Determinants of Collective Action in the Commons: An Empirical Study of Irrigation in China①

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Abstract

Irrigation systems have long been used as an important case for studying collective action in the empirical common pool resources (CPRs) literature. Based on a large-scale representative survey of Chinese rural areas, we use econometric analysis to examine the factors that influence collective action in the commons. The novelty of the current study is the introduction of a new ordered collective irrigation measure based on different types of rural irrigation and the subsequent study of labor outflow, a rarely explored but crucial variable in developing countries, and other factors affecting collective irrigation participation. We found that labor outflow had an adverse effect on participation in collective irrigation, and in cases of close proximity to urban centers or towns, widened inequality, and when occurring in hilly areas and areas with historically scarce water resource, the presence of fewer household laborers and poor water endowment tend to reduce the incentives to participate in collective irrigation. These findings remain robust for various equation specifications, taking into account measurement errors on both the dependent and control variables sides, thus contributing some new insights to the existing CPRs literature.

Keywords: collective action, common pool resources, irrigation systems, labor outflow, China

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1 Introduction

Collective action related to the governance of common pool resources (CPRs), such as forests, fisheries, and irrigation systems, has consistently attracted the attention of researchers, because of its critical importance to the economic and environmental well-being of the rural sector of developing economies (Jodha, 1986). The quality of commons governance depends on the collective action of multiple individuals, thus a longstanding academic challenge for scholars is to identify the factors that facilitate or impede collective action in the commons.

Empirical study of the specific contexts of different countries is the fundamental means of identifying the factors that influence collective action in the commons. Over the past three decades, a significant number of empirical studies have been conducted worldwide, especially in Nepal, India, and Philippines. As a result, more than three dozen factors have been discussed in the literature, which have been commonly divided into four categories, the attributes of the resource system, the attributes of the management group, the attributes of the institutional arrangements, and the external environment (Wade, 1987; Ostrom, 1992; Baland & Platteau, 1996; Vira, 1999; Sekher, 2001; Agrawal, 2001).

Empirical studies in different countries have gradually expanded the knowledge on commons-related collective action. Many factors are identified and reported repeatedly in empirical studies, such as Size, Number of users, Scarcity, Market access, Dependence on resources, Heterogeneity, Leadership, Norms, Social capital, Local Autonomy, Technology, etc. (Agrawal & Ostrom, 2001). Though debate exists on the direction, size, and significance of their effects, the importance of these factors to collective action in the commons has been widely acknowledged.

Given that the number and variety of existing empirical studies are both considerable, it is especially surprising that little research has been conducted to examine the factors of collective action in the commons in China, which is the largest developing country and which has a tremendously large population and numerous commons. Aimed at enriching the current evidence on factors of collective action in the commons, we examine the determinants of collective irrigation based on data from a comprehensive large scale survey in Chinese rural areas organized by Tsinghua University's China Institute for Rural Studies (CIRS) in 2012.

As a typical common-pool resource characterized by consumption rivalry and difficulty of exclusion, the irrigation system has long been used as an important case for studying collective action in the empirical CPRs literature. China has more than 10 million irrigation systems in diverse socio-ecological settings, with sizes ranging from millions of hectares, managed by governmental organizations, to just a few hectares, managed by local farmers. China's empirical data provides a great opportunity to test the robustness of the theory of collective action in the commons.

Some key strengths of this paper are the use of a large-scale multivariate data set (N = 1716) and the application of econometric tests to control for theoretically relevant factors such as natural geographic characteristics, resource users characteristics and irrigation system governance and institutional setup. More than a dozen variables have been examined in the econometric analysis, among which we highlight the variable of labor outflow, a rarely explored but crucial variable in developing counties. Another main strength of this paper is the introduction of a new ordered collective irrigation measure based on different types of rural irrigation, which is a novel method and which has proven to be an effective tool for measuring collective action.

The rest of the article proceeds as follows. In the next section, we review the literature on collective action in the commons. On the basis of this review, we use Section 3 to specify the data collection methods, the construction and measurement of variables, their possible impacts on participation in collective irrigation, and discuss empirical methodology issues we may encounter in the course of our econometric analysis. In Section 4, the findings are presented and discussed, while conclusions and limitations follow in Section 5.

2 Literature and motivation

Existing studies on collective action focus on the determinants of collective action, and explore the role of different factors of individuals' involvement. Ostrom (2009) has reviewed major studies and summarized 10 key variables that could influence self-organized collective action, including resource system size, system productivity, predictability of system dynamics, resource unit mobility, number of users, leadership, norms/social capital, knowledge of the social ecological system, as well as importance of resource to users. Though the importance of these variables has been recognized, they interact with each other in such a complex manner that limited consensus has been achieved regarding the direction, size, and significance of their effects.

Economic heterogeneity or inequality has long been regarded as a key variable that affects the success of collective action (Adhikari & Lovett, 2006; Stiglitz, 2012; Janssen & Anderies, 2013). Researches have pointed out farmers' groups that are internally differentiated on the basis of income or resources may not be so successful at collective action when compared to groups that are relatively more homogeneous (Bandopadyay & Eschen, 1988; Chambers et al., 1992). This may especially be the case in the context of management of CPRs such as irrigation canals, fisheries or forests that are characterized by features like non-excludability and subtractability in use (Ostrom, 1990). For instance, a study of 10 irrigation reservoirs in India found that the smaller the variance in farm size among farmers, the more farmers were likely to form water user associations (Easter & Palanisami, 1986). Lam (1996) revealed a negative relationship between inequality in landholding and irrigation systems performance. Another study revealed a negative relationship between variance in average family income among irrigators and degree of rule conformance and maintenance activity (Tang, 1992).

The presence of natural resource endowments is widely believed to impact collective irrigation. Collective action is regarded as difficult to organize in situations where the water supply is uniformly available, the width of the upstream and downstream water supply is very different, the size of the association is large, the population density is low, the ratio of non-farm households is high, and the experience with irrigated farming is limited (Fujiie, Hayami, & Kikuchi, 2005). But Kurian and Dietz (2004) have declared that heterogeneity of natural endowments, such as arable land, proportionate to household size may facilitate collective action in irrigation management.

