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Modes of Collective Action in Village Economies:
Evidence from Natural and Artefactual Field Experiments
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Abstract

In a canonical model of collective action, individual contribution to collective action is negatively correlated with group size. Empirical evidence on the group size effect has been mixed, partly due to heterogeneities in group activities. In this paper, we first construct a simple general model of collective action with the free-riding problem, altruism, public goods, and positive externalities of social networks. We then empirically test the theoretical implications of group size effect on individual contribution to four different types of collective action, i.e., monetary or nonmonetary contribution to directly or indirectly productive activities. To achieve this, we collect and employ artefactual field experimental data such as public goods and dictator games conducted in southern Sri Lanka under a natural experimental situation where the majority of farmers were relocated to randomly selected communities based on the government lottery. This unique situation enables us to identify the causal effects of community size on collective action. We find that the levels of collective action can be explained by the social preferences of farmers; we show evidence on the free-riding by self-interested households with no land holdings. The pattern of collective action, however, differs significantly by the mode of activities; the collective action which is directly related to production is less likely to suffer from the free rider problem than from indirectly productive activities. Finally, the monetary contribution is less likely to cause the free riding than the non-monetary contribution.

Keywords: collective action, social preference, natural and artefactual field experiment, irrigation, South Asia

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1. Introduction

In the real world, most political, social, or economic activities are undertaken by groups. Naturally, there has been active academic research in identifying determinants of individual contributions to collective action within a group. Particularly, group sizes and social and economic heterogeneities among group members are regarded as important determinants of members' effort levels.[1] While the canonical theory of free-riding shows the inverse group size effect on collective action (Olson 1965; Holmstrom 1982), empirical studies on the group size effect present mixed results (Bandiera et al. 2005; Banerjee et al. 2008).[2] Ostrom (2011) stated that "[u]nfortunately, we do not find that single variables such as size of group or amount of payoffs are always associated with failure or success in achieving collective action (p.52)." This paper aims at shedding a new light on heterogenous group size effects of collective action by employing artefactual field experimental data collected under a unique natural experimental situation in Southern Sri Lanka.

In the existing studies, mixed empirical evidence on the group size effect may arise from the following reasons. First, the net effect of group size on collective action is not necessarily theoretically unambiguous (Banerjee et al. 2008; Esteban and Ray 2001). It depends on the nature of goods, i.e., whether they are either local private goods or public goods (Agrawal and Goyal 2001; Banerjee et al. 2008; Dayton-Johnson 2000): As Esteban and Ray (2001) argue, when the collective good produced is purely private, an inverse relationship between effective collective action and group size arises but when the collective good is purely public and fully non-excludable, the free-riding problem never emerges.

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1. Bandiera et al. (2005), Banerjee et al. (2008) and Faysse (2005), discuss broader issues on the collective action.
2. Bardhan (2000) and Fujiie et al. (2005) find the negative community size effect. Larger community size reduces individual contribution to irrigation maintenance. On the other hand, Dayton-Johnson (2000) and Khwaja (2009) find insignificant community size effects. Agrawal and Goyal (2001) theoretically and empirically show that medium-sized group is more suitable to manage collective action. In the experimental studies, employing the public goods game, Isaac and Walker (1988) show that individual's contribution declines in larger group and this is attributed to the decline in the marginal benefit.

Collective action also reflects team production technologies—concavity of convexity; monitoring and commitment devices; and monetary incentives. If there is a convex technology arising from positive network effects, it is even possible to observe a positive correlation between individual contribution to collective action and group size. Also, a particular incentive contract can generate a positive group size effect too (Bandiera et al. 2005).

The conventional theories consider the one-shot non-cooperative games by selfish individuals. In this framework, collective action is poorly induced because of the prisoners' dilemma problem (Rapport and Chammah 1965), which, alternatively, can be called the problem of free-riding (Olson 1965) or the tragedy of the commons (Hardin 1968). On the other hand, the repeated game framework predicts cooperation without commitment or third party enforcement. This may be due to social capital among group members which solve the moral hazard and enforcement problems (Anderson et al. 2004; Durlauf and Fafchamps 2005).

Moreover, individual contribution to collective action can be explained by pro-social behavior such as altruism and voluntary cooperation (Chen and Li 2009, Falk and Fischbacher 2006; Fehr and Fischbacher 2002).[3]

Previous studies examine the group-size effect without focusing on heterogeneities in characteristics of group activities. Individuals may act differently when collective activities are for production purposes and for non-production purposes such as ceremonial and funeral events. Whether the nature of contribution is monetary or non-monetary may change the individuals' incentives significantly.

Finally, existing empirical studies do not take into account the endogeneity of group sizes, potentially leading to estimation bias (Bandiera et al. 2005, 475; Kosfeld et al. 2009). Hence the lack of a clear relationship between group size and collective action may be the result of econometric problems. For example, a community may have a specific mechanism to control

3. Experimental studies show that participants of the public goods games contribute some amount between the self-interested equilibrium and social optimum (Ledyard 1995).

group size so that it can maintain a desirable level of collective action. This will generate reversed causality.

This paper aims to carefully address these issues.[4] First, we aim to illustrate the mixed group size effects in the augmented Holmstrom (1982) model by differentiating local private goods from public goods, incorporating altruism, and considering scale economies. Second, we empirically identify the causal relationship between group size and collective action using unique data from a large-scale irrigation system in Southern Sri Lanka called Walawe Left Bank (WLB) Irrigation Area where an irrigation upgrading and extension project was implemented from 1995 until 2008 with financial assistance from the Japanese ODA loan. Under this project, all farmers received fairly homogenous land: 0.2 ha of land for residence, and 0.8-1.0 ha of agricultural field. This project provides us with natural experiments where the group sizes were assigned exogenously because lands were allocated by quasi-lottery mechanisms, and artefactual experiments in which altruism and voluntary public goods contribution are elicited precisely by laboratory experiments. Specifically, we compare four types of collective action – monetary or nonmonetary contribution to productive or nonproductive (indirectly productive) activities – to uncover differences in the patterns of voluntary contribution.

To preview the results of our empirical analysis, the pattern of collective action differs significantly by the mode of activities. First, irrigation maintenance activities which are directly related to production are less likely to suffer from the free rider problem. In contrast, free-riding is widespread in the indirectly productive activities such as expenses for ceremonies and participation in community work. We also find that monetary contribution is less likely to cause the free riding problem than non-monetary contribution for both irrigation maintenance and community events. Finally, selfish farmers with no land holdings are less likely to contribute in larger communities.

