G

game theory

The theory of games is a branch of mathematics devoted to the study of interdependent decision making. It applies to any social situation in which there are two or more decision makers, called *players*, each with a choice of two or more courses of action, called *strategies*; the outcome depends on the strategy choices of all the players; and each player has well-defined preferences among the possible outcomes, so that numerical payoffs reflecting these preferences can be assigned. Games such as chess and poker, together with many social, economic, political and military conflicts which are not commonly thought of as games, possess these properties and are therefore amenable in principle to game theory analysis. The primary goal of the theory is to determine, through formal reasoning alone, what strategies the players ought to choose in order to pursue their interests rationally, and what outcomes will result if they do so.

Although some progress was made by Zermelo in 1912, and by Borel during the early 1920s, the theory was not firmly established until John von Neumann proved the fundamental minimax theorem in 1928. This theorem applies to two-person, strictly competitive (zero-sum) games, in which one player's payoffs are simply the negatives of the other player's. If the number of strategies is finite, and the players are permitted to use randomizing devices to 'choose' weighted averages of their strategies, then each player can adopt a strategy that yields the best payoff given the most damaging counter-strategies available to the adversary. The minimax theorem asserts that these payoffs are equal, and that every game of this type therefore has a well-defined solution.

Applications of game theory in the social sciences have focused chiefly on non-zero-sum games. A famous example is the two-person *Prisoners' Dilemma*, identified in 1951 by Merrill Flood and later explicitly formulated and named by Albert W. Tucker. This game has the paradoxical property that whereas each player has a *dominant* strategy that yields the best payoff against both of the opponent's available counter-strategies, each player obtains a better payoff if both choose *dominated* strategies. A multi-person generalization of this, the *N-Person Prisoners' Dilemma*, was discovered in the early 1970s; in this game, every player is better off if all choose dominated strategies than if all choose dominant strategies. The N-Person Prisoners' Dilemma is a model of many familiar social problems, including resource conservation, wage inflation, environmental pollution, and arms races.

Experimental games have been used by psychologists to study co-operation and competition in two-person and multi-person groups, and economists have applied game theory to the study of bargaining and collective choice. In political science and sociology, game theory has been used to analyse voting behaviour and coalition formation, and numerous other applications of the theory in social anthropology and other fields have been attempted. During the 1970s, applications of the theory to the study of the evolution of social behaviour began to flourish in sociobiology.

Andrew M. Colman
University of Leicester

Further reading

Colman, A. M. (1982) *Game Theory and Experimental Games: The Study of Strategic Interaction*, Oxford.

Von Neumann, J. and Morgenstern, O. (1953) *Theory of Games and Economic Behavior*, 3rd edn, Princeton, NJ.

See also: game theory, economic applications; prisoners' dilemma; rational choice theory.