Leadership and social capital have also been thought to exert great influence on the results of collective action (Meinzen-Dick, Raju, & Gulati, 2002). The involvement of a charismatic or trusted individual reduces the transaction costs of organizing and provides assurance that makes people more willing to participate in collective action (Baland & Platteau, 1996; Kolavalli, 1995). For instance, the presence of college graduates and influential elders had a strong positive effect on the establishment of irrigation organizations in a stratified sample of 48 irrigation systems in India (Meinzen-Dick, 2007). Veldeld (2000) concluded that collective action is often enhanced when political elites and leaders are somewhat better endowed and wealthier than are average community members. Pretty (2003) demonstrated that in situations where the social capital of formalized groups is high, people have the confidence to invest in collective activities, knowing that others will do so too. Likewise, in communities characterized by close social proximity (with low costs of transaction and frequent communication) where people put a greater premium on the importance of social norms, collective action in common property resource management is likely to succeed (Runge, 1986). Li *et al* (2011) found that water user groups with high social capital and with high homogeneity of cultivated crop varieties can successfully manage water collectively.

Studies also suggest that collective action could be influenced by distribution of interests or skills within community groups. Those with greater endowments are willing to bear a disproportionate share of the initial costs of organizing institutional arrangements in order to stimulate action. The presence of wealthy and knowledgeable participants early in the process may encourage trust. In turn, inequality in distribution of benefits in the later stages of cooperation may reduce trust and reputation and constrain the emergence of further cooperation (Ostrom, 2007). Dayton (2004) pointed out that choice of distributive rule has a quantitatively larger impact on the level of infrastructure maintenance, controlling for other factors, than does the direct effect of structural characteristics such as group size or inequality. Schlager's case study (1990) underlined the importance of a stable economic environment and moderate to high returns for fishermen in sustaining collective actions. Gyasi (2004) found the resistance of landlords to a land redistribution policy to have a detrimental effect on the success of collective action for the local management of irrigation schemes.

In addition, researchers have also revealed other factors' roles. Araral (2009) found that collective action is associated with water scarcity, proximity to markets, group size, farm size, and governance structure, among which water scarcity has a curvilinear effect on collective action and is mediated by the governance structure. A number of other variables such as group size, rule enforcement capacity, property rights arrangements, distance to the market, characteristics of resources, collective-choice autonomy, biophysical characteristics, and gender relations are also expected to be related to the results of collective action (Wade, 1987; Ostrom, 1990; Uphoff et al., 1990; Baland & Platteau, 1996; Agrawal, 2001; Meinzen-Dick et al., 2002; Swallow, Garrity, & Van Noordwijk, 2002; Araral, 2005; Ostrom, 2007; Haller & Merten, 2008; Pandolfelli, Meinzen-Dick, & Dohrn, 2008; Bastakoti & Shivakoti, 2012). Recent studies conducted by the Center for the Study of Institutional Diversity at Arizona State University focus on the relationship between uncertainties in water availability and collective actions (Anderies, Janssen, Lee, & Wasserman, 2013; Rollins, Baggio, Pérez, & Janssen, 2014).

However, little attention has been paid to the influence of labor outflow on collective action, particularly on collective irrigation, which is a crucially significant variable in developing economies. According to the data provided by the China National Bureau of Statistics, in 2012 the number of migrant workers from rural regions had exceeded 0.26 billion, an astonishing figure that accounts for nearly 1/5 of the total population in China and 4/5 of the total population in the United States. In sharp contrast to this, the relationship between labor outflow and collective irrigation remains largely unexplored.

Theoretically, the connection of the two could be established through 2 intermediate variables. One is the dependence on resources. Transitioning out of rural areas to urban cities and from the agricultural sector to the industrial and service sectors would mean an exit option from farming for rural residents. As a result, people would become less dependent on the commons since they could earn income from other nonagricultural activities, which have also increasingly constituted their main source of revenue. Runge (1986) and Ostrom (2000) have claimed that greater dependence on a resource (salience) brings a positive force for cooperation to manage it. As a result, weaker dependence on resources could in turn weaken motivation to engage in collective action such as irrigation systems maintenance. Researches also show that a greater number of exit options reduces cooperative capacity as it weakens social cohesion (Bardhan, 1993), and increases the costs of enforcing rules, thus exerting further negative impacts on collective resources management (Stern et al., 2002).

Another intermediate variable could be the sense of community, which fundamentally refers to an individual's experience of community life (Hyde & Chavis, 2007; Mannarini & Fedi, 2009). In terms of its motivating power, sense of community is considered a catalyst for social involvement and participation in the community (Davidson & Cotter, 1986; Chavis & Wandersman, 1990), and evidence of the connection between sense of community and participation has generally been consistent across cultures and social groups (Brodsky, O'Campo, & Aronson, 1999; Liu & Besser, 2003; Perkins, Brown, & Taylor, 1996; Prezza et al.,1998; Albanesi, Cicognani, & Zani, 2007; Cicognani et al., 2008). As Klandermans (2002) has discovered, positive relationship with the community could strengthen group identification, which reinforces collective action. In this regard, labor outflow exerts a significantly negative impact on rural residents' sense of community, as people who stay in the village all year round have dramatically declined, leading to decreased time for individuals to participate in community life and interact with other rural residents, thus undermining shared emotional connection with other members, as well as reducing benefits that people could derive from their participation in rural community activities or collective action.

In this paper, we are going to explore the determinants of participation in collective irrigation in China with particular attention to the impact exerted by labor outflow, based on a large-scale representative survey of Chinese rural areas. We hope to understand and illustrate the mechanism by which labor outflow affects participation in collective irrigation, with other conditions being controlled.

3 Method

In this section, after a brief description of the sample survey used, the manner in which both dependent variable and control variables are constructed, defined and their possible impacts on participation in collective irrigation are described. Finally, empirical methodology issues commonly encountered in carrying out econometric analysis are discussed.

3.1 The survey and the data

The survey data used in the current study constitute a subset of a comprehensive large scale survey organized by the China Institute for Rural Studies (CIRS) at Tsinghua University in 2012. This survey was initiated at the beginning of May, 2012, launched in full force in June, and concluded at the end of August later that year, and was aimed at getting a general image of the production and living situation of Chinese rural areas through some 6000 representative households survey and about 200 village level interviews from 22 provinces. From mid-June, about 1000 university students, most majoring in agriculture-related subjects, from various prominent universities in Beijing, including Tsinghua University and China Agricultural

University, were recruited and trained at Tsinghua University by two survey experts from CIRS with basic survey and interview techniques. After that, these trained surveyors were put into 97 groups, and sent back to their home provinces to carry out the survey. Stratified sampling was implemented (in some places not so strictly) both at the village level and at the household level with the help of local cadres. In September, 5165 completed household survey pamphlets and 205 village-level pamphlets were returned, carefully screened and input by a professional data company under the guidance and instruction from the CIRS office personnel[②]. This survey turned out to be the most recent large nation-wide rural area survey carefully organized and conducted by a prominent academic institute in China.

