Retraction

Retracted: Third-Party Punishment Mechanism and Corporate Cooperation in Environmental Investment: Experiments on Public Goods Game

Discrete Dynamics in Nature and Society

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Y. Liao, L. Zhang, S. Lei, M. Song, W. Deng, and D. Hu, "Third-Party Punishment Mechanism and Corporate Cooperation in Environmental Investment: Experiments on Public Goods Game," *Discrete Dynamics in Nature and Society*, vol. 2021, Article ID 6192629, 7 pages, 2021.

Research Article

Third-Party Punishment Mechanism and Corporate Cooperation in Environmental Investment: Experiments on Public Goods Game

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In the context of corporate environmental investment (EI), this paper designs an experiment on public goods game without punishment and an experiment on that game with third-party punishment (TPP). Then, the influence of IEP and TPP mechanism on corporate EI behaviors was tested in details. The results show that different enterprises vary in IEP and took heterogenous behaviors in the two corporate EI experiments; the introduction of TPP pushed up the environmental resource investment of enterprises and increased the success rate of EI cooperation; IEP and TPP exerted a significantly positive influence on corporate EI behaviors; the introduction of TPP, coupled with the consideration of corporate IEP, can effectively elevate corporate EI and improve the eco-environment.

1. Introduction

While promoting economic growth, enterprises strain the carrying capacity of the eco-environment. Governments around the world have attached great importance to environmental governance and prepared relevant laws, regulations, and policies [1, 2]. However, it is not rare that enterprises illegally discharge pollutants, which damage the eco-environment. In 2020, China released the *Bulletin on the Second National Census on Pollution Sources*, which discloses that, in 2017 alone, Chinese industrial enterprises discharged up to 1,225,900 tons of pollutants into water bodies and 29,271,400 tons of pollutants into the air. In general, government legislation and supervision have not reached the expected effects. The environmental pollution induced by the economic boom is yet to be solved. Being the main source of environmental pollution, enterprises ought to shoulder the responsibility of environmental protection, step up environmental investment (EI), and actively promote the eco-environment [3, 4]. Due to the presence of

externality and cooperative dilemma, the EI as special public goods is often short supplied. The government usually resorts to punitive supervision methods, such as law enforcement and supervision, and environmental admonition, demanding enterprises to take EI behaviors to prevent environmental pollution. The EI behaviors include paying excess discharge fee and building pollution control facilities.

Third-party punishment (TPP) refers to the punishment imposed on the stakeholder by an individual independent of that stakeholder. The individual does not lose or gain any benefit by imposing the TPP [5]. Through experiments on public goods game, Fehr and Gachter [6] found that the punishment mechanism makes people take actions that violate the traditional hypothesis of economic man. The internal punishment dominated by the second party differs from the external punishment dominated by the third party in action mechanism and effect [7, 8]. Public goods experiments have shown that the cooperation level under the TPP imposed by external subjects is higher than that under the second-party punishment [9]. The punishment

mechanism can boost the cooperation level of team members by affecting the economic cost of the potential party being punished. More importantly, the mechanism creates a model of good cooperation, which will be imitated actively by others [10]. In reality, there is usually no penalty against corporate investment in environmental protection. The environmental protection is mainly supervised by regulatory departments of the government. Therefore, this paper introduces a TPP mechanism to EI, making the research more realistic.

Corporate EI is mainly influenced by the punishment and supervision from the government. However, the government seldom fully considers the impact of the enterprises' preference for interaction and equity (IEP). During corporate EI, the behavior preference reflects the active rather than passive EI willingness of enterprises. IEP means a party in the game cares not only its own interest but also the equity and interaction between relevant stakeholders. Kahneman and Tversky [11] and Rabin [12] are pioneers in the theoretical research of IEP. Dufwenberg and Kirchsteiger [13] creatively proposed the concept of sequential reciprocity equilibrium (SRE), which extends the concept of equity to dynamic game. Many scholars have pointed out the varied impacts of the IEP on the selection of teamwork. Some suggested that the IEP maintains low levels of cooperation [14], some argued that the IEP and teamwork mutually promote each other [15], and some claimed that the impacts are uncertain [16]. Whichever is the case, interaction and equity always play a significant role in the behaviors of game players. The two criteria greatly affect the economic subjects' decisions on behaviors. However, only handful scholars have studied the IEP together with the TPP, and very few have linked the two criteria with corporate EI behavior.

