Endogenous Institutions: A Network Experiment in Nepal

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December 29, 2022

Abstract

This paper studies the demand for a monitor and its effect on cooperation across social groups. Mapping the networks of 19 Nepali villages, we conduct a two round contribution game in groups of three. The paper first studies how the endogenous institutional choice depends on the social proximity—whether close or far—of the three participants. Close groups are 40 percentage points less likely to choose a monitor, whereas sparse groups tend to prefer a monitor who is central. Second, the paper explores how the democratic selection of monitoring improves cooperation by up to 22 percent compared with an exogenous assignment, but only in sparse groups. Finally, we find that the positive effect of endogenous monitoring can spillover to games played under exogenous assignment.

KEY WORDS: networks, peer monitoring, experiment, public goods game.
JEL CLASSIFICATION: C93, L14, P48.

We would like to thank CEPREMAP, LABEX OSE and Sarah Andrieux Fund for the funds to conduct the field experiments. We thank our partner organization, Rooster Logic Nepal and the enumerators for the execution of the field project. We are grateful to Philippe Jehiel, Abhijit Banerjee, Margherita Comola, Habiba Djebbari, Nicolas Jacquemet and Philipp Ketz for their tremendous guidance. We have benefited from the comments of Francis Bloch, Yann Bramoulle, Horacio Larreguy, Beatrice Boulu Reshef, Emily Breza, Vessela Daskalova, Fabrice Etile, Edoardo Gallo, Gabrielle Demange, Esther Duflo, Ben Golub, Cynthia Kinnan, Sylvie Lambert, Jonathan Lehne, François Libois, Jean François Laslier, Karen Macours, Emanuela Migliaccio, Agnieska Rusinowska, Santiago Sanchez-Pages, Paolo Santini, Paul Seabright, Lennart Stern and Karine Van Der Straeten. In addition, we thank the participants of the BREAD Conference 2021, and of seminars at Harvard, MIT, NEUDC, CTN, PSE for their feedback. We acknowledge financial support from the Belgian French speaking community ARC project n. 15/20-072 of Saint-Louis University - Brussels. This field experiment is registered as AEARCTR-0007274 and is approved by the IRB.

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1 Introduction

Cooperation across groups has been found important to ensure better outcomes, and inherent punishment mechanisms can help improve cooperation (Fehr and Gatcher 2000, Charness et al. 2008, Guilen et al. 2006). In the absence of punishment, reputation concern may act as a strong factor to incentivize cooperation. In this regard, Ostrom 1990 highlights how mechanisms based on peer effects and social ties can sustain high levels of cooperation. Social networks have been shown to be effective in reinforcing cooperation through a reputation channel (Chandrashekhar et al. 2018, Breza and Chandrashekhar 2019). So far the literature has established effectiveness of peer monitors but not studied their demand across social groups. In this paper, we aim to fill this gap by studying the endogenous demand for peer- monitors and its effect on cooperation.

We think of the social network affecting cooperation in two ways. The first is through social proximity – interacting with close relations have different incentives than interacting with people far away in the network. Research has well established that the level of altruism decreases with social distance (Goerre et al. 2010, Lieder et al. 2009). Socially close individuals are therefore more likely to have an ex-ante higher level of cooperation, even without external enforcement. The second way is through one's position in the network – central individuals have a strategic advantage of being connected to more people. They are more well suited to influence people and spread information (Banerjee et al. 2019). In this paper, we vary the social proximity to study monitor choice and cooperation behavior. We let individuals choose from one of the three options when electing a monitor: no-monitor, high-central and low-central.

Ideally, we would want to randomize the intensity of social interactions to study the impact of social proximity on cooperation and peer-monitor choice. Unable to do so with real networks, we instead randomly form groups of three people with pre-existing social ties and different levels of social proximity to play a cooperation game. Individuals play a contribution game in both socially close (dense) and socially far (sparse) group composition. In line with the literature, we expect to observe higher cooperation in dense groups. With our experiment, we aim to answer how demand for a peer monitor relying on reputation concerns varies across the two groups. Further, we want to understand how democratic selection of monitors (endogenous choice) affects cooperation across groups.

In our experiment, individuals play a non-anonymous contribution game in groups of three in both group compositions, dense and sparse. Before playing the game and after the group composition is known, individuals decide if they want to elect a monitor to oversee the game. The peer monitor simply observes everyone's contribution to the public good, which would otherwise be private information. No punishment occurs within the game; the only way these peer monitors can be effective is via reputation concerns, the threat that information about contributions could be communicated outside the field. The monitor is costly and chosen at the individual level where cost of the monitor is borne by the individual not the group. The group then plays two rounds of the contribution game: one with the monitor chosen by the group (endogneous) and the other randomly assigned by us (exogenous)

Given that we are looking at real networks, one might worry network position may correlate with individual unobserved characteristics. We tackle this concern by having each participant interact twice in two different groups. Using a difference-in-differences approach, we are then able to extract individual fixed effects that are invariant across groups and monitoring environment. We further control for group-level similarity in a set of characteristics. Specifically for the endogenous choice of monitor, group level unobserved characteristics may determine monitor choice, thereby varying the monitor environment. In this case, we provide only a within-group-level causal analysis of cooperation.

Our findings show dense groups are likely than sparse groups to opt out of a monitor. Sparse groups are 40% more likely than dense groups to elect a high-central monitor. In terms of exogenous monitors, the presence of a high-central monitor improves cooperation. This effect is stronger for sparse groups than for dense. To obtain a causal estimation of an endogenous monitor, we conduct a within-group comparison. Within sparse groups that choose a high-central monitor, contribution is 8.6% higher under the democratically elected endogenous monitor. The increase is 22% when sparse groups choose to elect no-monitor.

To our knowledge, this paper is the first that tries to disentangle effects of endogenous monitor choice on cooperation through the reputation-concern channel in networks. In the literature, concern about a bad reputation as non cooperators spreading outside the laboratory is seen to be more efficient than punishment in increasing cooperation.[1] Beersma and Kleef 2011 show in the context of public-goods games that fear of being reported increases cooperation. Reputation concerns via anticipation of future interactions helps make such reputation based peer monitoring effective. In our setting, we show heterogeneity in the effectiveness of reputation concern to enforce cooperation across the social network. To do this, we vary group composition, choice of monitor and assignment of the monitor (endogenous vs. exogenous).[2]

Why would the monitor affect cooperation in the game? Central individuals (well connected) in the network are shown to be particularly effective in monitoring, due to their higher ability to spread information in the form of gossip (Ballester et al. 2006

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[1] For more details, see Wu et al. (2015, 2016), Sommerfeld et al. (2007), Glockner et al. (2007), Galbiati and Vertova (2008), Fonseca and Peters (2018) and Fehr and Sutter (2019)).

[2] A large literature also shows the effect of punishment in public-goods and voluntary contribution games. Fehr and Gachter (2000), Masclet et al. (2003), Charness et al. (2008) and Fiedler Harvey (2016).

and Banerjee et al. 2013). These social ties not only facilitate information flows but also provide an opportunity to use social sanctions (Besley and Coate 1995, Grief 1989, 2006, Karlan et al. 2009). Further, in the context of common resource management, Ostrom 1990 suggests how mechanisms based on social ties have sustained cooperation rather than mere punishment.

Why would the composition of the group matter? Chandrasekhar et al. 2018 establish that capacity for cooperation in the absence of contract enforcement depends on players' network position. Evidence from a recent lab in the field experiment by Breza et al. 2016 find cooperation in a closely-knit pair is slightly crowded out by the presence of a central monitor. On the other hand, socially distant pairs have greater cooperation [3] in the presence of a central monitor. In their work, monitors are exogenously given and their design does not allow them to extract fixed effects at the individual level. The novelty of our design is to vary not only the social distance and monitor position, but also how the monitoring institution is selected. By introducing monitor choice, our goal is to contribute to the literature on institutional choice by studying whether the endogenous choice of a monitoring institution outperforms its exogenous assignment and how it varies across close and sparse groups.

Why would the democratic selection of monitor matter? Tyran and Feld 2006 show endogenously choosing (self-imposed) mild law is more effective in achieving compliance, by triggering the expectation of cooperation. Similarly, Dal Bo et al.,2010 show that the effect of a policy on the level of cooperation is greater when it is chosen democratically by the subjects than when it is exogenously imposed. Endogenous institution choice improving cooperation has been established in the literature (Sutter et al.2010, Grossman and Baldassarri 2012). In this paper, we identify heterogeneous effects across group composition. In particular, we show social proximity plays a role in effectiveness of endogenous institution selection. Further, the choice of monitor acts as an extra signal to the group about expected level of cooperation (Herold 2010).

The rest of this paper is organized as follows: Section 2 describes the experimental protocol and the data collection process. Section 3 sketches the framework. Section 4 describes the results of the experiment and the econometric specifications. We discuss the results and conclude in Section 5.

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[3] For details, see the literature on social norms and reputation where players' concerns about their social image drives contribution (Kranton et al. (1996), Bowles (2008), Jackson et al. (2011), Andreoni and Sanchez (2020), DeAngelo et al. (2020). In the same spirit, experiments in the lab (Hoffman et al. (1996), Glaeser et al. (2000), Leider et al. (2009), Goeree et al. (2010)) and in the field (Etang et al. (2011), Baldassarri and Grossman 2013) show that cooperation increases with decreasing social distance.

2 Experiment

2.1 Context and network data

We conducted our experiment in September 2018 in the mid-hills of Nepal, covering 19 villages in Thaha Municipality in the district of Makwanpur. Villages on average comprised 70 households, for an average of 120 women per village. Our network survey covered more than 2000 women[4] ages 18-60. We used a village census to administer the network survey to every woman in the village.

We started by mapping the social network of villages, with a special focus on relations of trust. The questionnaire consisted of a set of questions designed to elicit social networks, inspired by Banerjee et al. 2013. These questions are meant to elicit ties of friendship and trust and span various dimensions of social interactions. A link between two individuals i and j was established when either i nominated j or vice versa in any of the questions. We then aggregated the networks obtained from different questions into one, undirected network.

As an incentive to participate, individuals were given 100 Rs (1 euro) for participation and were informed they could earn more. On average, the total gain was around 220 Rs per individual, which is half a day's wage. Participants assigned as monitors were given a fixed sum of 250 Rs for their participation. Our experiments were typically conducted early in the morning in schools close to each village. Typically, three sessions were run in parallel in separate classrooms, with one session lasting for around 15 minutes.

