granted without questioning where they came from. Second, many games, such as Edgeworth's bilateral bargaining dilemma in cooperative game theory, have several equilibria with no means to select between them. Finally, payoff dependence leads to suboptimal outcomes in many circumstances. This is an example of an externality.

While using Game theory in a decision-making procedure, following are the guidelines in context that are said to be the most important one’s with respect to the research work

1. Calculate a firm's payoffs based on each course of action and its competitor.
2. Determine if the firm and its competitor have a dominant strategy.
3. In the absence of a dominant strategy, a company must make the best estimations feasible about the optimal course of action, as well as its competitor, by locating the Nash equilibrium if possible.

5.2 Recommendations

This research can be proved useful to the upcoming business person having a perfect picture of the marketing conditions in a business that they are looking forward to work with. This study can be proved useful while searching for gaps in a business, thus allowing the analysts to understand the consequences and work on improving the strategies. For example a geographic rival map which can be useful while researching or looking into the gaps of retail and food businesses.
In a competition to launch new product, there is a lot of competition in introducing new features, may it be a cell phone or a television, this research helps in understanding that competition gives birth to product development. Theoretic models like Cournot Model, Stackelberg Model etc. help us to determine the various ways in which the firms or companies can attain maximum profits. The ways can be more than one for example, it is not always necessary that profits are only attained when a firm produces a lot of products, the firm can even decide to not produce the products at all even that might result in the benefits of that firm.
This research can also help us understand the Market trends. It can be useful for gaining the upper-hand when a firm knows exactly when to invest in particular goods and services, making the most of the preferences available.

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