To make up for the gap, this paper designs experiments on public goods game in the context of corporate EI, following experimental economics. Then, the IEPs of all subjects were measured. On this basis, the authors discussed the difference between enterprises in EI and the influence of the TPP on corporate cooperation in EI under the IEP.

2. Experiment Design

2.1. Participants. In December 2020, a total of 87 undergraduates were recruited from Hunan University of Finance and Economics. The subjects were divided into four batches to participate in our experiments at the Experiment and Training Center of the university. Males and females take up 34% and 66% of the subjects, respectively. The subjects are on average 19.38 years old. The oldest subject is 22 and the youngest is 17. The median age is 19. The subjects are college students from grade 1 to 4. Prior to the experiments, the subjects read the instructions on the experiments, which include the anonymity and independence of the experiments, the environmental policies of China, the EI practices and requirements of different enterprises, etc.

2.2. Parameters. It is assumed that three enterprises of the same group cooperate with each other to invest in an EI public project. In the ith group, enterprise j initially possesses an amount of resources E_{ij}, $j \in 1, 2, 3$ and $i \in 1, 2, \ldots, n$. In each round of experiment, the resource investment amounts to C_{ij}, and the total resource investment of the group stands at $T_i = \sum_{j=1}^{3} C_{ij}$. If $T_i \geq 150$, the jth enterprise receives a public benefit $U_{ij} = T_{ij} - C_{ij}$; if $T_i < 150$, $U_{ij} = 0$.

The results analysis involves the following variables:

(1) The resource investment rate R_j of an enterprise, which is defined as the ratio of the resource amount of EI to the initial resource amount. This variable reflects the contribution of an individual enterprise. The R_j value can be calculated by $R_j = C_{ij}/E_{ij}$.

(2) The mean total resource investment amount of all groups $\overline{T} = \sum_{i=1}^{n} (\sum_{j=1}^{3} C_{ij}/n)$.

(3) The success rate of cooperation R_s, which is defined as the ratio of the number of groups s with total investment amount $T_i \geq 150$ to the total number of groups n in the same round of experiment. This variable reflects the probability of successful completion of the EI public project. The R_s value can be calculated by $R_s = s/n$.

2.3. Experimental Procedure. During the two public goods game experiments, the subjects were asked to fill out a questionnaire on preference measurement. The first part of the questionnaire is about personal information. The second part aims to measure the IEP against a scale and construct preference indices by the coefficient of variation method. A total of 87 questionnaires were issued during the experiments, and all of them were effectively recovered.

The first experiment is a punishment-free public goods game (NP_treatment). In the context of corporate EI, three subjects were randomly allocated into a group, representing three different enterprises. The initial resource combination E_{ij} of the three enterprises can be described as (100, 100, 100). The marginal per-capita return (MPCR) of the EI public project is 0.4 [17]. No public benefit or MPCR will be generated, unless $T_i \geq 150$. When $T_i \geq 150$, the public benefit equals MPCR $* T_i$. In this case, the computer system automatically judges that the public project is successful.

The second experiment is a public goods game under the effect of TPP (WP_treatment). This experiment has two phases: an investment phase and a punishment phase. In the first phase, the three enterprises invest in the public project. In the second phase, the experimental platform automatically penalizes the enterprises based on the relevant policies and experimental evidences and set the punishment coefficient to 0.2 [18]. The subjects, whose resource investment rate to the public project is below the mean resource investment rate of their group, were punished by reducing their residual asset by 0.2.

