
Endogenous and costly institutional deterrence

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Modern economies rely on central-authority institutions to regulate individual behaviour. Despite the importance of such institutions little is known about their formation within groups. In a public good experiment, groups selected the level of deterrence implemented by the institution, knowing that the administrative costs of the institution rose with the level of deterrence. Results suggest that groups readily self-impose costly deterrent formal institutions. The strictly deterrent institutions implemented here increased contributions sufficiently to completely offset the administrative cost and significantly increase earnings.

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JEL Classification: C92; D70; H41

I. Introduction

Modern economies rely on formal, central-authority institutions to enhance cooperation and thereby improve welfare. Such institutions enhance cooperation by deterring selfish behaviour. In a public good experiment, deterrence is effective when it is in the self-interest of individuals to cooperate because the expected cost of free riding exceeds the benefit. The expected cost is a function of the level of sanction imposed for uncooperative behaviour and the probability of being sanctioned (monitored).

The literature has focused on the level of the sanction assuming perfect monitoring and no administrative expense. Tyran and Feld (2006) found that deterrent institutions can enhance welfare whether they are exogenously or endogenously imposed but that nondeterrent institutions do so only when endogenously selected.¹ Putterman *et al.* (2011) investigated the choice of sanction level and found that groups self-impose deterrent sanctions when additional deterrence involves no administrative costs.²

This article reports on a public good experiment wherein subjects may self-impose a costly formal institution. The novelty of the experiment is that

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¹ Engel (2014, *forthcoming*) motivate the effectiveness of nondeterrent institutions using a model of social preferences.

² Galbiati and Vertova (2008) investigate a nondeterrent, imperfect monitoring, institution that is exogenously imposed at no cost. They manipulate the level of contribution required to avoid the sanction and show that a nondeterrent institution can enhance welfare when the obligation is high.

deterrence is endogenous and includes an administrative expense. Deterrence is manipulated through the probability of being sanctioned, which is a function of how many group members are likely to be monitored. To increase the deterrence the group must allocate additional resources to monitoring, which reflects the fact that formal institutions are costly to administer and are often imperfect. For example, consider a central authority's attempt to regulate traffic. The administrative costs include those of monitoring drivers and imposing the legal sanction through the court system. Some of these costs are incurred regardless of individual behaviour, but others increase with the level of monitoring.

Building on the literature showing that groups self-impose deterrent institutions when additional deterrence involves no administrative costs, we found that groups overwhelmingly self-impose some level of deterrence even when it is costly, rather than imposing less costly nondeterrent institutions.

II. Experimental Design and Procedures

The experiment consisted of 25 paid periods broken into three phases. In groups of five, subjects began each period with an endowment of $e = 20$ experimental dollars (EDs). Phase 1 (periods 1–3) introduces the standard voluntary contribution mechanism (VCM) wherein subjects decide how much to contribute to a group account. The payoff (π) for subject i is:

$$\pi_i = e - x_i + \alpha \sum x_j$$

where x_i is the subject's contribution and $\alpha = 0.4$ is the marginal per capita return from the group account. With $\alpha < 1 < n\alpha$ there is a unique Nash equilibrium where every subject free rides, and a unique Pareto efficient equilibrium where every subject contributes their entire endowment. The literature has established that initial contributions are roughly half of one's endowment and that contributions decline with repetition but remain above the level predicted by self-interest (Ledyard, 1995; Chaudhuri, 2011).

All periods following phase 1 include a sanctioning mechanism. With this institution each subject's contribution *may* be monitored, and, if monitored,

the subject's earnings for the period *may be* reduced. Pay-offs are as follows:

$$\pi_i = e - x_i + \alpha \sum x_j - \frac{mz}{n} - ps(e - x_i)$$

where $z \in \{0,1,2,3,4,5\}$ is the number of subjects who may be monitored and $m = 5$ is the cost of monitoring each additional subject. The administrative cost of the institution, mz , is split evenly among subjects in the group. The number of subjects who may be monitored determines the probability of being monitored, $p = z/n$. For example, if $z = 1$ then $p = 0.2$ and each subject independently faces a 20% chance of having their contribution monitored. The level of the sanction, $s = 1$, is set so the sanction is equal to the amount remaining in the subject's private account ($e - x_i$).

