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# Can Social Capital Boost Irrigation Capital: Empirical Evidence from North China

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Can Social Capital Boost Irrigation Capital: Empirical Evidence from North China

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**Abstract**

Using data from China Water Institution and Management (CWIM) survey, the study first constructs measures of all three most studied dimensions of social capital: trust, networks, and norms. The study then examines if social capital has any predictive powers of individual farmers' contribution decisions as well as farmers' contributions aggregated at the village level. Farmers' choices between different forms of contributions (labor versus cash) are also analyzed. Our results suggest that all three dimensions of social capital explain farmers' contribution decisions. Governance quality of local irrigation systems and the norm of cooperation have strong predictive powers of farmers' decisions to contribute. Strongly agree other villagers can be trusted is positively correlated with farmers' decisions to contribute cash instead of labor and the share of total cash investment at village level contributed by farmers.

Keywords: Social capital; Network; Trust; Norms; Governance; Irrigation investment; Village level irrigation system; North China

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**Dedication**

*To my fabulous grandfather and grandmother*

*Yaobang Nian*

and

*Ruoqi Dai*

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## 1 Introduction

Increasing irrigation investment is a crucial step for countries that rely on irrigation but are facing water shortage problems. Recent surveys of world leaders of business and government have consistently ranked water crisis among the top three global risks in terms of its impact (World Economic Forum 2017). Since agricultural irrigation accounts for 70% of all water withdrawals globally (World Bank 2017), actions within the agricultural sector are necessary to alleviate water stress. Improving on-farm irrigation efficiency is the most widely proposed solution.[1] However, irrigation systems, especially at the tertiary levels where water is delivered to farmers' fields, have underperformed in many developing countries due to inadequate investment in maintaining or rehabilitating irrigation infrastructure (Davis and Hirji 2003). Since more efficient use of water often requires new irrigation investments, such as lining canals or installing water measurement equipment along the canals, and public spending on irrigation has declined in the early 1990s (e.g., Meizen-Dick and Rosegrant 2005), irrigation investments in maintaining current infrastructure and building new infrastructure are urgently needed to improve agricultural water use efficiency in developing countries (FAO 2016).

The role of farmers as investors of irrigation systems has become more important, partly due to the reforms that took place in irrigation sectors in the past few decades. Since the 1980s, the responsibility of managing local irrigation systems have been transferred from upper-level governments to farmer-run organizations such as Water User Associations (WUAs) or irrigator

[1] Recent studies have questioned whether more efficient irrigation would result in reduced consumptive water use (e.g., Pfeiffer and Lin 2014). Unintended consequences such as the expansion of irrigated acreage, increased evapotranspiration of existing crops and shifts to more water intensive crops could all result in higher overall consumptive water use. However, Huang, Wang, and Li (2017) show that at least in the context of China where farmers are limited in their capacity to expand farm size and do not seem to adjust their crop mixes, the use of water saving technologies does have the potential to reduce water use, given the currently low levels of on-farm irrigation efficiency.

associations through Irrigation Management Transfer (IMT), or shared between upper-level governments and local users through Participatory Irrigation Management (PIM) intended to increase farmers' participation in irrigation management (FAO 2007; Senanayake, Mukherji, and Giordano 2015). The rationale of PIM and IMT programs is that local agents have better local knowledge and can do a better job matching the provision of irrigation services with local demands. Other changes have also pushed up the importance of farmers' contributions to irrigation investments. For example, in rural China, a series of fiscal reforms that started in 1994 have stripped village leaders of the financial resources they used to have for irrigation investment, which left an investment void that the central government hoped contributions from farmers would fill (Boyle, Huang, and Wang 2014).

Three branches of literature can offer insights on which factors may boost farmers' investment in irrigation systems. The first branch of literature examines which factors affect the successes of collective action in managing irrigation systems as local commons (e.g., Meizen-Dick, Raju, and Gulati 2002; Fujiie, Hayami, and Kikuchi 2005; Araral 2009; Nagrah, Chaudhry, and Giordano 2016). As a typical type of common property resource (CPRs) or local commons (Ostrom 1990), many aspects of irrigation system management, including operation and maintenance (O&M) and investments, often require the successful coordination of collective action among users. Previous studies have identified a large set of factors that may influence the likelihood of collective action (e.g., Meinzen-Dick, Raju, and Gulati 2002; Araral 2009). Meinzen-Dick (2007) groups these factors into social and economic settings, characteristics of irrigation systems and water supply, characteristics of governance systems, and characteristics of irrigation system users. The second branch of literature focuses on public goods provision in general (e.g., Leonard, Croson, and de Oliveira 2010; Tu et al. 2011; Li and Wang 2013; Cai, Zhu, and Chen

2016) and the third branch of literature focuses on conservation and management of community natural resources (e.g., Pretty and Ward 2001; Pretty 2003; Cramb 2005; Nepal, Bohara, and Berrens 2007; Bodin and Crona 2008; Bouma, Bulte, and van Soest 2008; Ishihara and Pascual 2009; Beekman and Bulte 2012; Willy and Holm-Müller 2013). Studies in the second and third branches of literature share a common interest on a particular factor, social capital. Only a few studies in the first branch of literature studying collective action in managing irrigation systems have touched on the concept of social capital (e.g., Meinzen-Dick, Raju, and Gulati 2002).

Although there is no consensus among scholars on what constitutes social capital, most studies cite the definition put forward by Putnam, Leonardi, and Nanetti (1993): “Social capital here refers to features of social organization, such as trust, norms, and networks, which can improve the efficiency of society by facilitating coordinated action.” In some sense, programs like IMT and PIM can be seen as attempts to develop trust, change norms and build networks of resource users (Pretty 2003). Ostrom (1990) summarizes eight design principles (or essential elements) that could have accounted for the successes of the long-enduring, self-organized, and self-governed CRPs she studied. Among these principles are participation of those affected in modifying the operational rules, mechanisms of monitoring, sanctions, and conflict resolution. Elements of social capital could be conducive to successful collective action by reducing the transaction costs of acting collectively, such as the costs of monitoring and enforcement to prevent or punish free-riding behavior, and encouraging participation/cooperation among community members (Putnam, Leonardi, and Nanetti 1993; Jones, Malesios, and Botetzagias 2009). In communities with high levels of trust, an individual can trust other members to reciprocate his/her voluntary contributions instead of having to invest time or money to monitor others (Putnam, Leonardi, and Nanetti 1993; Pretty 2003; Bouma, Bulte, and van Soest 2008). By reducing the need for monitoring, trust could lower transaction costs and increase the likelihood of cooperation. The most important way networks can facilitate collective action is the transmission of information across individuals about the trustworthiness of others (Putnam, Leonardi, and Nanetti 1993; Ostrom and Ahn 2008). Past interactions occurred in networks generate such reputational information. Networks also lower the cost of gathering such information by allowing it to become transitive, that is, the trust in a particular individual can be derived from other network members' trust in him/her (Putnam, Leonardi, and Nanetti 1993). Networks can also facilitate cooperation in other ways. Communication among members of the same network can increase awareness of community needs (Leonard, Croson, and de Oliveira 2010). Private benefits an individual can gain from involvement in social networks (e.g., better employment outcomes) increase the costs of free-riding through channels such as social ostracism (Putnam, Leonardi, and Nanetti 1993). Norms, especially those that define rules and expected behavior of resource uses have more direct links to collective action. Norms of reciprocity signal that most community members are trustworthy (Ostrom and Ahn 2008). Norms of cooperation encourage participation in collective activities (Coleman 1990; Beekman and Bulte 2012). Strong norms of sanction can deter free-riding behavior (Ostrom 1990).

