



A NOVEL APPROACH OF THE PRISONER'S DILEMMA IN INDIA'S NAXAL-AFFECTED STATES

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ABSTRACT-

The prisoner's dilemma involving two people and two strategies is now well known. The goal of this study is to begin an examination into the more fascinating multiple-person, multiple-strategy counterpart of the prisoner's dilemma. This research focuses on a multi-player, two-strategy game. It attempts to demonstrate how a traditional game, such as the prisoner's dilemma, is a game with incomplete information and strategies that are not known by everyone. It has been observed that three Indian states affected by Naxalism and facing the same danger of Naxal attacks do not want to join a joint counter-attack.

KEYWORDS-Game, Game theory, non-cooperative game, Classical game, Prisoner's dilemma, Strategy, Prisoner's Dilemma.

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I. INTRODUCTION

On a daily basis, we encounter a diverse range of printed and electronic reports. These papers provide us with information on a diverse array of topics, encompassing politics, society, and the economy. In game theory, a player's decision-making skill is dependent on the actions of other players involved in the game. Game theory encompasses a wide array of logical notions that can be precisely articulated with

minimal mathematical formalism. These concepts are readily available since they are pertinent to the common experiences of humanity as a whole. Game theory is the academic discipline that examines conflict scenarios and the reciprocal impact of decisions made by individuals or groups. [7,8].

A game is a competitive activity or sport in which participants use their skills, strategies, and knowledge to achieve a



desired outcome. There are only so many possible strategies, moves, and rules in a game. Individuals, teams, organizations, and even nations can all play a role in a game. Since everyone in the group is dependent on him or her, every action has repercussions for everyone. Players in a game are represented by a collection of possible outcomes, or tactics, for completing the game in accordance with the rules. Every modern strategy relies heavily on Game Theory, especially when faced with a real-world decision-making circumstance [10]. Another way to look at game theory is as the study of how rules in a competitive situation might decide the ultimate fate of an individual or group. In its mathematical context, the famous English proverb "Tit for Tat" exemplifies game theory. This is why it sounds so dramatic whenever one player gives their opponent the same treatment.

II HISTORICAL BACKGROUND AND INFLUENCE OF GAME THEORY

In 1838, Antoine Cournot provided the oldest known instance of a game-theoretic analysis by examining a duopoly. John von Neumann, a well-known mathematician, published his "theory of parlour games" in 1928. This theory was built upon the formal theory of games proposed by mathematician Emile Borel in 1921. The field of game theory gained recognition as an independent discipline following the release of the seminal book "Theory of Games and Economic Behaviour" in 1944. This influential work was authored by mathematician John von Neumann and economist Oskar Morgenstern [12]. It is possible to trace the origins of contemporary game theory back to this work, which contains the core concepts and problem settings. In the year 1950, John Nash made a statement that indicated that there is a point of equilibrium in every finite game. When this phase arrives, each player makes a decision regarding the best possible move to make in light of the acts taken by their competing player.

The development and enhancement of this fundamental concept have been a primary focus of non-cooperative game theory since its inception. Game theory

was employed in political and military solutions during the 1950s and 1960s, and it was also theoretically expanded during this period. Nash, John Harsanyi, and Reinhard Selten were awarded the Nobel Prize in Economics in 1994 for their advancements in game theory[5]. This honour was bestowed upon them annually. An important application of game theory had emerged by the time the 1990s came to a close, and that was the organisation of auctions. This led to the rapid advancement of game theory. Researchers from all over the world began incorporating it into their own research. Leonid Hurwicz, Eric Maskin, and Roger Myerson were the three recipients of the Nobel Memorial Prize in Economics in 2007. The recipient was recognised for "having established the foundations of mechanism design theory," as indicated in the award's citation. Lloyd S. Shapley and Alvin E. Roth were both granted the Nobel Prize in Economics in 2012[11]. They both contributed to the field under consideration by developing the theory of stable allocations and the practice of market design. According to the citation, the prize was granted "for the practice of market design." Reference was made to the accomplishment in this text. In 2014, Jean Tirole, a game theorist, was awarded the Nobel Prize in Economics.

