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Ambiguity on audits and cooperation in a public goods game ☆

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ABSTRACT

We investigate the impact of various audit schemes on the provision of public goods, when contributing less than the average of the other group members is centrally sanctioned and the probability of an audit is unknown. We study how individuals update their beliefs about the probability of being audited, both before and after audits are permanently withdrawn. We find that when individuals have initially experienced systematic audits, they decrease both their beliefs and their contributions almost immediately after audits are withdrawn. In contrast, when audits were initially less frequent and more irregular, they maintain high beliefs and continue cooperating long after audits have been withdrawn. This identifies the compliance effect of irregularity and uncertainty due to learning difficulties. By increasing both the frequency of audits and the severity of sanctions, we also identify an educative effect of frequent and high sanctions on further cooperation.

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1. Introduction

It is well known that the provision of public goods suffers from free-riding (Isaac et al., 1985; Andreoni, 1988; Ledyard, 1995) but that cooperation increases when a decentralized sanction mechanism is introduced (Fehr and Gächter, 2000; Masclet et al., 2003; Bochet et al., 2006; Carpenter, 2007). Although this mechanism is inherently uncertain, it may improve long-term efficiency (Gächter et al., 2008) but only in some instances (Engelmann and Nikiforakis, in press). Moreover, it has also detrimental effects.[1] Replacing peer punishment with legal sanctions (Yamagishi, 1986; Polinsky and Shavell, 2000;

[1] The positive impact of a decentralized sanction mechanism on cooperation may be higher when sanctions are more severe (Egas and Riedl, 2008; Masclet and Villeval, 2008; Nikiforakis and Normann, 2008). This mechanism may have a detrimental effect because of a deterioration of altruistic

Andreoni and Gee, 2012), whether deterrent or not (Tyran and Feld, 2006), or with subsidies and taxes (Andreoni and Bergstrom, 1996; Falkinger, 1996) may avoid these effects. In particular, sanctioning negative deviations and rewarding positive deviations from the mean contribution of group members increase efficiency (Falkinger et al., 2000). The mechanism assumes, however, that deviations are measured continuously. Thus, while it removes uncertainty on audits, it may entail excessively high auditing costs and people may suffer from being permanently monitored.

In this paper we study how to improve the efficiency of a centralized sanction mechanism in a public goods game by exploring in a dynamic setting the impact of the (ir-)regularity and the frequency of audits when there is ambiguity about their occurrence. Under ambiguity, can less frequent audits sustain cooperation while minimizing their cost? By ambiguity we mean that individuals are not informed about the probabilities of audits but can infer these from experience (Ellsberg, 1961). By varying the pattern of audit sequences, we analyze how individuals adjust their contributions after experiencing a sequence of continuous audits *vs.* a sequence of less frequent and irregular audits. This allows us to measure the residual effects of various policing regimes over time in order to find the optimal interval between successive controls in terms of compliance. Ambiguity, continuity of audits, and alternation of audit regimes capture important real-world features. Indeed, ambiguity prevails, as authorities typically do not provide information about the probability of audits.[2] There are also many examples of systematic audits (*e.g.*, video cameras at traffic lights, screening of passengers at airports, ticket inspection in railways). Crackdowns illustrate continuous/systematic audits in a dynamic framework. They correspond to episodes of very high officer presence, followed by a sudden drop in controls.[3] More generally, auditing policies are often dynamic.[4]

We hypothesize that cooperation can be sustained longer after experiencing irregular as opposed to long continuous audit sequences. If the probability of an audit is unknown, (ir)regularity might limit the capacity to learn the actual probability and thus, impact the evaluation of costs and benefits of contributing. In a different setting it has been shown that under ambiguity, intermittent reinforcers have greater effects on behavior than continuous ones even after a regime shift.[5] Similarly, learning is much slower when incentives involve probabilistic rather than continuous reinforcement (Bereby-Meyer and Roth, 2006). However, although some studies have found a positive effect of uncertainty on compliance (Friedland, 1982; deAngelo and Charness, 2012; Tan and Yim, 2014), others have shown that less uncertainty may lead to better outcomes. Alm et al. (1992) found a positive effect of uncertainty on compliance when the fines are lost but a negative link when they are redistributed as in a public goods game. It is thus unclear *a priori* whether ambiguity and higher irregularity of audits do or do not increase contributions to public goods.

To address this question, we designed a three-player linear public goods game in which negative deviations from the mean contribution of the other group members trigger a centralized sanction in case of an audit. We implemented a relative mechanism because sanctioning negative deviations is consistent with the centralized sanction mechanism proposed by Falkinger (1996) – except that, for the sake of simplicity, we do not reward positive deviations. The advantages of this mechanism are its simplicity and the fact that it does not require more information than other mechanisms (for example, central authorities know the mean reported income in each occupational category; individual deviations from the mean can signal a willingness not to contribute).[6] Also, in sharp contrast with previous literature (Alm et al., 1992; Mittone, 2006; Kastlunger et al., 2009; deAngelo and Charness, 2012), players are not informed about the audit probability; they must infer this from experience. Moreover, while the game lasts 50 periods, a regime shift is introduced by eliminating audits after period 22.

Before the regime shift, the frequency of audits and the severity of sanctions vary across treatments. In the Cont Low Fine treatment (*Cont* for Continuous), each of the first 22 periods is audited. In the Int 7 High Fine treatment (*Int* for Intermittent), only seven audits are randomly assigned across periods and the severity of sanctions is tripled (to maintain

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