Previous studies have provided empirical evidence on the positive influence of all three dimensions of social capital (e.g., Nepal, Bohara, and Berrens 2007; Bodin and Crona 2008; Bouma, Bulte, and van Soest 2008; Beekman and Bulte 2012; Willy and Holm-Müller 2013). The findings of no effects are also common. Furthermore, studies have pointed out that a high level of social capital does not necessarily provide favorable conditions for collective action. For example, strong networks among the dominant group of a community may exclude members of marginalized groups from participating in collective action (Ishihara and Pascual 2009). In India and Nepal, rules of community forestry groups and norms of the societies have excluded women from meaningful participation (Agrawal 2001). In short, the links between social capital and collective action are empirical in nature and should be done in a context-specific fashion.

Using the case of surface water irrigation systems in rural China, this study aims to examine if social capital has any predictive powers of farmers' decisions to contribute to irrigation investment. Individual farmers' contribution decisions as well as farmers' contribution aggregated at the village level are studied. In addition, farmers' choices between different forms of contributions (labor versus cash) are also analyzed. The study contributes to the literature in several ways. First, this study adds to the literature on collective action in irrigation management by studying farmers' investment behavior. With a few exceptions (e.g., Boyle, Huang, and Wang 2014), most previous research focuses on farmers' contributions toward O&M of irrigation systems (e.g., Meizen-Dick, Raju, and Gulati 2002; Fujiie, Hayami, and Kikuchi 2005; Araral 2009; Nagrah, Chaudhry, and Giordano 2016). In many developing countries, farmers' involvement in O&M of irrigation systems is common. Irrigation investments, on the other hand, may be customarily considered as the responsibility of governments. Thus, how to boost farmers' contributions to irrigation investment is a crucial policy question and a more challenging task. Findings from this study can provide useful policy advice on the topic.

Second, this study also contributes to the literature that examines the relationship between social capital and public good provisions and management of community natural resources management. Even though social capital is a multi-faceted concept, most studies only include a sub-set of its components in their analysis. Most often only social networks (e.g., Cramb 2005; Nepal, Bohara, and Berrens 2007; Cai, Zhu, and Chen 2016) or trust (e.g., Bouma, Bulte, and van Soest 2008; Tu et al. 2011) is used to measure social capital. Such an approach may not accurately capture the influence of social capital. For example, in the study of a rural fishing village in Kenya, Bodin and Crona (2008) find that the community has a relatively high level of social capital if it were only assessed using social network measures. However, the community also has the strong norm of not reporting rule-breaking behaviors, which is not in favor of sustainable resource management. Furthermore, the reluctance to report rule-breaking behaviors is partly due to the strength of social networks in the community. Then analysis that only includes social networks and omits social norms may generate biased estimates of the effect of social networks. Our analysis improves the operationalization of the concept of social capital by including all three dimensions: networks, trust, and norms. In addition, we use measures of social capital that are more relevant for the activity under study, i.e., village level irrigation system management. For example, in addition to the number of friends and relatives a farmer has and the density of social networks of non-water-related associations, a measure of water-related networks is also included. Instead of general measures of social norms such as civic participation, our study measures norms that are important in irrigation management such as those related to farmers' participation in O&M activities, conflict resolution and monitoring.

Third, a unique feature of the study is that we distinguish different forms of contributions farmers can make. In particular, we study famers' choices between cash and labor contributions. It is common in many developing countries, such as China and the Philippines, for farmers to contribute money for irrigation fees and voluntary labor for O&M (e.g., Araral 2009; Boyle, Huang, and Wang 2014). In Indonesia, households pay membership fees to various associations either in cash or in kind including labor contribution (Grootaert 1999). Cash contribution differs from labor contribution in several aspects. When a farmer contributes labor, he/she works with other farmers on irrigation projects together. Farmers' labor contributions are easily observable to each other through their physical presence in the teamwork. Cash contribution, in contrast, is less observable unless such information is made public. In addition, cash contribution runs the risk of embezzlement and so factors such as trust in the agents in charge of irrigation management may matter more. The trends in the economic development of many developing countries such as better access to off-employment opportunities may tip farmers' preferences toward cash contribution by increasing their opportunity costs of time. Araral (2009) is among the few studies that investigate both monetary and labor free riding in collective action in irrigation O&M activities. However, monetary and labor free riding are analyzed separately. Our study analyzes the joint choice of whether to contribute and what to contribute (cash or labor).

The rest of this paper is organized as follows. The next section provides background information on the funding structure of village level irrigation systems in rural China. Section 3 describes data and measures of social capital used in the empirical analysis. Section 4 presents the empirical strategies. Section 5 reports estimation results and discusses findings, while Section 6 presents conclusions and limitations of the study.

## 2 Village-level surface water irrigation systems in China

Surface water irrigation systems in China consist of larger irrigation systems and village-level irrigation systems. The former includes main canals that divert water from major rivers and branch and lateral canals that divert water from main canals into villages. The Ministry of Water Resources of China, water resource bureaus (WRBs) at various levels (provinces, prefectures, counties, and townships) and irrigation districts (IDs) are responsible for the construction, O&M and other activities such as upgrading of the larger irrigation systems. Following Boyle, Huang, and Wang (2014), these administrative units are referred to as upper-level governments in the study.