The structural questionnaire for this round of the CIRS survey was designed and developed by experienced field researchers and post doctor fellows affiliated with CIRS, covering seven major topics like land circulation, well-being of elderly and children in rural villages, education, irrigation, heath and rural hygiene, rural finance and also emerging cooperatives and other organizations in rural areas. One of the most noteworthy characteristics of the survey design for the current study is that it contained related information both from the village and the household level, thereby enabling the investigation of how village level factors affect individual strategies and providing further evidence at the village level to analyze using household level data. To the best of our knowledge, few studies had been designed to analyze collective irrigation at both of these levels. However, it must also be pointed out that this kind of design was not implemented without difficulty. For example, in certain parts, the completeness and quality of responses varied a lot both at the household and at the village levels. Also, it might be conceivable that for those

② More details and findings regarding this survey can be found in a book published by CIRS with the name “See Rural China through Pure Vision”, China Development Press, 2013.

villages with corresponding valid households of less than 10, the quality of the survey may be less satisfactory. With these two considerations in mind and matching village data to household data, the subsample we included for the current study was significantly reduced to 1716 households from 18 provinces, 53 counties and 74 villages. The composition and distribution of respondents over regions are reported in Table-1. In general, the subsample is still much larger compared with the prevailing literature and is regionally representative overall.

[Table-1 roughly here]

3.2 Variables definition and construction

A. Dependent Variable

A widely acknowledged challenge in empirically studying the determinants of collective irrigation is identifying the appropriate measurement of the dependent variable or the degree of collective action. Up until now, two ways of measuring collective action have been suggested. The first one proposed by Bardhan (2001) is to assess the outcome of successful collective action with indicators like maintenance status of irrigation facilities, where the relative absence of conflicts or rule violations in rural or community irrigation systems is defined as good maintenance and active participation; and the second approach employed by Fujiie *et al* (2005) is to approximate collective action by counting successfully organized collective activities, such as collective lobbies, and joint maintenance of canals and tanks.

Although the existing literature focuses on direct measurement, this study makes use of a somewhat indirect but also illuminating indicator to denote different levels of collective action.

Specifically, we assign ordered dummy variable for different types of irrigation arrangements with 3 as the highest score and which is assigned to open channel irrigation, 2 to lifting irrigation, 1 to flooding irrigation and 0 to relying exclusively on rain-fed irrigation. These rankings were based on the widely recognized ideas that coordination and cooperation required for maintaining open channel irrigation are the highest, that close coordination is not that essential to the maintenance of lifting and flooding irrigation, and that rain-fed irrigation has the lowest cooperation requirements. Although somewhat subtle and indirect, an obvious advantage of this form of measurement is that only the more objective or observable information regarding irrigation type in use need be taken into consideration, rather than ex-ante self-reported maintenance efforts or inputs from households, which might suffer from exaggeration bias in some circumstances, or the subjective appraisal of maintenance status recalled by interviewees. Nevertheless, to maintain compatibility with the existing literature, we repeat key regressions for collective action with traditional dependent variables like participating in collective irrigation maintenance at the household level and evaluation of the maintenance status at the village level and use them as robustness checks for our baseline regressions with this novel collective action measurement.

B. Factors affecting collective irrigation

Largely consistent with the setup common among the empirical CPRs literature, we included four sets of variables that augment the determinants of collective irrigation in the standard collective action equation: natural endowment, social economics factors, institutional setup and household level controls. A new element that we added to the classical framework and that we would like to emphasize in the current study is labor outflow in rural areas, one of the most important facets in the urbanization process of developing economies which is highly stressed in development models but is surprisingly less explored in the collective irrigation literature.

B1: labor outflow

Labor outflow from rural areas to urban sectors has long been noted by development economists as a key factor for boosting economic development in developing countries. It revitalizes a great number of residual laborers in rural areas and raises the marginal productivity of rural land production on one hand, and lowers wage costs for the urban service and manufacturing sectors on the other hand. However, labor outflow is also associated with side effects and new challenges for traditional villages, such as inadequate support for the elderly and children as noted in the rural studies literatures.

For the purposes of the current study, we'd like to suggest that labor outflow also reduces the incentive to participate in collective irrigation. The logic is as follows: (1) more labor outflow would significantly raise the costs for gathering and communication related to public affairs such as irrigation meetings in rural villages, which is vital for coordinating public irrigation arrangements; (2) more labor outflow would reduce the incentives for and relative importance of participating in collective irrigation due to the increased income percentage from the non-agricultural sector; and (3) higher mobility accompanying increased labor outflow would also considerably attenuate social capital in rural villages, which further decays the foundation for collective irrigation. In sum, we hypothesize that labor outflow would have a negative effect on collective irrigation.

B2: natural endowment

We included four variables, namely topography, location, distance to town, and water conditions to control the geographic heterogeneity affecting collective irrigation arrangements.

Topography

We used a simple 0-1 dummy to denote topographical differences, with 1 for plains and 0 for hills or mountainous areas. The cost for the construction and maintenance of collective irrigation systems is obviously much cheaper in situations of plain topography, since there is less need to dig channels through hills and mountains. Also the scale economy of a large irrigation system is more likely to be achieved in plain areas than in hilly or mountainous areas. Hence, we expected that residents living in plains would prefer collective irrigation systems such as open channels and lifting irrigation over rain-fed irrigation.

Location and Distance to town

It's often found that more access to market opportunities encourages participants to be engaged in collective actions (Meinzen-Dick, Raju, & Gulati, 2002). And normally the distance to the nearest market is used as a proxy for access to market opportunities. In the current study, however, we don't have an exact distance measurement of this kind. Instead, we turned to two other related indicators as substitutes. The first is the distance to the nearest high school reported in each interview after using a log transformation. And the second is a dummy denoting village location type, 1 for non-suburban village and 0 for otherwise. Provided the fact that most high-schools are located in towns or counties, the distance to high school could serve as an acceptable substitute. Consistent with the existing literature, we expected that distance to town would give more credit to collective irrigation *ceteris paribus*.

Water endowment

Adequate water supply may reduce the urgency of collective irrigation. However, scale economies of collective irrigation are also more likely to perform better and be more competitive in places with abundant water resources. In this sense, water scarcity will have a negative effect on the adoption of collective irrigation. For the current study, we assigned ordered variables integral values ranging from 1-5, so as to denote relative water scarcity in the household questionnaire, with 5 representing situations with the most severe water scarcity in the last few years and 1 representing situations of minimal water scarcity. We thus expect a negative sign for this variable in our regressions for collective irrigation.

B3: socio-economic factors

Besides the labor outflow indicator, there are the other two variables accounting for socio-economic differences at the village level in the current study, namely, village scale and income inequality, denoted by Gini coefficient, which may influence collective irrigation preference at the household level.

