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Economic Games

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Economic games enable the study of individual decisions in a social dilemma in which the interest of the group and the individual are in conflict. The simplest economic game is the prisoner's dilemma: Two players each decide simultaneously to cooperate or not with the other player. They achieve the highest joint gain if both cooperate. If one cooperates and the other defects, the defector gains most and the cooperator least. If both defect, they jointly gain less than had they both cooperated—hence the dilemma. The most famous social dilemma is the tragedy of the commons. It states that a public resource will be overused whenever people have free access. Eventually, the resource will collapse, causing a tragedy for all. The economic game mimicking this social dilemma is the public goods game, in which each member of a group contributes anonymously to a fund that will be doubled and redistributed among all group members irrespective of their contribution. Not contributing gains the individual the most but induces others to join free-riding until nobody contributes. Some examples are cattle overgrazing common pastures and the global carbon dioxide output that causes climate change. There are economic games mimicking other social dilemmas.

History

Economic games can be dated back to John von Neumann (1902–1977) and Oskar Morgenstern (1903–1957). These games were further developed in experimental economics by Nobel laureate Vernon [Smith \(1987\)](#) and in evolutionary biology by John [Maynard Smith \(1982\)](#). Mathematician von Neumann and economist Morgenstern regarded their game theory as a mathematical foundation for economics ([von Neumann & Morgenstern, 1994](#)). Morgenstern demonstrated mathematically that there is always a rational course of action of two players when their interests are opposed ([Poundstone, 1992](#)).

At the RAND corporation, a global policy nonprofit think tank, Merrill Flood and Melvin Dresher devised a simple, baffling game that challenged part of the theoretical basis of game theory. RAND consultant Albert Tucker dubbed this game the prisoner's dilemma in 1950 ([Poundstone, 1992](#)). If the game is played only once, mutual defection is the only strong equilibrium. Irrespective of what the other player decides, one gains more by defection. If the game is played repeatedly by the same players who can remember previous actions, then any sequence of *cooperate* (C) and *defect* (D) is possible. To explore whether there was a strategy, to play Cs or Ds, that is superior, Robert [Axelrod \(1984\)](#) organized a tournament in 1979 for which he invited colleagues to devise computer strategies to compete in an iterated prisoner's dilemma in an everyone-against-everyone fashion. Of the 14 entries, it was not a selfish strategy that won after 1000 generations but a nice and forgiving strategy, *tit for tat*, submitted by Anatol Rapoport, with two rules: begin with C, and then repeat what your partner decided in the previous round. This means you retaliate to partner's D, but if they turn to a C, you are forgiving by responding with C. Cooperation is easily reestablished. When Axelrod repeated the tournament with 62 participants after informing them about *tit for tat* and its success, the winner was again *tit for tat* ([Axelrod, 1984](#)). From then on, only cooperative rules such as *generous tit for tat* ([Nowak & Sigmund, 1992](#)) and *win stay, lose shift* ([Nowak & Sigmund, 1993](#)) were propagated by theorists.

Core concepts

A multitude of established economic games exist (see, e.g., [Brosnan, 2021](#); [Thielmann et al., 2021](#)), but a few in particular frequently appear in the literature.

The prisoner's dilemma

In the prisoner's dilemma, each of two players can either cooperate (C) or defect (D). If one cooperates and the other defects, the defector gains most and the cooperator least (see [Figure 1](#)). They achieve the highest joint gain if both cooperate. If both defect, they jointly gain less than had they both cooperated. If you know the other will cooperate, you gain more by defection, if you know the other will defect, again you gain more by defection. The other player comes to the same conclusion; thus, both will defect, caught in the dilemma. In repeated interactions, other solutions are possible.

		Column Player	
		Cooperate	Defect
Row Player	Cooperate	3 (3)	0 (5)
	Defect	5 (0)	1 (1)

Figure 1

The prisoner's dilemma. The payoffs for the row player are listed first and the column player in parentheses (modified from [Axelrod, 1984](#)).

The public goods game

In the public goods game, each member of a group contributes anonymously to a fund that will be doubled and redistributed among all group members irrespective of their contribution. It is a standard game used in behavioral economics. Many published experiments showed *free-riding* dominates after several rounds, and initial cooperation collapses. Two solutions to this were published in the same year: When participants were allowed to implement a costly punishment to individual free-riders from the previous round, stable cooperation was established ([Fehr & Gächter, 2002](#)). The net gain after including the costs of punishing and being punished was low, and punishing paid off only after many rounds ([Gächter et al., 2008](#)). When rounds of the public goods game were alternated with rounds of a game for which having a good reputation is essential, such as

indirect reciprocity ([Alexander, 1987](#); [Wedekind & Milinski, 2000](#)), players avoided damaging their reputation by free-riding in the public goods game, and stable cooperation was established ([Milinski et al., 2002](#)).

