

Game Theory

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Reviewed by Adam Hayes

What is Game Theory?

Game theory is a theoretical framework for conceiving of social situations among competing players. In some respects, game theory is the science of strategy, or at least the optimal decision-making of independent and competing actors in a strategic setting. The key pioneers of game theory were mathematicians John von Neumann and John Nash, as well as economist Oskar Morgenstern.

[Important: As with any concept in economics, there is the assumption of rationality. There is also an assumption of maximization. It is assumed that players within the game are rational and will strive to maximize their payoffs in the game.]

The Basics of Game Theory

The focus of game theory is the game, which serves as a model of an interactive situation among rational players. The key to game theory is that one player's payoff is contingent on the strategy implemented by the other player. The game identifies the players' identities, preferences, and available strategies and how these strategies affect the outcome. Depending on the model, various other requirements or assumptions may be necessary.

Game theory has a wide range of applications, including psychology, evolutionary biology, war, politics, economics, and business. Despite its many advances, game theory is still a young and developing science.

Game Theory Definitions

Any time we have a situation with two or more players that involves known payouts or quantifiable consequences, we can use game theory to help determine the most likely outcomes. Let's start out by defining a few terms commonly used in the study of game theory:

- *Game*: Any set of circumstances that has a result dependent on the actions of two or more decision-makers (players)
- *Players*: A strategic decision-maker within the context of the game
- *Strategy*: A complete plan of action a player will take given the set of circumstances that might arise within the game
- *Payoff*: The payout a player receives from arriving at a particular outcome. The payout can be in any quantifiable form, from dollars to utility.
- *Information set*: The information available at a given point in the game. The term information set is most usually applied when the game has a sequential component.
- *Equilibrium*: The point in a game where both players have made their decisions and an outcome is reached.

The Nash Equilibrium

Nash Equilibrium is an outcome reached that, once achieved, means no player can increase payoff by changing decisions unilaterally. It can also be thought of as "no regrets," in the sense that once a decision is made, the player will have no regrets concerning decisions considering the consequences.

The Nash Equilibrium is reached over time, in most cases. However, once the Nash Equilibrium is reached, it will not be deviated from. After we learn how to find the Nash Equilibrium, take a look at how a unilateral move would affect the situation. Does it make any sense? It shouldn't, and that's why the Nash Equilibrium is described as "no regrets." Generally, there can be more than one equilibrium in a game. However, this usually occurs in games with more complex elements than two choices by two players. In simultaneous games that are repeated over time, one of these multiple equilibria is reached after some trial and error. This scenario of differing choices over time before reaching equilibrium is the most often played out in the business world when two firms are determining prices for highly interchangeable products, such as airfare or soft drinks.

Impact on Economics and Business

Game theory brought about a revolution in economics by addressing crucial problems in mathematical economic models. For instance, neoclassical economics struggled to understand entrepreneurial anticipation and could not handle imperfect competition. Game theory turned attention away from steady-state equilibrium toward the market process.

In business, game theory is beneficial for modeling competing behaviors between economic agents. Businesses often have several strategic choices that affect their ability to realize economic gain. For example, businesses may face dilemmas such as whether to retire existing products or develop new ones, lower prices relative to the competition, or employ new marketing strategies. Economists often use game theory to understand oligopoly firm behavior. It helps to predict likely outcomes when firms engage in certain behaviors, such as price-fixing and collusion.

Types of Game Theory

Although there are many types (e.g. symmetric/asymmetric, simultaneous/sequential, et al.) of game theories, cooperative and non-cooperative game theories are the most common. Cooperative game theory deals with how coalitions, or cooperative groups, interact when only the payoffs are known. It is a game between coalitions of players rather than between individuals, and it questions how groups form and how they allocate the payoff among players. Non-cooperative game theory deals with how rational economic agents deal with each other to achieve their own goals. The most common non-cooperative game is the strategic game, in which only the available strategies and the outcomes that result from a combination of choices are listed. A simplistic example of a real-world non-cooperative game is Rock-Paper-Scissors.