Village scale

In the existing CPRs literature, it's generally assumed that the larger the community, the harder will it be to maintain institutions and rules governing local collective resources or commons due to mounting coordination costs and free rider problems associated with increasing numbers of participants. However, as collective irrigation frequently exhibit scale economy characteristics, in communities and villages with larger populations, collective irrigation may be increasingly preferred or benefit more people with decreasing unit costs. In this sense, the impact of village scale on collective irrigation is uncertain and is contingent upon the relative force of mounting coordination costs and scale economy benefits. We used two measurements for village scale, namely, total population and total households reported, respectively, at the village level.

Heterogeneity in income

The more homogeneous the group, the easier it will be to coordinate collective action, since there are less conflicting interests, and the private preference information for public goods is much more alike, which is important for aggregation. Thus conversely, with the increase of heterogeneity in certain groups the difficulty and costs of reaching a collective agreement may surge exponentially. In line with convention, we calculated some income inequality measures to capture heterogeneity at the village level based on the corresponding household income data. As smaller village respondent samples are less representative and the calculation of their inequality index less precise, we just included those villages with valid interviews exceeding 10 households into our subsample for regression analysis. However, even with this kind of sample refinement procedure, our calculation for income inequality measure may still be subject to considerable measurement error due to the aforementioned sampling implementation difficulties. We adopted two strategies to address this in the following empirical setup. Firstly, we use other methods of calculation less dependent on adequate observations such as log standard deviation in income, and repeated baseline regressions to see whether our main regression results still hold. Secondly, we turned to weighted regressions that assign more weight to villages with more respondents, and compared the new results with the baseline regression to check whether the estimates maintain compatibility after taking into account sample representative issues.

B4: Institutional setup

Governance at the village level was found to influence preference for collective irrigation in the following two ways. Firstly, the institution setup for common public affairs is complementary to collective irrigation, since public discussion and bargaining is less costly in places with more success in dealing with public affairs and goods, while in places where conflicts of various kinds are more likely to necessitate the involvement of a higher authority, the foundation for collective action may be poor, thereby diminishing incentives for collective irrigation. Secondly, specific rules and institutional arrangements for collective irrigation, such as punishment for privately cutting channels or evading irrigation fees, help to punish free riders and rule violators, which is good for maintaining a well-established irrigation system, making collective irrigation more feasible.

Following this line of argument, we constructed two variables denoting governance quality and institutional setup at the village level. The first is a dummy variable, with 1 representing villages having petitions in the last three years over land circulation, and 0 representing otherwise. Observing petition indicates that there are some kinds of conflicts that cannot be resolved at the village or local level, which may also jeopardize collective irrigation. The second is also a dummy variable, denoting irrigation system punishment arrangements, with 1 assigned to places with punishments against privately cutting channels or evading irrigation fees, and 0 assigned to otherwise. We expect the first dummy for petitions to have a negative sign, while the sign of the punishment dummy is expected to be positive in our regression.

B5: Household level heterogeneity

Household level heterogeneities also influence the preference for collective action as noted in the literature. For the purposes of this study, we included five variables to account for heterogeneity at the household level.

Household labor

On one hand, labor force size is generally connected with shares of land as well as natural resources in villages, making collective irrigation more attractive at the household level because of its enhancement of resource management. On the other hand, more household laborers may also improve the labor supply available for collective irrigation. Thus, we expected that increasing household labor will have a positive effect on preference for collective irrigation.

Distance to irrigation system

The distance of household land to irrigation system is a variable commonly mentioned in the existing literature. Often, there are two indicators for measuring distance, one is relative location to irrigation system, such as upstream or downstream, and the second is absolute distance. In our questionnaire, we considered these two types of measures. However, the data showed that there were many strange outliers in terms of absolute distance measurement, which might be partly due to some misunderstanding regarding measurement units. Hence, we turned to the first approach, using two separate dummies denoting relative distance to public irrigation system, namely long distance or middle distance. It's observed that the incentive for collective irrigation is the highest for households at a middle distance, for households at a long distance or located nearby the incentive was diminished due to relative decreasing benefits or relative water abundance.

Historically scarce water resources

Obviously, a history of water resource scarcity will discourage households from retreating back to private irrigation. We used a simple evaluation variable with an integral value ranging from 1 to 5, denoting relative irrigation scarcity in the past three years, with 5 representing the most severe. We expected that this variable will have a negative effect on collective irrigation preference.

The impact of Insufficient Irrigation on household living conditions

Besides experience with water scarcity, we also included a variable accounting for the impact of insufficient irrigation on the household. It can be argued that the more influential irrigation scarcity is on household living conditions, the more proactive will the household be to acquire more reliable and effective irrigation. Thus, we expect that the dummy for irrigation influence will have a positive sign in our regression.

Others: Education and age of head of household

Finally, we also included the education and age of head of household to our baseline regression as control variables for the purpose of controlling certain unobserved heterogeneity at the household level. Thus, unlike previous sets of controls at the household level, there is no specific clue for their signs in the regressions.

The definition, construction and expected signs of variables used in the following regression analysis are summarized in Table-2.

[Insert table-2 roughly here, variables definition and their possible signs]

3.3 Empirical methodology

We used the following ordered probit model to empirically study the impacts of labor outflow on preference for collective irrigation in rural areas.

$$\mathrm{prob.}(\mathrm{OCI_i}) = \alpha flowout_{\mathrm{i}} + \mathrm{X_i}\beta_{\mathrm{i}} + \mathrm{Y_i}\gamma_{\mathrm{i}} + \mathrm{Z_i}\delta_{\mathrm{i}} + \mathrm{W_i}\theta_{\mathrm{i}} + \varepsilon_{\mathrm{i}} \ldots\ldots\ldots\ldots\ldots(1)$$

Where the left side is the dependent variable, such as the ordered collective irrigation (OCI) dummy. And $flowout_{\mathrm{i}}$ is the labor outflow rate of household i, which is the focus of the current study, $\mathrm{X_i}$ and $\mathrm{Y_i}$ is the natural geographic controls and socio-economic controlled matrix at the village level, $\mathrm{Z_i}$ denotes institution and governance in the village, and lastly $\mathrm{W_i}$ contains a set of variables accounting for household heterogeneity. As usual, ε_i is the residual term, presumed to be *i.i.d.* α, β_i, γ_i, δ_i, and θ_i, are coefficient or matrix for estimation.