Each experiment lasted about 60 min. The students completed all experimental steps on the Z-Tree software platform [19]. After the experiments, each student was awarded USD 2.94 on average.

3. Results' Analysis

3.1. Behavior Heterogeneity. The behavior decisions of the subjects were observed through the descriptive statistics and difference test of the resource EI rate of each enterprise in different rounds of experiment.

Table 1 lists the mean, standard deviation, median, and mode of the corporate resource investment rates in the four rounds of NP_treatment and WP_treatment, respectively. The results show that, in the two experiments, the corporate resource investment rates generally increased with the growing rounds. For example, during the NP_treatment, the mean resource investment rates of Rounds 2 and 3 were 0.021 higher than the mean of Round 1; the mean resource investment rate of Round 4 was 0.017 higher than the mean of Round 1. During the WP_treatment, the mean resource investment rates of Rounds 2 and 3 were 0.016 and 0.062 higher than the mean of Round 1, respectively; the mean of Round 4 was basically the same as that of Round 3.

Table 2 presents the Mann–Whitney U test results on the resource investment rates of the same rounds between the two experiments.

Step 1: mix the two sets of sample data, and grade the data in ascending order of size. Take the mean value if the mixed data have the same grades.

Step 2: calculate the grades, and R_1/R_2 of the two samples, respectively.

Step 3: set up the formulas of U_1 and U_2 ($U_1 = R_1 - n_1 * (n_1 + 1)/2$; $U_2 = R_2 - n_2 * (n_2 + 1)/2$), where n_1 and n_2 are the number of observations in the first and second sets of samples, respectively; R_1 and R_2 are the sum of all grades in the first and second sets of samples, respectively.

The results show that the pairs of data series from the same rounds between NP_treatment and WP_treatment had a correlation below the significance level of 0.05. Thus, the null hypothesis is rejected, and the enterprises must differ significantly in the resource investment rate.

The above results indicate that, during different corporate EI experiments, the enterprises in different groups cared about the equity and interaction of benefits and made different investment decisions, i.e., their behaviors were heterogenous.

3.2. Investment Distribution of Individual Enterprise and TPP. The initial resource combinations in both experiments were (100, 100, 100). The only difference between the two experiments is that the TPP is considered in the second experiment. Here, the influence of TPP on corporate cooperation in EI is investigated by comparing the resource investment amounts of group members between the two experiments.

Figure 1 presents the distribution of cumulative resource investment amounts in the two experiments. During the NP_treatment, the investment amounts of enterprises (39.42%) mainly concentrated between 40 and 50. Meanwhile, the proportion of enterprises with investment amount falling in that range was merely 29.49% during the WP_treatment. During the NP_treatment, 43.26% of enterprises invested more than 50 and 18.60% invested more than 60. During the WP_treatment, the two proportions were 51.92% and 31.09%, respectively. It can be seen that many enterprises would not invest more than half of their total resources in the NP_treatment, while more than half of all enterprise would invest over 50% of their total resources, due to the presence of the TPP mechanism.

The above results show that the corporate investment amounts in NP_treatment without TPP were much smaller than those in WP_treatment with TPP. A member will be punished if its resource investment rate in public projects is smaller than the mean rate of the group. Hence, the introduction of TPP indeed affects the investment decisions of enterprises: the TPP boosts the investment of members in the same group and encourages them to cooperate with each other.

3.3. Investment Distribution of Enterprise Group and TPP. Next, the influence of TPP on corporate cooperation in EI was discussed from the following aspects: mean resource EI amount, mean resource investment rate, and success rate of cooperation of enterprise groups.

3.3.1. Mean Resource Investment Amount. Figure 2 shows the mean resource investment amounts of enterprise groups in the four rounds under the two experimental schemes. With the growing round, the mean resource investment amounts of most groups gradually picked up; only a few groups saw oscillations in that amount during the middle rounds. For example, during NP_treatment, the mean resource investment amount of Round 3 was lower than that of Round 3.