Our focus is village-level irrigation systems consisting of tertiary canals within villages that deliver water directly into farmers' fields. Before the 2000s, a top-down approach was used in the funding of village-level irrigation projects. In the political environment where easing farmers' burden takes the top priority, irrigation fees paid by farmers are still at levels far below the cost of supplying water and thus are not sufficient for funding irrigation projects (Lohmar et al. 2003; Boyle, Huang, and Wang 2014). Instead, funding comes from three major groups of stakeholders: upper-level governments (through fiscal transfers), village leaders, and farmers (Bolye, Huang, and Wang 2014). Village leaders could utilize coffers of village revenues from agricultural tax revenues, various fees and surcharges levied on farmers, and other sources such as village enterprise revenues. Village leaders also had the authority to mobilize mandatory labor contributions from farmers (corvée labor) for village level irrigation projects. Farmers' contributions, either in the form of fees and surcharges levied on them or in the form of corvée labor, were largely mandatory in nature.

A series of reforms in China has changed the funding structure of village level irrigation projects. The fiscal recentralization started in 1994 significantly reduced the share of tax revenues accrued to villages (Wong 1997). The tax-for-fee reform in the early 2000s stripped village leaders of the authority to levy fees and surcharges on farmers (Oi et al. 2012). By the end of 2006, agricultural tax was completely eliminated (Oi et al. 2012). These fiscal reforms have significantly shrunk the size of the fiscal resources village leaders previously had and led to a sharp decline in irrigation investment nationwide (Liu 2004). In response, fiscal transfers from upper-level governments were increased to fund public goods in the village (Boyle, Huang, and Wang 2014). In addition, the central government started to promote a new funding mechanism of "run by local people with assistance from the state" (i.e., partnership between farmers and upper level governments) and stipulated that funds should be allocated on a “project-by-project assessment” where farmers voluntarily contribute to local public goods (CCCPC and General Office of the State Council of China 2005; MFC and MWR 2005). In the 2000s, many provincial governments also started to limit or remove the authority village leaders had to mobilize corvée labor (Oi et al. 2012). With these reforms, the role of village leaders in local public goods provisions is significantly weakened. More importantly, farmers make contributions to irrigation investment on a voluntary basis.

Under the new funding structure, the importance of addressing the provision problem associated with CPRs or local commons (Ostrom 1990) is highlighted. Members of a village cannot be excluded from access to its irrigation systems without costly enforcement. The difficulty of exclusion creates incentives for farmers to free ride on O&M efforts as well as any investments to improve the irrigation systems. The temptation to avoid contributing to the provisions of irrigation systems, the provision problem, is exacerbated by the changes brought on by the reforms, in particular, the now voluntary nature of famers’ contributions. In fact, studies have documented low rates of participation in irrigation matters (Zhang and He 2008) and low levels of contributions by farmers post reforms (Boyle, Huang, and Wang 2014). How to boost farmers’ voluntary contributions necessities the study of potential factors that could lead to the successful coordination of collective action in the specific context of rural China.

## 3 Data and variable construction

Data used in the study come from the China Water Institution and Management (CWIM) survey. The sample areas covered three provinces in two important river basins in North China: Ningxia province in the upper reaches of Yellow River Basin (YRB), Henan province in the middle reaches of YRB and Hebei province covering most of the Hai River Basin and surrounding Beijing.

Within each province, a stratified random sampling strategy was used to select villages with varying degrees of water scarcity. In Ningxia province, five counties were randomly selected from two irrigation districts (ID). One ID is near where the Yellow River enters the province and the other is in the central area of the province. In Henan province, counties were randomly selected from IDs at varying distances to the Yellow River, which is highly correlated with the degree of water scarcity. Groundwater is the major source of irrigation water in Hebei province. One county was randomly selected from each of the three zones with varying degree of groundwater abundance: the coastal belt (scarcest), the inland belt next to the mountain area (most abundant), and the zone between the coastal belt and the mountain area. After the sample counties were selected, 88 villages were randomly selected from the sample counties. Since this study focuses on surface water irrigation projects investment, only villages that use surface water for irrigation are included in the analysis. The final sample used in the empirical analysis includes 189 households from 52 sample villages (32 in Ningxia, 13 in Henan, and 7 in Hebei).

In the CWIM survey, enumerators interviewed four types of respondents: village leaders, four randomly selected households per village, canal managers, and well operators. Separate survey questionnaires were administered to each respondent and answers were not disclosed to other respondents. Information collected in the interviews with village leaders, farmers, and canal managers is used to construct variables used in the empirical analysis. Farmers were asked if they contributed to investment in building surface water infrastructure and the form of the contributions they made (cash, unpaid labor, or both). Some examples of investment include building new canals, lining canals, purchase and installation of water measurement equipment, purchase of other equipment such as pumps and engines, drainage equipment and gates. Village leaders were also asked to report out of the total amount invested, how much come from farmers. Answers to these questions are used to construct the dependent variables in the empirical analysis. Table 1 reports descriptions and summary statistics of variables.

### 3.1 Construction of social capital measures

Information collected in the CWIM survey allows us to construct variables to measure the three most studied dimensions of social capital: networks, trust, and norms. Partly because networks are the most tangible part of social capital, they have been included in many studies on social capital. Types of social networks matter in that the flow and the quality of information exchanged are often different among different types of social networks (Granovetter 2005). A large part of the social network in rural China is based on kinship (Tu et al. 2011; Cai, Zhu, and Chen 2016). Although such network with direct and frequent contacts can help farmers reach consensus and achieve behavioral consistency partly by repeatedly spreading homogeneous information (Granovetter 1973), in-network members may converge to a level of public good provision that is sub-optimal (Cai, Zhu, and Chen 2016). In addition, it may exclude other members of the community that are also relevant stakeholders in providing local public goods (Tu et al. 2011). In contrast, broad social networks that measure the connections among larger groups of people and serve to spread new and heterogeneous information may be more relevant for public good provisions. Furthermore, social network that provides more relevant information for the activity under study is more likely to have an impact. Nepal, Bohara, and Berrens (2007) show empirically social networks such as forest user groups provide critical information about forest conservation and have the largest and positive impact on households' tree-planting behavior in rural Nepal, while other social networks that are remotely or not related to forest conservation have smaller or no impacts.