The dependent variable in the current study is an ordered dummy denoting different degrees of collective irrigation, thus the ordered probit model is the appropriate choice in performing the econometric analysis, which can reveal the influence of each variable in determining the probability of choosing collective irrigation. In general, typical challenges for a consistent estimate of α in equation (1) include unobserved heterogeneity, omitted variable bias, and measurement error in both dependent and control variables. For unobserved heterogeneity, which means that although some unobserved factors may affect irrigation arrangement in some specific places, their information could not be obtained through questionnaires, we tend to trigger or minimize this kind of bias in the following two ways. Firstly, we include sets of common indicators all believed to be important factors in explaining collective irrigation to absorb observed heterogeneity both at the village and the household levels. Secondly, for those fixed factors such as climate, cultural features and water abundance of a certain region, which may also influence irrigation arrangements in specific areas but could not be taken into account in the model, we added province dummies into equation (1). As long as these factors are constant at the provincial level, our provincial fixed effect setup would significantly reduce the bias caused by this kind of unobserved heterogeneity and also omitted variables bias. Meanwhile, provided that province dummies may not be that sufficient to capture some fixed differences at the provincial level, we also supplement the “provincial fixed effects” setting with provincial level water endowment data from statistical yearbooks. With regard to possible measurement error for both dependent and control variables, we used different measures or indicators for those likely suffering measurement errors, or simply dropped those unsatisfactory measurements and observed whether our main estimates remained compatible or not. A last concern for the regression analysis is whether the subsample on which we based empirical analysis is representative for our whole survey sample, given that we just had about one third of the total sample. To address this concern, we repeat our main regressions using full sample village datasets. If our key estimates still hold for the village sample with information available, then it will give us more confidence that our results from the household level are less likely to be suffering sample selection bias.

4. Results and Discussion

The empirical findings are reported in the following sequence. In subsection 4.1, we report the results of the baseline regression with and without province fixed effects taking into account the impacts of both observed and unobserved heterogeneity. For the baseline regression, we also check the inclusion of provincial water endowment variables as an alternative specification test for provincial fixed effects controls, and see whether weighted regression affects our main estimates. A robustness check for the baseline regression will be reported in subsection 4.2, where we will deal with the impact of measurement error, repeat main regressions with other collective irrigation measurements to maintain compatibility with the existing literature, and also duplicate main setups with the village level dataset. Finally, the comparison using different estimating models and corresponding marginal effect is provided and discussed in subsection 4.3.

4.1 Baseline regression

The first part of the results for baseline regression are presented in Table-3, in which Column (3) and (4) are exact pair-wise province fixed effects estimates counterparts of column (1) and (2) respectively. The difference between column (1) and (2) is that we added a further dummy control for long distance to irrigation system in column (2) to more precisely check the effect of distance on collective irrigation. For column (5) and (6), we include different combinations of location controls.

[*Insert table-3 roughly here: baseline regression: the determinant of collective irrigation*]

On the whole, the estimates from column (1) to (6) show goodness of fit of our regression models, most variables have the expected signs and are significant in most setups. Labor outflow has a significantly negative impact on collective irrigation, consistent with our expectations. From column (1) and (2) to column (3) to (6) with province fixed effects controls, the coefficients of labor outflow are uniformly bigger, which indicates that the omission of unobserved heterogeneity may cause an underestimate of the impact of labor outflow on collective irrigation. Also, the estimates of labor outflow from column (3) to (6) are fairly comparable in magnitude, thereby improving our confidence that the estimates are robust to some extent and less likely to suffer from specification bias. For other socio-economic controls, increasing heterogeneity by village Gini coefficient has a consistently negative effect, which is consistent with studies conducted by Bandopadyay & Eschen (1988), Ostrom (1990), Chambers *et al* (1992) and Stern *et al* (2002); but contradicts some studies (Bardhan, 1999), the result here shows that enlarging village scale has a positive impact, indicating that the benefits of the scale economy of an irrigation system offsets the effect of rising coordination costs.

For natural geographic controls, it’s less costly both to build and maintain collective irrigation facilities such as channels, thus people in plain areas had a significantly greater preference for collective irrigation; in accordance with the work of Araral (2009), disadvantage in water endowment reduced the incentive to build large irrigation systems, and the water scarcity indicator is significantly negative in our regressions as expected. It was somewhat surprising that distance to town from column (1) to (4) has a negative sign, which means that for villagers located near a town or county, the incentive for collective irrigation is greater, contradicting the hypothesis that market opportunity may encourage villagers to opt out for non-agricultural opportunities, thereby discouraging public action. This inconsistency with prevailing findings (Bardhan, 1999) may be partly due to unsatisfactory measurement of market opportunity. To further check this issue, in column (5) we added a dummy variable denoting sub-urban village to baseline setup, and the significantly positive estimates show that non-suburban villages prefer more collective irrigation compared with suburban ones. In column (6), we dropped this less satisfactory measurement and re-estimated column (5), the coefficient for village location remains positive and significant, although a little bit smaller. Jointly, these indicate that the positive estimate in the first four columns for distance to town might also be influenced by some effect other than market opportunity.

The results for the impact of governance and institutional setup at the village level generally meet our expectations, more petitions and conflicts in villages tend to reduce the incentives for collective irrigation, while there is punishment against free riders and rule violators, collective irrigation turns out to be preferable, which is consistent with the broader literature (Gibson et al., 2005; Araral, 2011). Our expectations for household level controls were borne out in the following ways, more family labor significantly increased the incentives for collective irrigation, historical water scarcity had a significant adverse effect on choosing collective irrigation, while the influence of irrigation shortage had a positive effect but was insignificant in column (1)-(6), suggesting that greater dependence on a resource (salience) brings a positive force for cooperation to manage it (Runge, 1986; Ostrom, 2000; Beyene, 2009). Concerning the distance of land to irrigation system, the estimates in column (3) and (4) show that location at a middle distance is associated with the largest incentive to join collective irrigation, and for those land owners at a long distance the incentive to join is also positive and significant but a little bit smaller. It's worth noting that in column (3) the reference point for distance dummy is non-middle distance location including both upper stream and lower stream, while in column (4) short distance or upper stream serves as a reference point. Thus, the coefficient of middle distance increased about 18% from column (3) (0.365) to column (4) (0.432) providing additional indirect evidence consistent with the prevailing observation that middle location has the largest incentive for collective irrigation.

