



Using an exogenous mechanism to examine efficient probabilistic punishment



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ABSTRACT

Free riding can be made more costly by increasing either the probability of being caught or the severity of the punishment. However, neither option is without cost. What is the tradeoff between these strategies? In this study, we introduce an exogenous punishment mechanism that varies the probability and magnitude of punishment to examine this tradeoff. In our punishment system, sanctions are imposed on the lowest contributor according to a predetermined probability rather than assigned by the participants. Our results indicate that exogenous punishment enhances cooperation. Moreover, we show that a punishment of an intermediate magnitude imposed with a 50% probability is significantly more effective than a more severe punishment with a 10% probability or a lesser but certain punishment, even though the expected value of the punishment is equal across the punishment treatments.

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1. Introduction

Every day we face tradeoffs between what is socially optimal and what is privately beneficial. Do we drive through a yellow light or come to a stop? Should we show up on time for a group discussion or arrive late to avoid having to wait for others? Do we drive to work or join a carpool? Among the crucial factors we consider when making such decisions is the likelihood of disapproval or punishment from other parties. Punishment can be made more painful for free riders by either increasing the probability that they will be caught or by increasing the severity of the punishment. However, both options are costly to implement. What is the tradeoff between these strategies? This study reports the results of a new public goods game designed to determine which punishment option produces a more significant deterrent effect.

The literature on the economics and enforcement of laws sheds light on the effectiveness of increasing both the probability and severity of punishment. In Becker's (1968) theoretical model, risk-averse individuals are deterred more when the severity of punishment is increased, whereas risk-loving individuals are deterred more by an increase in the probability of detection. Following Becker's work, a number of empirical studies (e.g., Eide, 2000; Levitt, 1998; Shimshack & Ward, 2005)

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have suggested that penalty increases (e.g., stiffer fines or jail terms) have a larger and more significant effect than increases in the probability of detection and conviction. The results of many of these studies are controversial, however, because of their sample selection, their use of individual self-reported data, and the potential endogeneity issue that arises with aggregate-level data. The experimental literature on this issue is limited and inconclusive. Block (1995), for instance, reported that in a trading experiment with a cartel deterrence setting, prisoners were more responsive to increases in the probability of detection, whereas students responded more to a monetary penalty than to risk. In their experiment examining voluntary discovery and disclosure violations among firms, Murphy and Stranlund (2008) found that compliance was unaffected by changes in the probability of detection. Friesen (2012) shows that increasing the severity of punishment is a more effective deterrent than increasing the probability of punishment to be equivalent to that in the context-free lottery choices or the compliance choices, where subjects can choose between paying a certain compliance cost (c), or paying a fine (F) with a given probability of inspection (p).

These studies provide evidence for the deterrent effect of sanctions. However, to the best of our knowledge, there are no experimental studies addressing the issue of the tradeoff between punishment severity and punishment probability, particularly in the free-riding behavior context. In this study, we designed an exogenous punishment mechanism in a public goods game, and varied the probability and magnitude of punishment to isolate their effects from those of other factors.

The results of previous experiments (Chaudhuri, 2011; Ledyard, 1995) suggest that in a repeated public goods game without punishment there are high levels of contribution at the beginning, but cooperation among group members gradually breaks down in subsequent periods until it converges to almost zero in the final period. Since Fehr and Gächter's (2000) pioneering work, lab experiments have tended to add endogenous punishment opportunities to the public goods game to encourage cooperation. These games usually consist of two stages. The first stage is the same as the traditional public goods game without punishment: subjects can invest any amount of their endowment in a public account. In the second stage, subjects have the right to impose a costly punishment on other group members. The results of these experimental games show that free-riding behavior is restrained by punishment opportunities even though, for rational money-maximizers, contributing nothing and punishing no one is the optimal strategy. Masclot, Noussair, Tucker, and Villeval (2003) and Noussair and Tucker (2005) extended this line of research to non-monetary punishment. Anderson and Putterman (2006), Carpenter (2007), Nikiforakis and Norman (2008), Houser, Xiao, McCabe, and Vernon (2008), Guillen, Enrique Fatas, and Branas-Garza (2010), and Xiao and Houser (2011) further examined the effectiveness of endogenous punishment.

One of our main reasons for adopting an exogenous punishment mechanism in the study reported in this paper was to increase the external validity of our experimental design. Although lab-based experimental studies have identified useful mechanisms for promoting cooperative behavior, which is not predicted by equilibrium theory, endogenous punishments are rarely allowed to deter selfish behavior in real social interactions. For instance, law-abiding members of society are not normally granted the freedom to impose punishments on their peers at a cost to themselves. To the best of our knowledge, a more realistic exogenous punishment mechanism has yet to be extensively tested experimentally. The experiment we report here provided compelling evidence on this issue. Our experimental design allowed us to compare the effectiveness of a probabilistic punishment mechanism. In our exogenous punishment system, punishment was not initiated by the subjects, but was enforced automatically by a computer program using well-defined rules. In each round of the game, the computer program imposed a punishment on the subject who contributed the least to the public account. There were two special cases. First, when two or more subjects in a group contributed the same amount to the public account and it was the lowest amount in the group, a random draw determined who would be punished. If all of the group members contributed the full endowment, then no one was punished.

More than 300 subjects participated in our experiment. The results not only show that an exogenous punishment system promotes stronger cooperation in the public goods game, they also provide compelling evidence that when individuals face a 50% probability of a potential punishment that would reduce their payoff to zero, they free-ride significantly less often than when they face a very small probability of a punishment that would reduce their payoff to a negative amount, or when they face a definite punishment that would deduct a very small amount from their payoff.

The remainder of this paper is organized as follows. In Section 2 we introduce the experimental design in detail. In Section 3 we analyze the experimental data with non-parametric tests and an econometric regression. We then summarize and discuss our main findings. In Section 4 we provide some concluding remarks and discussion.

2. Experimental design

We designed four treatments to examine the effectiveness of the exogenous punishment mechanism. The first treatment was a control condition that used the traditional public goods game with no punishment. The other three treatments had the same expected penalty of 10 points for the player who contributed the least, but the probability and degree of punishment varied in each treatment. Each subject experienced only one of the four treatments and each game was repeated 10 rounds. Four subjects were randomly matched to form a group in each round. This random-match design was intended to reduce the effect of reputation, but could potentially reduce the independence of the observations as more subjects might interact with each other.

Each of the three treatments with punishments comprised two stages. In the first stage, the subjects had to decide how many of their 20 endowment points to put into the public account (using integer amounts only). Every point contributed

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