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Participation in the construction of a local public good with indivisibilities: An application to watershed development in Ethiopia

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Limitations of both the market and the state have caused a growing interest in the potentialities of local-level collective action for development. The burgeoning literature on collective action suffers from two main weaknesses. First, theoretical studies typically fail to describe inter-agent interactions in a satisfactory manner. Second, empirical studies do not provide adequate hard data and quantitative analysis to allow us to advance our knowledge about individual motives for co-operation and conditions conducive to the emergence and evolution of co-operative behaviour.

This study is a modest attempt to fill this gap in knowledge by depicting collective action in the provision of an indivisible public good in a simple game-theoretical framework. It systematically investigates the joint role of leadership and private interests as key determinants of farmer participation in the construction of a local public good, namely a central drainage channel, in a watershed area of the Ethiopian highlands.

Theoretical framework

The problem of creating a local common good or using common resources is sometimes explained in terms of a simple game, prisoner's dilemma, in which collective decisions produce outcomes harmful to the group as a whole without intervention from some higher authority. For example, members of a village may graze their cattle on a common range of fixed size in such a way that while the level of grazing may be advantageous to the individual, this level may overgraze the common range. Under some circumstances, the villagers may agree to graze co-operatively to preserve the common range for sustained use. Some empirical studies show the existence of classical prisoner's dilemma in common resource management while others show that individuals actually co-operate in agrarian societies under various circumstances.

However, the studies in agrarian societies often fail to explain inter-agent interactions in a satisfactory manner, particularly when problems of co-ordination and trust among agents, and the role of leadership are involved. An individual's willingness to co-operate in a 'co-ordination game' may be influenced by opportunistic tendencies or self-interest.

This study attempts to surmount the above analytical confusion, apparent in many studies, by representing collective action for the construction of an indivisible public good as a non-co-operative co-ordination game. Using this framework, the study investigates whether and to what extent participation in a collective undertaking for the construction of a drainage channel in the Ginchi watershed area can be traced to essentially self-interested motives. In other words, the hypothesis is tested that individuals who have larger stakes in a collective endeavour contribute more to make it succeed.

The problem of provision of a pure public good can be modeled by a set of agents, a utility profile and a production function turning labour services into an indivisible public good if the sum of individual contributions meets or exceeds a fixed cost. Labour is voluntarily contributed and the production function is discontinuous in character in the sense that no agent would have an incentive to produce the public good alone, but the community as a whole would produce the good as it would benefit everybody.

Study area and methodology

Population pressure in Ethiopia is heavily concentrated in the highlands, which account for as much as 90% of all cultivated land and 80% of the total population. Potentially fertile heavy black clay soils, known as Vertisols, are found in the highlands. When Vertisols are located in seasonally flooded depressions or other kinds of bottom lands, they are subject to serious problems of poor internal drainage, flooding and waterlogging during the wet season. Due to such problems, Vertisols in lower slope highland areas of Ethiopia remain uncultivated or eroded, and are largely used for dry-season grazing.

The removal of constraints to crop production in highland Vertisol areas is the main objective of the programme of improved management of Vertisols initiated by the Joint Vertisol Project (JVP). The JVP provides various components of a technology package including a broadbed maker (BBM) to drain excess water, early sowing of improved wheat and other crop varieties, planting of grass in gullies and of leguminous trees on steep slopes to control erosion and provide animal feed. While the use of a BBM may be effective on a given plot, it often creates externalities by expelling excess water to nearby plots. The construction of a local public good, in the form of a common drain across private landholdings, therefore, provides an obvious solution to this externality problem arising at the plot level.

The Ginchi pilot watershed, the focus of this study, covers about 350 ha and is part of a Peasant Association (PA) inhabited by about 250 households. Within this watershed, a sub-watershed of about 50 ha, held by 57 households, was chosen by the JVP for the construction of a common drain. The drainage channel was built with the participation of the concerned land-owners before the onset of the main rains, in May and June 1995.

The construction of the central drainage channel in the Ginchi sub-watershed clearly involves important indivisibilities. Unless a critical amount of labour is available for the undertaking, the channel will not yield any benefit in terms of increased productivity. However, additional labour beyond that critical amount will not increase productivity. Due to scattered land holdings across the sub-watershed, the drainage channel within the sub-watershed area is also not susceptible to division into several segments that could be the object of separate construction decisions by sub-groups of farmers. This consideration is especially important with respect to the lower part of the Ginchi watershed, situated near an outlet for the discharged water, where sub-coalitions of farmers with lands concentrated in a well delimited area would have been more likely to emerge.

To identify farmer attributes motivating individual choice of participation, data were collected for 53 households owning land in the Ginchi sub-watershed, using two different methods. First, detailed data were recorded by measuring the exact number of days and hours allocated by each household to the public good construction, the amount of land owned in the sub-watershed, the extent of subdivision of all household landholdings and the exact location of the various plots. Second, a household survey was conducted which generated information on various aspects of the demographic structure, asset position and economic activities of the sampled farming households.

Determinants of individual contributions

An explanation of the observed individual labour contributions to the drainage channel in the Ginchi watershed can be attempted using an econometric model. The dependent variable, measuring the extent of participation of households in the construction of the common drain, is defined in terms of total working hours spent by household members on both earth work and in attending JVP preparatory meetings. The explanatory variables used include factors that bear upon households' stake in the project.

