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Game Theory

Game theory is a branch of mathematics concerned with the analysis of the behavior of decision makers (called "players") whose choices affect one another.

An important distinction exists between the disciplines of individual and interactive decision making. Individual decision making, whether under certainty or uncertainty, leads to well-defined optimization problems, like maximizing an objective function (e.g., expected utility) subject to certain constraints. While these problems may be difficult to solve in practice, they involve no conceptual issues. Once the objective function is specified, the meaning of "optimal decision" is clear (even when actual behavior, for one reason or another, is not optimal). In interactive decision making, the meaning of "optimal decision" is unclear, because no player completely controls the final outcome of the interaction. A formal analysis of interactive decision making must address the conceptual issue of defining the problem before providing procedures for solving it. Game theory is concerned with both matters. It defines solutions, known as "solution concepts", to various classes of interactive decision making situations which appear in various areas of application and then investigates their properties and provides procedures for their computation.

The theory was first introduced as a scientific discipline by von Neumann and Morgenstern in their monumental book Theory of Games and Economic Behavior. It has seen rapid expansion in the last twenty years or so. The largest single area of application of game theory has been economics; many modern textbooks in microeconomics and most of the journals in this discipline present or discuss game theoretical models in one form or another. Other important areas of application include political science (e.g., voting systems, power, international relations), social psychology (e.g., two-person bargaining, social dilemmas, coalition formation), sociology, evolutionary biology, accounting, marketing, computer science, law, and branches of philosophy such as ethics and epistemology. As is the case with many branches of mathematics, the relation between theory and applications has been two-sided: the theory has helped to structure interactive decision making situations in these disciplines, understand their logic, prescribe rational solutions, and occasionally account for empirical phenomena and experimental findings, whereas experimental findings and applications have posed new questions and introduced new challenges that have led to new interpretations of existing concepts and additional theoretical developments.

Game theory may be viewed as a sort of umbrella theory for interactive behavior in the social sciences, where "social" is interpreted very broadly to

include human beings as well as other kinds of players (collectives such as corporations and nations, animals, plants, computers, etc.). Only the essential aspects of the interactive situation are discussed and formally analyzed rather than the entire situation with its peculiarities, ambiguities and subtleties, and as such can be applied in principle to all interactive situations.

These essential aspects typically include the following: There must be at least two players whose decisions affect each other. The game begins by one or more players making a choice (called "move") among a number of specified alternatives. Following that, a certain situation results determining which player makes the next move and what alternatives are open to her. The choices made by some or all of the players may or may not become known; therefore, when she has to make a choice, the information each player has about the previous choices of all other players must be specified. There is a termination rule determining when the possible plays of the game are completed. Finally, each situation defining an end of a play determines a payoff to each of the bona fide players. The game allows for chance moves by Nature (uncertainty), but if Nature intervenes in the game, it is considered a dummy player in the game deriving no payoff.

Solution concepts are divided in terms of a basic distinction between cooperative games, where agreements, promises, and threats are fully binding and enforceable, to noncooperative games where commitments, even when reached by pre-play communication, are not enforceable. The noncooperative approach focuses on the strategic choices of players—how they play the game and what strategies they choose to achieve their objectives. It is, therefore, intimately concerned with and strongly influenced by the details of the interactive process and the rules governing the game. In contrast, the cooperative approach focuses on the options available to the group of players—what coalitions form and how their members disburse their joint payoff.

The basic solution concept for noncooperative games is the Nash equilibrium. A vector of strategies—one for each player—is a Nash equilibrium if no player has an incentive (in terms of improving his payoff) to deviate from his part of the strategy vector. What makes Nash equilibrium a natural solution concept is the fact that any prediction about the outcome of a noncooperative game is self-defeating if it specifies an outcome that is not a Nash equilibrium. Nash proved the existence (but not uniqueness) of at least one equilibrium for every game with a finite number of strategies for each player. Subsequent research has attempted to eliminate equilibria that rely on noncredibe threats by "refining" the notion of Nash equilibrium, has explored alternative interpretations of Nash equilibria for games played repeatedly by players who are not necessarily "rational" and who need not know the structure of the game, and has started to execute the "Nash program" which calls for reformulating cooperative games as noncooperative ones and then solving for their equilibria.

Social psychology has borrowed many of the basic concepts of game theory (e.g., payoff matrix, pure and mixed strategies, equilibrium) in order to construct theories of social interaction and design experiments to test them. Early experiments were mostly concerned with two-person zerosum games, where the interests of the two players are diametrically opposed, and with two-

person nonzerosum games such as the Prisoner's Dilemma and Chicken, which include outcomes that are preferred to other outcomes by both players. Subsequent research has shifted the focus to assess the descriptive power of various solution concepts in the areas of bargaining , social dilemmas, and coalition formation. However, most of the experimental research in the last twenty years or so on interactive behavior has been conducted outside of psychology within the rapidly growing discipline of experimental economics.

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HYPERTEXT TERMS (for the item "Game Theory" by Rapoport and Zwick)

Cooperative games
Experimental economics
Game theory
Individual decision making
Interactive decision making
Nash equilibrium
Nash program
Non zero sum games
Noncooperative games
Objective function
Prisoner's Dilemma
Solution concepts
Theory of Games and Economic Behavior
Utility
von Neumann and Morgenstern
Zero sum games