4. Shoji et al. (2010) use the same dataset as this paper and examine the way in which the heterogeneity of crop choice affects participation in community work, but they do not compare various modes of collective actions.

The rest of this paper is organized as follows. Section 3 describes the theoretical framework. The study site, our dataset, and the empirical strategies are discussed in Section 3. Section 4 presents the expected results followed by concluding remarks in Section 5.

2. Theoretical

We augment the basic Holmstrom (1982) model of team production to determine the amount of effort provided by farmers. We do so by incorporating altruism and scale effect of social network. Suppose that there are N farmers, who jointly produce a single output, g, that is, for example, the quality of an irrigation facility or system. The amount of effort from the i-th farmer is denoted by a_i. Therefore, the joint output, e.g., the level of irrigation quality, can be described by the following function: $g = g\ (a_1,\ a_2,\ a_3,\ \ldots..,\ a_N;\ X_1,\ X_2,\ X_3,\ \ldots..,\ X_N)$, where X_i is a matrix of observables which affect the output. Let us assume that the utility function of a farmer i is expressed as $u_i = s_i - a_i$, where s_i is the output share of farmer i.[5]

The efficiency regime of this economy can be solved as the following social planner problem: $\underset{\{a_i\}}{Max}\ g(a_1, a_2, \cdots, a_N; X) - \sum_{i=1}^{N} a_i$. The first-order condition (FOC) of this problem is $\frac{\partial g}{\partial a_i} = 1$. Suppose that the function g takes an additive separable form: $g(a_1, a_2, \cdots, a_N; X) = \sum_{i=1}^{N} X_i a_i^{\gamma_i}$, where γ_i<1. Then the FOC becomes, $X_i \gamma_i a_i^{\gamma_i - 1} = 1$, and then the Pareto optimal level of effort, a_i^* which satisfies this FOC becomes:

(1) $$a_i^* = (X_i \gamma_i)^{\frac{1}{1-\gamma_i}}$$

5. Alternatively, we can employ a general convex disutility function from effort provision, denoted by $v_i(a_i)$. Such a generalization will not change the qualitative results.

In contrast, a Nash equilibrium is derived by solving an individual farmer's utility maximization problem: $\underset{\{a_i\}}{Max}\, s_i(g) - a_i$, given the production technology, g, where si(g) is the sharing rule or technology of the joint output. The FOC is: $\frac{\partial s_i}{\partial g}\frac{\partial g}{\partial a_i} = 1$, where $\frac{\partial s_i}{\partial g}$ is a private benefit from the irrigation infrastructure and $\frac{\partial g}{\partial a_i}$ is the marginal output of effort. This FOC gives an individually optimal effort level, a_i. Under the functional form of production technology, we have the individual optimal effort level: $\lambda_i X_i \gamma_i a_i^{\gamma_i - 1} = 1$, where $\lambda_i \equiv \partial s_i / \partial g$. In equation (2), λ is a weight which shows the degree of benefits a farmer i obtains from this joint irrigation management. This FOC provides us with the effort level under individual optimization:

(2) $$a_i = (\lambda_i X_i \gamma_i)^{\frac{1}{1-\gamma_i}}.$$

We consider three cases of team production: the first case when the collective goods is purely private; the second case when there is positive altruism and/or voluntary public goods contribution; and the third case when the collective good is public good or involves positive externalities from social network.

2.1 Joint production of pure local private goods

The case of pure local private goods, which are rivalrious, can be formalized by a condition, $\sum_{i=1}^{N} s_i = g$, or equivalently, $\sum_{i=1}^{N} \lambda_i = 1$. For expositional purpose, if we further assume that the benefit of irrigation is equally divided among participants, then we have $s_i = g/N$ and thus the optimal effort level becomes: $a_i^P = (X_i \gamma_i / N)^{\frac{1}{1-\gamma_i}}$, which is strictly smaller than a_i* if $N > 1$. This is the moral hazard problem in team production formalized by Holmstrom (1982). It is evident that the requirements of the Pareto optimal effort level and the individual optimal level contradict each other if $N > 1$. The only situation where the Nash equilibrium is at a Pareto optimum is when there is only one farmer, i.e., $N = 1$, $\lambda_i = 1$ and thus $a_i^P = a_i^*$. However, as N increases, the gap between the Pareto optimal effort level and the individually optimal effort level widens because of the free-rider problem.

2.2 Joint production of pure local private goods with altruism

To investigate the case of pure private goods with altruism, we assume that the utility function of a farmer i takes an additive separable form, $u_i = s_i + \rho(\Sigma_{j\neq i}\, s_j) - a_i$, where ρ is altruism parameter. Since equally divided private goods can be described by $s_i = g/N$ for all i, we have: $s_i = g\,[1 + \rho(N\text{-}1)] / N$. Hence, $\lambda_i \equiv \partial s_i/\partial g = [1 + \rho(N\text{-}1)] / N > 1/N$ if $N > 1$ and $\rho > 0$. This means that the optimal effort level under private goods with altruism becomes:

$$a_i^A = (\lambda_{it} X_i \gamma_i)^{\frac{1}{1-\gamma_i}}, \tag{3}$$

which is larger than a_i^P under the assumptions of $N > 1$ and $\rho > 0$. Also, it is easy to show that $\partial a_i^A/\partial\rho > 0$. These analytical results indicate that altruism mitigates the free-riding problem unambiguously. Note that in the case of full altruism with ρ=1, $a_i^A = a_i^*$, indicating that the individual solution becomes socially optimal. In other words, the free-rider problem arises when there are multiple farmers who are motivated by self-interests over private goods.

2.3 The case of pure public goods

The case of pure public goods with non-excludability and non-rivalriousness, can be described by the case of $s_i = g$ for all i, or, alternatively, $\lambda_i \equiv \partial s_i/\partial g = 1$ for all i. It is straightforward to show that the individual optimization can achieve social optimality. In addition to the condition that $\lambda_i \geq 1$, positive "perceived" externalities arising from the group social network can be formulated by the case of $\partial\lambda_i/\partial N > 0$. In this case, the individual effort level will be even higher than that of the social optimal.

3. Study site and data description

3.1 Natural experiment in the study site

Our study site is the Walawe Left Bank (WLB) Irrigation Area, located in the Hambantota and Moneragal districts in the southern part of Sri Lanka. Figure 1 shows the map of five study blocks in this region. In this area, the Walawe Left Bank Irrigation Upgrading and Extension Project was implemented from 1995 until 2008 with financial assistance from the Japanese ODA loan (JBIC Institute 2007). Under this project the old irrigation system was rehabilitated and a new irrigation system was constructed. In this project area, all farmers received fairly homogenous land: 0.2 ha of land for residence, and 1.0 ha of irrigated paddy field or 0.8 ha of field for other food crops.