The survey results show that out of the 53 sampled households, 33 (62%) participated in the drainage project. Among the 33 participant households, 13 (about 40%) attended at least one preparatory meeting while the remaining 20 households contributed to earth work, yet did not participate in any meeting. Some 137 person days, corresponding to 397.12 person hours, were contributed by the sample households for the project. Two-thirds of the total time allocated to the drain was provided by households which participated for at least 5 days in the collective project. Moreover, about 70% of the total amount of time contributed was used to construct the drainage channel while the remaining 30% was spent in preparatory meetings.

Econometric results

An important feature of the dependent variable to be used in the econometric model is that it has many zero observations. Applying the standard Ordinary Least Square procedure in such a case is unsatisfactory because it would yield inconsistent and biased estimators. In view of this, the procedure used is the censored regression or limited dependent variable model, known as the Tobit model, which yields consistent and asymptotically normal maximum likelihood estimators.

The model specification, which measures participation by the comprehensive index (including attendance at meetings), includes the following independent variables: land area owned in the watershed (LAND); proportion of land parcels owned in the sub-watershed that form a compact set with at least one parcel bordering on the drainage channel (PROX); the ratio of the number of draft animals owned to the adjusted size of the family workforce (CAPL); the adjusted size of the family workforce (WORKF); a dummy variable (LEAD) representing leadership qualities (equal to 1 if the household head is a member of the executive committee of the local PA, and 0 otherwise); a dummy variable (YALT) representing access to non-agricultural incomes (equal to 1 if any member of the household earns incomes from non-agricultural activities, and 0 otherwise); the proportion of land owned by the household outside the sub-watershed (LOUT); and the proportion of land allocated to wheat growing in the sub-watershed (CROP).

The results of the estimation show that four variables, namely LAND, PROX, CAPL and LEAD, are highly significant statistically. All the coefficients are of the expected sign. In particular, the intensity of participation in the construction of the drainage system is directly related to the amount of land owned in the watershed (LAND); to the relative number of parcels owned that form a compact set with one border along the channel (PROX); to the potential effectiveness of cultivation measured by the capital/labour intensity of owned factors (CAPL); and finally to the leadership qualities of the household head (LEAD).

The significant impact of the landscape variable PROX suggests that farmers can benefit from scale economies when they can construct and maintain secondary or tertiary drains on a large compact landholding bordering on the channel. Regarding leadership, members of the executive committee of the local PA contributed an average 22 hours, compared with 12 hours for all participating households and 7.5 hours for all sample households. To the extent that a position of leadership somehow entails better awareness of the potential gains from a public good, even the impact of leadership may be traceable to considerations of material self-interest. However, this could be too narrow an interpretation since leaders may be less self-interested than other farmers or may be driven by self-interested motives related to political

career or social prestige.

The model results also show that a number of explanatory variables have no significant impact on participation. There is no significant relationship between off-farm income-earning opportunities and participation. Similarly, the type of crop grown does not influence participation, confirming that farmers are able to vary their crops from year to year. Likewise, the coefficient of the workforce variable is not statistically significant and is very small in absolute terms, perhaps reflecting the widespread disguised unemployment in the Ginchi area. Finally, the proportion of land owned outside the sub-watershed has no significant impact on participation, indicating that the opportunity costs of labour are not correlated with landholding outside the sub-watershed and only reflect a taste for leisure.

Overall, with the exception of the leadership variable, individual labour contributions to the public good appear to be well explained by factors which determine the potential benefit which individuals can derive from the public good. Participation rates are largely influenced by personal benefits which different farmers can expect to draw from the creation of the drainage infrastructure.

Conclusions

An attempt was made in this paper to clarify the structure of the problem facing farmers presented with the possibility of collectively constructing a public good. Given that the drainage channel built in the Ginchi sub-watershed area is an indivisible public good, the theoretical game chosen as appropriate to describe the pattern of interaction among Ginchi farmers was a co-ordination game that yielded multiple equilibria, including the Pareto-inefficient equilibrium in which no agent contributed.

Another objective of the study was to determine whether the relationship between the size of expected benefits and active participation in the collective undertaking was positive or not. The study results show that there is a clear positive relationship between the magnitude of personal stakes and efforts spent on building the drain. Thus, a social norm of 'from each according to his expected gains' appears to have been at work. Motivations associated with practical knowledge of the potential gains of collective action, with ability to draw potential benefits and with membership in local organisations were also found to be important in the farmer's choice to participate.

An important caveat of the study relates to the ambiguous impact of wealth inequality on collective action. Wealthier farmers, with larger or better located lands, contributed more towards the construction of the drain. Thus, as a more unequal wealth distribution increased the incentives of the wealthy to participate in the production of public goods, it also reduced the incentives of the poor to contribute. In the presence of such redistribution of incentives to participate among different wealth groups, a priori prediction of whether such change will lead to a more or less efficient level of production for the public good is impossible. Of course, if aggregate wealth rises, but not at the expense of the poor, the chances that the amount of public good provision gets nearer to an efficient level are higher.

For more information on this issue see: Gaspart F., Jabbar M., Mélard C. and Platteau J.-P. 1998. Participation in the construction of a local public good with indivisibilities: An application to watershed development in Ethiopia. *Journal of African Economies* 7(2):157-184.