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Errors Can Increase Cooperation in Finite Populations

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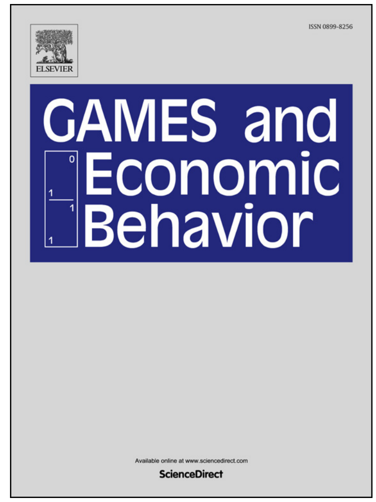

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Errors Can Increase Cooperation in Finite Populations☆

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Abstract

I use an evolutionary game to investigate how the level of noise influences cooperation and efficiency in a dynamic setting. Players choose strategies to play indefinitely repeated prisoner's dilemmas; the strategies are represented by finite automata, and complexity costs are imposed. Players update their strategies based on the successfulness of the strategies. Using both theoretical analysis and computational experiments, I show that the presence of noise dramatically changes the system dynamics. The effect of noise interacts with the benefit of cooperation: noise can increase cooperation, but only when its level is low and the benefit of cooperation is high. In the noise-free environment, I observe constant oscillations between cooperation and defection. In contrast, the presence of noise makes Win-Stay Lose-Shift (WSLS) a successful strategy when the benefit of cooperation is sufficiently high, making cooperation relatively stable and leading to an efficient outcome.

Keywords: Cooperation; Prisoner's Dilemma; Evolutionary Game Theory; Evolutionary Dynamics; Uncertainty; Learning; Bounded Rationality.
JEL Classification: C63, C72, C73, D80.

1. Introduction

Economists have used the theory of repeated games to explain how cooperation can arise in a population of self-interested individuals. Consider the prisoner's dilemma depicted in Figure 1, which is characterized by one parameter $r > 1$. In this game, the benefit of cooperation is r, that is, a cooperative action costs 1 and benefits the opponent by r. While it is socially efficient for players to Cooperate (C), the unique equilibrium is for both players to Defect (D) if the game is played only once. Various folk theorems have shown that if the game is repeated infinitely and players are sufficiently patient, cooperative play can be supported as an equilibrium (Friedman, 1971; Aumann and Shapley, 1994; Fudenberg and Maskin, 1986).[2] These theorems also characterize a great many equilibrium outcomes (including the uncooperative outcomes) but are silent on which outcome is likely to occur. As a result, many economists have shifted their attention to an evolutionary perspective for more useful predictions (Binmore and Samuelson, 1992; Foster and Young, 1990; Fudenberg and Maskin, 1990; Kandori et al., 1993; Selten, 1991; Young, 1993).

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[2]The evolution of cooperation in repeated games are also studied in evolutionary biology under the name reciprocal altruism and direct reciprocity (Trivers, 1971; Axelrod and Hamilton, 1981; Zhang and Perc, 2016).