Solving the first-order condition with respect to x_i suggests that the institution is strictly deterrent if $ps > 1 - \alpha$, which implies that the expected cost of free riding is greater than the benefit. Solving for $z = n(1 - \alpha)/s$ implies that the institution is strictly deterrent when $z \in \{4,5\}$. Similarly, the institution is weakly deterrent when $z = 3$ and strictly nondeterrent when $z \in \{1,2\}$. When $z = 0$ no institution is implemented and subjects play the VCM.

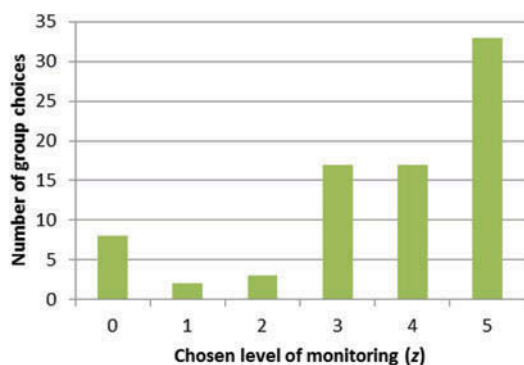
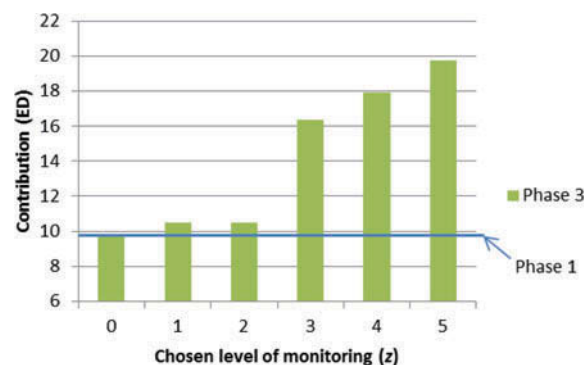
Phase 2 (periods 4–15) is used to familiarize subjects with the sanctioning institution. In this phase, z is exogenously imposed so that each group encounters (in random order) each level of monitoring twice. In Phase 3 (periods 16–25), the sanctioning institution is endogenously determined. At the beginning of each period subjects vote on the level of monitoring to be imposed, knowing that the median vote will be implemented.

III. Results

Forty subjects (eight groups of five) participated in the experiment. The unit of observation is the period average at group level. This provides 24 observations across the 3 VCM periods, 96 observations across the 12 exogenous periods (16 at each level of monitoring), and 80 observations across the 10 endogenous periods (the number of observations at each level of monitoring varies) (Table 1). The experiment lasted approximately 75 minutes and subjects earned an average of \$12.64.

Table 1. Average group contributions and earnings (in experimental dollars)

	Number of subjects likely to be monitored					
	0	1	2	3	4	5
<i>Phase 1: VCM</i>						
<i>N</i>	24					
Contribution	9.93					
Earnings	29.93					
<i>Phase 2: institution exogenously imposed</i>						
<i>N</i>	16	16	16	16	16	16
Contribution	7.71	10.03	12.99	16.30	17.88	17.28
Earnings	27.71	26.90	28.90	31.06	32.21	29.55
<i>Phase 3: institution endogenously imposed</i>						
<i>N</i>	8	2	3	17	17	33
Contribution	9.73	10.50	10.47	16.38	17.89	19.73
Earnings	29.73	25.00	26.13	30.53	32.22	34.45

**Fig. 1. Frequency of chosen monitoring levels (phase 3)****Fig. 2. Average contribution (phase 3)**

The analysis presented here focuses on the behaviour in phase 3 relative to the VCM of phase 1.³ In phase 3, subjects nearly always voted for some level of deterrent monitoring (Fig. 1). Only eight votes resulted in no monitoring (a single group was responsible for all eight occurrences) and only five votes resulted in positive but strictly nondeterrent levels of monitoring, $z \in \{1,2\}$. The remaining 67 votes resulted in some level of deterrence: 17 votes for $z = 3$, 17 for $z = 4$ and, 33 votes for $z = 5$. Thus, despite the administrative expense, a majority of groups self-imposed strictly deterrent, $z \in \{4,5\}$, monitoring.