In our analysis, three measures are used to characterize social networks in sample areas. The first two measure close and broad social network. The density of close social network is measured by the number of relatives or friends will provide support if a farmer is having financial difficulties. Broad social networks are often built through involvement in social groups in the communities. This study looks at five types of non-water-related associations in villages: farmers' association, women's associations, religious groups, culture groups (e.g., dance teams) and other groups. Instead of just totaling up the number of such associations to indicate their presence or absence, following Nepal, Bohara, and Berrens (2007), we use information on three components of an association to reflect the strength and density of the network: number of years in operation (stability), number of members (coverage), and frequency of activities (effectiveness). Define $x_{nj}$, $min(x_{nj})$, and $max(x_{nj})$ as the actual, minimum possible, and maximum possible values of the $n^{th}$ component of an association ($n$ = 1, 2, 3) in village $j$. Then the index for the $m^{th}$ non-water association, $NA_{mj}$, is:

$$NA_{mj} = \sum_1^n \frac{x_{nj} - min(x_{nj})}{max(x_{nj}) - min(x_{nj})} \quad (1)$$

Then adding up the indices for all non-water associations gives the adjusted number of non-water-related associations, which is used to measure the density of broad social networks in the village.

The third measure of network is embedded as an element in the governance structure of local irrigation systems. In rural China, local irrigation systems could be governed in three different ways, often distinguished by the type of agents in charge: WUAs, canal contractors, or village leaders (Huang et al. 2009). WUAs are considered as the type of social network most relevant for irrigation investment. Some villages have more than one type of governance. For example, within the same village, some canals are contracted out to individual farmers who manage the canals for a profit, while others are managed by WUAs. In other villages, WUAs may jointly manage a canal with village leaders. Boyle, Huang, and Wang (2014) use a dummy variable to indicate the existence of WUAs or contracting in their analysis of the levels and shares of irrigation investment from village collective, upper level government or farmers. However, the difference between different governance systems may only exist in names. For example, a large overlap between the leadership of WUA and village leaders is often observed in rural China (Huang et al. 2009). Therefore, it is important to use measures that reflect the quality of governance. To construct such an index, we follow the approached used to construct the composite index for broad social network. Instead of just indicating the presence of one or more types of governance systems, we adjust the number using three informational components. The first component is years in operation. The sub-index is scaled by the maximum possible length of time a governance system could have been in place so that it is bounded between 0 and 1. For example, the first WUA was established in south China in 1995 with the assistance of the World Bank (2003). So at most a WUA could be 17 years old. The sub-index is 1 if village leaders are in charge since this is the traditional way irrigation systems are managed in rural China. The second component, information transparency, is measured by out of three types of information (total amount of water fees collected, total amount of water use, and total irrigated areas), how much information is made public to all farmers. The sub-index for information transparency can take on the values of 0, 1/3, 2/3 or 1. The third component is a dummy variable indicating managers are elected by farmers (in contrast to be appointed by village leaders or by township or county governments). The final index for governance quality is the sum of all the sub-indices for all types of governance systems in the village.

The second dimension of social capital, trust, is also analyzed in many studies. One of the most commonly used measure of trust is constructed using answers to the trust question from the

World Value Survey: “Generally speaking, would you say that most people can be trusted or that you need to be very careful in dealing with people?” Results are mixed on whether such attitudinal survey-based measures of trust reflect actual trusting behavior. Glaeser et al. (2000) find that trust measured this way is not a good predicator of trusting behavior in economic exchange revealed in trust games. Rather it measures trustworthiness. Anderson, Mellor and Milyo (2004), however, find that agreement with the statement that “most people can be trusted” does have predictive powers of contributions in a public-goods experiment. Leonard, Croson, and de Oliveira (2010) suggest that when examining the relationship between trust and voluntary contributions to local charitable organizations, it makes more sense to measure an individual’s trust in other members of the same community, who are the users and potential providers of local services. Given these insights from the literature, attitudinal survey-based measures of trust are used in this study but the trust questions are only asked about relevant stakeholders of the local irrigation systems, instead of the general population. In rural China, two groups of agents are relevant in the provision of local irrigation services: village leaders who often make investment decisions and farmers whose role as contributors have become more important. Two questions were used in the 2011 round of the CWIM survey: “Do you agree that most villagers can be trusted?” and “Do you agree that village leaders can be trusted?” Most farmers (77%) answered “Agreed” to the statement that most villagers can be trust (Table 1). A much smaller share of farmers (19%) answered “Strongly agree” to the same statement. Similarly, most farmers (71%) answered “Agree” but few farmers (13%) answered “Strongly agree” to the statement that village leaders can be trusted. The high trust level observed in our data is consistent with findings in other studies in China (e.g., Tu et al. 2011) and also observed in other developing countries such as Burundi (Beekman and Bulte 2012).

Out of all three dimensions of social capita, norms are the least clearly defined and are often omitted in empirical studies of social capital. In the literature on the management of CPRs, norms are usually defined as the aspects of social capital that can enhance the ability of local communities to self-regulate. Empirically, they are characterized as mechanisms for conflict resolution and monitoring (Ostrom1990; Bodin and Crona 2008). In our analysis, the norm of conflict resolution is measured by a dummy variable that equals one if village leaders resolve water allocation conflicts and zero if farmers resolve conflicts by themselves. Another dummy variable is used for the norm related to monitoring, which equals one a farmer said he/she would report rule-breaking in water use behavior (e.g., not taking turns in water allocation or water theft) if he/she observed it. In addition, two dummy variables are used to measure norms related to cooperation in the village: villagers mitigate extreme weather shocks on their own and villagers cooperate to mitigate extreme weather shocks.[2]

Several studies (e.g., Jones, Malesios, and Botetzagias 2009; Beekman and Bulte 2012) also include political participation (voted or not) as a proxy for social norms. Instead of measuring participation in general political matters, we measure farmers' participation in activities more relevant to activities under study. For each of the nine major canal operation and maintenance tasks (such as cleaning canals, distributing water, and collecting water fees), canal managers were asked to list who were in charge. Pre-coded answers include village leader, WUAs, canal managers, farmers and others. Canal managers can choose multiple answers. The degree of farmers' participation in irrigation management is measured by the number of tasks farmers are fully or partially in charge.

[2] These variables are constructed from answers to the survey question "If village wide extreme weather events (such as droughts or floods) occurred, how the shocks would be mitigated?" Pre-coded answers include 1). Farmers mitigate on their own; 2). Farmers cooperate to mitigate; 3). Village leaders/collective mitigate; 4). Township, county or other local or upper level governments mitigate; 4). Other (Please explain).