The rehabilitation and construction started in the north of WLB close to the Uda Walawe reservoir and gradually extended toward the south. By the end of the first phase of the project, 2,900 ha of the irrigated area was rehabilitated and 1,040 ha of irrigated area were newly developed in the northern blocks such as Sevanagala, Kirribanwewa and Sooriyawewa blocks (Figure 1). In the second phase, an additional 5,340 ha of irrigation system was newly constructed in the southern part of WLB, the Extension area. By the end of 2008, almost all households had access to irrigation facilities except for the rainfed part of Sevanagala block, i.e., Block 2 in Figure 1.

The structure of the WLB canal system is composed of the main canal, the branch canals, the distribution canals, and the field canals with the last one being the smallest unit. In each distribution canal (D-canal), there is a formal organization called Farmers Organization (FO), which is used as a unit of collective action in this paper.[6] According to the farmers' responses to our survey, the objectives of FOs are to maintain irrigation facilities and communal roads, to procure farm inputs collectively, to cooperatively market products, and to prepare for community activities such as religious festivals, funerals and weddings. All farmers in the irrigated areas are required to register with the FO. While registered farmers are supposed to contribute to activities of the registered FO, an effective enforcement mechanism of such contribution is not necessary. In this study, we consider the FO as a unit of the community to perform collective action and, in the areas without access to irrigation facilities, we use villages as a unit of community.

We focus on four different types of collective action organized by FOs: expenses for irrigation maintenance, labor participation in the irrigation maintenance, expenses for ceremonies, and participation in community works. As summarized in Table 1, we classify these actions as monetary contributions to productive activity, nonmonetary contributions to productive activity, monetary contributions to indirectly productive activity, and nonmonetary contributions to indirectly productive activity, respectively. The irrigation maintenance is one of the most important tasks of the FOs. Expenses for ceremonies include those for religious festivals, funerals, and weddings.[7] Regarding the community work, FO members attend informal meetings, *Shramadana*, literally meaning free labor supply and devote their time to community activities such as cleaning communal roads and preparing for religious festivals.

6. In order to manage the irrigation canals, Farmers Organizations were established by the Mahaweli Authority of Sri Lanka. There is another agricultural organization, Join Management Committee, whose members include farmers and public officers to make decisions on agricultural plans.
7. It should be noted that there is possibility that households could expend for the ceremonies in different FO communities. However, the ceremony groups, such as funeral societies, are formed based on the geographical characteristics and this is largely overlapped with the FO communities. Therefore, we still use the FOs as a unit of this collective action.

An important unique feature of this irrigation area is that the size of FO was exogenously determined for each household due to a particular land distribution process, which enables us to identify the causal relationship between group size and collective action. Interestingly, when the government distributed irrigated plots and residences to farmers, the government used lotteries in each block. Table 2 reports that approximately 30% of households followed this process and received plots for certain crops regardless of their characteristics. As to the remaining farmers, around 50% of households could claim their preference on the location of plots at the plot level. Such households were basically those who had lived in the project areas before project implementation and therefore were forced to relocate. However, it may still be reasonable to assume that the "size" of FO is exogenous given for farmers even without the lottery process because the exact routes of the irrigation canals and thus number of farmers connected to their own distribution canals were not known prior to construction. Indeed, the observed household characteristics, such as household head characteristics and demographics, are not significantly different between the farmers with and without the lottery process (Shoji et al. 2010). Hence, we consider that community and household characteristics – such as the size of FOs, neighborhood characteristics, irrigation access, and distance to their plots – are exogenous.[8] Yet, we also perform robustness checks by including household fixed effects and period-specific block effects.

3.2 Data and experimental design

This study uses a seven-round panel data set which we collected from 2001 until 2009. The first four surveys were conducted in June and October of 2001 and June and October of 2002 with 858 randomly selected households, which comprises about 4.6% of the total population of

8. For the detail of the test on the exogeneity of land allocation to the settlers, see Aoyagi et al. (2010). They regress settlers' observed characteristics in comparing across blocks, where the government has done the relocation programs gradually from north blocks to south blocks. The results show that households were exogenously allocated to D-canal as well as within D-canal area.

18,767 households (Hussain et al. 2002). The timing of each survey corresponds to the cropping season in the study area. In June and October 2007, in order to examine the five-year changes in the livelihoods in the formerly and newly irrigated area, the fifth and sixth surveys were conducted with 193 households who were randomly chosen out of the original 858 households. Finally in March 2009, we conducted the artefactual field experiment such as public goods and dictator games with a total of 268 households: 186 from the original 858 households and 82 newly invited households.[9]

The dictator game is played by two participants, i.e., a sender called a dictator and a receiver (Camerer and Fehr 2004; Levitt and List 2007; Cardenas and Carpenter 2008). A sender and a receiver are randomly matched from the same distribution canal in an anonymous setting. The sender receives Rs.500 of the initial endowment, which is roughly equivalent to a prevailing daily wage in the area, from experimenters and the receiver gets nothing initially. The dictator then can transfer as much as he wishes of his endowment to the receiver from the possible transfer amounts. The material payoff of the dictator and receiver are $500 - \rho$ and ρ, respectively, where ρ denotes the amount he allocates to the receiver and $x \in \{0, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500\}$. Since there is no reason for self-interested dictators to transfer money and the dictator's zero transfers is a Nash equilibrium, the amount of transfer is interpreted as a measure of pure altruism (Camerer and Fehr 2004). Since we asked all participants from each distribution canal to play as both dictator and receiver using the strategy method in an anonymous setting, we are able to obtain the altruism measure of all participants.

The second artefactual experiment is the canonical public goods game (Camerer and Fehr 2004; Levitt and List 2007; Cardenas and Carpenter 2008). In this game, each participant is placed in a group of four participants from the same distribution canal anonymously with the initial endowment of Rs.500. Each group has an investment project in public goods. The total

9. While the sample size changes across the surveys, according to our qualitative assessment of the survey results, this is not because of the migration or refusal of the survey households.

investment amount by the group members is doubled by the experimenters and returns back to the four participants equally regardless of the individual contribution amounts. The material payoff of participants is the sum of the amount kept initially and the reallocation from the public goods. Each participant decides how much out of the endowment to contribute to the public goods under this situation. Again, the zero investment amount is the Nash equilibrium, and thus the positive investment amount can be interpreted as a measure of reciprocally expected cooperation (Camerer and Fehr 2004), altruism, fairness, and conditional reciprocity (Levitt and List 2007), or social capital (Anderson, Mellor, and Milyo 2004).