Phase 3 average contributions were similar to the VCM (phase 1) level of 9.93 EDs when the institution was nondeterrent, but substantially higher

otherwise (Fig. 2). Wilcoxon rank-sum tests (used throughout) confirm this result: $z = 3$ ($p < 0.01$), $z = 4$ ($p < 0.01$) and $z = 5$ ($p < 0.01$). Average period earnings exceeded those of the VCM (29.93 EDs) only when the institution was strictly deterrent: $z = 4$ ($p < 0.01$) and $z = 5$ ($p < 0.01$) (Fig. 3). Earnings were similar to those of the VCM when the institution was weakly deterrent ($p = 0.24$) or when no institution was implemented ($p = 0.73$).⁴

Results within the strictly deterrent levels of monitoring are of particular interest. Strict deterrence implies that it is in the interest of each subject to contribute their entire endowment, and incentivizes the same level of contribution. However, given costly deterrence, moving from monitoring four group members to monitoring

³ Analysis of the phase 1 (VCM) and phase 2 (exogenous institution) results are available upon request.

⁴ Earnings appear low when monitoring is strictly nondeterrent but the number of observations is too small to allow statistical analysis.

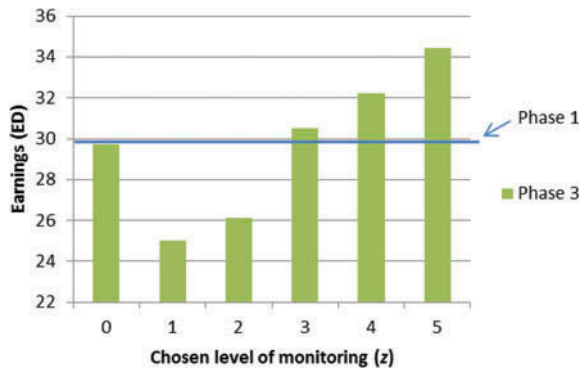


Fig. 3. Average earnings (phase 3)

five involves greater administrative expense and potentially lower earnings. Nevertheless, contributions were significantly higher when all members were monitored ($p < 0.01$). The increase in contributions more than offset the greater administrative expense and significantly increased earnings ($p < 0.01$).

IV. Discussion and Conclusion

This article presents an experiment that allows groups to self-impose a central authority to deter selfish behaviour, but the level of deterrence is both costly and potentially imperfect. In order to increase deterrence groups must devote greater resources to the institution. This relationship between individuals and state authority reflects the reality that central authorities imperfectly monitor behaviour. Imperfect monitoring, a result of limited state resources, makes it possible for individuals to deviate from the established rules without facing a legal sanction.

Despite the effectiveness of nondeterrent, endogenously imposed institutions in the literature, groups overwhelmingly imposed some level of deterrent monitoring, foregoing the opportunity to lessen the administrative expense. Further, perfect monitoring ($z = 5$) was the most commonly chosen option. This preference for perfect monitoring is reminiscent of the results presented in Kosfeld *et al.* (2009), who explored the endogenous formation of deterrent institutions. In their design each group member decided whether or not to be part of

the institution. After observing the number of group members willing to be governed by the institution, the willing members voted on implementing the institution. The institution only regulated the behaviour of the members within the institution and allowed those outside the institution to free ride. Despite the incentive to form institutions that regulated only subgroups, results suggest that such institutions were often rejected. That is, subjects appeared unwilling to implement a welfare enhancing institution where some players had the opportunity to free ride.

Note that the administrative cost of perfect monitoring implemented here is rather modest. A higher monitoring cost may limit the willingness of groups to self-impose deterrent levels of monitoring. Research suggests that groups prefer informal institutions over formal institutions (with perfect monitoring) unless the latter are free or only include a modest administrative expense (Kamei *et al.*, 2011; Markussen *et al.*, 2014). Future research is required to investigate how the willingness to self-impose deterrent institutions varies with monitoring cost.

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