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**Vladimir PETKOVSKI*)**

# GAME THEORY- PREFERENCES AND SPECIFICATION ON DIFFERENT TYPES OF GAMES

**Abstract**

The concept of game theory is to study the actions of several independent agents in a given situation, which can be resolved with a conflict or cooperation. These agents may be individuals, groups, firms, or any combination of these. Game theory is a tool for analyzing different types of decision in a previously given situation in which a choice must be made by the players if they want to benefit from the game.

Game theory is a mathematically founded tool for analyzing and predicting a possible outcome based on the decisions of rationally involved players. The base of the game theory as stated before is the decision. Finding the way to track, analyze and structure the true definition of a decision made by an individual or group in a given surroundings is a primary goal of the game theory. Its efforts as presented in this article include a variety of strategic challenges and different methods of resolving each one of them always concerning the rational game play and benefit cravings from the players.

**Key words:** game theory, strategy, Nash equilibrium, dominance, games, decision, payoffs, players.

*) M.sc. Integrated Business Faculty, Skopje E-mail:vlatkopet@yahoo.com

## 1. DEFINITIONS OF GAMES

The object of study in game theory is the *game*, which is a formal model of an interactive situation. It typically involves several *players*; a game with only one player is usually called a *decision problem*[1] .

Games can be divided into cooperative and no cooperative. *Cooperative game* specifies the benefits that players gain from mutual cooperation. In contrast, *no cooperative game* deals with more individual approach i.e. the players choose their maximum benefit regarding the situation and in the process don't care about the outcome of the other players. Yet all types of games have one thing in common, and that is the concept of rationality. The concept of rationality states that players always choose an action which gives the outcome he most prefers, given what he expects his opponents to do. The goal of the game theory is to predict the outcome when played by rational opponents and according to the prediction define the most payable strategy in certain situation.

The *strategic form* (also called normal form) is the basic type of game in no cooperative game theory. A game in strategic form lists each player's strategies and the outcomes the result from each possible combination of choices[2] . The benefit form each outcome is measured by the payoff and liking from the player. Often games that are more complex and strategically more dependent are shown in a game three, and rules of engagement and choice consideration are also stated.

## 2. DOMINANCE

Players always make rational choices according to the doing of their opponents. When one choice (let's call it a strategy) has better outcome for another choice for a certain player it's called a dominant strategy for that player. A rational player will never choose a strategy that that it's not dominant for him if he gains more benefit from a dominant strategy.

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1) Emmanual N. Barron, "Game theory: an introduction", John Wiley & Sons, Inc., 2008, pg 3-4

2) James N. Webb, "Game theory: decisions, interactions and evolution" , Springer, 2007, pg.32

### *Prisoner dilemma*

The prisoner's dilemma is a game in strategic form between two players. Each player has two strategies, called "cooperate" and "defect". The story behind the game prisoner's dilemma is that of two prisoners held suspect of a serious crime. There is no judicial evidence for this crime except if one of the prisoners testifies against the other. If one of them testifies, he will be rewarded with immunity from prosecution (payoff 3), whereas the other will serve a long prison sentence (payoff 0). However if they both cooperate with each other by not testifying at all, they will only be imprisoned briefly (payoff 2 for each). The defection for them mutually beneficial outcome is to testify, which gives a higher payoff no matter what the other prisoner does, with a resulting lower payoff to both. This constitutes their dilemma.

**Picture 1: Prisoner dilemma**[3)]

| Prisoner | B.Cooperate | B.Defect |
|---|---|---|
| A.Cooperate | 2<br>2 | 3<br>0 |
| A.Defect | 0<br>3 | 1<br>1 |

Picture 1 shows the payoffs in the game. Player A chooses a row, either Cooperate or Defect, and so does player B. According to the playable strategy that they each player has chosen certain payoffs are immanent. In this case the best possible choice for strategy will always be the choice to cooperate by both side, thus here the total beneficiary payoff for both sides is maxed. But the rational game play states that the strategy with payoffs (1; 1) will be chosen because each player will chose the part for his dominating chance i.e. part to defect. Therefore a much bigger beneficiary effect (according to the payoffs 2 and to) is alluded in order to have a chance to dominate a game. Somewhat paradoxically, the players will always have to satisfy with less (1; 1) instead (2; 2) if they tend and in most cases will play rationally.

3) Origins: Author

### *Nash equilibrium*

The central concept of Nash equilibrium recommends a strategy to each player that the player cannot improve upon by himself unless other players follow his recommendation. Since the other players are also rational, it is reasonable for each player to expect his opponents to follow the recommendation as well.

If a game has more then one Nash equilibrium, a theory of strategic interaction should guide players towards the most reasonable equilibrium upon which they should focus. However, it's easier to see this game outcome when observing the game rather than playing. Still it the end this abstract theory game model states that the players will eventually manage to play towards the best possible equilibrium i.e. Nash equilibrium.