In addition, the mean of the mean resource investment amounts in each round of the two experiments also steadily increased. From Round 1 to Round 4, this mean value rose from 158.15, 166.92, 171.93, to 174.44. Among the mean resource investment amounts of the eight rounds in the two experiments, only the amount of the first round in NP_treatment was smaller than 150, and all the other seven amounts were greater than 150, i.e., reaching the threshold for successful cooperation in EI.

Furthermore, the authors examined the effectiveness of TPP. On the one hand, the mean resource investment amount of Rounds 1–4 in WP_treatment was 170.16, 177.49, 189.3, and 191.53, respectively; the mean resource investment amount of Rounds 1–4 in NP_treatment was 146.14, 156.34, 154.56, and 157.35, respectively. The minimum amount of WP_treatment was 170.16 in Round 1, which is higher than the amount in any round of NP_treatment. On the other hand, the

Table 1: Corporate resource investment rates in different rounds.

	NP_treatment				WP_treatment			
	Round 1	Round 2	Round 3	Round 4	Round 1	Round 2	Round 3	Round 4
Mean	0.493	0.514	0.514	0.510	0.562	0.579	0.625	0.622
Standard deviation	0.152	0.140	0.140	0.133	0.150	0.162	0.185	0.219
Median	0.500	0.500	0.500	0.500	0.550	0.600	0.633	0.633
Mode	0.450	0.450	0.450	0.600	0.550	0.600	0.800	0.700

Table 2: Mann–Whitney U test results on the resource investment rates in different rounds

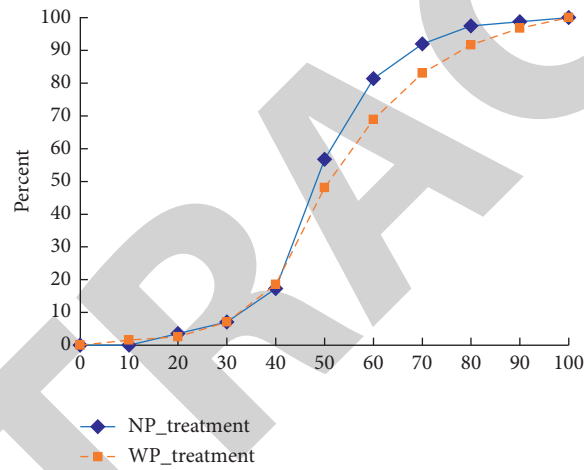| Experiments	Rounds	Test results	
		Z-score	P value
	Round 1	−2.559	0.011
WP_treatment-NP_treatment	Round 2	−3.224	0.001
	Round 3	−4.188	≤0.001
	Round 4	−4.083	≤0.001

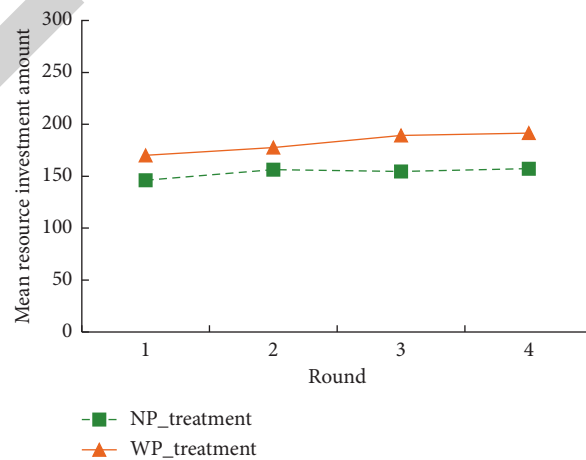Figure 1: Comparison of cumulative resource investment amounts between the two experiments.

Figure 2: Mean resource investment amounts of enterprise groups.

mean of the mean resource investment amounts in the four rounds of NP_treatment was 153.60, smaller than that (182.12) of WP_treatment. Therefore, the cooperation level in investment of WP_treatment was higher than that of NP_treatment, which does not involve TPP increase of cooperation level in investment.