2.2 Overview and the role of monitors

In each village, two women were assigned the role of monitors and the rest were assigned to groups of three with varying social proximity. The individuals assigned as monitors belonged to the top (high-central) and bottom (low) 5% of the centrality distribution. The rest of the women were assigned to dense groups, with an average path length less than 1.6, and in sparse groups average path length higher than 4.[5] In other words, being in a dense group implies the members of the group are no more than two steps away from each other whereas in the sparse group they are at least four steps away. The starker the difference between dense and sparse groups, the more different the behavioral response

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[4] We focus on networks of only women, due to the high emigration rate of men either to Kathmandu or abroad, as shown by our pilot experiment conducted in spring 2018. In the districts we worked in, social networks are often gender-specific and women play a preponderant role: they are responsible for households' finances, agricultural production and their children.

[5] The dense groups would correspond to topography that represents a triangle (average path=1)and a line (average path=1.3). The cutoffs defining dense and sparse were carefully chosen to amplify the respective contrast in trust and reputation while maximizing the number of observations.

in the different treatments. Figure 6 in Appendix B shows the distribution of the average path length of all groups we formed. We oversampled dense groups to make a reliable comparison with sparse ones. We end up with 503 women who played in both sparse and dense groups, as defined by our thresholds. The summary statistics are presented in Table 8. In total, we have four observations for each participant, for a total of 2012 observations.

The monitor candidates were chosen with respect to their eigenvector centrality and their assignment to groups was determined by either democratic election or random exogenous assignment. We chose eigenvector centrality because it captures how much information emanating from a monitor spreads in the network, also reaching individuals who are not directly connected to the monitor (Banerjee et al. 2016, Banerjee et al. 2019, Breza and Chandresekhar 2019). These works show individuals' eigenvector centrality can explain their capacity to spread information in the larger network and that villagers can accurately identify central members of the community.[6] Underlying the framework is the assumption that participants' behavior in the experiment will likely affect market and non-market interactions outside the laboratory, such as access to jobs, informal loans, or other opportunities. In this context, we assume monitors can induce cooperation through their capacity to report outside the laboratory bad behavior that occurred within our experiment.

To provide support for our framework, in 2019, we surveyed more than 300 random women. We shared with them a vignette of our experiment and asked several questions about the reputational power of monitors. The purpose of this survey was to capture their perceptions of the role of monitors and possible motivations behind voting for one of them. We described our study and asked subjects whether information about misbehavior in the experiment would spread, how the spread would depend on the identity of the monitor, and what could be the motivations for voting to have a monitor. As seen from Figure 2, we find that, on average, respondents believe high-central monitors can spread information to almost 60% of the village population, whereas low-central or average-central monitors would reach less than 40% of the village population. Similarly, more than 80% of respondents declared they would vote for a monitor to keep other group members in check through the threat of reputation.

2.3 Experimental design

Each participant played one round of voting and two rounds of contribution game, endogenous and exogenous, in two different group compositions, dense and sparse. Our experiment has three different treatment components. We used the network to randomize each individual into two groups of contrasting social density. First is group composition. Groups were composed either of close friends or of people socially distant in the network.

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[6] As seen from Table 1, we show that our measure of centrality is highly correlated with degree and betweness centrality. Our results are therefore robust to using any other measures of centrality.

Second is the centrality of monitors. In our experiment, we offer three monitoring options: high-central monitors, low-central monitors, and no monitors. Third is the process whereby monitoring institutions are assigned: either democratically elected by the group or exogenously imposed. The full timeline of the experiment is presented in Figure 1.

Randomize groups. After assigning two women per village as high-central and low-central monitors, we divide the rest of the individuals into groups of three with varying group composition, either dense or sparse. Individuals play in groups of three in both the dense and sparse treatment in a randomized order. In Figure 8, we show two possible groups for the player circled in green. She plays both with her closest friends (circled in red) and with individuals far in the social network (circled in blue). By always reshuffling groups in such a way that every individual plays in exactly two different groups, we can extract individual fixed effects. This part of the design is of paramount importance because of the intrinsically endogenous nature of networks: the network position of player i is endogenous to her observable characteristics, which are in turn affecting her contribution. This design allows a neat disentanglement of the endogenous position in the network from the contribution, through the extraction of fixed effects at the individual level. At the start of each session, group players are gathered in a room where they can see each other, but no communication is allowed. Each member of the group receives 10 tokens of a different color, where the value of 1 token is marked at 10 Rs.

Voting. Each player privately casts a vote for her preferred monitoring option.[7] Players have the option to choose between a high-central monitor (H), a low-central monitor (L), or no monitor at all (NM). Note that this monitor is a fourth individual that remains the same for all groups within a village. The cost of choosing the monitor is 20 Rs.[8] This cost makes always choosing a monitor a non-dominated strategy. The cost is paid by participants who vote to have a monitor (either high-central or low-central), irrespective of the voting outcome of the group.[9] The monitor is elected by a majority rule and the result of the vote is not immediately revealed. The monitor does not have the power to impose fines and simply observes the contribution of each player in the contribution game which would otherwise be private information.

Randomize order. As seen in Step 3 of Figure 1, the group is then randomly assigned to either the endogenous or exogenous treatment. The randomization is implemented by picking one of two balls: if a green ball is drawn, the endogenous treatment is played first and the exogenous follows. If the ball drawn is pink, the exogenous is played first, followed by endogenous. The result of the voting is only revealed just before playing the endogenous treatment. In the exogenous treatment, the group is randomly assigned

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[7] In case of a tie, the monitor choice was determined by a random draw. Ties represent around 6% of cases.

[8] In line with public good literature, the cost of the option was around 7% of the average earnings across all games. Also, the fee player i pays when choosing a monitor is directly detracted from the realized payoff of that specific round and does not directly affect the payoff of other players nor monitors.

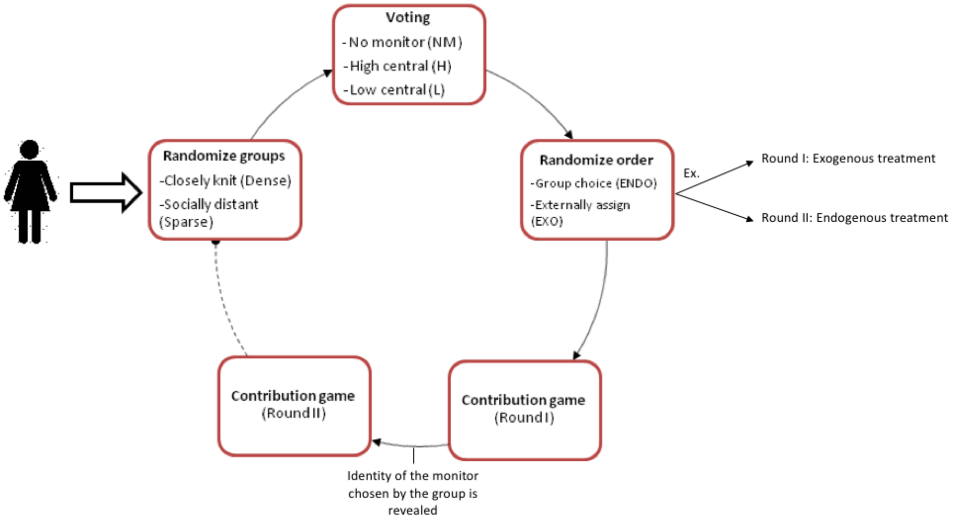
[9] If x votes for a monitor but no monitor is elected by the group, x stills pays the cost of voting for a monitor.

either to a high-central, low-central, or to no-monitor treatment.

Contribution game. The group plays a public-good game in which each player decides how many tokens out of the 10 are to be contributed to the public pot. The players are told that the money in the public pot will be increased by 50% and then divided equally among them. Once the contributions are made, the monitor – either elected or assigned – is called into the room to see how much each player contributed to the public pot. The monitor can distinguish the contributions belonging to each player by the different colors of the tokens they were endowed with. Moreover, the monitor does not have the power to impose fines and simply observes how much each player contributed. In the same group, this contribution game is played twice: with an endogenous-monitoring institution and with an exogenous institution, where the order of the two is randomized.

We exploit only the informational channel whereby the players' reputation can be affected (e.g. gossips, reporting, etc.), following the assumption that it would drive much of real-life interaction in the village. We study how the fear of being reported on by the monitor outside the lab drives the behavior of people and how it consequently affects the demand for third-party monitoring.[10] To sum up, the contribution game is played twice in the same group without receiving any feedback: once with the monitor option chosen by the group (endogenous) and once with the randomly assigned monitoring option (exogenous).

Figure 1: Timeline



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[10] Breza et al. 2016 do not find a significant difference between information and punishment treatments

3 The Framework

We think of the interactions among our participants as being influenced by two intertwined factors. The first factor is the individual propensity to care for the material utility of another person. We call this altruism, and we assume, in line with the literature (Liedler et al. 2009 and Goeree et al. 2010), i's altruism to be greater towards individuals who are socially close to her than towards individuals who are socially further away. In the context of our experiment, we think of altruism as being on average higher in dense groups compared to sparse groups. This perspective is consistent with anecdotal evidence with participants and with a larger literature in sociology and anthropology. Second, we think of reputation as the main channel through which monitors can effectively enforce social norms. As shown by the results of our survey in Figure 2, monitors are consistently perceived as capable of spreading information about people's behavior in the game, thus affecting their reputation and their longer-term interactions outside of the experimental sessions.

More formally, agents are embedded into a fixed network of relations. We model the contribution behavior of individuals with an *altruism* parameter α. We think of this parameter as representing how much an individual cares about the material utility of others and as determining the propensity of higher contribution. As people become more altruistic, the value of α increases, individuals care more about the material utility of others and are more likely to contribute a higher amount. Each individual i has a level of altruism α_i that depends on the group she plays in, where $\alpha_i \in \{\alpha_l, \alpha_h\}$ and $\alpha_h > \alpha_l$. Player i knows her level of altruism α_i and has a prior $\mu_{0i}(\alpha_j)$ on the level of altruism of the other player j . Let us assume agent's i ex-ante subjective probability of j being a high type $\mu_{0i}(\alpha_j = \alpha_h)$ depends on how close they are in the network. Agents i and j can form a group of type $G(ij) = G(ji) = \{d, s\}$, they can form either a dense group or a sparse group. In this context, i's prior about j being type α_h is higher in dense than in sparse groups. In our model, the effects of social interactions are introduced in the mechanics of the model through the different initial priors and the reputational "enforcement" power of the monitor. This approach mimics the fact that in dense groups, people perceive their neighbors to be more altruistic than those to whom they are not directly connected.