III. DEFINITIONS

A. Game theory

Game theory is the term used to describe the scientific study of both cooperative and competitive playing methods. It is possible for agents to construct game-theoretic concepts due to the dependency that exists between them. People acting alone, organizations, or enterprises could all fall within this category of actors. It is possible to formalize, analyses, and make sense of strategic situations by employing the vocabulary that is associated with game theory. A 'game' is a concept that can be analyzed within the realm of game theory [4]. The complete set of regulations that govern a game is what defines it. For instance, a play is an illustration of the game. Many people enjoy playing games because of the enjoyment value they provide.

"He/She is playing the game" is a phrase that is occasionally used to describe someone who goes off the deep end in their day-to-day existence. Chess, checkers, football, judo, tic-tac-toe, and squash are all examples of games that involve two players or teams competing against each other.

B. Player, Strategy, and Pay-off

During a game, a "Player" is a participant who is responsible for making decisions and employing strategies. A comprehensive plan of action that delineates the player's response to and management of each event that occurs during the game is referred to as a "strategy" [5]. The term "strategy" refers to a comprehensive plan of action. In this context, the "payoff" is the reward that a player receives for effectively achieving a specific outcome. Payoffs may come in the form of monetary compensation, or they may be the satisfaction that comes from a job well done.

Three key components are present in any game: players, strategies, and payoffs. So, in its most basic form, a game has [1]:

- a) A finite number of players. $P = \{1, 2, 3, \dots, n\}$, i.e. $\{P_1, \dots, P_n\}$
- b) Each player is provided with a collection of strategies known as S_i . The set $\{S_1, \dots, S_n\}$
- c) Players derive advantages from a set of utility/payoff functions: The set $\{U_1, \dots, U_n\}$

C. Different types of games: cooperative and non-cooperative

A cooperative game refers to a situation where the outcomes of negotiations can be turned into a legally binding agreement, and the terms of this agreement can be enforced [2]. A 'non-cooperative game' refers to a game where the participants do not collaborate or cooperate in any manner. The most well-known example of a competitive game that does not include cooperation is rock-paper-scissors.

In a cooperative game, the players are seen as a coalition, and the goal is to achieve a joint payoff that is distributed among the members of the coalition. The representation of this can be achieved through the use of a characteristic function, which assigns a payout

to each coalition of players based on their collaborative efforts. Mathematically, a cooperative game can be denoted as a pair (N, v) , where N represents the set of players and v represents the characteristic function.

The strategic decisions made by each participant determine the outcome of a non-cooperative game, in which players act independently. A matrix is typically employed to represent the game, with each row representing a strategy for one participant and each column representing a strategy for another. The payoff to each player is represented by the entry in the matrix, which is based on the combination of strategies that both players have selected. A reward matrix is a method for modelling games such as the prisoner's dilemma or the hawk-dove game.

D. Zero-sum game and non-zero-sum game

The term "zero-sum game" denotes a game in which the aggregate of all payoffs to the participants is zero. A positive payoff for one player necessitates a positive incentive for another player. Poker, a card game, and chess, a board game, are both instances of games that are considered to be zero-sum games. There is a very low probability that games that take place in the real world are zero-sum [3,4]. A "non-zero-sum game" is a reference to any game in which the payout for a participant is not equal to zero. This is the definition of the word "non-zero-sum game."

A zero-sum game is a type of game where the total payoff for all players is consistently zero. This implies that any advantage gained by one player is always offset by an equal and opposite disadvantage experienced by the competitor. In a zero-sum game, the total sum of payoffs given to each participant is always zero. Payoff matrices are commonly employed to represent these games. A zero-sum game can be mathematically defined as a triplet (N, A, u) , where N represents the set of players, A represents the set of possible actions or strategies, and u represents the reward function that assigns a payoff to each player for each conceivable outcome.

In a non-zero-sum game, the overall payment to all players might be zero, negative, or

positive. This indicates that players may collectively encounter victories or defeats, or a mixture of both. Payoff matrices are commonly employed to represent non-zero-sum games, where the sum of the payouts to all participants is not necessarily zero. A non-zero-sum game can be formally represented as a triplet (N, A, u) , where u is the reward function that assigns a payoff to each player for every feasible outcome, A represents the set of possible actions or tactics, and N denotes the set of players.