The empirical analysis of this study uses only the 186 households which participated in both the panel surveys and the experiment, making the sample size of our econometric analysis 1,072 samples. Figure 2 presents the results of the public goods game and dictator game experiments (Cardenas and Carpenter 2009).[10] We can see that a majority of subjects exhibit pro-social behavior by sending positive amounts in these two games.

Figure 3 depicts the Kernel density of FO size, showing two peaks around at 120 households and 250 households.[11] Table 3 shows the descriptive statistics of the variables used in this paper by the size of FO community—note that we set the median of the FO size, 126 households, as the threshold to divide samples in this table. Panel A reports descriptive statistics of the four collective action variables, which we use as dependent variables. It is shown that production activities are likely to be active in large communities, although we can verify that the opposite tendency applies to the other activities. Panel B of the table 3 summarizes the descriptive statistics of the independent variables. Since these variables do not change much over time, Panel B reports the numbers from the first round survey only. We confirm that most of household characteristics are uncorrelated with the FO size. While the land sizes and numbers of

10. The instructions of these experiments are available from the corresponding author upon request.
11 Since the FO size variable includes missing values, we use the mean value of reported data at the D-canal level.

children are systematically different depending on the size of FO, we will use these variables as control variables in regression.

3.3 Empirical strategy

We empirically implement the theoretical implication contained in equation (3) because the marginal share variable, λ, summarizes the different cases we present in the theory section. More importantly, our econometric strategy utilizes the natural experimental situation to examine the impact of exogenous community size, N, on the contribution to the four types of collective actions. Specifically, we estimate the following estimation equation which is based on equation (2) and (3):

$$\text{(4)} \qquad \alpha_{it}^{\,j} = \lambda^{j}(\rho_{it}, N_{it}) + X_{it}\beta^{j} + u_i^{\,j} + u_{B,t}^{\,j} + \varepsilon_{it}^{\,j},$$

where $\alpha_{it}^{\,j}$ is a proxy for the effort level, a_i, and takes unity if household i contributes to activity j at period t; and zero otherwise. The number of households in the FO community is denoted by N. X includes the other observable determinants of collective action such as irrigated and unirrigated land holdings, indicators of household preference, household head characteristics, demographics, and geographic characteristics. Regarding the household preference, we use the results of the dictator and the public goods games, as measures of altruism and voluntary cooperativeness, respectively. The last three terms in the right-hand side of equation (3) are the household fixed effects, period-specific block effects, and a well-behaved error term, respectively.

To distinguish the different cases of collective action described in the theory section, we estimate equation (4) by assuming the function, $\lambda(\cdot)$ is a piece-wise liner function of the community size and the interaction terms with the preference variables and land holdings. i.e.,

$$\lambda^{j}(\rho_{it}, N_{it}) = \delta_1{}^{j} N_{it} + \delta_2{}^{j} N_{it} \bullet \rho_i{}^{1} + \delta_3{}^{j} N_{it} \bullet \rho_i{}^{2} + \delta_4{}^{j} N_{it} \bullet L_{it}{}^{U} + \delta_5{}^{j} N_{it} \bullet L_{it}{}^{I} \qquad (5)$$

where $\rho_i{}^1$ denotes the proportion of investment out of the endowment in the public goods game. Similarly, ρi2 denotes the proportion of endowment that the respondent transfered to his partner in the dictator game. The remaining two variables, $L_{it}{}^{U}$ and $L_{it}{}^{I}$ are unirrigated and irrigated land sizes, respectively.

Under our natural experimental situation, we believe that we can plausibly assume that N in equation (5) and ε in equation (4) are uncorrelated, generating unbiased estimates of δ_1, δ_2, δ_3, δ_4, and δ_5. To mitigate remaining confounding factors, we employ the linear probability model with household level and/or period-specific block level fixed effects. In all estimations, we use the cluster adjusted robust standard errors at the D-canal level. This addresses the possible correlation of residuals over time across households within each D-canal community.

4. Empirical results

4.1 Regression results

Table 4 reports the estimation result of the four dependent variables separately shown in blocks (A), (B), (C), and (D). The first columns of each variable block show the simplest specifications without the cross terms of farmer organization size and household fixed effects. In these specifications, the community size does not systematically predict contribution to collective action. While these unclear empirical results may be seen as consistent with the existing studies, the lack of robustness may be generated by specification errors. As to the other variables, the first column of block (A) shows that the irrigated and unirrigated land ownerships, respectively, are correlated with higher and lower contribution to irrigation maintenance expenses. The other three blocks also show a similar qualitative result although coefficients are statistically insignificant.

Columns (2) and (3) in each block include the cross terms, and are estimated without and with the household fixed effects, respectively. The Columns (3) of the four blocks indicate evidence that a large community involves a small contribution amount to collective action: First, the coefficients δ_1 are negative and statistically significant in column (3) of blocks (A) and (D), suggesting that selfish households with no land holdings are less likely to contribute to the collective action in larger communities. This result is consistent with the theoretical implication of the free-riding problem in the case of pure private goods.

Second, the coefficients for the interaction variable of public goods contribution and group size, δ_2, are negative except for block (C). This suggests that the marginal effect of cooperativeness declines as community size becomes larger, which is consistent with the canonical free-riding model with pure private goods.

Yet, the table also shows results that are not simply explained by the team production framework or pro-social behaviors: directions and statistical significance of the altruism coefficient, δ_3, are not necessarily consistent across specifications and activities. The coefficients of unirrigated land holdings are largely negative, and the cross terms with the size of farmer organization, δ4, are positive in most cases [columns (3) of blocks (A), (B), and (C)]. These results suggest that when the group size is small, the marginal effect of the unirrigated land size is negative, but it turns to be positive as the size becomes larger. A similar positive size effect can be found for irrigated land size for monetary contribution to productive activities in block, i.e., the coefficient δ5, in the column (3) of block (A). A possible interpretation is the case of public goods with positive externalities arising from social network

(Labonne and Chase 2011). The return to the social network investment would be larger when the group size is larger, and our result is consistent with this interpretation.

4.2 Marginal effect of community size

To grasp the marginal effect of the community size on the collective action variables, we compute the following predicted value of the marginal group size effect based on the columns (3) of Table 4 for each dependent variable:

$$(6) \qquad \frac{\partial \hat{\alpha}_{it}^{j}}{\partial N_{it}} = \hat{\delta}_1^j + \hat{\delta}_2^j \cdot public_{it} + \hat{\delta}_3^j \cdot altruism_{it} + \hat{\delta}_4^j \cdot unirrigated_{it} + \hat{\delta}_5^j \cdot irrigated_{it}.$$

Based on equation (6), we then draw the Cumulative Distribution Function (CDF) of these predicted values of the marginal group size effect (Figure 4). Two patterns can be seen from the figure.

