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Yao Yao, Shen-Shen Chen

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ACCEPTED MANUSCRIPT

# Multiplicative noise enhances spatial reciprocity

Yao Yao[a], Shen-Shen Chen[a]

[a]*Henan Electric Power Survey & Design Institute, Zhengzhou, He Nan, 450007, China*
*E-mail: yaoyaohust01@gmail.com (YY); css0703@126.com(SSC)*

**Abstract**

Recent research has identified the heterogeneity as crucial for the evolution of cooperation in spatial population. However, the influence of heterogeneous noise is still lack. Inspired by this interesting question, in this work, we try to incorporate heterogeneous noise into the evaluation of utility, where only a proportion of population possesses noise, whose range can also be tuned. We find that increasing heterogeneous noise monotonously promotes cooperation and even translates the full defection phase (of the homogeneous version) into the complete cooperation phase. Moreover, the promotion effect of this mechanism can be attributed to the leading role of cooperators who have the heterogeneous noise. These type of cooperators can attract more agents penetrating into the robust cooperator clusters, which is beyond the text of traditional spatial reciprocity. We hope that our work may shed light on the understanding of the cooperative behavior in the society.

*Keywords:* Evolutionary Game, Spatial Reciprocity, Noise, Heterogeneity, Network Dynamics

## 1. Introduction

Understanding the emergency of cooperation among the population of selfish individuals denotes one challenge in natural and social science [1, 2]. To interpret the survival of cooperation, a theoretical framework that has shed light onto this long-standing issue is the evolutionary game theory [3, 4, 5, 6]. In particular, a simple, paradigmatic model, the prisoners dilemma (PD) game, has attracted much attention, both theoretical and experimental [7, 8, 9, 10, 11, 12, 13]. In its basic version, two players simultaneously decide to adopt one of two strategies: cooperation (C) and defection (D). They will receive the reward $R$ if both cooperate, and the punishment $P$ if both defect.

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