IV. PRISONER'S DILEMMA

The Prisoner's Dilemma is widely seen as the quintessential representation of game theory. A prisoner's dilemma is a strategic model used to analyze decision-making, when two rational individuals select options that maximize their personal benefits.[1]. Classical game theorists have been puzzling over this issue for a significant amount of time, but in more recent years, prominent economists and mathematicians have taken a significant amount of interest in the topic. Great mathematicians M. Flood and M. Dresher came up with the contradiction in 1950, but it was Tucker who came up with the modern interpretation [3,7,8]. The prisoner's dilemma

illustrates how, in a setting where cooperation is not possible, even the adoption of a tactic that appears to provide greater promise can ultimately end in less favorable outcomes. It is a game in which the players' strategies are put to the test.

Let us imagine that the police have apprehended two people who are suspected of being involved in a crime. The two suspects are being housed in separate cells and are not permitted to communicate with one another. The officer who is conducting the investigation questions the two people, giving them the opportunity to either remain silent or accuse another suspect. If both suspects admit guilt, their individual maximum sentences will be reduced to a two-year imprisonment term. If they accuse each other, both of them will be sentenced to five years in prison. In the event that one of the suspects levies an accusation against the other for the commission of the crime, and the accused suspect remains silent, the accusing suspect will be subjected to a three-year prison sentence, while the other suspect will be released. The potential benefits are outlined in the following table:

Let us name the suspects as P and Q and we can understand this type of game matrix mentioned below:

Table-1 Original Prisoner's Dilemma

		Q	
		Confess	Not Confess
P	Confess	$(-2, -2)$	$(0, -3)$
	Not Confess	$(-3, 0)$	$(-5, -5)$

The prisoner's dilemma is the oldest and most extensively studied model in game theory. The concept of its solution is likewise the most straightforward. Real-life scenarios akin to the prisoner's dilemma can arise in diverse and captivating circumstances, including arms races, price competition, dispute resolutions with or without legal representation, and numerous more. Every one of these potential outcomes has one thing in common: if everyone works together, there will be a

positive conclusion. However, because no one sees it as being in her own self-interest to act cooperatively, there will be a consequence that is less desired.

V. PURE AND MIXED STRATEGY

Game theory offers a mathematical framework that may be utilized to analyses ways in which players interact strategically with one another. According to this notion, a game is defined by three components: a group of players, a set of strategies available

to each player, and a payoff function that determines the rewards or costs associated with different outcomes of the game.

Players can utilize two distinct ways to make decisions in a game. These strategies can be classified as pure strategies or blended strategies. A pure strategy refers to a singular action that a player chooses in a game, while a mixed strategy involves a probabilistic blend of different pure strategies. A pure strategy refers to a precise and defined action that a player chooses to perform.

The mathematical analysis of pure and mixed strategies entails the computation of predicted payoffs for every player. The anticipated outcome of a pure strategy is the mean reward that a player would obtain if they were to consistently employ that strategy during every round of the game. The anticipated outcome of a mixed strategy is the

Jack's probability of playing rock is p , his probability of playing paper is q , and his probability of playing scissors is $1-p-q$, his expected payoff is:

$$E(\text{Jack}) = p*(-1) + q*(1) + (1-p-q)*(0) \dots\dots\dots (1)$$

Similarly, if Grag plays rock with a probability of r , paper with a probability of s , and scissors with a probability of $1-r-s$, his expected payment may be calculated:

$$E(\text{Grag}) = r*(0) + s*(-1) + (1-r-s)*(1) \dots\dots\dots (2)$$

In order to determine the Nash equilibrium of this game, which refers to the collection of tactics where neither player has a motivation to depart from their chosen strategy, we need to solve for the values of p , q , r , and s that maximize both players' expected payoffs simultaneously. This can be done using various mathematical techniques, such as linear programming or calculus.

VI. THE NAXAL ISSUE IN THREE INDIAN STATES

The Naxalite problem in Chhattisgarh, Jharkhand, and Odisha is a complex and long-standing issue that has been a challenge for the Indian government for many years. The Naxalite movement, commonly referred to as the Maoist insurgency, aims to depose the Indian government and establish a socialist state. The movement predominantly operates in rural and wooded regions of these states and has been accountable for a substantial number of violent occurrences, such as assaults on security forces, government infrastructure, and citizens.[6].