3.3.2. Success Rate of Cooperation. Figure 3 records the success rates of EI cooperation of enterprise groups in the four rounds of each experiment. From Round 1 to Round 4, the success rates of EI cooperation of WP_treatment were higher than those of NP_treatment by 22.23%, 18.52%, 25.93%, and 18.52%, respectively. During the NP_treatment, the mean success rates of cooperation of enterprise groups were 55.57%, which was increased to 76.85% after the introduction of TPP.

The above results show that although the mean resource investment amount and success rate of cooperation of enterprise groups evolve differently in the four rounds of two different experiments, the EI distribution of enterprise groups always gradually increased with the growing rounds, a sign of the steady increase of cooperation level in investment. In addition, the inclusion of TPP influences the overall decision-making on investment of enterprise groups. The TPP elevates the mean resource investment amount and success rate of cooperation. This further verifies that TPP can effectively promote EI cooperation between enterprises.

3.4. Regression Test

3.4.1. Modeling. The above analysis shows that, during the different experiments on corporate EI, the members in a group differ greatly in resource investment amount, and their investment decisions are affected by the TPP. Besides, the introduction of TPP influences the overall investment behaviors of enterprise groups. Overall, the following regression model was constructed:

$$C = \alpha + \beta R + \varepsilon P + \lambda_1 X_1 + \lambda_2 X_2 \cdots + \lambda_8 X_8 + \mu, \quad (1)$$

where the explained variable c is the resource investment amount of group members and the explanatory variable R is the IEP. The next step is to measure the IEP against a scale and construct preference indices by the coefficient of the variation method.

Following the coefficient of the variation method, the IEP preference indices were constructed in the following process. First, calculate the mean $\overline{R}_k$ and standard deviation δ_k of different preference questionnaires and compute the coefficient of variation $V_k = \delta_k/\overline{R}_k$. Assign a large weight to relatively large coefficients and a small weight to relatively small coefficients. Second, normalize the coefficient of variation to get the weight of each preference $w_k = V_k/\sum V_k$ and synthesize the preference indices corresponding to the explanatory variable R. The larger the value of R, the deeper the IEP of the group members.
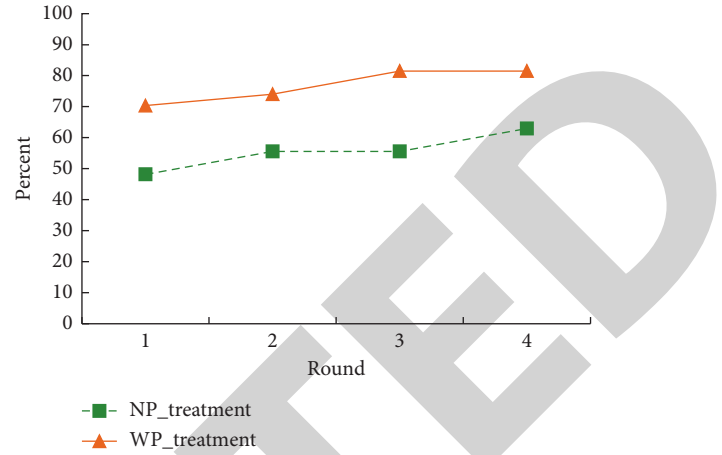

Figure 3: Success rates of cooperation of enterprise groups.

β is the coefficient of R, and the estimated value of the IEP, reflecting the degree of impact of the IEP on c (if the β value is insignificant, the influence of IEP is not significant; if the β value is significantly negative, the IEP can lower the c value; if the β value is significantly positive, the IEP can increase the c value); the explanatory variable P is the presence/absence of TPP (if $P = 0$, there is no punishment; if $P = 1$, there is a punishment); ε is the coefficient of P, and the estimated value of TPP; control variables X_1–X_8 are personal features: age, gender (1 is male; 2 is female), grade (1–4 are grades 1–4, respectively), education of parents (1–4 are graduates from primary school, secondary school, undergraduate program, and postgraduate program, respectively), only child (1 is being the only child; 2 is not being the only child), score ranking (1–3 are the top 30%, 30–70%, and bottom 30%, respectively), student cadre (1 is being a student cadre; 2 is not being a student cadre), and experiment experience (1 is with experimental experience; 2 is without experimental experience); μ is a random disturbance term.