### *Evolutionary games*

The Nash equilibrium differs when applied to a large number of players. Equilibrium can be viewed as the outcome of a dynamic process rather then conscious rational analysis, this is called the bandwidth choice game.

Picture 2 shows a game where each player has two strategies High and Low. The main difference between this game and the game in picture 1 is the bigger payoff difference when the same strategy is called by the players. This is called a bandwidth game.

**Picture 2: The bandwidth choice game**[4]

| Prisoner | B.High | B.Low |
|---|---|---|
| A.High | 5<br>5 | 1<br>0 |
| A.Low | 0<br>1 | 1<br>1 |

The assumption of this game is that in a large population of players one's who will be chosen to play will not always be as rational and sophisticated as theory expects. This indicates that the experience of the most beneficiary choice will apply and players will evolve in their decisions always choosing the High strategy. The concept

4) Origins: Author

of this game is that more successful strategies will be used more frequently by the players and in the end will become more beneficiary and prevail. This is called an evolution.

## 3. MIXED STRATEGIES

Equilibrium is defined by a strategy for each player where no player can gain more than average payoff. But a game need not to have equilibrium depending on payoff's offered by to the players. However the outcome of the strategy is still determined by the players and their decisions which all randomed with certain probability.

Suppose a gambler goes to casino, agreeing to follow the house rules. The gambler has an incentive to violate the house rules. The manager of the casino would like to verify that the gambler is abiding by the agreement to respect the house rules, but doing so requires inspections which are costly (can decrease the casino's reputation. If the manager does inspect and catches the gambler cheating, the manager can demand a large penalty payment for noncompliance.

**Picture 3: Mixed strategy game** [5)]

| Players | 2.Don't cheat | 2.Cheat |
|---|---|---|
| 1.Don't Inspect | 0<br>0 | 50<br>-50 |
| 1.Inspect | 0<br>-10 | -100<br>-5 |

Picture 3 shows possible payoffs for such a game. The standard outcome, the reference payoff zero for both the manager of the casino (player 1) and the gambler (player 2) is that the manager chooses not to inspect and the gambler chooses to play by the rules. Without the inspection, the gambler prefers to cheat since that gives him payoff 50, with resulting negative payoff for the casino manager of -50. The casino manager may also decide to inspect. If the gambler does not cheat, inspection leaves him payoff 0 unchanged, while the manager incurs a cost result in a negative payoff -10. If the gambler cheats, however, inspection will result in a heavy penalty (payoff -100 for player 2) and still create a certain amount of hassle for player 1(payoff -5).

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5) Origins: Author

In all cases, player 1 would strongly prefer if player 2 didn't cheat, but this is outside of player's 1 control. However the manager prefers to inspect if the gambler cheats (since -5 is better then -10). If the manager always prefers not to inspect, then this would be dominating strategy and be a part of equilibrium where the gambler cheats. The circular arrow structure in Picture 3 shows that this game has no equilibrium in pure strategies. If any of the players settles on deterministic choice (like not to inspect by player 1), the best response of player 2 will be unique (here cheat), to which the original choice would not be the best response (player 1 prefers to inspect when the player 2 chooses to cheat, against which player 1 in turn prefers to comply) therefore we can conclude that this game has no equilibrium in pure strategies.

***Mixed equilibrium***

What should the players do in the game of picture 3? One possibility is to prepare for the worst that is the choice called max-min strategy. A max-min strategy maximizes the player's worst payoff against all possible choices of the opponent[6]. The max-min strategy for player I is to inspect (where the manager guarantees himself payoff -5), and for player II is to comply (which guarantees the gambler payoff 0). However, this is not Nash equilibrium, since player I could switch his strategy and improve his payoff. A mixed strategy of player I is to inspect only with a certain probability. In the context of inspection, randomizing is also a practical approach that reduces cost. Even if an inspection is not certain, a sufficient high chance of being caught should distant the gambler from cheating, at least to some extent.

## 4. EXTENSIVE GAMES WITH PERFECT INFORMATION

There is no temporal component in games in strategic form. The assumption that in this game there is no temporal component means that the players choose their actions simultaneously, regarding any knowledge about the choices of the other participants. Extensive game is a more detailed model of a game tree. This section treats games of perfect information. In a game of perfect information, every player is at any point aware of the previous choices of all other players. Furthermore, only one player moves at a time, so that there are no simultaneous moves. A game where all the choices that we make are known to our competitor (other players) is known as a game of perfect information. In this game there is no simultaneous movement or, simultaneous making decisions, only one player moves at a time. Therefore all the necessary information about other players and their decisions is known when it comes the time for us to make one.