We model our experiment as a game in which agents play a two-stage game. The game unfolds as follows. First, agents simultaneously vote for their preferred monitor $m_i \in \{0, 1\}$, where $m_i = 0$ implies no monitor is chosen by individual i, and $m_i = 1$ means i votes for having the monitor. Once participants cast their votes, the group-preferred monitoring technology is assigned to the group. In the second stage, agents play a voluntary contribution game that can be overseen either by a third-party monitor or by no one. The third-party monitor can either be assigned through a random lottery

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[10] We present here a simplified model with two agents for the sake of exposition, but we extend the main results to three agents in the Appendix to match the experimental design.

or elected through a democratic vote, which happens in the first stage. The total contribution of all players is increased by 50% and divided equally among the group members. The utility of player i is a function of her own contribution c_i and that of the other $c_{j \neq i}$, the level of altruism α_i, and the rate of return of the contribution game. We assume a convex cost of contributing to represent the behavioral burden of contributing and to ensure the existence of an interior solution.

In the case where a monitor is voted for or elected, two additional elements enter our modeling exercise: the cost of monitor election mc and a reputation cost $-\delta P(c_i < \theta)$. Voting for the monitor is costly, and i pays mc if she votes for the monitor, irrespective of whether the monitor is elected. If elected, the monitor can impose a reputation cost on the players. The parameter $\delta > 1$ represents the penalty from a contribution lower than the social norm θ in the presence of the monitor. As corroborated by qualitative evidence presented in Table 2 and for the sake of exposition, we use a fixed value of δ. However, we could incorporate a varying power of monitors depending on their centrality, by allowing $\delta \in \{\delta_H, \delta_L\}$, where $\delta_H > \delta_L$, that is high-central monitors are more effective in spreading information and can inflict stronger reputational penalties. The social norm is a stochastic parameter θ representing the fact that different groups would have different norms about what is considered an acceptable cooperative behavior.[11]

Finally, and most importantly, players are considered Bayesian. When the identity of the third-party monitor is decided by the group, individuals process the election outcome as carrying information about the types of their group players. They do so by updating their beliefs regarding the types of the individuals they played with. More formally, i updates her prior about all players j's type $\mu_{0i}(\alpha_j)$ to $\mu_{1i}(\alpha_j)$ depending on the outcome of the voting m^*. When players do not observe the outcome of the group vote, when third-party monitoring is exogenously assigned, players do not observe any signal and do not update their priors.

4 Results

The hypothesis is that the individual demand for peer-monitoring varies depending on the composition of groups, namely across dense and sparse groups. In particular, we expect individuals in dense groups to not choose a monitor and to enforce cooperation on their own. This result would not hold for socially sparse groups, where the ex-ante level of contribution is lower, given the lower level of altruism and trust. Thus, socially sparse groups might have a stronger incentive to pay the fixed cost of electing a monitor who can strengthen the reputation channel and spur cooperative behavior. The presence of a monitor – especially so for a high-central one – increases the possibility of being reported on outside the lab in case of "defection." We expect dense groups to be more

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[11] The social norm parameter varies across dense and sparse groups. Individuals would be expected to contribute more than in sparse ones.

cooperative than sparse groups, irrespective of the treatments. Finally, we expect that the political process whereby the monitoring institution is assigned (either endogenously or exogenously) will matter. The group's choice of the monitor is revealed only before the endogenous treatment and potentially carries additional information about the group's altruism level.

4.1 Preliminary findings and possible limitations

We start the analysis by looking at the individual-level variation in the choice of the monitor. In Table 2, the numbers along the diagonal represent the percentage of individuals who always choose the same voting strategy irrespective of group composition. The largest proportion (34.95%) always chooses to have no monitor, followed by those that always vote to have a high-central monitor (19.68%). The voting result shows substantial variation in voting strategy. In terms of heterogeneity in monitor choice within a group, we find no significant difference across dense and sparse groups. Around 50% of the groups unanimously agree on the same monitoring institution. Looking at the aggregate demand for peer monitoring, we find that sparse groups vote more often to have a central monitor. Figure 3 shows that in dense groups, around 32% of players vote for a high-central monitor, whereas in sparse groups, more than 39% of players do so. The low-central monitor is seldom chosen, accounting for around 13% in both dense and sparse groups. For contribution, exogenous monitoring increases contributions only in sparse groups, as seen from Table 3. We want to study how this result differs when individuals play under the monitor that has been endogenously chosen by the group.

Before presenting the results, we highlight a possible threat to our results and point to a possible solution. Several recent studies have focused on the role that group inequality could play in contribution games (e.g., Nishi et al. 2015, Fehr and Schmidt 1999, Bolton and Ockenfels 2000). We build three variables to capture inequality along dimensions that are particularly relevant to our context: wealth, caste, and education. The inequality indices are simply the group variance of the indices we constructed with our questionnaire on individual-level characteristics. We observe that the 19 villages where we conduct our experimental sessions display very high degrees of homogeneity along these three dimensions. We control for these variables in all regressions under the label "Group Characteristics," which also embed a set of socio-economic characteristics at the individual level. None of these variables have a significant impact on cooperative behavior, and our results are robust to their inclusion among the regressors.

4.2 Statistical estimation

4.2.1 Impact of group composition on monitor voting: election

As suggested by the preliminary results shown in Figure 3, we conduct a Mann-Whitney test to understand whether the proportion of participants choosing a given monitor is significantly different across group compositions. We find that the no-monitor option is chosen significantly more often in dense groups than in sparse groups (p-value 0.07) and that high-central monitors are chosen more often in sparse than in dense groups (p-value 0.002). To estimate how the demand for monitors varies depending on the group composition, we use a multinomial logistic regression with individual and round fixed effects. Because players vote once in a dense and once in a sparse group in a random order, we can include both individual and round fixed effects, thereby exploiting a "within" design and getting rid of the confounding effect deriving from the intrinsic endogeneity of real networks. The fixed-effects, multi-logit model is therefore defined by the logistic probability of the choice of monitor y_{jt}, where y_{jt}=0 represents the no-monitor option being chosen, y_{jt}=1 represents a low-central monitor being chosen, and y_{jt}=2 represents a high-central monitor being chosen. We take y_{jt}=0 as the base category and can write the fixed-effects logit as

$$Pr(y_{jt} = 1) = \frac{1}{1 + e^{-(\alpha+\beta_1 G_{jt}+\beta_2 X_g+\rho_j+\nu_t+\epsilon_{jt})}}$$

$$Pr(y_{jt} = 2) = \frac{1}{1 + e^{-(\alpha+\beta_2 G_{jt}+\beta_3 X_g+\rho_j+\nu_t+\epsilon_{jt})}}$$

where y_{jt} is the chosen level of monitoring, G_{jt} is a dummy for group composition equal to 1 if the treatment is for dense groups, X_g is group characteristics, ν_t is round fixed effects, and ρ_j is individual fixed effects.

We present in Table 4 the results of the multinomial fixed-effects regression of individual monitor choice (voting) on the social composition of the group (dense vs.sparse). In the first column, we find dense groups to be 40 percentage points less likely than sparse groups to elect a high-central monitor. In the second column, we see this finding is also true when we control for group level characteristics, such as age, caste, education, wealth, and others.[12] This result is in line with our framework in section 3, whereby dense groups would prefer not to have monitoring, whereas individuals in sparse groups would want a high level of monitoring.

4.2.2 Impact of different exogenous monitoring

For contribution, we start with the baseline case where monitors are assigned exogenously, and study the difference in contribution between sparse and dense groups. As seen from Table 3, in sparse groups, average contributions increase significantly (p-value 0.014) by 7.4 Rs[13] (15.8% of the mean) in the presence of a high-central monitor (H) as compared with no monitor (NM). In dense groups, the increase is 4.5 Rs (8.3% of the mean), but the difference is not significant. This result is in line with the literature that suggests the presence of a central monitor increases cooperation only in sparse groups

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[12] The number of individuals in the sample drops from 503 to 459 because we do not have data on individual-level characteristics for all women. The same applies for all other regressions in the paper

[13] Note the value of 1 token is 10 Rs. The regression is in terms of tokens, but all the results are expressed in terms of Rs.

(Breza et al. 2016). Further, the cost of the monitor being 8% of the average payoff, it is optimal for sparse but not dense groups to vote for a monitor. Taking only the exogenous-monitor treatment, we run a linear regression with fixed effects on the contribution concerning the type of monitor that was assigned and the group composition. It takes the following form:

$$c_{jt} = \alpha + \beta_1 \cdot Dense + \beta_2 \cdot H + \beta_3 \cdot L + \beta_4 \cdot H \times Dense + \beta_5 \cdot L \times Dense + \rho_j + \nu_t + \epsilon_{jt}$$

where c_{jt} is the contribution of individual j in round t, $Dense$ is the dummy equal to 1 if the group is dense, H is the dummy equal to 1 if a high-central monitor is assigned, L is a dummy equal to 1 if a low-central monitor is assigned, ρ_j is individual fixed effect, and ν_t is round fixed effects. We also check the robustness of our empirical results against the inclusion of group characteristics (wealth, education, and caste inequality).

We are particularly interested in the coefficient β_2 that shows the effect of being assigned a high-central monitor and in the coefficient β_4 that shows the difference in the effect across dense and sparse groups. In Table 5, the dependant variable is the individual-level contribution. We see individuals in dense groups generally contribute 13.7 Rs more (23% of the mean) than sparse groups. Next, contributions increase by 7.25 Rs (11% of the mean) in the presence of a high-central monitor (H). As seen from the interaction term, [14] the effect is starker in sparse groups. The effects are robust, and even stronger when including group characteristics. In both specifications, we control for consensus in voting where the dummy variable takes a value of 1 if all three members of the group picked the same monitor option. This evidence in line with our framework where, in the presence of a high-central monitor, contributions increase in sparse groups, due to the threat of reputational penalty.

4.2.3 Impact of endogenous monitoring: increase in cooperation

The process whereby the monitoring institution is chosen can impact cooperative behavior, and we investigate this possibility through a within-group comparison. We estimate a linear fixed-effect regression that takes care of participants' self-selection into the monitoring "technology".[15] In the endogenous treatment, individuals select into an institution that in turn drives their contribution behavior. To overcome this selection problem, we keep monitoring fixed and compare groups that play both exogenous and endogenous treatment under the same monitor. Our identification strategy is to overcome selection by comparing the same group, with the same monitor treatment, differing only in how this monitor was obtained. Inspired by Dal Bo et al. 2010, an individual i's action in the game may depend on the group density $G \in \{dense, sparse\}$, on the elected monitor $M \in \{NM, H, L\}$, and on the mechanism that selected the monitor

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[14] $H \times Dense$ being an interaction term represents $[(H=1)-(H=0)|Dense]-[(H=1)-(H=0)|Sparse]$

[15] We can extract fixed effects at the individual level even in this case, because each participant plays twice – once in the endogenous and once in the exogenous treatments – in the same group composition.