Another social norm relevant for irrigation investment and specific to rural China regards who should pay for irrigation investment. Village leaders used to make investment decisions and finance irrigation projects with funds from collective coffers of local revenues. Bouma, van Soest, and Bulte (2007) show that a village maintenance fund discouraged private individuals to undertake investments in common pool resources in India. China's fiscal reforms intended to change the funding norm to be a public-private partnership where farmers voluntarily contribute to irrigation investment. We use a social support variable to gauge whether this new norm is widely accepted by farmers. The social support variable indicates financial support would be available from other villagers (as opposed to village leaders or upper level government) when a villager had no access to irrigation water for a whole year.[3] A similar social support variable is also used in Willy and Holm-Müller (2013) as a component of social capital.

It should be noted that although we have reported social capital measures by networks, trust and norms, there is no clear-cut distinction between these three dimensions. For example, previous studies have used trust and norms interchangeably (e.g., Beekman and Butle 2012). Factor analysis with the method of principal Component Analysis (PCA) is used to discover patterns among all social capital measures we have constructed (Appendix 1). Results of factor analysis indicate that most social capital measures are largely consistent with the underlying construct they are intended for. For example, both social capital measures constructed using answers to the two trust questions have high factor loadings on Factor 1, which is consistent with our intention to use both measures as social trust. Both adjusted number of non-water associations

[3] Factor analysis with the method of Principal Component Analysis (PCA) is applied to a set of dummy variables constructed using answers to the survey question is "If your neighbor had no access to irrigation for a whole year, who do you think would help him or her financially? Please list the three most likely sources." Pre-coded answers include 1). nobody; 2). relatives; 3). neighbors; 4). friends; 5). village leaders; 6). county or township government; 7). irrigation district; 8). other administrative units; 9). other (please explain). Since only a few respondents listed options 6-8, we combine them with option 5. One factor is retained since it has an eigenvalue greater than one.

and governance quality have high factor loadings on Factor 2, which is consistent with our intention to use both measures as index for broad social network. Both variables used to measure the norms of cooperation load onto the same factor (Factor 6). Overlaps between different dimensions also exist. For example, the two variables we use to measure social support and group under norms (relatives or friends help financially and neighbors help financially) load onto the same factor (Factor 4) as the variable we use to measure close networks (number of relatives or friends). The variables we use to measure norms of social support, monitoring, and conflict resolutions load onto the same factor (Factor 5). Part of the reason may be because these three variables all measure whether village leaders are still the key actors in irrigation-related matters. The first two variables (village leaders help financially and village leaders resolve water allocation conflicts) directly characterize village leaders' roles. The third variable also indirectly depict village leaders' role. Answers to the follow-up question "If you would report rule-breaking behavior, who you would report to?" indicate that village leaders are the most cited persons of contact. In the empirical analysis, the social capital measures we constructed, instead of factors, are used since their coefficients are easier to interpret. In addition, we are also interested in investigating whether different measures of the same underlying factor (e.g., trust in village leaders versus trust in villagers, non-water associations versus governance quality) have different predictive powers.

## 4 Empirical strategies

The first part of this section models individual farmers' decisions to contribute to surface water irrigation projects and choices between labor and cash contribution. The second part analyzes the aggregate level of contributions made by farmers at the village level. Only cash contribution is analyzed in this part due to the lack of data on aggregate labor contributions. Given that so far only 14% of cash investment in village level irrigation infrastructure come from farmers in rural China (Boyle, Huang, and Wang 2014), the focus on cash investment can generate important insights for improving local irrigation systems in rural China.

### 4.1 Individual level regression

We first model individual farmers' decisions regarding contribution to village level surface water irrigation projects as a two-step process. A farmer first decides whether to contribute. Conditional on the decision to contribute, the farmer then chooses between two forms of contributions: labor or cash. In our sample, labor contribution is the dominant format. More than half of the sample farmers (53%) contributed only labor to surface water irrigation projects in 2011 (Table 1). A much smaller share of farmers (10%) contributed only cash. An even smaller share of farmers (only 5%) contributed both cash and labor. To simplify the analysis, these farmers are categorized as those that contributed cash.

A sequential logistic model can be used for such two-step decision-making processes (Amemiya 1981; Kahn and Morimune 1979). In the first step, the utility farmer $i$ in village $j$ gains from contribution to surface water irrigation projects, $y_{ij1}^*$, is related to a set of factors as:

$$y_{ij1}^* = \mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1 + \varepsilon_{ij1} \quad (2)$$

The vector $\mathbf{s}_{ij}$ contains the social capital variables that are of key interest in this study. The vectors $\mathbf{h}_{ij}$ and $\mathbf{v}_j$ contain household and village characteristics. Instead of $y_{ij1}^*$, we only observe the binary variable, $y_{ij1}$, which equals 1 if the farmer decides to contribute:

$$y_{ij1} = \begin{cases} 1 \text{ if } y_{ij1}^* > 0 \\ 0 \text{ if otherwise} \end{cases} \quad (3)$$

Assuming the error term $\varepsilon_{ij1}$ follows a logistic distribution,

$$\begin{aligned} \Pr(y_{ij1} = 1) &= \Pr(\varepsilon_{ij1} > -(\mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1)) \\ &= \frac{\exp(\mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1)}{1 + \exp(\mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1)} \end{aligned} \quad (4)$$

In the second step, the farmer chooses between cash or labor contributions. We observe the second binary variable, $y_{ij2}$, which equals 1 for cash contribution. With the assumption of a logistic distribution,

$$\Pr(y_{ij2} = 1) = \Pr(\varepsilon_{ij2} > -(\mathbf{s}_{ij}\boldsymbol{\beta}_2 + \mathbf{h}_{ij}\boldsymbol{\delta}_2 + \mathbf{v}_j\boldsymbol{\gamma}_2)) = \frac{\exp(\mathbf{s}_{ij}\boldsymbol{\beta}_2 + \mathbf{h}_{ij}\boldsymbol{\delta}_2 + \mathbf{v}_j\boldsymbol{\gamma}_2)}{1 + \exp(\mathbf{s}_{ij}\boldsymbol{\beta}_2 + \mathbf{h}_{ij}\boldsymbol{\delta}_2 + \mathbf{v}_j\boldsymbol{\gamma}_2)} \quad (5)$$