First, irrigation maintenance activities directly related to production are less likely to suffer from the free-rider problem. Intriguingly, the marginal group size effect of equation (4) is estimated to be positive for around 50% and 80% of farmers in participation and expenses, respectively, for the irrigation maintenance. This may be attributed to the fact that the households with unirrigated land are more likely to contribute to the irrigation maintenance when the community size is larger, as shown in coefficient δ_4 in block (A) and (B) of Table 4 as well as the positive group size effects for irrigated land ownership, i.e., the coefficient δ_4, in block (A) of Table 4. In other words, irrigation maintenance may be interpreted as investments to public goods of irrigation quality, involving positive externalities arising from social networking. In contrast, more than 80% of households show the negative marginal effect in the indirectly productive activities which may be related to pure private goods.

Second, the monetary contribution is less likely to cause the free-riding problem than the non-monetary contribution in the cases of both irrigation maintenance and community events. Unlike labor contributions, the monetary contributions involve collection of fees which can be easily tracked and verified, possibly leading to better enforcement of collective action. Also, the collective action problem in the case of non-monetary contribution may be due to binding time allocation. Since non-monetary contribution is made in labor contribution, labor contribution directly decreases time available for other activities. Due to this opportunity cost of labor contribution, the marginal effect shows a similar pattern as in the case of pure private goods.

We can verify whether these differences in Figure 4 are statistically significant. To compare the pairwise CDFs among activities, we perform the two-sample Kolmogorov-Smirnov tests. The results are reported in Table 5, which shows that these depicted CDFs are statistically different in the sense of the first order stochastic dominance.

Also, using the median farmer organization size as the threshold size, we divide the observations into larger and smaller farmer organizations to estimate specification (3) of Table 4 separately and to compare the marginal effects. We find that free riding is more likely to occur in the smaller organizations; three activities except for the participation in maintenance present negative and smaller marginal effects in the smaller organizations. At the 1% level, the differences are statistically significant.

5. Conclusion

In this study, we investigate the impact of farmer's group size on their decisions in four different modes of collective action. Besides the free rider problem predicted by the team production framework, we also examine the social preference such as the altruism and voluntary cooperativeness elicited by the artefactual field experiments. We combine the artefactual field experiment data with the unique panel data under a natural experimental situation in southern Sri

Lanka where irrigation facilities were constructed under pre-determined exogenous rules and farmers were randomly allocated to their land.

We find evidence of free-riding by self-interested households with no land holdings. It is also shown that the social preference explains the behavior in the collective action. The pattern of collective action, however, differs significantly by the mode of activities; the collective action which is directly related to production is less likely to suffer from the free-rider problem, while it is widespread in the indirectly productive activities such as expenses for ceremonies and participation in community work. Finally, we find that the monetary contribution is less likely to cause free-riding than the non-monetary contribution for both irrigation maintenance and community events.

Related to our study, there are several possible promising research areas. It would be important to examine the effectiveness of farmer organizations and collective action in improving farm productivity and household welfare. Since the role of irrigation is in providing water even during dry seasons, dynamic outcomes such as production, income, and consumption smoothing should be studied carefully (Sawada et al. 2010).

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Table 1. Categories of four collective action

	Direct Production activity	*Indirect* production activity
Monetary contribution	Expenses for irrigation maintenance	Expenses for ceremonial events
Nonmonetary contribution	Labor participation in irrigation maintenance	Labor participation in community work

Table 2. Implementation of land allocation

	Residences	Irrigated Plots
Any opportunity to state your preferences?	Obs. = 165	Obs. = 150
Not at all	29.70%	31.54%
Block level	10.91%	12.75%
Unit-canal level	2.42%	2.69%
D-canal level	1.21%	2.01%
Plot level	55.76%	51.01%
Total	100.00%	100.00%
Land allocation process	Obs. = 162	Obs. = 148
Acquired the preferred area without process	51.23%	45.95%
Lottery within or outside the claimed area	24.08%	29.06%
First come, first served basis	8.02%	9.46%
Negotiation among the resettlers	3.70%	4.05%
No formal permission regarding land use	8.64%	6.76%
Others	4.32%	4.73%
Total	100.00%	100.00%

Table 3. Descriptive statistics of variables

	FO less than 126 households		FO more than 126 households		Mean Diff.
	Mean	S.D.	Mean	S.D.	
Panel A: Collective Action Variables (Binary variables)					
Expenses for Irrigation Maintenance	0.288	0.453	0.212	0.409	***
Participation in Irrigation Maintenance	0.201	0.401	0.164	0.371	
Expenses for Ceremonies (religious festivals, funerals, weddings)	0.562	0.497	0.625	0.485	**
Participation in Community Works (Shramadana)	0.740	0.439	0.778	0.416	
Observations	573		499		
Panel B: Control Variables					
Time Variant Variables					
Size of Farmers Organization (x 10^3 households)	0.083	0.030	0.175	0.049	---
Holdings of unirrigated land (ha)	1.299	1.516	2.022	1.781	***
Holdings of irrigated land (ha)	1.435	1.201	1.032	1.169	***
Observations	573		499		
Time Invariant Variables					
Investing proportion in the public goods game#	0.436	0.237	0.414	0.243	
Sending proportion in the dictator game#	0.295	0.212	0.267	0.207	
Age of head (x 10^3)	0.047	0.011	0.044	0.010	
Schooling years of head	5.773	3.272	5.347	3.230	
Female headed dummy	0.102	0.305	0.061	0.241	
Males aged 16 or over	1.761	1.093	1.561	0.850	
Females aged 16 or over	1.784	0.976	1.643	0.997	
Children	1.386	1.245	2.143	1.478	***
Distance to city (km)	4.460	4.030	4.398	1.984	
Sample Households	88		98		

#: The data were collected at the seventh wave in 2009. Otherwise, the time invariant statistics on Panel B reports the result of the first wave.

The variables in Panel A take unity if the household contributes to the activities at least once during the survey period, and zero otherwise.