$I \in \{Endo, Exo\}$ and her type α_i. The probability of cooperation is therefore determined by $P_i = f(M, G, I, \alpha_i)$.

We fix group G and monitor M to determine the effect of the mechanism by which the monitor is elected. More formally,

$$E(P_i|G = dense, M = NM, \alpha_i, Endo) - E(P_i|G = dense, M = NM, \alpha_i, Exo)$$

By doing so, we eliminate the threat of self-selection and can disentangle the effect of the exogenous versus endogenous treatments. In terms of regression, it translates into the following fixed-effect equations:

$$\begin{aligned} c_{jt} &= \alpha + \beta_1 \cdot (Endo \mid G = S, M = H) + \rho_j + \nu_t + \epsilon_{jt} \\ c_{jt} &= \alpha + \beta_1 \cdot (Endo \mid G = D, M = H) + \rho_j + \nu_t + \epsilon_{jt} \\ c_{jt} &= \alpha + \beta_1 \cdot (Endo \mid G = S, M = NM) + \rho_j + \nu_t + \epsilon_{jt} \\ c_{jt} &= \alpha + \beta_1 \cdot (Endo \mid G = D, M = NM) + \rho_j + \nu_t + \epsilon_{jt} \end{aligned}$$

where c_{jt} is the contribution of individual j in round t, *Endo* is a dummy variable that takes value of 1 if monitor is endogenously chosen , given group $G : \{D = dense, S = sparse\}$ and monitor choice $M : \{NM = No\, monitor, H = High\, central\, monitor\}$[16], ρ_j is individual fixed effect, and ν_t is round fixed effects. We are primarily interested in the coefficient β_1 that captures the effect of having an endogenous monitor as compared with having a monitor assigned exogenously.

Figure 4 shows the average contributions for subsamples that are free from the selection effect. We see that for sparse-groups, contribution increases under an endogenous-monitoring setting, as seen from the red bars. In particular, in an endogenous no-monitor setting, the contribution increases significantly (p-value 0.009) by 9.1 Rs, while with a high-central monitor it increases by 5 Rs, but not significantly. The change in dense groups across endogenous and exogenous monitoring institutions is not significantly different. We find that only in sparse groups, allowing individuals to choose their monitoring institution leads to better outcomes than externally imposing a third-party monitor.

The first two columns in Table 6 report results for individuals in sparse groups who self-selected into no-monitor and high-monitor institutions. This is followed by dense groups in the third and fourth columns. We see sparse groups electing no monitor (NM) endogenously increase contributions by 9.13 Rs. (21.9% of mean). Similarly, sparse groups electing a high-central monitor (H) endogenously increase contribution by 5 Rs.

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[16] We also tried to conduct individual level analysis by looking at variation in monitor choice within groups. We find 50% of the groups vote unanimously for the same monitor option, and hence do not provide much power for us to study this effect.

(8.6% of the mean). No significant effect arises for dense groups. Consistent with our theoretical framework, we observe that in the endogenous treatment contribution increases in sparse groups, where the effect is strong and highly significant. In dense groups, even if the effect is not statistically significant, we observe that the point estimates are negative. The fact that the effect is stronger and more significant when no monitor is chosen is in line with the fact that in sparse groups, where trust and reciprocal altruism is lower, the election of no monitor sends a strong signal of trust to group members.[17] This result presents evidence to believe that a sort of endogeneity premium exists in sparse groups: individuals facing the same monitoring institution behave differently depending on whether the institution is chosen by the group itself or imposed.

4.2.4 Impact of order of endogenous and exogenous on contributions

In this section, we look at possible channels that led to an increase in contribution for sparse groups under endogenous monitors. We study whether having revealed the monitor chosen by the group acts as an additional signal influencing contributions in both rounds. In presenting this comparison, we plot the average contribution in treatments across the two rounds. Because the order of endogenous and exogenous is randomized, we compare cases in which endogenous was played first with cases in which it was played second. The result of the vote is only revealed in the endogenous case. Hence, if endogenous is played first, the information is revealed through the vote outcome[18] could affect the contribution in both rounds. We focus on cases in which participants play with no monitor and high-central monitors, because of the very few observations we have for low-central monitors. Figure 5 provides evidence of a possible significant effect of the order, especially in sparse groups. The election of a high-central monitor in dense groups decreases contributions by 8.1 Rs. When no monitor is elected, contributions increase by 9.6 Rs in sparse groups (p-value 0.06) and 8.9 Rs in dense groups. We run OLS regressions controlling for individual-level characteristics to further investigate this effect. Our variable of interest takes a value of 1 if the endogenous round is played first and 0 otherwise. The dependent variable is represented by the average contribution across the two rounds: endogenous and exogenous treatments.[19] We use the following econometric specification:

$$c_{jg} = \alpha + \beta_1 \cdot (Order \mid G = S, M = H) + \beta_2 \cdot X + \epsilon_{jt}$$

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[17] This explanation is also in line with the separating equilibrium σ we presented in the theoretical section, wherein sparse groups have more agents of type α_l than of type α_h. Consequently, low type agents in sparse group observing that no monitor was chosen infer group members are surely high types, whereas observing that a monitor was chosen, they infer at least one of the other two group members is of a high type. Hence, the increase in contribution is lower for sparse groups when a high-central monitor is elected

[18] We hypothesize that this information could act as a signal of the level of trust in the group vis à vis each other.

[19] We are not able to extract fixed effects at the individual level because we take the average of contributions across endogenous and exogenous treatments and conditions on the monitoring technology.

where c_{jg} is the average contribution of individual j in group g, $Order$ is a dummy variable that takes a value of 1 if the endogenous treatment is played first , given group $G : \{D = dense, S = sparse\}$ and monitor choice $M : \{NM = No\, monitor, H = High\, central\, monitor\}$. X is individual characteristics (caste, wealth, age and education). We are primarily interested in the coefficient β_1 that captures the effect of having played an endogenous monitor round first, followed by the exogenous one.

In Table 7, we see that in sparse groups in which no monitor was chosen, the effect of revealing the group's choice has a strong positive effect that spills over to the exogenous round, thus increasing the average contribution when the endogenous treatment is played before the exogenous treatment. The average contribution increases significantly by 10.7 Rs (17.7 % of mean) for sparse groups when groups played endogenous first and elected no monitor (NM). On the contrary, the average contribution decreases slightly in dense groups that played endogenous first. This result is also in line with our theoretical framework and our previous empirical findings.

5 Conclusion

By using original network data and a novel design, we try to understand how the varying demand of peer monitoring depends on group density and how this monitor in turn affects cooperation. We divide the network into groups of three individuals with varying network distance, where dense implies each individual is at most at distance 2 (average path length < 1.6) and sparse implies each individual is at least at distance 4 (average path length > 4). We first show dense groups prefer to have no monitor whereas sparse groups choose to have a central one, reflecting variation in trust. Low-central monitors are seldom chosen. In line with previous literature, when individuals are socially close (dense), they can sustain a higher level of cooperation without outside intervention. Dense groups contribute more than the sparse groups in the contribution game.

Next, we show how an institution is assigned matters for cooperation. The endogenous choice of monitoring increases cooperation only in sparse groups. Looking at the order of the monitor treatment, the outcome of the vote being revealed in the endogenous treatment carries additional information regarding individual preferences and hence, when revealed, acts as a signal to the group. When the endogenous treatment is played first and the group chooses no monitor, individuals tend to contribute more in both groups. However, when the endogenous treatment is played first and the group chooses a monitor, the contribution decreases only in dense groups, due to a stronger prior about the level of altruism. This interesting finding suggests monitoring should be catered to the needs of the community. It is also in line with the argument that repeated interactions in dense groups imply higher concern about reputation.

Given the increased popularity of community-based interventions and focus on peer monitoring, understanding the role social networks play in small-scale societies is important. We propose here a theoretical framework, followed by a simple experiment that shows the effect of a monitor can be very different depending on the density of the network. Our work opens avenues for further research. We would like to understand the choice of the monitors further by presenting individuals with a panel of monitor options rather than just the high and low-central ones.