4.2 Robustness check

1. Accounting for measurement errors on the controls side

Table-4 reports the impact of possible measurement error in the labor outflow indicator and the income inequality measure on our baseline regression, with column (1)-(2) using some slightly different measurement for labor outflow, and column (3)-(5) replacing Gini index with the other two income inequality measures. A little bit different, flowout1 was defined as the share of labor outflow in village total population, and flowout3 was the share of labor outflow in total village laborers. Due to the larger denominator used in constructing flowout1 and flowout3, the coefficients rose compared with those we had in Table-3 for flowout2. But on the whole, the coefficients of labor outflow remain negative and significant in column (1)-(2) of Table-4, and estimates for other control variables are mostly comparable or the same compared with their counterparts in Table-3. These comparisons assure us that our findings in baseline regressions are robust to possible measurement error from the labor outflow indicator. Roughly the same story applies to the check for the measurement error of the income inequality measure, although there are differences in the magnitude of estimates, however their sign and significance in determining the preference of collective irrigation is the same. Also, in column (5) we dropped irrigation scarcity variables out of concern that some variables at the village level may be closely correlated with similar controls at the household level. Similar coefficients for labor outflow indicators in column (3) **-** (5) indicates that our results in the baseline regression are less likely to be challenged by measurement errors in other control variables or some other specifications.

[*Insert table-4 roughly here: accounting for measurement error of control variables*]

2. Repeating baseline regressions with traditional measures for collective irrigation

To maintain compatibility and reference with the existing literature, we also used self-reported frequency of participation in maintaining a collective irrigation system as a substitute for our ordered collective irrigation measure to see whether our key hypothesis that labor outflow has a negative effect on participation in collective irrigation still holds. Results for this robustness check are presented in Table-5.

[*Insert table-5 roughly here: duplicating baseline regressions with traditional collective irrigation participating measure*]

In column (1) - (2), we duplicated the baseline setup in Table-3 with and without provincial fixed effects controls using traditional participation in collective irrigation maintenance as the dependent variable. And in column (3), we added a further control denoting who is responsible for irrigation maintenance, 1 for irrigation unit office, 2 for village committee and 3 for water user association. Since the information for this was available only for a very limited subsample, in column (3) the sample of the regression shrunk further to 1015. As done in the previous sub-section, in column (4) we used new combinations of labor outflow measures and income inequality measures to check the robustness for possible measurement error. Consistent with the findings in the baseline regressions, labor outflow from column (1) to (4) uniformly and significantly discourages participation in the collective maintenance of irrigation systems. And other control variables are of the same sign, although in some circumstances of less significance. These findings justify the rationale behind our ordered collective irrigation measure, and also suggest that our former estimates are less likely driven by this new collective irrigation measure.

3. Repeating regressions with a village level sample

Besides the biases related to unobserved heterogeneity, omitted variables and measurement error discussed above, there is still the risk that the subsample we used is not representative of the whole survey. We address this concern by repeating key regressions with a subsample covering more villages, and restrict our empirical analysis of collective action in irrigation at the village level rather than at the household level. Notably, the collective irrigation variable we used for the village level regression is another ordered dummy constructed using evaluation points ranging from 0-2 such that 2 points denoted good maintenance and 0 denoted poor maintenance of irrigation facility, as maintenance outcome is commonly used as a measurement of level of participation, which could then also be viewed as providing a second opportunity to check whether our findings remain robust for different collective action measurements.

In addition to the control variables at the household level, we include similar control variables for the village regressions, and the results are presented in Table 6. From column (1) to (3), we used water endowment at the provincial level to account for provincial level heterogeneity. And in column (4) we control provincial fixed effects. In column (5) we calculated marginal effect based on the setup of column (4). It is noteworthy that the coefficients before the labor outflow indicators are all negative and significant in column (1)-(4), and are comparable in terms of magnitude, which means that our key hypothesis which argues that labor outflow would discourage participation in collective irrigation can also be justified in a sample covering many more villages, and is less likely to be suffering from sample selection bias.

[*Insert table-6 roughly here: repeating key regressions with village level dataset*]

4.3 Using different models and marginal effect

To see the impact of using different estimation models on our results, the baseline regression in Table 3 was further adjusted and performed using na ïve OLS and Ordered Logit Model, and the corresponding results are presented in column (1) and (2) in Table 7, respectively. Compared with their counterparts in column (2) and (4) of Table 3, the estimates from the ordered logit model are almost the same, while the OLS results are a little bit smaller for our key variable—labor outflow, proving that the baseline regressions is better estimated using the ordered probit model rather than linear OLS. For the remaining columns in Table 7, we calculated the marginal effect of each variable based on baseline regression estimates in column (2) and (3) in Table 3, respectively, that is with and without province fixed effects controls. Consistent with the previous regression findings, the impact of labor outflow on preference for collective irrigation is underestimated in setups without controls for province fixed effects. The calculation in column (4) tentatively suggests that a one percent rise in the labor outflow rate will lead to a 5.6% increase in the probability of choosing private irrigation, which is almost of the same magnitude as its village counterpart in the final column of Table 6, and location at a middle distance to irrigation system tends to incentivize collective irrigation the most, increasing probability for collective irrigation by 8.5% compared with upper and lower stream.

[*Insert table-7 roughly here: different estimation model and marginal effect*]

5 Conclusions

Irrigation systems have long been used as an important case in studying collective action in the empirical CRPs literature. China has the largest irrigation sector in the world and more than 10 million sites of irrigation management, all of which provides a great opportunity to test the theory developed to explain collective action in the commons. As the determinants of collective actions in the commons in China have not been sufficiently explored and specified, this paper adopts a large-scale representative survey of China’s rural areas to reveal the roles of different factors, as is highlighted by the literature. One of the contributions of this paper is that we introduced a new ordered collective irrigation measure based on different types of rural irrigation.

Among the four sets of control variable groups, namely socio-economic controls, natural geographic controls, governance and institutional setup, as well as household level controls, we found that socio-economic controls generally plays a more significant role in affecting collective action in the commons. While looking into single variables, close to urban city or town, severe inequality, location in hilly areas, historical water scarcity, fewer household laborers and poor water endowment tend to reduce incentives for participating in collective irrigation. The above findings are consistent with the existing literature and confirm the robustness of the theory of collective action in the commons.

Particularly, our results demonstrate that labor outflow exerts an adverse effect on participation in collective irrigation, which is a contribution to the literature on collective action in the commons. The possible reason is that large scale and frequent labor outflows reduce the social capital in villages and communities, thus raising the costs of gathering and coordinating public affairs such as irrigation meetings in rural villages, which is vital for collective irrigation; and weakening the constraints on local social norms. It is consistent with the arguments in the literature that declining social capital in formalized groups reduces people’s confidence and incentives to invest in collective activities (Runge, 1986; Pretty, 2003; Li et al., 2011).