Key Takeaways

- *Game theory is a theoretical framework for conceiving of social situations among competing players and producing optimal decision-making of independent and competing actors in a strategic setting.*
- *Using game theory, real-world scenarios for such situations as pricing competition and product releases (and many more) can be laid out and their outcomes predicted.*
- *Game theoretic scenarios include the prisoner's dilemma and the dictator game, among many others.*

Game Theory Examples

There are several 'games' that game theory analyzes. Below, we will just briefly describe a few of these.

The Prisoner's Dilemma

Prisoner's Dilemma is the most well-known example of game theory. Consider the example of two criminals

arrested for a crime. Prosecutors have no hard evidence to convict them. However, to gain a confession, officials remove the prisoners from their solitary cells and question each one in separate chambers. Neither prisoner has the means to communicate with each other. Officials present 4 deals, often displayed as a 2x2 box.

1. If both confess, they will each receive a 5-year prison sentence.
2. If prisoner 1 confesses but prisoner 2 does not, prisoner 1 will get 3 years and prisoner 2 will get 9 years.
3. If prisoner 2 confesses but prisoner 1 does not, prisoner 1 will get 10 years and prisoner 2 will get 2 years.
4. If neither confesses, each will serve 2 years in prison.

The most favorable strategy is to not confess. However, neither is aware of the other's strategy and without certainty that one will not confess, both will likely confess and receive a 5-year prison sentence. The Nash equilibrium suggests that in a prisoner's dilemma, both players will make the move that is best for them individually but worse for them collectively.

'Tit for tat' has been determined to be the optimal strategy for optimizing a prisoner's dilemma. Tit for tat was introduced by Anatol Rapoport, who developed a strategy in which each participant in an iterated prisoner's dilemma follows a course of action consistent with his opponent's previous turn. For example, if provoked, a player subsequently responds with retaliation; if unprovoked, the player cooperates.

Dictator Game

This is a simple game in which Player A must decide how to split a cash prize with Player B, who has no input into Player A's decision. While this is not a game theory strategy *per se*, it does provide some interesting insights into people's behavior. Experiments reveal about 50% keep all the money to themselves, 5% split it equally and the other 45% give the other participant a smaller share. The dictator game is closely related to the ultimatum game, in which Player A is given a set amount of money, part of which has to be given to Player B, who can accept or reject the amount given. The catch is if the second player rejects the amount offered, both A and B get nothing. The dictator and ultimatum games hold important lessons for issues such as charitable giving and philanthropy.

Volunteer's Dilemma

In a volunteer's dilemma, someone has to undertake a chore or job for the common good. The worst possible outcome is realized if nobody volunteers. For example, consider a company where accounting fraud is rampant but top management is unaware of it. Some junior employees in the accounting department are aware of the fraud but hesitate to tell top management because it would result in the employees involved in the fraud being fired and most likely prosecuted.

Being labeled as a whistleblower may also have some repercussions down the line. But if nobody volunteers, the large-scale fraud may result in the company's eventual bankruptcy and the loss of everyone's jobs.

The Centipede Game

The centipede game is an extensive-form game in game theory in which two players alternately get a chance to take the larger share of a slowly increasing money stash. It is arranged so that if a player passes the stash to his opponent who then takes the stash, the player receives a smaller amount than if he had taken the pot. The centipede game concludes as soon as a player takes the stash, with that player getting the larger portion and the other player getting the smaller portion. The game has a pre-defined total number of rounds, which are known to each player in advance.

Limitations of Game Theory

The biggest issue with game theory is that, like most other economic models, it relies on the assumption that people are rational actors that are self-interested and utility-maximizing. Of course, we are social beings who do cooperate and do care about the welfare of others, often at our own expense. Game theory cannot account for the fact that in some situations we may fall into a Nash equilibrium, and other times not - depending on the social context and who the players are.

[Fast Fact: 20 game theorists have been awarded the Nobel Memorial Prize in Economic Sciences for their contributions to the discipline.]