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Figures

Figure 2: Supplemental Survey Evidence

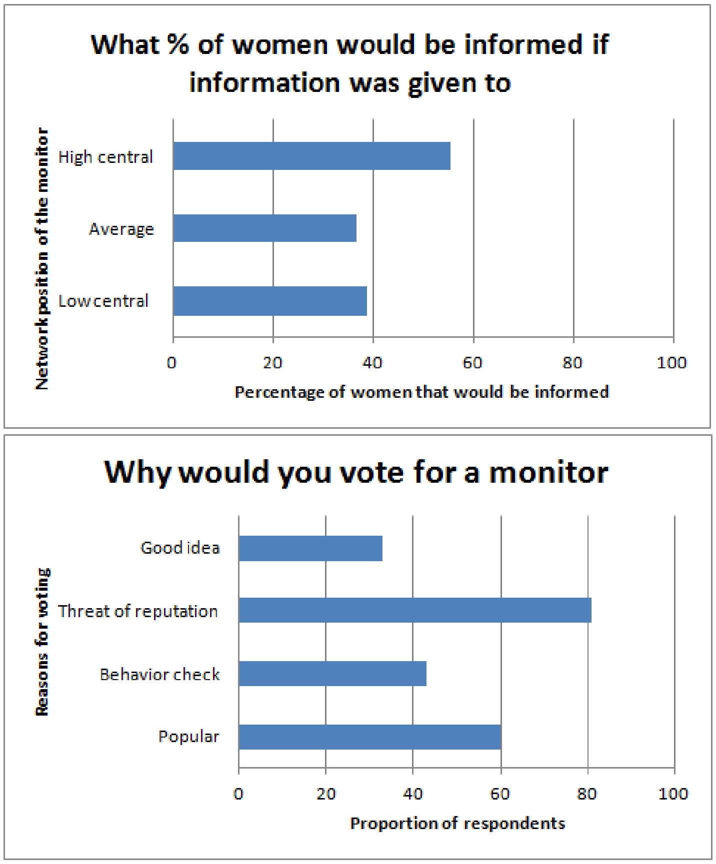


Figure 3: Percentage of individuals voting in Sparse and Dense groups

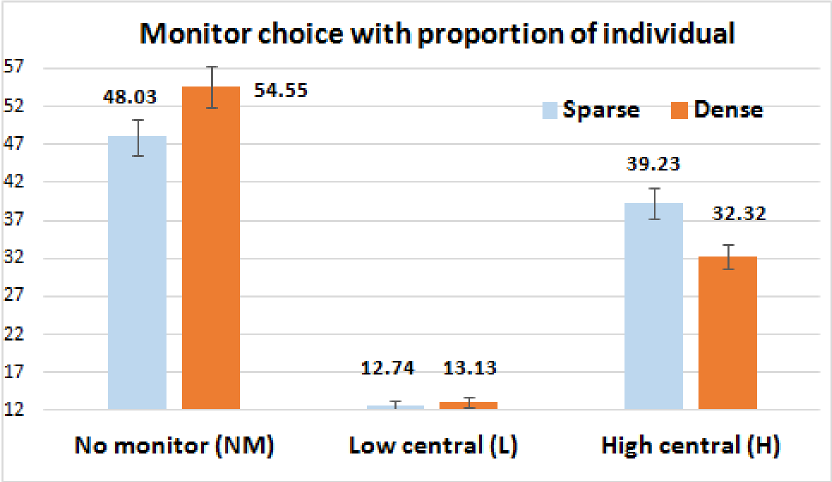
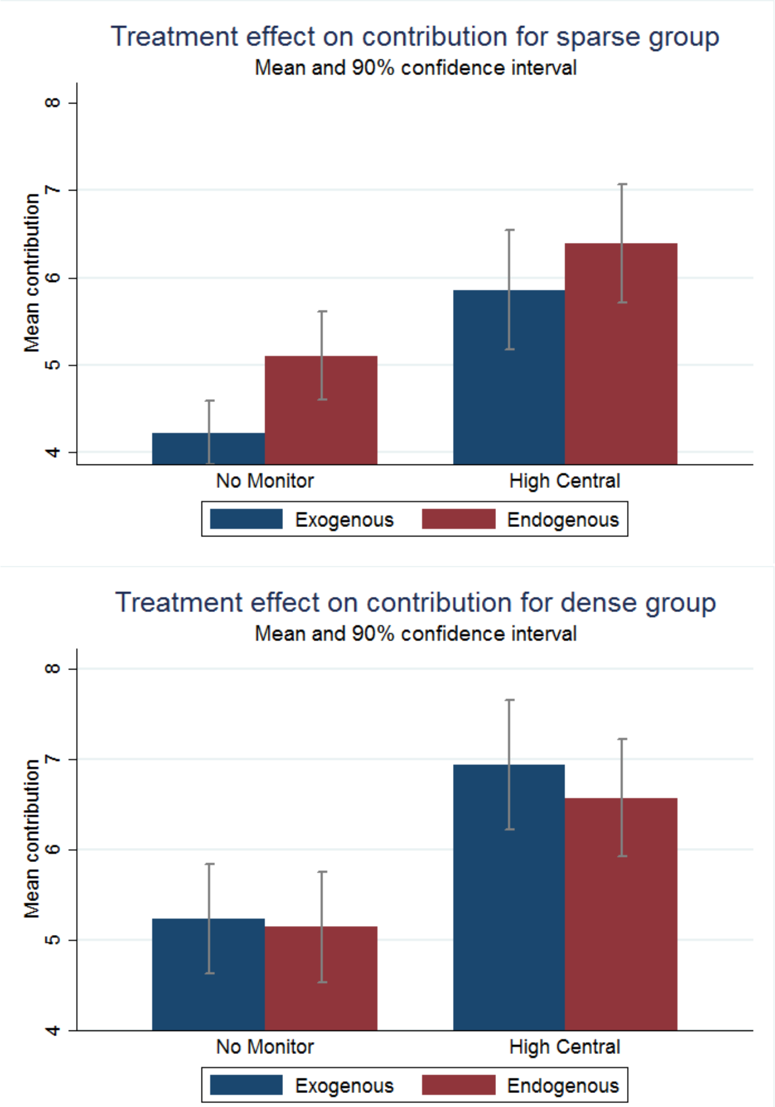
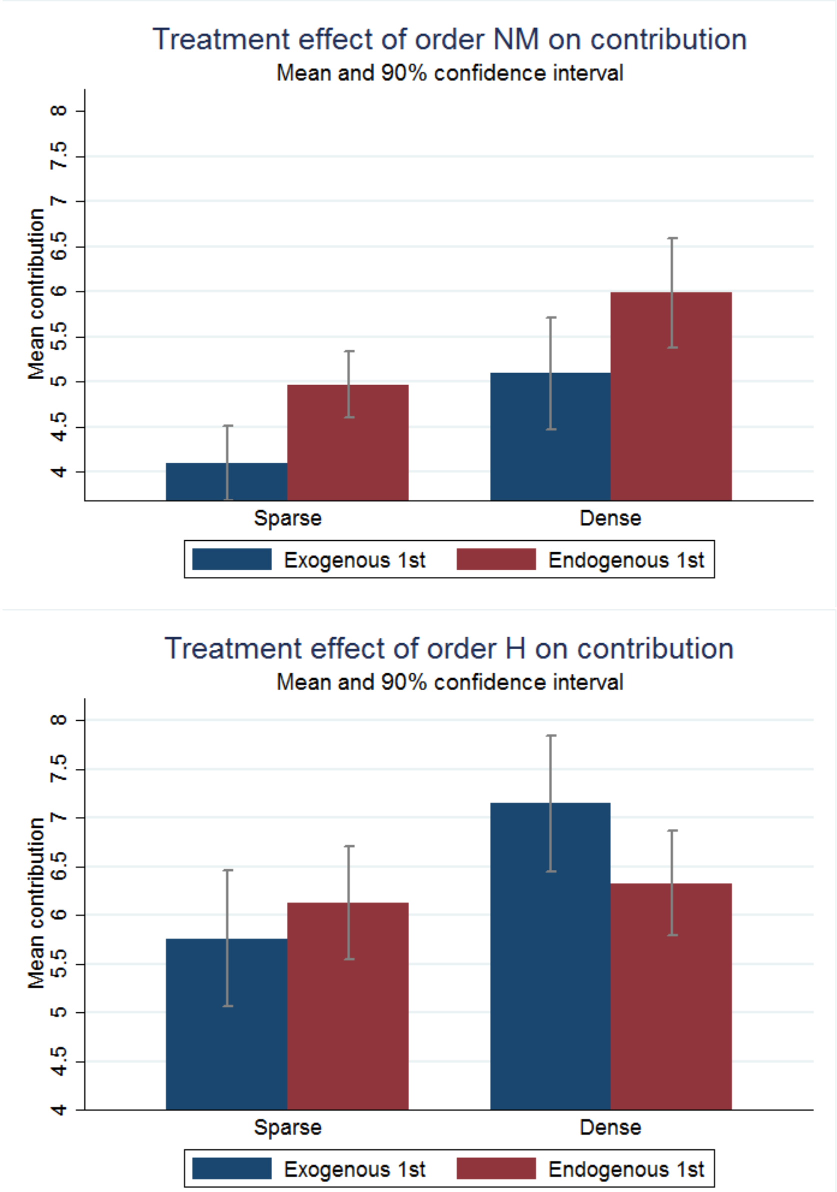


Figure 4: Contribution with Endogenous and Exogenous Monitors



Notes: Contribution with endogenous v/s exogenous monitors without selection. In the bar graph, x-axis represents group composition and y-axis represents average contribution. We focus on a sub sample where the same group plays under the same monitoring condition both exogenously and endogenously.

Figure 5: The Order of Endogenous and Exogenous Monitor Treatment



Notes: Order of the endogenous monitoring institution matters. In the bar graph, x-axis represents group composition and y-axis represents average contribution. The blue bar represents monitoring when exogenous monitor is played first.

Tables

Table 1: Correlations between Different Centrality Measures

	Degree	*Betweenness*	*Bonacich Centrality*
Degree	1	0.7844	0.9161
Betweenness	0.7844	1	0.8686
Bonacich Centrality	0.9161	0.8686	1

Table 2: Variation in Voting within Individual across Different Groups

		Dense group		
		No monitor	*Low central*	*High central*
Sparse group	*No monitor*	34.95%	4.57%	9.34%
	Low central	5.17%	4.37%	2.98%
	High central	14.71%	4.17%	19.68%

Table 3: Average Contribution in the Exogenous Treatment

	NM	**L**	**H**
DENSE	5.35	5.82	5.84
SPARSE	4.68	4.84	5.38

Note: Dense group contribute more than the sparse ones. In the presence of a high-central monitor, contribution increases significantly in sparse groups.

Table 4: Monitor choice regression with individual fixed effects

	Monitor choice	Monitor choice
Low central		
Dense	-0.088	-0.114
	(0.23)	(0.25)
High central		
Dense	-0.408**	-0.580***
	(0.17)	(0.20)
N	2012	2012
Group characteristics	No	Yes

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Notes: No monitor is the base outcome. Monitor choice refers to the individual choice out of: no-monitor, high-central monitor and low-central monitor. Dense is a dummy that takes value 1 if the group is dense (average path length <2) and 0 otherwise. Group characteristics include measures of group-differences in wealth, education and caste as well as individual level characteristics.

Table 5: Contribution under Exogenous Monitors

	contribution	contribution
Dense	1.333***	1.366***
	(0.28)	(0.29)
Low central	0.381	0.330
	(0.30)	(0.30)
High central	0.687**	0.639**
	(0.30)	(0.30)
Low central × Dense	-0.851**	-0.807*
	(0.42)	(0.42)
High central × Dense	-0.882**	-0.839*
	(0.43)	(0.43)
Consensus in choice	0.006	0.063
	(0.18)	(0.18)
N	2012	2012
Group characteristics	No	Yes

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Note: Dense is a dummy variable with 1 if the group is dense (average path length < 2) and 0 otherwise. H is a dummy variable with 1 if a high-central monitor is elected and L is a dummy which is 1 if a low-central monitor is elected. We control for group characteristics and fixed effects at the individual level. Consensus is a dummy variable that is 1 if everyone in the group chose the same monitor option. Group characteristics include dummy variables that look at similarity across: wealth, education, caste and age

Table 6: Endogenous v/s Exogenous Contribution without Self-Selection: Fixed Effects

	Sparse H	Sparse NM	Dense H	Dense NM
Endogenous	0.536**	0.883***	-0.370	-0.093
	(0.24)	(0.22)	(0.24)	(0.19)
N	104	172	104	130

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Note: Contribution is the amount given by individuals under each sub group. Sparse (H) refers to sparse groups (average path length $>$ 4) who played both endogenous and exogenous treatment under a high-central monitor (H). Dense NM refers to dense groups (average path length $<$ 2) who played both endogenous and exogenous treatment under no monitor. Endogenous is a dummy that takes value 1 if contribution was made with choice of the group. We control for individual and round fixed effects.