Since the above results remain robust for various equation specifications, taking into account measurement error at both the dependent and control variables sides, this paper contributes to the understanding of the factors influencing collective action in the commons, and thus adds some new insights to the existing CPRs literature. Meanwhile, there are also some limitations of this study. The sample size of the data from China can be expanded to test the robustness of the findings further. Also more types of commons in China remain to be studied to enrich the theory of collective action in this field. Although there is a growing consensus regarding the factors that influence collective action in the commons, the complex interactions among the underlying factors remain to be studied in order to deepen the understanding of complex institutional arrangements in diverse socio-ecological settings.

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Table 1. Region composition of subsample in use

province	obs	percentage	cumu.
anhui	41	2.39	2.39
chongqing	133	7.75	10.14
fujian	59	3.44	13.58
gansu	5	0.29	13.87
guangxi	315	18.36	32.23
guizhou	73	4.25	36.48
hebei	29	1.69	38.17
henan	94	5.48	43.65
hubei	100	5.83	49.48
hunan	153	8.92	58.39
jiangsu	109	6.35	64.74
jiangxi	103	6	70.75
neimenggu	54	3.15	73.89
ningxia	92	5.36	79.25
shandong	48	2.8	82.05
sichuan	87	5.07	87.12
yunnan	206	12	99.13
zhejiang	15	0.87	100
total	1716		

Source: CIRS Hundreds of Villages Survey, 2012.

Table 2. Variables definition and expected impact on collective irrigation

Dep.	Definition	Expected sign
odca	ordered collective action (household)	\
cltmtn	collective maintenance (household)	\
odcm	ordered collective maintenance (village level)	\
Controls		
flowout2	Flow out house/total house	-
gini	Gini index: Village level family income inequality measure	-
total house	Village scale: Total house	pending
Natural geographic controls:		
plain	plain=1 and 0 otherwise	+
distotown	distance to nearest high school in klm	-
igtscarcity	irrigation scarcity in last three years ranging from 5 to1, 5 is hardest	-
location	suburban village=1 and 0 otherwise	-
Governance and institution setup		
vpafailure	village governance failure: 1 for petitions and conflicts, 0 otherwise	-
vpunish	punishment: 1 for punishment against free riders, 0 otherwise	+
Household Level Controls:		
hlabor	Household labor: percentage of labors out of total household	+
igtshortage	irrigation shortage history: 1=never; 5=frequent	-
imptshortage	Impact of insufficient irrigation: 1=bad impact,0=no impact	+
mdistance	middle distance to public irrigation	+
lgdistance	Long distance to public irrigation	+/-
age	Age	uncertain
edu	Education	uncertain

Table 3. The determinant of participation in collective irrigation

	dep.=ordered collective irrigation (odca)					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
flowout2	-0.161***	-0.157***	-0.243***	-0.235***	-0.246***	-0.211***
	(0.042)	(0.042)	(0.050)	(0.050)	(0.051)	(0.050)
Other social economics controls:						
gini	-1.619***	-1.551***	-1.489***	-1.445***	-1.421***	-1.798***
	(0.238)	(0.239)	(0.286)	(0.287)	(0.288)	(0.268)
log(total house)	0.103***	0.102***	0.124***	0.120***	0.131***	0.159***
	(0.030)	(0.031)	(0.037)	(0.037)	(0.037)	(0.034)
Natural geographic controls:						
plain	0.340***	0.356***	0.577***	0.571***	0.632***	0.643***
	(0.073)	(0.073)	(0.102)	(0.102)	(0.105)	(0.102)
Log(distotown)	-0.090***	-0.092***	-0.081**	-0.087***	-0.132***	
	(0.027)	(0.028)	(0.033)	(0.034)	(0.035)	
igtscarcity	-0.094***	-0.096***	-0.087**	-0.088**	-0.101***	-0.105***
	(0.032)	(0.032)	(0.037)	(0.037)	(0.037)	(0.037)
location					0.481***	0.292***
					(0.110)	(0.097)
Governance and institution setup:						
vpafailure	-0.223***	-0.218***	-0.115*	-0.113*	-0.113*	-0.108*
	(0.057)	(0.057)	(0.063)	(0.063)	(0.064)	(0.062)
vpunish	0.225***	0.216***	0.181**	0.173**	0.187**	0.203***
	(0.068)	(0.068)	(0.080)	(0.080)	(0.081)	(0.077)
Household Level Controls:						
hlabor	0.457***	0.462***	0.236**	0.241**	0.250**	0.223**
	(0.109)	(0.109)	(0.115)	(0.115)	(0.115)	(0.113)
igtshortage	-0.186***	-0.190***	-0.138***	-0.141***	-0.136***	-0.130***
	(0.025)	(0.025)	(0.027)	(0.027)	(0.027)	(0.027)
imptshortage	0.091	0.096	0.101	0.103	0.099	0.076
	(0.069)	(0.069)	(0.076)	(0.076)	(0.076)	(0.074)
mdistancel	0.442***	0.535***	0.365***	0.432***	0.417***	0.457***
	(0.061)	(0.064)	(0.064)	(0.067)	(0.067)	(0.066)
lgdistance		0.404***		0.261***	0.267***	0.267***
		(0.082)		(0.085)	(0.085)	(0.083)
age	-0.001	-0.000	-0.007***	-0.007***	-0.007***	-0.007***
	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)
edu	-0.011	-0.010	-0.020**	-0.019**	-0.017*	-0.019**
	(0.009)	(0.009)	(0.010)	(0.010)	(0.010)	(0.009)
Province Fix	No	No	Yes	Yes	Yes	Yes
Observations	1,716	1,716	1,716	1,716	1,716	1,780
chi2	339.7	364.3	633.8	643.3	662.5	643.8

r2_p	0.0752	0.0807	0.140	0.142	0.147	0.137

Standard errors in parentheses

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

Table 4. accounting for measurement error of control variables

	dep.=ordered collective irrigation (odca)				
VARIABLES	(1)	(2)	(3)	(4)	(5)
flowout1	-0.468*				
	(0.272)				
flowout3		-0.329***			
		(0.090)			
flowout2			-0.239***	-0.267***	-0.244***
			(0.050)	(0.049)	(0.047)
mld			-0.854***		
			(0.150)		
lincmsd				-0.210***	
				(0.044)	
gini	-1.549***	-1.697***			-1.336***
	(0.276)	(0.281)			(0.279)
		(other controls omitted)			
Province Fix	Yes	Yes	Yes	Yes	Yes
Observations	1,769	1,735	1,716	1,716	1,770
chi2	586.4	622.6	639.0	629.1	647.8
r2_p	0.126	0.137	0.142	0.139	0.139

Standard errors in parentheses

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

Note: (1) mld= mean log deviation family income; (2) lincmsd= the standard deviation of logs family income.