Table 4. Regression results: Linear probability model

Category of Dep. Vars.	(A): Productive, Monetary			(B): Productive, Non-monetary			(C): Indirectly Productive, Monetary			(D): Indirectly Productive, Non-monetary		
Dep. Vars.	Expenses for Irrigation Maintenance			Participation in Irrigation Maintenance			Expenses for Ceremonies			Participation in Community Works		
Period specific block fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household fixed effects	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Non-linear impact of FO size?	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
δ_1: Size of Farmers Organization	0.2213	-0.1889	-0.6326*	0.0211	0.4224	0.4959	0.0333	-0.5915	-0.2453	-0.1777	-0.6852	-1.1749**
	(0.166)	(0.603)	(0.357)	(0.235)	(0.509)	(0.430)	(0.230)	(0.434)	(0.557)	(0.354)	(0.510)	(0.540)
Investing proportion in the public	-0.0716	0.0395		0.0142	0.0184		0.0444	-0.0300		0.0364	0.0816	
goods game	(0.052)	(0.073)		(0.040)	(0.078)		(0.071)	(0.116)		(0.065)	(0.095)	
δ_2: x Size of FO		-0.8242**	-1.2126*		-0.1489	-0.0681		0.5416	0.9672		-0.4616	-0.9861*
		(0.391)	(0.631)		(0.432)	(0.309)		(1.180)	(1.209)		(0.574)	(0.536)
Sending proportion in the dictator	0.0528	0.0419		0.0111	0.0047		-0.0007	-0.0230		-0.0590	-0.2274*	
game	(0.063)	(0.145)		(0.073)	(0.167)		(0.122)	(0.148)		(0.086)	(0.124)	
δ_3: x Size of FO		0.0119	0.7760		0.1091	-1.1553***		0.1438	-0.1509		1.3363*	0.7467**
		(0.697)	(1.041)		(0.949)	(0.342)		(1.075)	(0.871)		(0.707)	(0.347)
Holdings of unirrigated land	-0.0154*	-0.0373	-0.0660***	0.0023	-0.0015	-0.0173	-0.0125	-0.0367	-0.0001	-0.0094	-0.0390	-0.0639*
	(0.008)	(0.022)	(0.018)	(0.006)	(0.018)	(0.013)	(0.011)	(0.030)	(0.041)	(0.014)	(0.026)	(0.032)
δ_4: x Size of FO		0.1592	0.4133***		0.0288	0.1757***		0.1744	-0.0639		0.2100	0.3758***
		(0.097)	(0.081)		(0.099)	(0.059)		(0.193)	(0.267)		(0.133)	(0.132)
Holdings of irrigated land	0.0514*	-0.0079	-0.0543	0.0186	0.0768**	0.0530	0.0139	0.0142	0.0693	0.0087	0.0203	-0.0014
	(0.026)	(0.047)	(0.038)	(0.016)	(0.031)	(0.037)	(0.013)	(0.033)	(0.041)	(0.016)	(0.039)	(0.044)
δ_5: x Size of FO		0.5015*	0.6750**		-0.5026*	-0.3281		-0.0025	-0.3860		-0.1126	0.1192
		(0.257)	(0.262)		(0.249)	(0.236)		(0.221)	(0.260)		(0.240)	(0.306)
Age of head	3.7056**	3.5404**	3.3118	-1.4891	-1.1465	-4.7176	0.0343	0.1366	-9.7690	0.3389	0.6555	-0.0833
	(1.477)	(1.629)	(3.578)	(1.361)	(1.316)	(4.020)	(1.999)	(2.094)	(6.401)	(0.967)	(0.995)	(3.625)
Schooling years of head	0.0008	0.0002	0.0140*	-0.0016	-0.0011	-0.0067	-0.0009	-0.0010	0.0031	-0.0051	-0.0052	0.0097
	(0.004)	(0.004)	(0.008)	(0.005)	(0.005)	(0.008)	(0.006)	(0.006)	(0.014)	(0.003)	(0.003)	(0.014)
Female headed dummy	-0.0119	-0.0138	-0.0532	-0.0937*	-0.0936*	-0.1213	-0.0016	-0.0020	-0.1920	-0.0619	-0.0613	0.1379
	(0.045)	(0.046)	(0.112)	(0.052)	(0.051)	(0.111)	(0.076)	(0.076)	(0.229)	(0.045)	(0.047)	(0.189)
Males aged 16 or over	-0.0054	-0.0046	-0.0058	0.0084	0.0065	-0.0218	-0.0031	-0.0031	-0.0243	0.0122	0.0111	0.0341*
	(0.025)	(0.025)	(0.030)	(0.012)	(0.012)	(0.024)	(0.013)	(0.013)	(0.041)	(0.013)	(0.013)	(0.019)
Females aged 16 or over	-0.0017	-0.0022	-0.0171	0.0250	0.0264*	0.0227	-0.0003	-0.0003	-0.0191	0.0065	0.0063	0.0232
	(0.014)	(0.014)	(0.030)	(0.015)	(0.014)	(0.029)	(0.017)	(0.017)	(0.039)	(0.011)	(0.011)	(0.023)
Children	0.0024	0.0022	-0.0234	-0.0084	-0.0087	-0.0253***	-0.0165	-0.0170	0.0063	0.0080	0.0085	0.0129
	(0.008)	(0.008)	(0.026)	(0.007)	(0.006)	(0.008)	(0.013)	(0.013)	(0.022)	(0.008)	(0.007)	(0.015)
Distance to city	-0.0111	-0.0128		0.0035	0.0061		-0.0057	-0.0044		-0.0067	-0.0050	
	(0.008)	(0.008)		(0.004)	(0.004)		(0.007)	(0.008)		(0.004)	(0.005)	
Constant	0.5087***	0.5772***	0.2697	0.0602	-0.0150	0.5081**	0.4653***	0.5347***	0.9003*	0.6237***	0.6726***	0.8522***
	(0.094)	(0.162)	(0.163)	(0.110)	(0.128)	(0.210)	(0.149)	(0.163)	(0.453)	(0.150)	(0.162)	(0.246)
H_0: $\delta_4 = \delta_5$		2.99*	0.69		6.32**	3.70*		0.44	1.21		2.26	0.91
H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$		4.11***	16.78***		3.58**	4.27***		1.71	1.61		4.54***	4.62***
Observations	1,067	1,067	1,067	1,067	1,067	1,067	1,067	1,067	1,067	1,067	1,067	1,067
R-squared	0.570	0.573	0.564	0.243	0.248	0.227	0.064	0.065	0.068	0.149	0.153	0.168

Cluster-adjusted robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Five observations are dropped because of data problem.