Table 7: Effect of order on Contribution

	Sparse H	Sparse NM	Dense H	Dense NM
Order	0.181	1.076**	-0.592	-0.495
	(0.61)	(0.50)	(0.76)	(0.77)
N	170	130	106	104
Individual characteristics	Yes	Yes	Yes	Yes
Group characteristics	Yes	Yes	Yes	Yes

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Note: Order is a dummy that takes value 1 if endogenous treatment was played first. Contribution is the amount given by individuals under each sub group. Sparse (H) refers to sparse groups (average path length $>$ 4) who played both endogenous and exogenous treatment under a high-central monitor (H). Dense NM refers to dense groups (average path length $<$ 2) who played both endogenous and exogenous treatment under no monitor.

Appendix for ONLINE Publication

5.1 Appendix A

IMPORTANT CLARIFICATION

The text in italic is not meant to be read aloud to experiment participants. It has the explanation of what experimenters should do. The remaining text that is not in italics is meant to be read aloud to experiment participants.

EXPERIMENT

Divide the research team into two groups: team A and team B. As participants enter the venue, team A must welcome them and locate their ID number based on their name *from the individual identification list. The research team must then provide the participants with the consent forms, read the forms aloud, explain to them the contents of the forms and that the participants are free to leave at their discretion, answer any questions participants may have, and obtain their consent.* [Go to Consent Form]

Then, team B should be ready to enter data on contributions.

EXPERIMENT BEGINS

Thanks for coming today! We are researchers from Rooster Logic. You are participating in a study on daily decision-making. Today you will play a series of short games. The information gathered here will be confidential and used for research purposes only.

OVERVIEW

Today, we will ask you to play a game with two different groups of people for two rounds each. You will randomly be placed in groups of three for the game, whose identity will be known. In each game, you and your group members will make some decisions. The result of these decisions will determine how much money you will earn today.

The games will represent situations and decisions you make every day in your life. You earn some money, you keep some money for yourself, you might give some money to your neighbors or friend, use the money to fund a common project etc.

EXPLANATION OF PAYMENT

Let us now discuss how you will make money today. First, you will receive 100 Rs. for simply participating in our games. Second, you will make money from the decisions made during the game.

You will play the same game with two different groups. In the beginning of each game, you will get some income in the form of tokens in a bag we call an 'INCOME POT'. The game is easy and all that you need to do is decide how many tokens you want to keep for yourself and how many tokens you want to contribute to the 'PUBLIC POT'. The total amount collected in the 'PUBLIC POT' will be increased in value by 50%. In both games, the experimenter will collect the tokens that you want to contribute in two different 'PUBLIC POT'.

At the end of the experiment, we will pick one 'PUBLIC POT' out of the 4 and the total amount with the additional 50% increase will be equally divided among the four players in your corresponding group. You will receive equal share, irrespective of how much you put in the 'PUBLIC POT', Respectively, the tokens you decided to keep for yourself in the 'INCOME POT' corresponding to that game will be yours.

Demonstrate: The experimenter should explain that they will be playing four rounds during the day with two different groups of people. Please show them the graphical image and explain how the contribution game works and how they would earn.

See then that the decisions you make in all rounds count but you will only be paid the amount in one randomly chosen game. Before I explain the game you will play today in detail, are there any questions?

Answer any questions that they may have.

EXPLANATION OF THE GAME

The game I will explain to you is a very simple one. In this game, you will be matched randomly with 3 more people who you will interact with. You are not allowed to talk to each other throughout this game. At the beginning of the game, you and your partners will get some money that you can either keep for yourself or contribute to a common pot.

There are two stages in this game: First you will be given the choice to elect a monitor to oversee the contribution game that we just briefly explained. The monitor vote will be followed by the contribution task. Let me explain in detail what the contribution task is.

At the beginning of each game, each of you will be given an initial income of Rs 100. All earnings during the games will be represented by tokens, each with a value of Rs 10. Then, each of you will be provided with 10 tokens that are worth Rs 100 in total. This cup will be known as 'INCOME POT'.

Demonstrate procedure, the objective you should have in mind is that individuals acquire a sense of the physicality of the game.

Now, we will explain how you can use your income in the game. You can either keep the tokens for yourself in the INCOME POT or you can contribute to the PUBLIC POT. The money that you decided to keep in the INCOME POT will be yours. The tokens that you will put in the PUBLIC POT will be added to the tokens that rest of your group put in the PUBLIC POT. The total amount contributed by the group will then increase in value by 50%.

The amount you contribute to the PUBLIC POT will not be revealed to the rest of the members of your group. To contribute to the PUBLIC POT, you will give the number of tokens you want to contribute to the experimenter in the PUBLIC POT. Remember that 1 token is worth 10 Rs.

Demonstrate the procedure via the chart again. Explain to them that 2 tokens= 20 Rs

In the first stage, you will be given a chance to elect a monitor to oversee this contribution task. The monitor will observe the amount contributed by each individual to the PUBLIC POT which is otherwise not known. In order to choose a monitor, you will put a tick next to one of the two choices: either having a monitor or not having a monitor. If you decided to have a monitor by putting a tick on the square, you will choose the name of the person you want to elect in the same sheet. If you decide to vote for having a monitor, you will be charged 10 Rs from the money you have been given for participation in the game.

Demonstrate the voting sheet to participants.

We will consider the choices of everyone in your group. The option that gets the highest number of votes will be chosen. Now, to see whether the majority choice will be implemented or an external option will be randomly assigned, we will pick a ball from this box without looking. In the box which we will call the CHOICE BOX.

We have two balls, 1 Pink and the other Green. We will pick a ball from the box, if a green ball is chosen, then the option chosen by the group will be implemented. If a pink ball is chosen instead, we will randomly assign one of the 3 options to your group.

Demonstrate the voting procedure to the participants with four enumerators. Make sure they understand the use of the CHOICE BOX

Do we have any questions at this point? Have you understood the two stages of the game? Now, we will demonstrate the complete game.

Five members of the team of experimenters should do the demonstration. Four of them should take the role contributors. The fifth person should represent himself and we will refer to him/her as the experimenter.

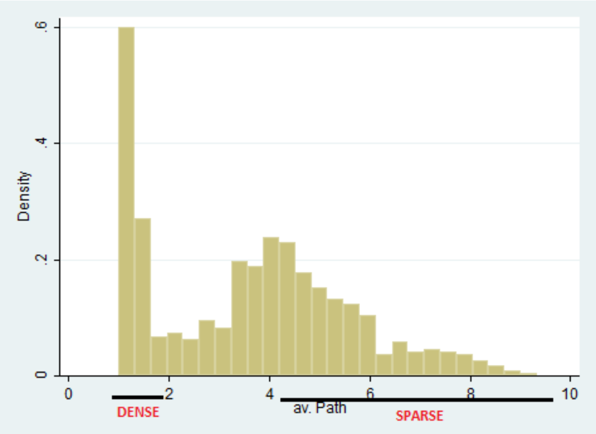
Do you have any questions?

Now, we will practice the game. Note that this will only be practice rounds and that you will not actually play with your actual partner. You will play the actual games with your actual partners after we explain the contribution game, practice them and we answer any question you might have about the games.

Participants play three rounds of the game and information is recorded exactly as if the game was actually being played.

5.2 Appendix B

Figure 6: Distribution of Groups' Average Path Length



Notes: This is the distribution of average path length in the 1006 groups we formed. Average path length is defined as the average number of steps along the shortest paths for all possible pairs of the group. We over sampled closely knit groups with average path length <2 (dense). Sparse group is defined as groups with average path length >4.

Table 8: Summary Statistics

	Mean	**Std.dev**	**N**
Individual Characteristics			
age	35.8	11.43	503
education	3.06	3.85	503
no. of links	11.38	4.46	503
centrality	0.052	0.071	503
wealth index	-0.253	1.503	503
Group Characteristics			
Same caste	0.74	0.438	503
Same education	0.3801	0.485	503

5.3 Appendix C: The Model

5.3.1 Model elements

Timing, actions and payoffs

We model our experiment as a game where agents play a two-stage game. The game unfolds as follows. First, agents simultaneously vote for their preferred monitor $m_i \in \{0, 1\}$, where $m_i = 0$ implies no monitor is chosen by individual i and $m_i = 1$ means i votes for having the monitor. Once participants cast their votes, monitoring technology is assigned to the group according to the

In the second stage, agents play a voluntary contribution game which can be either overseen by a third-party monitor or by no one. The third-party monitor can be assigned either through a random lottery or can be elected through a democratic vote, which happens in the first stage.

$$m^* = \begin{cases} 1 & \text{if } m_i = m_j = 1 \\ 0 & \text{if otherwise} \end{cases}$$

where m^* denotes the outcome of the vote. Second, agents make their contribution decision $c_i \in \mathbb{R}_+$. The action profile of agent i is then (m_i, c_i). The total contribution of all players is increased by 50 % and divided equally among the group members, implying that the rate of return for the contribution game with two players is $\frac{3}{4}$. The utility of player i is a function of both c_i and c_j, the level of altruism α_i and the rate of return of the contribution game. We assume a convex cost of contributing to represent the behavioral burden of contributing and to ensure the existence of an interior solution. Further, we believe that in this context belief-dependant motivations deeply affect players' actions and, in the spirit of psychological games[20], we assume that how much player i values the utility of player j depends on i's belief about altruism of player j, $\mu_{0i}(\alpha_j)$. In this regard, we take inspiration from Rabin (1993) which models the reciprocity of one agent as a function of beliefs about the other agent. The payoff of player i in the contribution game without a monitor is then

$$U(\alpha_i | m^* = 0) = W - c_i - c_i^2 + \frac{3}{4}(c_i + c_j) + \alpha_i \cdot \mu_{0i}(\alpha_j)\Big(W - c_j - c_j^2 + \frac{3}{4}(c_i + c_j)\Big)$$