Chhattisgarh has been the epicenter of Naxalite activity, with the southern parts of the state being the most affected. The Bastar

mean payout that a player would obtain if they were to randomly choose pure methods based on the probability indicated by their mixed strategy[9].

To demonstrate this concept mathematically, we will examine the game of Rock-Paper-Scissors. Consider a scenario where there are two participants, Jack and Grag, who have the option to select between rock, paper, or scissors for the game. In the event where both players select the identical move, the game results in a tie, and each player is awarded a payment of 0. In the event that one player's move triumphs over the other player's move (rock triumphs over scissors, scissors triumph over paper, paper triumphs over rock), the victorious player is rewarded with a payout of 1, while the defeated player is penalized with a payoff of -1.

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region, which comprises seven districts, has seen the most violent clashes between the government forces and the Naxalites. Jharkhand, which borders Chhattisgarh, is also heavily affected by the Naxal issue, with the eastern parts of the state being the most affected. The districts of Latehar, Palamu, and Garhwa have seen the most intense Naxalite activity. Odisha, which borders both Chhattisgarh and Jharkhand, has also been affected by the Naxal issue, with the southern parts of the state being the most affected. The districts of Malkangiri and Koraput have seen the most Naxalite activity

VII. A NOVEL APPROACH TO PRISONER'S DILEMMA

The three Indian states affected by Naxalite insurgency are Odisha, Jharkhand, and

Chhattisgarh. Each of the three states frequently encounters the threat of Naxal attacks, and they must collectively decide whether or not to implement a dynamic counter-Naxal free mission (NFM). All three states have two choices: they can either go it alone or go it with NFM. Let's say that the cost of making a state free of Naxals is \$50 and the

gain is \$20. If all states go for NFM on their own, they all get a gain of $-10(50-3 \times 20)$. Even if the other two states stay neutral, if one of the three states goes to the NFM on its own, it will get benefit $-30(20-50)$, while the other two states will only get benefit -20 . The Prisoner's Dilemma says that there is no state that wants to join the joint NFM.

Case 1:

If Jharkhand decides to NFM alone –

Table- 2 Prisoner's Dilemma

	Chhattisgarh		
		NFM alone	NFM joint
Odisha	NFM alone	$(-10, -10, -10)$ O C J	$(-30, 20, -30)$ O C J
	NFM joint	$(20, -30, -30)$ O C J	$(20, 20, -30)$ O C J

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Here, O- Odisha, C-Chhattisgarh, J-Jharkhand

NFM alone –Naxal Free Mission alone attack

NFM joint - Naxal Free Mission joint attack

Case 2:

If Jharkhand decides to NFM joint –

Table- 3 Prisoner's Dilemma

	Chhattisgarh		
		NFM alone	NFM joint
Odisha	NFM alone	$(-30, -30, 20)$ O C J	$(-30, 20, 20)$ O C J
	NFM joint	$(20, -30, 20)$ O C J	$(0, 0, 0)$ O C J

Here, O- Odisha, C-Chhattisgarh, J-Jharkhand

NFM alone –Naxal Free Mission alone attack

NFM joint - Naxal Free Mission joint attack

Thus, it follows that no state dares to join in NFM joint attack.

VIII. CONCLUSION

Game theory is fascinating because, although having very straightforward concepts, it can be used in a wide variety of contexts. Over the

course of the last few decades, it has made a number of previously unavailable paths available. It is now possible to model it and make accurate predictions because it has



been put into practice in all spheres of life. The prisoner's dilemma is a renowned conundrum in the realm of game theory. Based on our research, the game of prisoner's dilemma is characterised by undisclosed game strategies and insufficient knowledge. In the game of the prisoner's dilemma, it is obvious that the strategies employed by the other players are unknown, whereas the choice space is obvious. In this game, our aim is to minimise the amount of unknown information while simultaneously increasing our expected return on investment. We also found that the applications of the Prisoner's Dilemma to the Naxal issue in India's Naxal-affected states highlight the importance of cooperation, trust, and compromise in resolving complex conflicts. By understanding the incentives and strategies of the different players involved, and by finding ways to break out of the cycle of violence and retaliation, it may be possible to achieve a more peaceful and stable resolution to this long-standing conflict.

CONFLICT OF INTEREST

The authors have verified that there are no conflicts of interest to disclose for this publication.

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