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Game Theory: Prisoner's Dilemma and its applications

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Abstract

The purpose of the study is to understand the basics of game theory and the most widely used game that is the prisoner's dilemma and its application in Indian market.
Game theory involves strategic decision making where the outcome of the game depends on the strategies or moves taken by the each participant called "player".
There are two types of games:
Cooperative game.
Non cooperative game.
In a cooperative game players form a group and aims for joint profit maximisation.
In a non-cooperative game, there is no cooperation among the players of the game. Each player decides on his own strategy to maximise the profit.
The most commonly used game in game theory is prisoner's dilemma. This was developed by Albert W. Tucker, in 1950.
It describes a situation where two suspects have been arrested for a crime, jointly committed by them. However the police men have no direct evidence for the crime. The two prisoners are kept in the two separate cells, so that they cannot communicate with each other. Each suspect is informed that if he does not confess and the other one confesses then his jail term will be for 10 years, while if he does confess the crime then the jail term will be reduced to 5 years. If both of them confess then each prisoner will be jailed for 5 years. However if none of them confesses the crime, then their jail term will be reduced to zero due to lack of information .

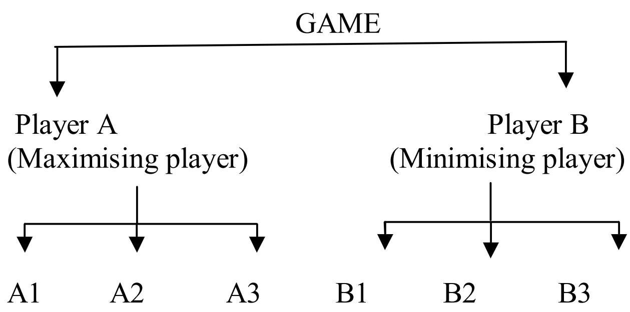
The payoff matrix is as follows:

		Prisoner 2	
		Not confess	*Confess*
Prisoner 1	*Not Confess*	*(0,0)*	*(10,5)*
	Confess	*(5, 10)*	*(5,5)*

Keywords: Game, Players, Strategy, Prisoner's dilemma, Firm.

Introduction

Game theory is a branch of applied mathematics and economics which deal with situations where players choose different actions in an attempt to maximise their returns. The theory was invented by John Von Neumann in 1928. The situations of conflict and competition between two opponents are referred to as a competitive game or simply a game.



Each opponent of the game is called a player. If player A and player B are two opponents in a game, then A1, A2, A3 and B1, B2, B3 are the different strategies , a moves taken by player A and player B respectively.

A strategy is defined as a plan of action that a player of the game will take among the available courses of action. Player A is called the maximising player as his motive is to maximise the profit while player B is called the minimising player since his motive is to minimise the loss.
Now, the possible outcomes of the strategic decision at the end of the game are represented with the help of a payoff matrix.

Let us consider an example to understand the following above terms that are commonly used in a game:

		Player B			
		B1	B2	B3	B4
	A1	4	2	-3	1
Player A	A2	0	-3	4	6
	A3	3	2	2	-2

The meaning of the above pay off matrix is given below:

I. The player A is called maximising player or row player.
II. The player B is called minimising player or column player.
III. In the above matrix player A has 3 strategies (or moves) A1, A2, A3 and the player B has 4 strategies B1, B2, B3, and B4.
IV. When A takes his pure move A1 and B takes his pure move B1, then the gain of the player A is 4 units from B

When A & B take their pure moves A3 & B4 respectively then A's gain is -2 units i.e. losses two units to B.

V. When A & B assume their pure moves A2 and B 1 respectively then A's gain is 0 unit that is there is neither loss nor gain.

The no of rows and columns of the payoff matrix is determined by the no. of strategies of player A &B . If player A has m strategies and player B has n strategies then the order of the payoff matrix is m*n.

Lower value and upper value of a game

$$
\begin{array}{cc}
 & \text{Player B} \\
\text{Player A} &
\begin{array}{cccccc}
a_{11} & a_{12} & a_{13} & \cdots & \cdots & a_{1n} \\
a_{21} & a_{22} & a_{23} & \cdots & \cdots & a_{2n} \\
\vdots & \vdots & \vdots & & & \vdots \\
a_{m1} & a_{m2} & a_{m3} & \cdots & \cdots & a_{mn}
\end{array}
\end{array}
$$

In the above matrix $[a_{ij}]$ m*n
The maximum value for A is max [min a_{ij}]
&minimum for B is min [max a_{ij}]
The maximum value of the game is called the lower value and is denoted by $\underline{v}$ and the minimum value is called the upper value, which is denoted by $\overline{v}$.