Table 5. Two-sample Kolmogorov-Smirnov test

	max{F(x) – G(x)}	min{F(x) – G(x)}
Test 1		
F(x): Expenses for irrigation maintenance	0.000	-0.673***
G(x): Expenses for ceremonies		
Test 2		
F(x): Participation in irrigation maintenance	0.006	-0.435***
G(x): Participation in community work		
Test 3		
F(x): Expenses for irrigation maintenance	0.000	-0.342***
G(x): Participation in irrigation maintenance		
Test 4		
F(x): Expenses for ceremonies	0.049*	-0.226***
G(x): Participation in community work		

*** p<0.01, ** p<0.05, * p<0.1

Figure 1. Study site

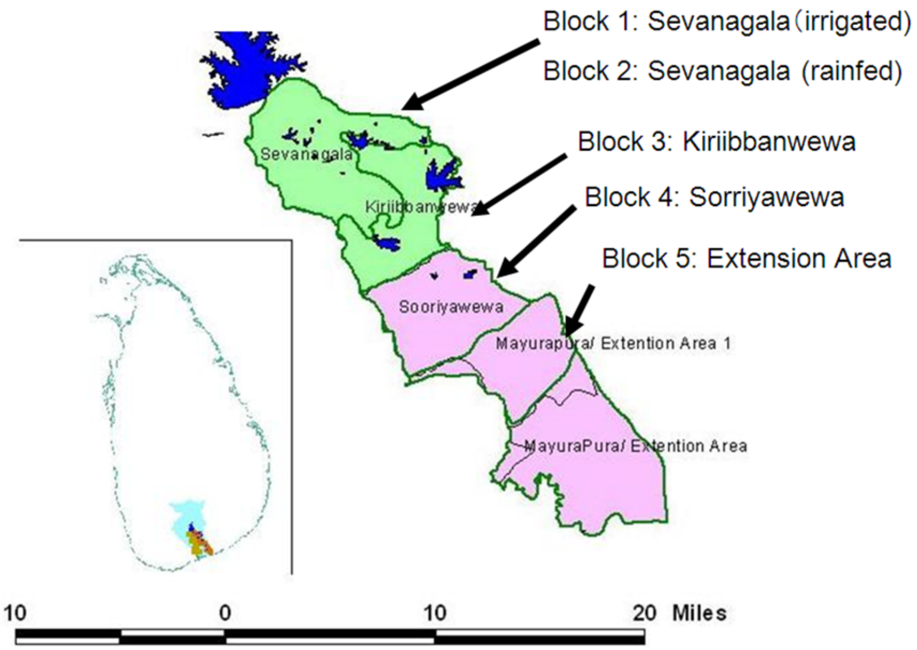


Figure 2. Histogram of experiment result

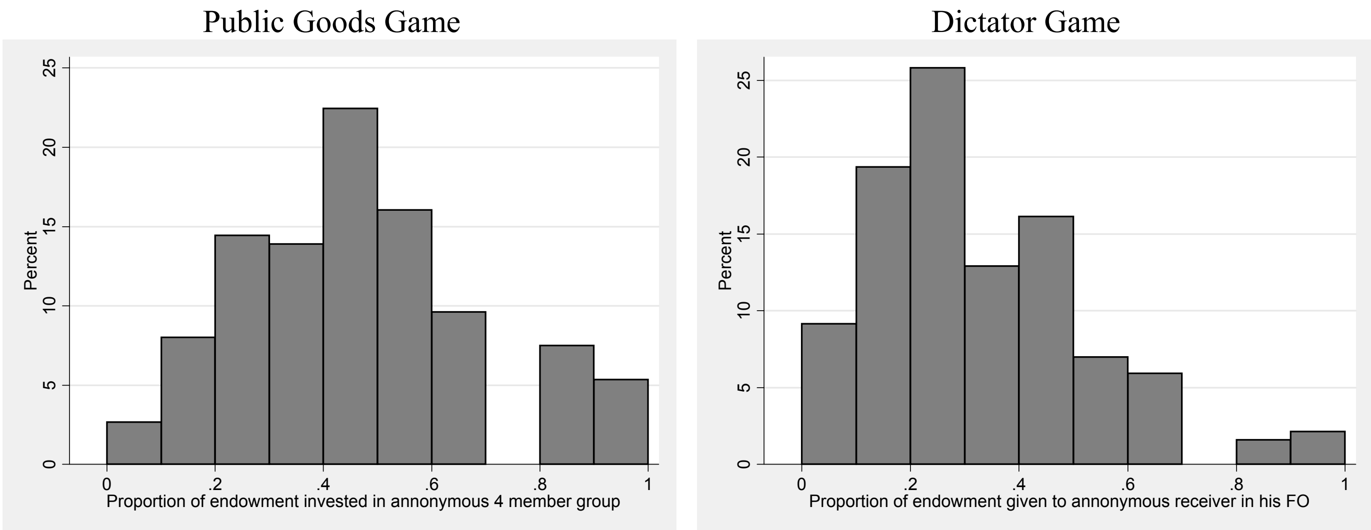


Figure 3. Kernel density function of the size of farmers organization