In the case where a monitor is elected, we add two terms to the above utility function: a cost of monitor election mc and a reputation cost $-\delta P(c_i < \theta)$. Voting for the monitor is costly and i pays mc if she votes for the monitor, irrespective of whether the monitor is elected or not. If elected, the monitor can impose a reputation cost on the players. The parameter $\delta > 1$ represents the penalty from a contribution lower than the social norm θ in the presence of the monitor. As corroborated by qualitative evidence presented in Table 2 and for the sake of exposition, we use a fixed value of δ. However, we could incorporate a varying power of monitors depending on their centrality by allowing $\delta \in \{\delta_H, \delta_L\}$, where $\delta_H > \delta_L$, i.e. high-central monitors are more effective in spreading information and can inflict stronger reputational penalties. The social norm is a stochastic parameter representing the fact that different groups would

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[20] For a review on psychological game refer to Attanasi and Nage, 2008.

have different norms about what is considered an acceptable cooperative behavior[21]. It is assumed to be uniformly distributed between $[0, \bar{\theta}]$ where $\bar{\theta}$ is the highest possible contribution. It can also be interpreted as a reference point that varies with each monitor (Kahneman and Tversky, 1991), i.e. it hinges on the distribution of θ. The probability of one's contribution to be higher than the norm is then simply $\frac{c_i}{\bar{\theta}}$ and the probability of contributing below the acceptable social norm can thus be represented as

$$P(c_i < \theta) = \begin{cases} 1 - \frac{c_i}{\bar{\theta}} & \text{if } c_i < \theta \\ 0 & \text{otherwise} \end{cases}$$

The utility of agent i when a monitor is elected $(m^* = 1)$ can be written as

$$\begin{aligned} U_i(\alpha_i | m^* = 1) =& W - \hat{c}_i - \hat{c}_i{}^2 + \frac{3}{4}(\hat{c}_i + \hat{c}_j) - mc - \delta P(\hat{c}_i < \theta) + \\ & \alpha_i \cdot \mu_{0i}(\alpha_j) + \Big(W - \hat{c}_j - \hat{c}_j{}^2 + \frac{3}{4}(\hat{c}_i + \hat{c}_j) - mc - \delta P(\hat{c}_j < \theta) \Big) \end{aligned}$$

Moreover, players are Bayesian and i updates her prior about j's type $\mu_{0i}(\alpha_j)$ to $\mu_{1i}(\alpha_j)$ depending on the outcome of the voting , m^*. When players do not observe the outcome of the group vote, e.g. when third-party monitoring is exogenously assigned, i does not receive a signal on j's type and cannot update her prior.

Equilibrium

We assume that the altruism parameter α_i of individual i fully determines her demand for peer monitoring. More formally, we consider an equilibrium of the form below. An (altruistic) player i of type α_h cares strongly about the utility of the other player irrespective of j's type. She would therefore prefer not to elect a monitor[22] to avoid the other player being punished through the spread of bad reputation in case of low contribution. For a player i of type α_l, however, the cost of electing a monitor and the negative reputation effects for both herself and j is outweighed by the increase in group contribution driven by the presence of the monitor. Thus, agents would contribute differently depending on their type α_i, the outcome of the vote m^* and the updated belief μ_{1i} about player j, once the outcome of the vote is revealed. The separating equilibrium would then be

$$\sigma_i(\alpha_i) = \begin{cases} m_i = 0 & \text{if } \alpha_i = \alpha_h \\ m_i = 1 & \text{if } \alpha_i = \alpha_l \end{cases}$$

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[21] This would vary across dense and sparse groups. In dense groups, individuals would be expected to contribute more than in sparse ones.

[22] Given that dense groups have a higher subjective probability of being altruists, the demand of peer monitoring should be lower than that in sparse as seen in Fig 3.

Given the equilibrium above, when $\alpha_i = \alpha_l$, agent i would always vote for a monitor. Given the voting rule m^* defined above, she can perfectly infer the voting choice of player j. In this case, i updates her prior to $\mu_{1i}(\alpha_j = \alpha_h) = 1$ if $m^* = 0$ and $\mu_{1i}(\alpha_j = \alpha_h) = 0$ if $m^* = 1$. On the other hand, type α_h always votes for $m_i = 0$ and no monitor is elected ($m^* = 0$) irrespective of the vote of the other player. In this case player i cannot infer anything about j's type and she keeps the original prior $\mu_{1i}(\alpha_j) = \mu_{0i}(\alpha_j)$. First, we solve the above set of equations and calculate the value of optimal contributions across the different scenarios. Secondly, given c_i, we study when the above separating equilibrium holds. We find that for type α_l, voting for the monitor is an optimal strategy for certain values of initial prior $\mu_{0i}(\alpha_j) < \overline{\mu_{0i}}(\alpha_j)$. On the other hand, for type α_h it is always a dominant strategy to vote for no monitor. Therefore, to have a separating equilibrium people should have a low prior on the proportion of altruists, which by construction occurs in sparse groups. In what follows, we present our theoretical results in the same order as the empirical ones to match and guide progressively the experimental findings.

Let us assume that δ is large and θ is small enough. Then, there exists a value of the initial prior $\overline{\mu_{0i}}$ such that for $0 < \mu_{0i} < \overline{\mu_{0i}}$, the separating equilibrium σ exists, where low types α_l vote for the monitor and high types α_h vote for no monitor.

Proposition 1 says that the separating equilibrium σ holds only in sparse groups, while in dense groups both types pool their actions and do not vote for the monitor. We believe that the assumption of large δ is quite natural, given that in our context formal institutions are weak, and reputation concerns drive most of the social interactions. This assumption is also supported by the experimental evidence that low central monitors are very rarely chosen by participants. Similarly, the ex-ante level of cooperative behavior of these villages is quite modest, hence justifying the assumption of low values of θ. The mechanism underlying this proposition lies in the fact that high type players α_h always vote for no monitor, irrespective of the group they are in. Moreover, Proposition 1 gives us reason to believe that a story of reciprocal altruism well describes the voting behavior we see in the experimental data, i.e. players vote more often for having a monitor in sparse groups (low μ_{0i}) rather than in dense ones. This Proposition also gives theoretical support to our experimental results presented in Table 4.

In the game with exogenous monitors, high-type players α_h contribute always more than low-type ones α_l. Moreover, at equilibrium the contributions of both players' types are higher in the presence of the monitor than without,

$$\hat{c}_i^{exo} > c_i^{exo}$$

for $i = h, l$. Moreover, the increase in contributions caused by the monitor is stronger for high-central monitors and in sparse groups.

where $\hat{c}_i^{exo}$ indicates the optimal contribution when the contribution game is played in presence of a monitor and c_i^{exo} when no monitor is overseeing the game. The result is simply driven by the reputation effect of the monitor, which can entail the penalty δ in case of contributions lower than the social norm θ. The second part of Proposition 2 derives simply from the fact that high-central monitors have a stronger capacity of imposing reputational penalties compared to low-central monitors, i.e. $\delta_H > \delta_L$. Similarly, the impact of the monitor is stronger in sparse groups since we assume that the social norm of contribution is higher in dense groups rather than in sparse ones. These results match our empirical results presented in Table 5.

We now study the optimal contributions in the setting with the endogenous election of the monitor. In this case, the elected monitor serves as a signal of each other's types. Players are Bayesian and update their prior beliefs about the opponent's type, knowing their vote in the election stage. In Proposition 3 below we study the effect on contribution of having a monitor who is endogenously chosen by the group.

In sparse groups, endogenously chosen monitoring increases average contribution for all election outcomes, while in dense groups it decreases contribution.

Having a monitor chosen by the group has a positive effect for $\mu_{0i} < \overline{\mu_{0i}} = \frac{5\alpha_l + 2\alpha_h}{6(\alpha_l+\alpha_h)}$, i.e. for sparse groups, while in dense groups the effect is negative. The election of monitors – or the lack thereof – serves as a signal for agents who can infer other players' types as the game unfolds. In the case of exogenously assigned monitors, i's benefit of contribution increases linearly with the prior belief of j's being of high type, which is higher in dense groups. On the other hand, in the case of endogenous monitors, the outcome of the election is internalized in the agents' optimization problem and the benefit of contributing is not anymore uncertain as agents update their beliefs accordingly and their priors are pushed either up or down. Given that in sparse (dense) groups there are more low (high) types than high (low) types, low type agents α_l drive the result in sparse groups while high type agents α_h drive those for dense groups. When an agent i is of type α_l and observes that the group decided not to have any monitor, it received a perfectly informative signal about the fact that both his group members are of type α_h. After the revelation of the vote outcome, there is no uncertainty, and contribution increases since $\mu_{1i} = 1$. When an agent i of type α_l observes that the group elected the monitor, she knows that with probability 2/3 one of the two group members is of high type and at least one group member is of type α_l. Consequently, her posterior is higher than the prior if the former is smaller than 2/3, i.e. in sparse groups. In dense groups, the prior is already high and the signal affects negatively contribution. Symmetric arguments can be done for α_h types in dense groups. This result guides our experimental analysis and gives support to the findings shown in Table 6.

5.3.2 Proofs

We expand the two agent model presented in the main body of the paper to three agents, for it to be more representative of the interaction we observe in the experiment.

Proof of Proposition 1

We divide the proof in three steps. First, we compute the optimal contributions for both α_l and α_h types when the monitoring technology is exogenously assigned. Second, we compute the optimal contributions when the monitoring technology is endogenously chosen and the election of a monitor acts as a signal to group members. Third, we compute the equilibrium utilities and find conditions for which the separating equilibrium σ exists.