In the data, the contribution decision of a farmer is represented by a categorical variable, $Y_{ij}$, which is coded to be 1 for no contribution, 2 for labor contribution and 3 for cash contribution. The probabilities can be expressed as:

$$\Pr(Y_{ij} = 1) = \Pr(y_{ij1} = 0) = \frac{1}{1 + \exp(\mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1)} \quad (6)$$

$$\Pr(Y_{ij} = 2) = \Pr(y_{ij1} = 1) \times \Pr(y_{ij2} = 0) = \frac{\exp(\mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1)}{1 + \exp(\mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1)} \times \frac{1}{1 + \exp(\mathbf{s}_{ij}\boldsymbol{\beta}_2 + \mathbf{h}_{ij}\boldsymbol{\delta}_2 + \mathbf{v}_j\boldsymbol{\gamma}_2)} \quad (7)$$

$$\Pr(Y_{ij} = 3) = \Pr(y_{ij1} = 1) \times \Pr(y_{ij2} = 1) = \frac{\exp(\mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1)}{1 + \exp(\mathbf{s}_{ij}\boldsymbol{\beta}_1 + \mathbf{h}_{ij}\boldsymbol{\delta}_1 + \mathbf{v}_j\boldsymbol{\gamma}_1)} \times \frac{\exp(\mathbf{s}_{ij}\boldsymbol{\beta}_2 + \mathbf{h}_{ij}\boldsymbol{\delta}_2 + \mathbf{v}_j\boldsymbol{\gamma}_2)}{1 + \exp(\mathbf{s}_{ij}\boldsymbol{\beta}_2 + \mathbf{h}_{ij}\boldsymbol{\delta}_2 + \mathbf{v}_j\boldsymbol{\gamma}_2)} \quad (8)$$

The parameters, $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$, $\boldsymbol{\delta}_1$, $\boldsymbol{\delta}_2$, $\boldsymbol{\gamma}_1$, $\boldsymbol{\gamma}_2$, can then be estimated by maximizing the following log-likelihood function:

$$\ln L = \sum_{ij} \ln\Pr(Y_{ij} = m)^{\mathbf{I}(Y_{ij} = m)} \qquad m = 1, 2, 3. \quad (9)$$

where $\mathbf{I}(\cdot)$ is an indicator function.

Several potential issues may lead to biased estimates of the coefficients of social capital variables. Bias may arise from the omission of factors that can influence the dependent variable and are also correlated with existing explanatory variables. The likelihood of omitted variable bias is minimized in our empirical analysis by the inclusion of a large set of variables in the vectors $\mathbf{h}_{ij}$ and $\mathbf{v}_j$ to control for likely confounding factors. The choices of the explanatory variables are based on the literature on collective action in resource management (e.g., Meinzen-Dick 2007; Araral 2009) as well as the literature on public good provision in rural China (e.g., Wei, Ling, and Ruan 2011; Cai, Zhu, and Chen 2016). The first set of variables measures the demographic characteristics of households including age, education, household size and gender. Of particular interest is the share of female household members, which may affect both the decision to contribute through gender differences in social preferences and the choices between labor and cash contribution possibly due to gender differences in physical labor.

The second set of variable measures household socioeconomic characteristics including total household asset and the degree to which household members were engaged in off-farm work. Farmers' access to off-farm employment might affect their decisions to contribute because it provides farmers an exit option from collective action (Wang, Chen, and Araral 2016); In addition, by changing the opportunity cost of time, off-farm employment may also influence the choice between labor and cash contributions. A greater dependence on a resource creates incentives for cooperation (e.g., Araral 2009; Meinzen-Dick 2007). Since rice is one of the most water intensive among all major crops in our sample areas, the share of land allocated to rice production is used to gauge the salience of irrigation to farmers' livelihoods, which can influence their incentives to contribute to irrigation projects. The last household level variable, average land per capita, measures household land endowment.

The conditions of village irrigation systems are the most important determinant of the needs for irrigation investment and are likely to influence farmers' decision to contribute. These include the share of total canal length in village that was lined, the share of canal command area that was actually irrigated, and a dummy variable indicating canals in village silted up easily. Characteristics of users also matter (e.g., Araral 2009; Meinzen-Dick 2007). Number of households per meter of canal is used. The last village level variable, the distance from a village to township government, measures the remoteness of the village. In addition to guard again omitted variable bias, the inclusion of these factors also allows us to examine the effects of social capital variables while controlling for the context in which these effects take place. In an alternative specification, a set of county dummies is also added (county fixed effects model) to control for any unobserved heterogeneity at the county level.

Another possible source of bias is measurement errors, which could shrink the magnitudes of the coefficients of mis-measured explanatory variables toward zero. Some social capital variables, such as the number of relatives or friends available for financial support, are not likely to be mis-measured since farmers do not have incentives to over- or under-report. For most social capital variables constructed using information in the village questionnaire, we are able to check their consistency with information reported by canal managers. Other variables, such as trust variables and whether a farmer would report rule-breaking behavior, may be more of a problem due to respondents' tendency to be compliant with "socially preferred answers". Two strategies are used to address potential measurement errors. First, during the survey, enumerators emphasized that our research team was not affiliated with any government agency that could regulate farmers and that their identities and answers would never be revealed. In addition, farmers were told that there was no correct or wrong answer to any of the social capital questions. Second, in an alternative specification, we check the robustness of results by replacing social capital variables with factors extracted from factor analysis with the method of PCA. The results are largely consistent between social capital variables and corresponding factors that tend to measure the same underlying construct.

A third possible source of bias is reverse causality, which occurs if farmers' contribution to irrigation projects (the dependent variable) could influence the accumulation of social capital (explanatory variables). Some social capital variables, such as number of relatives and friends and number of non-water associations, are not likely to suffer from reverse causality. However, the experience of working together on building new canals (e.g., through labor contribution to irrigation projects) may affect a farmer's trust in other villagers or their inclination to work cooperatively with others to mitigate weather shocks. To address the potential endogeneity of some social capital variables, instrumental variable (IV) estimation is used. To reduce the number of IVs needed, we use a specification that only includes social capital variables with statistically significant coefficients and thus only instrument for these variables. Six social capital variables are retained in the reduced model: strongly agree or agree that villagers can be trusted, strongly agree village leaders can be trusted, governance quality, villagers support financially when no irrigation and villagers cooperate to mitigate extreme weather shocks.