Table 5. Duplicating baseline regressions with traditional measure for collective irrigation

	dep.=participation in collective maintenance (cltmtn)			
VARIABLES	(1)	(2)	(3)	(4)
flowout2	-0.246***	-0.176***	-0.169**	
	(0.060)	(0.062)	(0.066)	
flowout1				-0.684***
				(0.233)
lincmsd				-0.198***
				(0.044)
gini	-0.681***	-0.398	-1.821***	
	(0.231)	(0.284)	(0.395)	
log(total house)	-0.040	-0.055	-0.181***	-0.080**
	(0.027)	(0.036)	(0.051)	(0.034)
plain	-0.012	0.035	-0.251*	0.018
	(0.067)	(0.090)	(0.132)	(0.091)
log(distotown)	-0.174***	-0.276***	-0.224***	-0.324***
	(0.025)	(0.032)	(0.041)	(0.030)
igtscarcity	-0.601***	-0.653***	-0.588***	-0.748***
	(0.033)	(0.038)	(0.051)	(0.038)
vpafailure	-0.182***	-0.181***	-0.201**	-0.120**
	(0.054)	(0.061)	(0.088)	(0.060)
vpunish	-0.057	0.060	-0.028	0.076
	(0.063)	(0.072)	(0.097)	(0.069)
hlabor	0.386***	0.610***	0.345**	0.617***
	(0.101)	(0.107)	(0.137)	(0.105)
igtshortage	-0.018	-0.048*	0.053	-0.034
	(0.024)	(0.025)	(0.034)	(0.025)
imptshortage	-0.153**	-0.141**	-0.158*	-0.133*
	(0.064)	(0.071)	(0.092)	(0.071)
mdistance	-0.048	0.096	0.032	0.084
	(0.057)	(0.060)	(0.075)	(0.060)
age	-0.004	0.001	0.011***	0.000
	(0.002)	(0.002)	(0.003)	(0.002)
edu	-0.052***	-0.024***	-0.003	-0.023***
	(0.008)	(0.009)	(0.012)	(0.009)
canalmatain			-0.279***	
			(0.050)	
Province Fix	No	Yes	Yes	Yes
Observations	1,712	1,712	1,119	1,770
chi2	604.0	1161	1015	1273
r2_p	0.117	0.224	0.295	0.239

Standard errors in parentheses

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

Note: (1) canalmatain: who is responsible for irrigation maintenance? (1=official irrigation unit office; 2=village; 3=water user association; 4=contracted individual; 5=nobody).

Table 6. Repeating key regressions with village level data

	dep.=ordered collective irrigation maintenance(odcm)				
VARIABLES	(1)	(2)	(3)	(4)	margins
flowout3	-0.228**	-0.218**	-0.264**	-0.261*	0.055*
	(0.104)	(0.100)	(0.117)	(0.139)	(0.028)
Other social economics controls:					
log(total house)	-0.123	-0.157	-0.187	-0.253*	0.053*
	(0.103)	(0.106)	(0.118)	(0.144)	(0.030)
economypower	-0.395**	-0.415**	-0.388**	-0.397*	0.083*
	(0.174)	(0.177)	(0.187)	(0.221)	(0.046)
Natural geographic controls:					
plain	0.154	0.352	0.198	0.143	-0.030
	(0.244)	(0.277)	(0.319)	(0.368)	(0.077)
location	-1.231***	-1.277***	-1.368***	-1.183***	0.249***
	(0.388)	(0.390)	(0.398)	(0.431)	(0.091)
log(distotown)	0.275	0.332	0.390	0.189	-0.040
	(0.299)	(0.302)	(0.313)	(0.371)	(0.078)
Governance and institution setup:					
vpacntrl	-0.353	-0.347	-0.335	-0.051	0.011
	(0.244)	(0.244)	(0.254)	(0.306)	(0.064)
vpunish	-0.506**	-0.520**	-0.578**	-0.483*	0.102*
	(0.213)	(0.214)	(0.226)	(0.256)	(0.053)
Provincial water endowment controls:					
lwaterendow		0.165	0.352*	14.594	-3.068
		(0.107)	(0.180)	(9.527)	(1.977)
lriverendow			-0.606	-20.175*	4.241**
			(0.552)	(10.295)	(2.095)
Province Fix	No	No	No	Yes	Yes
Observations	148	148	140	140	140
chi2	37.92	40.30	43.98	79.54	.
r2_p	0.123	0.131	0.152	0.275	.

Standard errors in parentheses

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

Table 7. Using different model and marginal effect

	dep.=ordered collective irrigation (odca)			
	(1)	(2)	(3)	(4)
VARIABLES	irripartlevl	ologit	margins	margins
flowout2	-0.120***	-0.266***	0.041***	0.056***
	(0.024)	(0.074)	(0.011)	(0.011)
gini	-1.283***	-2.378***	0.368***	0.346***
	(0.220)	(0.393)	(0.061)	(0.067)
plain	0.382***	0.562***	-0.087***	-0.134***
	(0.065)	(0.121)	(0.019)	(0.024)
ldistotown	-0.090***	-0.174***	0.027***	0.019**
	(0.028)	(0.048)	(0.007)	(0.008)
log(totalhouse)	0.079***	0.180***	-0.028***	-0.029***
	(0.027)	(0.050)	(0.008)	(0.008)
igtscarcity	-0.084***	-0.170***	0.026***	0.020**
	(0.031)	(0.053)	(0.008)	(0.009)
vpafailure	-0.218***	-0.364***	0.056***	0.027*
	(0.055)	(0.095)	(0.015)	(0.015)
vpunish	0.172***	0.389***	-0.060***	-0.042**
	(0.064)	(0.115)	(0.018)	(0.019)
hlabor	0.421***	0.788***	-0.122***	-0.055**
	(0.104)	(0.182)	(0.028)	(0.027)
igtshortage	-0.173***	-0.310***	0.048***	0.032***
	(0.023)	(0.042)	(0.006)	(0.006)
imptshortage	0.080	0.160	-0.025	-0.023
	(0.067)	(0.115)	(0.018)	(0.018)
mdistance	0.510***	0.898***	-0.139***	-0.085***
	(0.060)	(0.107)	(0.016)	(0.015)
age	0.000	-0.001	0.000	0.002***
	(0.002)	(0.004)	(0.001)	(0.001)
edu	-0.008	-0.022	0.003	0.005**
	(0.008)	(0.014)	(0.002)	(0.002)
lgdistance	0.364***	0.649***	-0.100***	
	(0.077)	(0.136)	(0.021)	
Province Fix	No	Yes	No	Yes
Observations	1,716	1,716	1,716	1,716
R-squared	0.182	0.0786		
chi2	.	354.7		

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1