1. Let us first consider the exogenous case with no signalling. Since the monitoring technology is randomly assigned and not chosen by the group, there is no update of the prior μ_{0i}. The voting rule m^* is slightly different with no tie possible. For types α_h the utilities when the monitor is elected ($m^* = 1$) or not elected ($m^* = 0$) write

$$\begin{aligned}
U(m^* = 1) = {} & \mu_{0i}(1-\mu_{0i}) \cdot [U(\hat{c_h}^{exo}, \hat{c_h}^{exo}, \hat{c_l}^{exo}) + U(\hat{c_h}^{exo}, \hat{c_l}^{exo}, \hat{c_h}^{exo})] + \\
& \mu_{0i}^2 \cdot [U(\hat{c_h}^{exo}, \hat{c_h}^{exo}, \hat{c_h}^{exo}) + U(\hat{c_h}^{exo}, \hat{c_l}^{exo}, \hat{c_l}^{exo})] \\
U(m^* = 0) = {} & \mu_{0i}(1-\mu_{0i}) \cdot [U(c_h{}^{exo}, c_h{}^{exo}, c_l{}^{exo}) + U(c_h{}^{exo}, c_l{}^{exo}, c_h{}^{exo})] + \\
& \mu_{0i}^2 \cdot [U(c_h{}^{exo}, c_h{}^{exo}, c_h{}^{exo}) + U(c_h{}^{exo}, c_l{}^{exo}, c_l{}^{exo})]
\end{aligned}$$

while for types α_l they write

$$\begin{aligned}
U(m^* = 1) = {} & \mu_{0i}(1-\mu_{0i}) \cdot [U(\hat{c_l}^{exo}, \hat{c_h}^{exo}, \hat{c_l}^{exo}) + U(\hat{c_l}^{exo}, \hat{c_l}^{exo}, \hat{c_h}^{exo})] + \\
& \mu_{0i}^2 \cdot [U(\hat{c_l}^{exo}, \hat{c_h}^{exo}, \hat{c_h}^{exo}) + U(\hat{c_l}^{exo}, \hat{c_l}^{exo}, \hat{c_l}^{exo})] \\
U(m^* = 0) = {} & \mu_{0i}(1-\mu_{0i}) \cdot [U(c_l{}^{exo}, c_h{}^{exo}, c_l{}^{exo}) + U(c_l{}^{exo}, c_l{}^{exo}, c_l{}^{exo})] + \\
& \mu_{0i}^2 \cdot [U(c_l{}^{exo}, c_h{}^{exo}, c_h{}^{exo}) + U(c_l{}^{exo}, c_l{}^{exo}, c_l{}^{exo})]
\end{aligned}$$

where $\hat{c}_i^{exo}$ denotes the contribution of player i when there is the monitor and c_i^{exo} when there is no monitor. Solving for each contribution level c_l^{exo}, c_h^{exo}, $\hat{c_l}^{exo}$, $\hat{c_h}^{exo}$ we get, for the exogenous assignment of monitoring technology, that the optimal contributions are

$$\begin{aligned}
\hat{c_l}^{exo} &= \frac{2\alpha_l\ \mu_{0i} - 1}{4} + \frac{\delta}{2\theta} & \qquad c_l^{exo} &= \frac{2\alpha_l\ \mu_{0i} - 1}{4} \\
\hat{c_h}^{exo} &= \frac{2\alpha_h\ \mu_{0i} - 1}{4} + \frac{\delta}{2\theta} & \qquad c_h^{exo} &= \frac{2\alpha_h\ \mu_{0i} - 1}{4}
\end{aligned}$$

2. In the endogenous case we have to take into account the election rule and now the monitor outcome (m^*) becomes a signal according to which players update their belief about other players' types. Given the updated priors, we can write the utility function for type α_h, considering the fact that the election of the monitor is perceived as a perfectly informative signal whereby an agent α_h can infer that with probability one the other two group members are types α_l. On the contrary, when no monitor is elected, the beliefs are updated to reflect that with probability 2/3 one of the other two players in group is of low type. The utilities write

$$U(\alpha_i = \alpha_h, \cdot, m^* = 1) = U(\hat{c_h}^{end}, \hat{c_l}^{end}, \hat{c_l}^{end})$$
$$U(\alpha_i = \alpha_h, \cdot, m^* = 0) = \mu_{0i}(1-\mu_{0i})[U({c_h}^{end}, c_h^{end}, {c_l}^{end}) + U({c_h}^{end}, c_l^{end}, {c_h}^{end})] + \mu_{0i}^2 U({c_h}^{end}, c_h^{end}, {c_h}^{end})$$

Following a symmetric argument for type α_l, we can write

$$U(\alpha_i = \alpha_l, \cdot, m^* = 0) = U(\hat{c_l}^{end}, \hat{c_h}^{end}, \hat{c_h}^{end})$$
$$U(\alpha_i = \alpha_h, \cdot, m^* = 0) = \mu_{0i}(1-\mu_{0i})[U({c_l}^{end}, c_h^{end}, {c_l}^{end}) + U({c_h}^{end}, c_l^{end}, {c_h}^{end})] + \mu_{0i}^2 U({c_l}^{end}, c_l^{end}, {c_l}^{end})$$

Solving for each contribution level c_l^{end}, c_h^{end}, $\hat{c_l}^{end}$, $\hat{c_h}^{end}$ we get,

$$\hat{c_l^{end}} = \frac{4\alpha_l - 3}{12} + \frac{\delta}{2\theta} \qquad c_l^{end} = \frac{2\alpha_l - 1}{4}$$
$$\hat{c_h}^{end} = -\frac{1}{4} + \frac{\delta}{2\theta} \qquad c_h^{end} = \frac{4\alpha_h - 3}{12}$$

3. In order to show the existence of the separating equilibrium, we evaluate the utilities of players at the optimal contributions computed in steps 1 and 2 and compare them with respect to the two possible actions of voting for the monitor or not. For players of type $\alpha_i = \alpha_l$ we can write

$$\begin{aligned} U(m_i = 1) = \mu_{0i}(1-\mu_{0i}) \cdot [U(\hat{c_l}^{exo}, \hat{c_h}^{exo}, \hat{c_l}^{exo}) + U(\hat{c_l}^{exo}, \hat{c_l}^{exo}, \hat{c_h}^{exo})] + \\ \mu_{0i}^2 \cdot [U({c_l}^{exo}, {c_h}^{exo}, {c_h}^{exo}) + U(\hat{c_l}^{exo}, \hat{c_l}^{exo}, \hat{c_l}^{exo})] \\ U(m_i = 0) = \mu_{0i}(1-\mu_{0i}) \cdot [U({c_l}^{exo}, {c_h}^{exo}, {c_l}^{exo}) + U({c_l}^{exo}, {c_l}^{exo}, {c_h}^{exo})] + \\ \mu_{0i}^2 \cdot [U({c_l}^{exo}, {c_h}^{exo}, {c_h}^{exo}) + U(\hat{c_l}^{exo}, \hat{c_l}^{exo}, \hat{c_l}^{exo})] \end{aligned}$$

It is easy to show that when δ is large enough there exists a $\overline{\mu}_{0i=\alpha_l}$ st. for $\mu_{0i} < \overline{\mu}_{0i=\alpha_l}$, agent i of type α_l is better off voting for the monitor rather than not, i.e. the difference $U(\alpha_i = \alpha_l | m_i = 1) - U(\alpha_i = \alpha_l | m_i = 0)$ is positive.

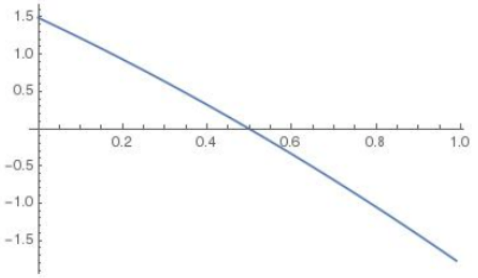

Figure 7: $U(m_i = 1) - U(m_i = 0)$ in function of μ_{0i}

Similarly, we can write for type $\alpha_i = \alpha_h$

$$\begin{aligned}
U(m_i = 1) = \mu_{0i}(1-\mu_{0i}) \cdot [U(\hat{c_h}^{exo}, \hat{c_h}^{exo}, \hat{c_l}^{exo}) + U(\hat{c_h}^{exo}, \hat{c_l}^{exo}, \hat{c_h}^{exo})] + \\
\mu_{0i}^2 \cdot [U(c_h^{exo}, c_h^{exo}, c_h^{exo}) + U(\hat{c_h}^{exo}, \hat{c_l}^{exo}, \hat{c_l}^{exo})] \\
U(m_i = 0) = \mu_{0i}(1-\mu_{0i}) \cdot [U(c_h^{exo}, c_h^{exo}, c_l^{exo}) + U(c_h^{exo}, c_l^{exo}, c_h^{exo})] + \\
\mu_{0i}^2 \cdot [U(c_h^{exo}, c_h^{exo}, c_h^{exo}) + U(\hat{c_h}^{exo}, \hat{c_l}^{exo}, \hat{c_l}^{exo})]
\end{aligned}$$

In calculating the difference, it easy to see that for any value of the prior μ_{0i} $U(\alpha_h|m_i = 1) - U(\alpha_h|m_i = 0) < 0$, and a high type would always vote for no monitor, irrespective of the group he plays in. Combining the two results above, there exists an interval of μ_{0i} where type α_l would choose a monitor whereas type α_h would choose no monitor. Therefore the σ separating equilibrium exists only for $0 < \mu_{0i} < \overline{\mu}_{0i}{*}_{\alpha_l}$. If $\mu_{0i} > \overline{\mu}_{0i}{*}_{\alpha_l}$ there is no separating equilibrium and both types vote for no monitor.

□

Proof of Proposition 2

Given the level of contribution under the exogenous monitor we computed in Proposition 1 it easy to compare contributions with or without the monitor. Irrespective of agents' types, the positive impact on optimal contributions of the monitor Δc writes

$$\Delta c = \frac{\delta}{2\theta}$$

Then, it follows immediately that the impact Δc is higher for δ_H, i.e. high-central monitors, and for low θ, which we assume regulate interactions in sparse groups. □

Proof of Proposition 3

We compare the total contribution prompted by endogenous monitors, i.e. after the priors are updated, with the average contribution when no such signalling occurs, i.e. for exogenously assigned monitors. In particular, we pool together the contributions of both α_l and α_h types to have get a more general result. However, the same results can be derived comparing contributions taking into consideration self-selection into monitoring technologies imposed by the separating equilibrium σ. In that case, the contrast would be even more neat.

The total contribution before the elected monitor is revealed writes

$$\frac{2\alpha_l\ \mu_{0i} - 1}{4} + \frac{\delta}{2\theta} + \frac{2\alpha_l\ \mu_{0i} - 1}{4} + \frac{2\alpha_h\ \mu_{0i} - 1}{4} + \frac{\delta}{2\theta} + \frac{2\alpha_h\ \mu_{0i} - 1}{4}$$

while the total contribution after the elected monitor is revealed is

$$\frac{4\alpha_l - 3}{12} + \frac{\delta}{2\theta} + \frac{2\alpha_l - 1}{4} + -\frac{1}{4} + \frac{\delta}{2\theta} + \frac{4\alpha_h - 3}{12}$$

Comparing the two total contributions we find that the latter is greater than the former only when

$$\mu_{0i} < \frac{5\alpha_l + 2\alpha_h}{6(\alpha_l + \alpha_h)}$$

which concludes the proof. $\square$

5.4 Appendix E: Figures

Figure 8: Example of formation of groups