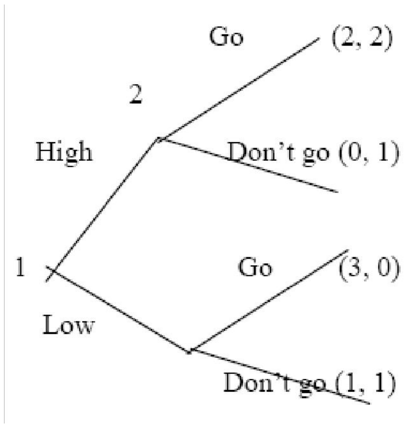
Picture 4 shows a perfect information game which is presented through a game tree. Every branching point, or node, is associated with a player who makes a move

[6] Hossein Bidgoli, "Encyclopedia of information systems" Volume 2, Academic Press, 2003, pg. 410

by choosing the next node. The connecting lines are showing the player's choices. The game starts at the initial, the root of the tree and ends at a terminal node, which establishes the outcome and determines the player's payoffs. Game trees can be drawn horizontally or vertically.

The travel manager provider, player 1, makes the first move, choosing High or Low quality for the destination and accommodation. Then the customer, player 2, is informed about that choice. Player 2 can then decide between going and not going to this vacation. The resulting payoffs are the same as in picture 1. However the game is different from the one in picture 1, since the players now move in a sequence rather then simultaneously.

**Picture 4: Game tree**




If we firstly considered the last possible choices of this perfect information game then the game can be analyzed by backward induction. Here, player 2 moves last and therefore can select the best action for him. If player 1 has chosen to provide High quality accommodation and destination, then the customer will surly prefer to go, since her resulting payoff of 2 is larger then 1 when not going. If the travel manager has chosen Low, then the customer prefers not to go on the vacation.

It can be clearly stated that in these case we are experiencing a phenomena called the first mover advantage also known as Stackelberg leadership by the economist who formulated it. A player in a game becomes a first mover or leader when he can commit to a strategy, that is, choose a strategy irrevocably and inform the other players about it[7)]. The first mover advantage states that if there is a chance in any kind of game that the player can become a leader he will always do so.

7) Hossein Bidgoli, "Encyclopedia of information systems" Volume 2, Academic Press, 2003, pg. 418

In example seen in picture 5 presumes that the market for producing sandwiches is dominated by two producers. The firms can choose to produce certain quality of sandwiches, say either high, medium, low, or none at all, mark by H, M, L, N for firm I and h, m, n, 1 for firm 2. As economic theory states with increasing the total quality produced by both companies the market price of the sandwiches will fall. In these case the prices can fall as low as zero. The firms are familiar with this situation and know the consequences. Picture 5 shows the game and its payoffs.

In picture 5 no production is dominated by low or medium production, so that row N and column n can be eliminated. Then high production is dominated by medium production, so that row H and column h can be also left out. At this point, only medium and low productions of sandwiches remain. In picture 5 medium is better to produce for both firms therefore, the Nash equilibrium of the game is (M, m), where both firms make a profit of 16. In this case a first mover advantage is also a possibility depending on the commitment on player 1 and the anticipation on player 2.

**Picture 5: Duopoly game [8)]**

| Firms | h | m | l | n |
|---|---|---|---|---|
| H | 0<br>0 | 8<br>12 | 9<br>18 | 0<br>36 |
| M | 12<br>8 | 16<br>16 | 15<br>20 | 0<br>32 |
| L | 18<br>9 | 20<br>15 | 18<br>18 | 0<br>27 |
| N | 36<br>0 | 32<br>0 | 27<br>0 | 0<br>0 |

8) Hossein Bidgoli, "Encyclopedia of information systems" Volume 2, Academic Press, 2003, pg. 419

## 5. ZERO-SUM GAMES AND COMPUTATION

The extreme case of players with fully opposed interests is embodied in the class of two player zero-sum (or constant sum) games. Familiar examples range from rock-paper-scissors to many parlor games like chess or checkers.[9)]

The natural device for zero-sum games which also include imperfect information is considered to be the mixed strategy. One's vulnerability against malicious responses is reduced by leaving one's actions open.

The concept of demonic no determinism is explained and modeled by zero-sum games. This concept is based on the assumption that the worst possible sequence will take place, when there is no order of events which is supposed to be specified. This randomization in which the players will play would result in a worst case scenario that later can serve as a benchmark.

### Conclusions

Game theory is a very significant economic model of today's strategically thinking and developing. Although the principals are simple the applications are far reaching. Decisions for cooperation and competition are potentially included in every setting on day to day basis by the self-interested agents. Therefore Game theory is based on different layers of strategic decisions, which lead to the most rational solution in a given situation. It can be used to decline or accept proposed statements by the others or to design credible commitments.

Today game theory finds it's usage in different fields of decision making process. Through modern politics, and economic issues to warfare and every day decision, a simple or more complicated situation searches for good defined strategy in order to accomplish our goals. These types of strategic decision and the influence they bring can not be imagined without a well based strategy one provided by a well thought game-play provided by the principals of the game theory.

9) Hossein Bidgoli, "Encyclopedia of information systems" Volume 2, Academic Press, 2003, pg. 417

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