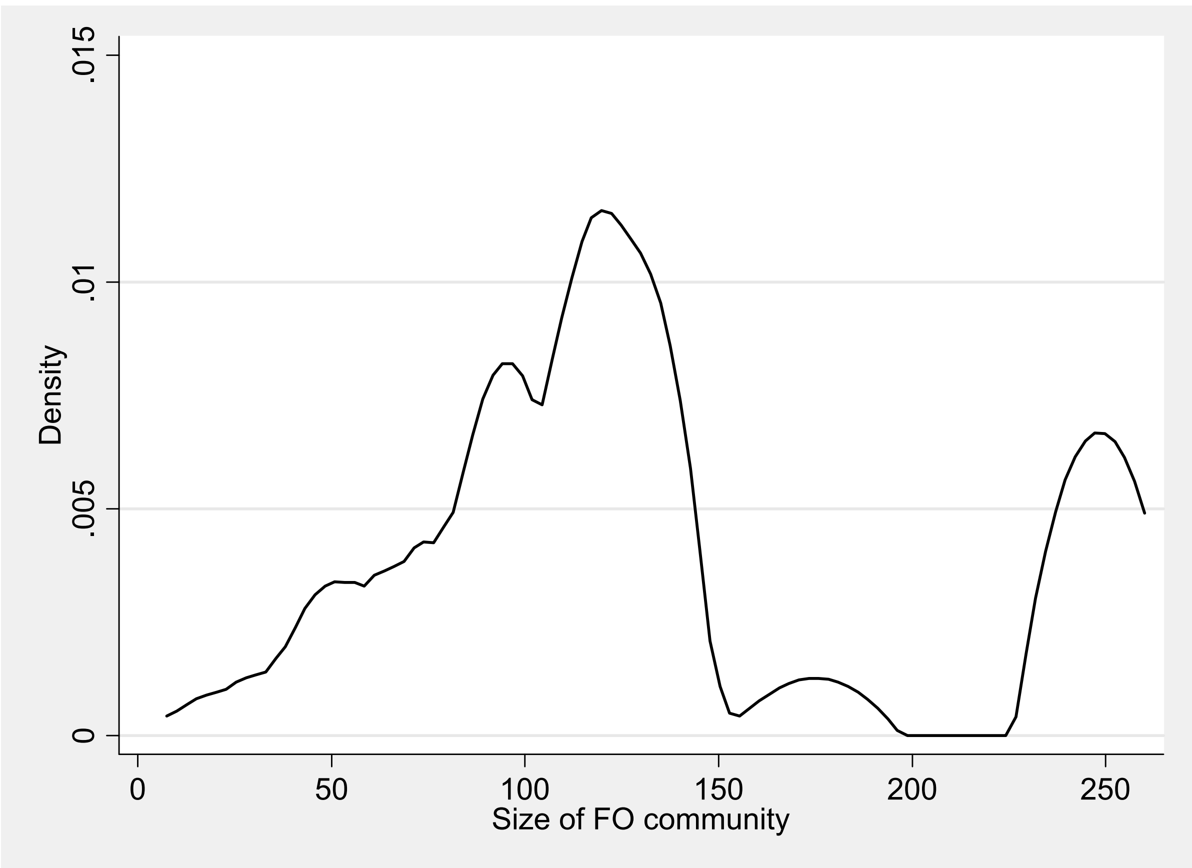
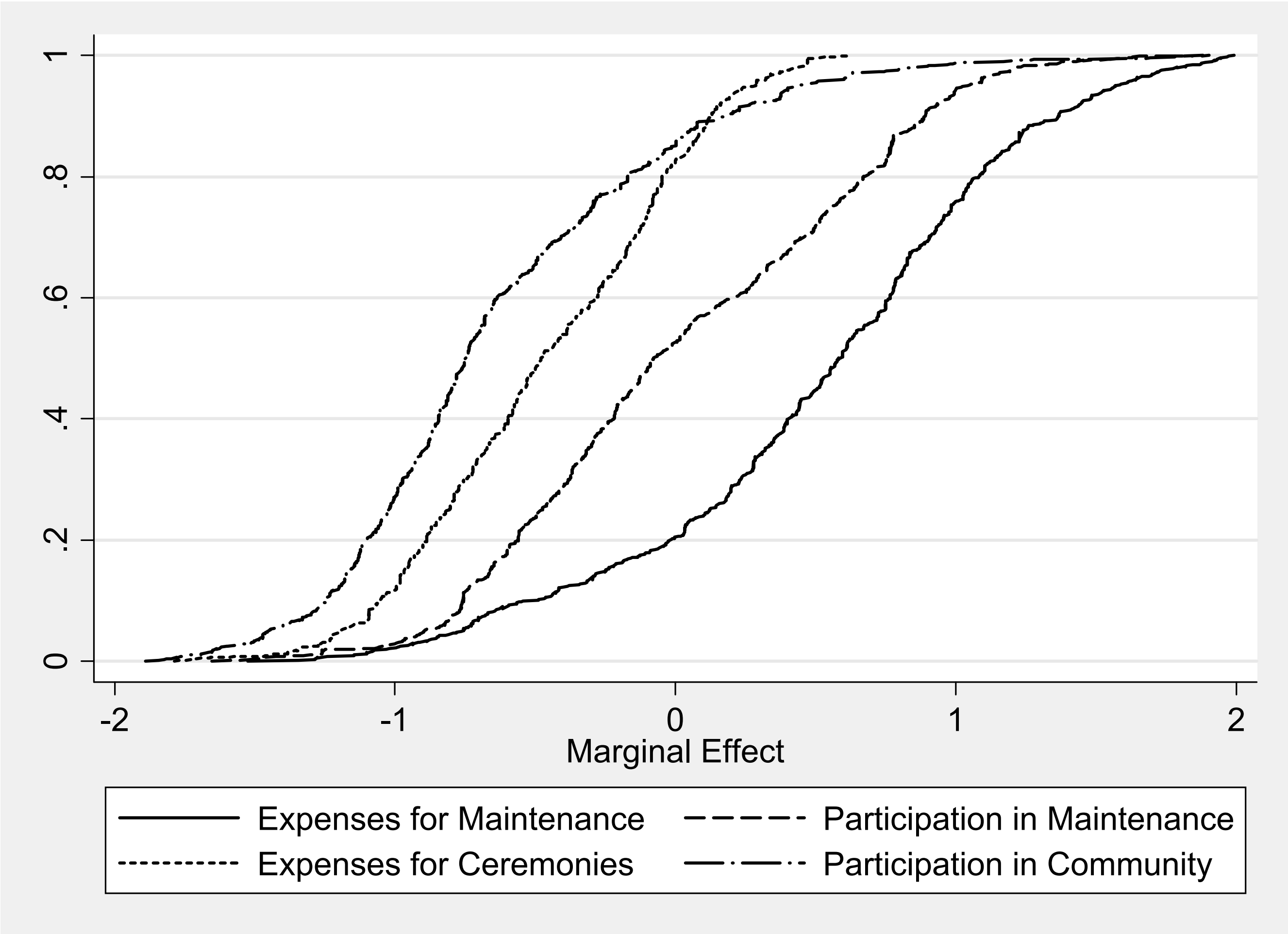


Figure 4. Cumulative distribution function of the marginal group size effect on collective action



Abstract (in Japanese)

要約

標準的な集合行為の理論によれば、集団に属する人数が増えると、集合行為に対する個々人の貢献は低下するとされている。しかし、先行の実証研究による結果は、必ずしもそうした標準的理論を支持しているとは言えない。その理由の一つは、集合行為の異質性が捨象されていることにあるのかもしれない。そこで、こうした既存研究の穴を埋めるべく、本稿では、より一般的な理論モデルを構築したうえで理論的示唆をスリランカ南部における自然実験・フィールド実験データを用いながら検証した。とりわけ、集合行為の異質性について、生産的・非生産集合行動と、金銭的・非金銭的集合行為という二つの軸によって分類し、集合行動と集団規模の関係についての実証分析を行った。結果によると、土地なし農民が集合行為に参加しない傾向を持つこと、非生産集合行動は生産に係るそれよりもフリーライダー（ただ乗り）問題がより深刻となっていること、労働による集合行為への非金銭的貢献は、金銭による貢献よりも、フリーライダー（ただ乗り）問題を顕在化させることが分かった。

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