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The effect of wealth-based anti-expectation behaviors on public cooperation

Le Wang, Tong Chen, Xinshang You, Yongjie Wang *

College of Management and Economics, Tianjin University, Tianjin 300072, PR China

HIGHLIGHTS

- The individuals' wealth level and anti-expectation behaviors are considered.
- The anti-expectation mechanism could stimulate cooperation under certain conditions.
- The propagation of positive anti-expectation behaviors could improve cooperation.
- Cooperation could be promoted with increasing the tolerance towards defectors.

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ABSTRACT

Wealth difference is a common sense in our society. It is unreasonable to assume people have the same capability to donate money to the common pool in public goods game (PGG). Individuals have behavioral expectation towards their neighbors. In this paper, we introduce wealth-based anti-expectation mechanism to explore cooperation. Through numerical simulation results, we are glad to find that the anti-expectation mechanism could stimulate cooperation when the positive effects are equal to or larger than the negative effects from anti-expectation behaviors. Based on this mechanism, we propose propagation mechanism which aims to propagate the positive effects from the poor to inspire more people to choose cooperative strategies. When individuals are tolerant towards defectors, The fraction of cooperators increases with the increment of propagation distance. Enlarging the distance is not wise when individuals are harsh towards defectors. Additionally, we find that the more tolerant towards defectors we are, the higher the cooperation rate is in general. Therefore in PGG, we could consider one's anti-expectation towards others' behaviors and improve cooperation by propagating the poor's anti-expectation effects.

1. Introduction

Cooperation is of vital importance in our life, especially when we make collective decisions [1–4]. Such as providing public goods, protecting the natural environment, preserving natural source and so on [5–7]. How to promote cooperation is a fascinating topic that appeals to extensive scholars [8–10]. The core problem individuals face is that everyone tries best to maximize personal benefits. However, there may be some conflicts with collective interests [11–13]. Scholars have paid much attention to solve this problem. The prisoner's dilemma game (PDG) is a good example which describes the conflicts between two rational persons' strategies and the choices beneficial for groups. Actually, public goods game (PGG) can be regarded as a multi-person prisoner's dilemma game [14–17].

* Corresponding author.
E-mail address: wang_yj@tju.edu.cn (Y. Wang).

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In PGG, if you choose to cooperate, you should pay for the common pool. However, your neighbors may not if they adopt defective strategy. The contribution of you and your neighbors will be summarized and multiplied by an enhancement coefficient r ($r > 1$). Then, the donations will be distributed between you and your neighbors evenly. It is unfair for cooperators. Because there are so many free riders who do not pay the cost but can exploit their payoff [18,19]. Under this circumstance, a rational person may not choose to cooperate anymore and the defectors will prevail [20–22]. Therefore, cooperation has evolved into a social dilemma. [23] To avoid this phenomenon, many scholars have proposed a number of ways to arouse individuals' willingness to choose cooperative strategy. Such as rewarding cooperators [24], punishing defectors [25,26], considering individuals' tolerance towards defectors [27,28], the effect of reputation [29–32], group interactions [33], individuals' heterogeneity [34–36] and so on. In addition, many scholars focusing on individuals' expectation to the cooperation level of groups [37–39] and the effect of wealth difference [40–44]. However, there are few papers studying that how wealth-based anti-expectation behaviors affect cooperation in PGG. Normal expectation is an estimation of neighbors' contributions before the game [37,45]. Anti-expectation means that one's actual donation is different from others' expectation. There are many aspects affecting individuals' expectation. Some aspects are invisible. Therefore, we concentrate on wealth-based expectation. The wealth difference among people is a common phenomenon in our society [46,47]. It is obviously unreasonable to assume that people have the same power to donate in PGG. In reality, one may expect his or her neighbors' cooperative strategies according to their wealth before the game [45]. Individuals' strategies can be influenced by their neighbors [48]. Whether the actual cooperative behaviors of their neighbors are consistent with the pre-expectation will affect individuals' social preference. Social preference may be related with individuals' cooperative behaviors. Therefore the change of social preference may lead to one's behavior change in the next round of PGG [49–53].

In recent years, people's income becomes higher and higher with the economy in China growing rapidly. At the same time, more and more people begin to pursue cultural satisfaction. Village opera is a kind of culture in some southern villages in China. It is funded by villagers' contributions and the committee's donations. Everyone can enjoy the opera regardless of their donations. Only the sum of contributions and donations is beyond a threshold, can the opera be held successfully. The money donated by villagers is not refundable when it does not reach the threshold [54]. Therefore people's contributions have a certain risk. Actually, the village opera is a kind of threshold public goods game (TPGG) [55,56]. In order to minimize the risk and promote the development and inheritance of village opera culture in China, we should take measures to arouse people's willingness to cooperate as much as possible.

In this paper, we focus that how wealth-based anti-expectation mechanism influences cooperation in PGG. In a village, individuals have a general understanding of their neighbors' wealth level. Therefore, they can expect their neighbors' strategies according to their wealth. The Law of Diminishing Marginal Utility indicates that when a person has much money, the additional utility of adding one dollar is diminishing compared with the one who has little money. The utility of adding one dollar to the poor is far greater than that brought to the rich [57,58]. Based on this law, personal income tax in China has seven progressive tax rate. The person does not have to pay the tax when one's wages are less than 3500 yuan. Personal income tax will increase with the increasing of wages correspondingly when one's wages are more than 3500 yuan. This reflects the attitude that the rich who consume more social resources should pay more tax correspondingly. Inspired by this principle, we combine individuals' wealth difference with others' expectation towards them in PGG. In general, people expect that the probability of their neighbors' cooperation will increase as their income increases. Therefore, we divide all the individuals into three different groups according to their wealth to distinguish different expectation. Namely, the rich group whose wealth is beyond w_2; the middle-income group whose wealth is between w_1 and w_2, including w_1 and w_2; the poor group whose wealth is less than w_1. (w_1 and w_2 are the value of wealth.)

2. Models

In PGG, individuals' donations may be related with their social preference [4]. Social preference varies from person to person, so that different individuals may make different strategies. We assume each person has an different hesitant interval $[i, j)$, respectively (i and j is between 0 and 1, including 0 but not including 1). The interval is generated randomly. A agent is an unconditional cooperator (UC) who always chooses cooperative strategy. We assume UCs' social preference is greater or equal to j. A person is a potential cooperator (PC) whose social preference is within hesitant interval. PCs may be influenced easily by others. They are payoff-driven players and will imitate others with higher payoff. A person is an unconditional defector (UD) whose social preference is less than i. Their choice is defective strategy all the time.

2.1. The normal PGG

The public goods game is staged on a network (shown in Fig. 1). In the graph, one node represents one player and edges are the interactions between players. The schematic graph is randomly generated according to the following rule. In the game, we set the total number of players to be N. We assume that the per capita number of neighbors is equal to k. Some players have many neighbors and some ones have few. Therefore, the total number of links in the network should be $(N * k)/2$. If the actual number of links is less than it, let one of the nodes create links with unlinked others randomly. Repeat this step until the number of links reach $(N * k)/2$. N is set to be 300, 500 and 1000, respectively, from the left to the right. The per capita number of neighbors is 6.

In this model, we assume that social wealth is subject to logarithmic normal distribution [59]. Both the rich and the poor account for a small proportion, represented as a_1 and a_3, respectively. The middle-income group accounts for a large