Six IVs are used. The first three variables attempt to measure the degree of heterogeneity in a village. Previous studies have found that social capital is more difficult to form in heterogeneous communities. For example, trust level tends to be lower in more ethnically heterogeneous communities (e.g., Bahry et al. 2005). In most rural areas in China including our sample area, not much ethnical difference is observed. Instead, households identify more with their last names since households sharing the last time are likely to be related. Therefore two variables are used to measure the diversity of last name in a village: a last name diversity index in the village[4] and a dummy variable indicating a farmer has the most common last name in the village (shared

[4] The last name diversity index in the village is calculated using the same measure as in Alesina, Baqir, and Easterly (1999): $I_j = 1 - \Sigma_r(s_{jr})^2$, where $s_{jr}$ is the share of households with last name $r$ in village $j$. The index takes a value between zero (perfectly homogeneous) and one.

by most households). A third variable, the number of villages merged to form the current village, is likely to be correlated with the degree of heterogeneity in a village as well. The merge of villages is a policy used by Chinese government since the 2000s in order to increase land use efficiency (Ong 2014). The next two variables, number of years a village has been formed and number of people per unit of land, may also influence the level of social capital. In villages with longer histories, trust levels may be high since farmers have known each other for a longer time. Cooperation and/or governance may be more difficult in villages with higher population density due to the difficulty of coordinating among more people. The last variable, past experience with natural disasters, may shape farmers' opinion of the benefits of cooperation as well as other villagers' trustworthiness. It may also increase the likelihood of farmers participating in social networks as insurance against future shocks.

Since it is difficult to operate IV estimation in nonlinear models with multiple endogenous variables such as the sequential logit model, two linear models are used to estimate the decision to contribute and the choice between cash and labor contributions separately. The use of linear models also allows us to add a set of county dummies (county fixed effects model). However, the model on farmers' choices between cash and labor contributions may suffer from sample selection bias since only farmers who contributed are included in the analysis. To correct for such sample selection bias, we follow the commonly used Heckman's two-step procedure (Heckman 1979) and include a selection correction term as an additional explanatory variable. The selection correction term, Inverse Mills Ratio (IMR), is computed using the estimation results of a probit model on the decision to contribute using the whole sample. The percent of land for rice production is used to identify the selection correction term and so is excluded from the regression on the choice between cash and labor contributions. Famers growing more rice is more likely to contribute since irrigation is essential to rice production. However, the share of land allocated to rice is not likely to have a strong correlation with the form of contribution farmers make.

## 4.2 Village level regression

The second part of the analysis examines the impact of social capital on the aggregate contributions made by farmers in the village. In particular, two outcomes, denoted by $H_{jk}$, are used: the share of total village level investment in surface water irrigation projects contributed by farmers and the share of maintenance expenditure from farmers.

$$H_{jk} = \alpha_k + \mathbf{c}_j\boldsymbol{\theta}_k + \mathbf{w}_j\boldsymbol{\eta}_k + \omega_{jk} \qquad (10)$$

Equation (10) is estimated for each of the two outcomes, index by $k$. The vector $\mathbf{c}_j$ contains the key variables of interest: social capital variables measured at the village level. For variables that measure individuals' social capital and constructed using information in the household questionnaire, the village average is used. Other variables, such as governance quality and adjusted number of non-water associations, measure village level social capital and are constructed using information from village leader questionnaire. These variables are included as is. The vector $\mathbf{w}_j$ contains three sets of village level variables, some of which are also used in individual level regressions. The first set measures conditions of local irrigation systems: share of total canal length in village that was lined, share of canal command area that was actually irrigated and a dummy variable indicating canals in village silted up easily. The second set of variables measure the characteristics of users of irrigation systems: number of households per meter of canal, share of villagers with junior high or above education, average income per capita and share of village labor force that worked off-farm. The third set includes two variables that measure other village characteristics: per capita land holding and distance from village center to township government. A set of county dummies is also added to capture any unobserved heterogeneity at the county level.

## 5 Results

In this section, we outline our main results linking social capital and farmers' investments in surface water irrigation projects. We first examine how social capital influences farmers' decisions to contribute to surface water irrigation projects at individual level. Then we investigate the relationship between social capital and the share of money to build or maintain surface water irrigation infrastructure from farmers at the village level.

In column 1 and column 2 of Table 2, the average marginal effects of the sequential logit model that estimates the joint probabilities of farmers' two decisions (whether to contribute to surface water irrigation projects and whether to make cash contributions or labor contributions) are reported. Some control variables show significant impacts on farmers' decisions. Variables indicating the percent of the irrigated area in the village and the number of household per meter of canal are positively correlated with farmers' decisions to contribute, implying that when farmers rely more on irrigation for crop production and share canals with more farmers (the amount of canals is in shortage), they have more incentives to participate in surface water irrigation projects to improve the current local irrigation systems. The variables indicating that the canals in village silt up easily and the distance of the village to the township government is further are positively correlated with farmers' decisions to contribute. The variable indicating household size is positively correlated with farmers' decisions to make cash contributions, indicating farmers with a large household size are more likely to make cash contributions.

Among social capital variables, two social norm variables of cooperation have statistically significant and positive impacts on farmers' decisions to contribute. In the village where farmers have a social norm to cooperate, indicated by villagers support each other financially when no irrigation and villagers cooperate to mitigate extreme weather shocks, farmers are more likely to make contributions. Social norms of cooperation create an altruistic characteristic among farmers.

Farmers have more community-oriented concerns (how can our neighborhood be improved) instead of self-oriented interests (how can I get richer). Hence, they are more likely to make contributions to surface water irrigation projects to increase the welfare of all villagers (Suebvises 2018).

Higher governance quality also appears to be a primary motivation for farmers to make contributions to village irrigation projects. It suggests that in villages with a higher quality governance of local irrigation systems, more information about local canals is shared among villagers. Thus, farmers are more aware of the needs for local irrigation systems, have a stronger sense of ownership of the local canals, and have a higher probability to contribute to surface water irrigation projects.

However, social network variables, the number of friends or relatives who provide help to a farmer and having more high-quality non-water-related associations in the village, do not affect farmers' decisions to contribute. It suggests that in these two types of social networks, farmers may not exchange information about irrigation practices, and thus they do not gain motivations to contribute to surface water irrigation projects.

In terms of the choice between labor and cash contributions, two variables indicating that farmers' trust fellow villagers have significant and positive effects on their decisions to contribute cash. Since farmers' cash contribution level is not revealed to each other, farmers' decisions to make cash contributions are highly dependent on the degree to which they trust other villagers would contribute a similar amount of cash. Farmers with a higher level of trust in fellow villagers would believe that other villagers would reciprocate their contribution of cash (via making reciprocal cash contribution), and thus are more likely to contribute cash. In contrast, farmers with a lower level of trust in fellow villages are more likely to make labor contributions because farmers make labor contributions by participating in a temporary task team to build new irrigation infrastructure. It ensures farmers can easily monitor each other and make a similar amount of labor contributions.