- If $\underline{v} = \overline{v} = v$ (say) $\neq 0$, then the game is called strictly determinable game. And if $\underline{v} \neq \overline{v}$ then the game is called none strictly determinable game.
- However, if $\underline{v} = \overline{v} = v$ (say) =0, then the game is called a fair game.

If the value of the game (v) $\neq 0$ then the game is called a biased game.

i. The game is said to be biased towards player A if $v > 0$
ii. The game is said to be biased towards player B if $v < 0$.

Saddle point in a game

A saddle point of a payoff matrix is a position of the matrix where the maximum of the row minima includes with the minimum of the column maxima.

Criteria for existence of a saddle point

If $\underline{v} = \overline{v}$, then we say that the game has a saddle point .
There may exist more than one saddle point in a game but the value of the game is unique.

Data and empirical PRISONER'S DILEMMA: It's Application

In practical situation, the competition between two players in a market arises either due to price or quantity of the products.

Case 1:

Indian e-commerce war from the point of view of Prisoner's dilemma:

Two big e-commerce companies Flipkart and Amazon offer the Big Billion Days sale and the Great Indian Festival sale respectively during the same period. Now let us see how this is related to the prisoner's dilemma.

Flipkart announces the big sale for the specific period of time in order to acquire more and more new customers and retain their existing customers by selling more units to them. Flipkart keeps on proving this sale till it remains the only company doing it.

However, if similar e-commerce sites like Snap deal & Amazon ignore the Flipkart sale then they would not be able to retain their customers. In order to prevent this, others need to announce their big sale which will prevent Flipkart from stealing those existing customers .This is a classic example of Prisoner's Dilemma.

The payoff Matrix is given below:

Other e-commerce sites

		Sale	No sale
Flipkart	Sale	(0.50, 0.50)	(0.56, 0.44)
	No Sale	(0.44,0.56)	(0.50,0.50)

Case 2:

For our study we take two firms- PepsiCo &Coca cola. which are selling the same products but are competitive products .Pepsi and Coke are substitute goods of one another. So the pricing strategy of the companies is the main factor in gaining the market share where prisoner's dilemma plays an useful role.

Most people have brand loyalty towards these two brands of soft drinks in terms of taste or others but for our study we assume that both Pepsi and coke are same products and both the companies are intended to maximise their market share. This can be done if the price of a can of the soft drinks can be changed.

Let us assume that a can of coke or Pepsi costs Rs. 50. Now, if neither of the firms changes the prices of the products then they both will maintain their existing market share.

Now, if both of the companies lower the price by 50%, then it might happen that the companies acquire some new customers due to a lower price of the soft drinks.

Now, a scenario arises where one firm (say Coca cola) lowers its prices but the other firm (say PepsiCo)fails in doing so. This will help Coca cola to fetch more number of customers, thereby increasing the market share. It may also attract new customers due to its cheaper price. Thus, Pepsi loses its market share in this case.

The payoff matrix is given below:

		Coke	
		Cut Prices	Do not Prices
PepsiCo	Cut Prices	(0.50, 0.50)	(0.80, 0.20)
	Do not Prices	(0.20, 0.80)	(0.5 0, 0.50)

Findings

The study consists of two cases: One is the conflict between the e-commerce sites like Flipkart, Amazon and Snap deal regarding the sales offered by them and the other is that of Pepsi and Coke when they cut down the prices.

It is observed that in both the cases, the best option for both PepsiCo and Coca cola is either to cut down the prices simultaneously or to maintain the stable prices which will help both the companies to retain their market share.

In case of the conflict between Flipkart and other e-commerce sites the Amazon, Snap deal etc., if both the firms opt for sale during the same period they are going to have the best payoff, none of them will be able to steal customers and simply retain their individual customers.

Thus, Prisoner's dilemma can be used extensively in an oligopolistic market where two or more firms compete.

Conclusion

The purpose of the study was to investigate how Prisoner's dilemma can be applied to real life business situations. It helps us to know how a balance can be maintained between competitions in a business.

In our study we have seen how two firms, selling similar products compete with each other and aims at maximising their profit. Each firm decides on a pricing strategy and it is observed that when one firm sets a comparatively lower price than the other firm, then it takes away a lot of customers from the rival firm, thereby reducing the profit. Thus the game of prisoner's dilemma has wide application in business.

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