3.4.2. Analysis of Empirical Results. Table 3 shows the parameter estimation results of model (1).

Table 3 presents the regression results on IEP, TPP, and personal features. Among the personal features, age, education of parents, only child, score ranking, student cadre, and experiment experience exerted significant impacts on the resource investment amount of group members. After controlling the personal features, the explanatory variable IEP R had a significantly positive impact on the investment behavior of group members, that is, their IEP increases with the investment amount. Finally, the explanatory variable TPP P had a significantly positive influence on the level of 1%, which further verifies the deterrent effect of TPP on group members: the TPP positively affects the resource investment level of group members.

Table 3: Estimated values of parameters in the regression model.

Explanatory variables	Estimated value	Statistic	P value
IEP R	0.180***	4.629	≤0.001
TPP P	0.239***	6.796	≤0.001
Age X_1	−0.159***	−2.694	0.007
Gender X_2	0.058	1.553	0.121
Grade X_3	0.048	0.803	0.422
Education of parents X_4	−0.091***	−2.518	0.012
Only child X_5	−0.068*	−1.832	0.067
Score ranking X_6	0.156***	4.061	≤0.001
Student cadre X_7	−0.078**	−2.114	0.035
Experiment experience X_8	−0.219***	−5.973	≤0.001

*Note.*** , **, and * are the significance on the levels of 1%, 5%, and 10%, respectively.

4. Conclusions

This paper innovatively introduces the corporate EI to experimentally investigate how TPP and IEP affect corporate cooperation in EI. The main contributions are as follows:

(1) The existing research in influencing factors of EI rarely analyzes corporate EI behaviors from the angle of IEP and TPP. The statistical test of IEP and TPP shows that, both IEP and TPP have a positive impact on corporate investment behaviors, which proves that investment decisions of enterprises are not only dominated by IEP; TPP can effectively promote cooperation between enterprises. Through public goods game experiments, this paper discusses the influence of IEP and TPP on corporate cooperation in EI and extends the research scope of EI factors.

(2) The previous experiments of behavioral science have not targeted corporate EI behaviors. This paper brings an innovative experimental economics method to the research of corporate EI behaviors.

(3) This paper provides experimental evidence of corporate EI, which demonstrates the implementation effect of the punishment mechanism under IEP. Therefore, policy makers of environmental protection should fully consider the features of corporate IEP and enable enterprises to form a benign, interactive, and fair atmosphere of EI.

The research findings provide policy makers certain reference for solving the free-riding among enterprises, and the dilemma of cooperative voluntary supply of public goods with insufficient EI. During the design of environmentally friendly public policies, the government can take TPP mechanism as an entry point and give consideration to the IEP features of corporate decision makers. On the one hand, the government should encourage green enterprises to continue with the protection of environmental public interests, lead other polluting enterprises to actively shoulder the social responsibility of environmental protection, and try to form an interactive and equal atmosphere for corporate EI. On the other hand, the government should, from the angle of institution construction, entrust regulatory agencies more power to objectively supervise enterprise behaviors,

and thus effectively maintain the order of cooperative environmental protection.

There are some limitations in our research. For instance, the sample size is relatively small. In future, more samples will be acquired to make more reliable trend analysis. Besides, all subjects are students, due to the constraints of manpower and financial resources. Of course, the authors have tried their best to make the students familiar with the background of our experimental design. In the context of corporate EI, more attention should be paid to the subjects' sense of social identity. The future research will try to carry out experiments on people of different identities and occupations in the society.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

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