The dictator game

In the dictator game, a player is given a sum of money and decides freely how much to keep versus give to a recipient who has to accept the dictator's decision. In experiments, dictators use a 50/50 division most of the time ([Andreoni & Bernheim, 2009](#)).

The ultimatum game

In the ultimatum game, one player is given a sum of money and decides freely how much to offer the other player, who decides whether to accept the offer. Both players are anonymous. Upon acceptance, both receive what was proposed. Upon rejection, the money is lost; neither receives anything. The money-maximizing offer is the minimum, which the other player should accept, or otherwise they gain nothing ([Güth et al., 1982](#)). In reality, student players offer about 40%, and offers below 30% are usually rejected.

The trust game

In the trust game, two players, a trustor and a trustee, are given an amount of money. The trustor decides how much of the money to send to the trustee. On the way, that amount is typically multiplied, for example, doubled, until the trustee receives it. The trustee then decides how much of the increased amount to send back to the trustor ([Berg et al., 1995](#)). The trustee could keep everything or share the money with the trustor. In experiments, 20% to 50% of trustees did not send anything back (e.g., [Brülhart, 2012](#)).

The collective-risk social dilemma game

The core of the collective-risk social dilemma is a risk that affects all members equally if a certain target is not reached. To avoid the risk, a group must collectively cooperate to reach the target through individual contributions. Each individual may be tempted to defect, hoping that others will cooperate enough to reach the target, allowing them to benefit from the group's success without incurring the costs of cooperation. The collective-risk social dilemma ([Milinski et al., 2008](#)) can be applied to various scenarios, including climate change mitigation, public safety initiatives (like flood prevention), and other situations in which collective action is necessary to achieve a positive outcome for all.

The volunteer's dilemma

In the volunteer's dilemma, someone has to take an action at a small cost that will benefit everyone. Everyone is in trouble if no one does it ([Diekmann, 1985](#)). An example is the bystander effect; individuals are less likely to help a victim in the presence of other people. The more bystanders there are, the less likely anybody helps; the collective thought is "let someone else do it."

Questions, controversies, and new developments

A controversy becomes obvious when comparing the many theoretical studies predicting cooperation among humans in contrast to the daily news reporting widespread uncooperative human behavior, suggesting that theory has overemphasized the good in people [see [Cooperation](#)]. A dramatic change in understanding the prisoner's dilemma addresses this by proposing *extortionate strategies* that enforce full cooperation of the partner ([Press & Dyson, 2012](#); [Stewart & Plotkin, 2012](#)). The extortion strategy is to cooperate randomly in slightly more than 50% of rounds, defect in other rounds, but respond to defection with defection. The partner can maximize their gain only in *cooperate–cooperate* interactions, thus finally choosing to cooperate 100% because of the profits in doing so. The extortioner profits from almost 50% of *defect–cooperate* interactions—an unbeatable strategy. Extortion won more head-to-head matches than any other known strategy ([Stewart & Plotkin, 2012](#)). A review of experimental studies shows the superiority of extortion strategies in various situations ([Milinski, 2022](#)). However, extortioners have problems succeeding in evolving populations because they end up with mutual defection when they meet each other ([Stewart & Plotkin, 2013](#)). Thus, there would be a limit to the frequency of extortion, above which more *generous* strategies have a higher overall payoff and can spread. About 40% of potential extortioners were found in experimental studies in competitive situations, suggesting the equilibrium frequency of extortion, in which its payoff is the same as that of generous.

Broader connections

Economic games are a valuable tool in cognitive science as well as in developmental psychology for understanding how individuals make decisions and interact with others in social situations. By manipulating game rules and observing player choices, researchers can explore the psychological and cognitive processes that drive social behavior ([Henrich et al., 2005](#); [House et al., 2013](#); [Sanfey et al., 2003](#)) [see [Theory of Mind](#)]. There are also real-world implications. Mitigating climate change is a tragedy of the commons ([Hardin, 1968](#)); to mitigate the dangers of climate change ([Schneider, 2001](#)), global carbon dioxide output, which has increased continuously for 70 years, needs to be reduced. In a *collective-risk social dilemma* game, groups of students have to collect a target sum as a group through individual contributions over 10 rounds from an endowment ([Milinski et al., 2008](#)). If the group fails to reach the target sum, each member loses all the remaining money with a probability of 90%. Only half of the groups reached the target because of free-riders investing little and profiting in the successful groups. Free-riders were identified as extortioners enforcing fair players to compensate for the extortion deficit in the successful groups, providing the extortioners with a large gain ([Milinski, 2016](#)). This approach was used by various authors to study the influence of natural variables in the climate change game.

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Further reading

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