Governance quality and social networks do not show significant impacts on farmers' choices between labor and cash contributions. It indicates that farmers consider the outcomes of labor and cash contributions have no difference in terms of improving local irrigation systems. Although farmers can be better informed about the needs of local irrigation systems with a high-quality governance and more social networks, they tend to be indifferent between making cash contributions and labor contributions. This is also supported by the evidence that farmers' choices between labor and cash contributions are not influenced by any variable indicating the condition of local canals because farmers consider both forms of contributions can improve the efficiency of water delivery in local irrigation canals.

In addition, the alternative specification, in which we only include statistically significant social capital variables from the previous results and other control variables, is also run (Column 3 and 4 of Table 2). This does not change any of the results. Governance quality of canals and the norm that villagers support each other financially when no irrigation have significant and positive impacts on farmers' decisions to contribute, while the degree to which farmers trust fellow villagers and village leaders has a statically significant influence on farmers' choices between cash and labor contributions.

To check the robustness of the results, a county fixed effects with correction for sample-selection model is also run (column 1 and 2 of Table 3). Here, we treat the dependent variables indicating whether to contribute to surface water irrigation projects and whether to make cash contributions as continuous variables. The county fixed effects are added to both regressions to capture unobservable effects at the county level. Inverse Mills Ratios (calculated from the first step of regression of contribution) are added to the second-step of the regression to correct for sample selection bias. Results are comparable with the sequential logit model.

To probe into the issue of reverse causality, we process with two models with instrumental variables (column 3 and 4 of Table 3). Unfortunately, attempts to instrument all social capital variables at the same time again lead to a weak instruments problem. We adopt the method of Andrews, Moreira, and Stock (2006) to adjust the standard errors so that significance tests have the correct size in the presence of weak instruments. We are limited to including one endogenous regressor at a time. All of the IV results thus should be interpreted cautiously. In fact, even when each of the social capital variables is the only endogenous variable in the regression, the estimated impacts are always statistically insignificant. Hence, we are unable to verify whether our earlier results for social capital stand up to closer scrutiny in an IV approach. In Appendix 2, the first stage results of IV approach are reported. It turns out that most of social capital variables tend to not be correlated with our instrumental variables, suggesting that social capital is hard to change. Social capital is built up slowly over a long time period of interactions with other villagers (e.g., Fukuyama 1995; Pretty and Ward 2001; Tu and Bulte 2010).

Table 4 reports the results that using the county fixed effects model to estimate how social capital influences the share of cash to improve local irrigation systems contributed by farmers in village. Here, the dependent variables are the percent of investment to build new public surface water irrigation infrastructure from farmers and the percent of maintenance expenditure for irrigation systems from farmers in the village. Consistent with the individual level regressions, variables indicating farmers trust fellow villagers show significant and positive signs in the equation of the percent of investment from farmers. When trust among villagers is well established, the need for costly monitoring and enforcement is eliminated since farmers expect others to act in accordance with the shared norms. Thus, more share of cash is contributed by farmers to build new surface water irrigation infrastructure in the village. At the same time, variables indicating farmers trust village leaders show significant and negative signs in the equation of the percent of maintenance expenditure from farmers, suggesting that when farmers trust village leaders contribute more to maintain irrigation infrastructure, the less share of maintenance expenditure will be contributed by farmers in the village. The number of relatives or friends for financial support show a positive and significant impact on the percent of maintenance expenditure from framers, suggesting that in villages that have dense social networks, more share of maintenance expenditure is contributed from farmers.

## 6 Conclusions

Using data from China Water Institution and Management (CWIM) survey, the study first constructs measures of all three most studied dimensions of social capital: trust, networks, and norms. The study then examines if social capital has any predictive powers of individual farmers' contribution decisions as well as farmers' contributions aggregated at the village level. Farmers' choices between different forms of contributions (labor versus cash) are also analyzed. In line with the literature on social capital, our empirical results from the different models suggest that few social capital variables do seem to influence farmers' investment in surface water irrigation projects. It has important implications for managing village irrigation projects, particularly in the context of developing countries embarking on decentralization reforms. In the decentralized irrigation governance structures, increasing farmers' contribution to surface water irrigation projects is a crucial means to improve the conditions of local irrigation systems. Rather than increasing farmers' contributions to village irrigation projects by providing them tangible incentives, such as subsidizing their contributions, local irrigation system managers should also pay attention to intangible motivations for collective action. For example, the relationship between local irrigation system managers and farmers is an important factor in determining the success of irrigation-related collective action. In the case of China, instead of encouraging villages to build WUAs to manage canals, the government should also need to find out how to improve the quality of governance of local irrigation canals. A stronger feeling of ownership, brought by high-quality governance of local irrigation canals, can effectively influence farmers' participation in collective surface water irrigation projects (Fontana and Grugel 2016).

In addition, a social norm of cooperation also encourages farmers to contribute to surface water irrigation projects. The social norm of cooperation provides farmers with strong incentives to cooperate to resolve issues, and thus increases farmers' contributions to surface water irrigation projects. One of the effective policies to help the community to gain a norm of cooperation is building voluntary organizations in the village. It teaches empathy, the art of compromise and cooperation, creates the peer pressure of helping each other, and thus encourages the formalization of the social norm of cooperation in the village (Newton 2001). Therefore, village leaders should also focus on building new voluntary associations in addition to operating the current associations in the village.

Last but not least, in terms of the choice between different types of contributions to surface water irrigation projects, the degree to which farmers trust other villagers turns out to be one of the most vital factors influencing the decision. When farmers have more trust in fellow villagers, they tend to make cash contributions instead of labor contributions. It indicates that local irrigation system managers should recognize the social environment rather than analyzing summary demographic information alone when encouraging farmers to contribute to surface water irrigation projects. The success of collective action is highly correlated with local context. For villages that have a high degree of trust among villagers, local surface water irrigation managers should target in improving farmers' cash contributions, otherwise, encouraging farmers to contribute labor is a more practical goal.

There are limitations to our study. Some social capital measures could be improved. For example, in future surveys, we could use trust questions from Tu et al. (2011) that asked respondents to rate how much they trust various groups with a scale from 0 to 10. IV estimation suffers from weak IV problem. Future data collection efforts that generate data sets of a larger sample size and panel in nature may enable analysis that looks into the causal effects of social capital variables.

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## Tables

Table 1. Variable descriptions and summary statistics

| Variable name | Description | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| **Dependent variables** | | | | | |
| Contributed | Dummy variable, =1 if a farmer contributed to building surface water irrigation infrastructure in 2011 | 0.68 | 0.47 | 0 | 1 |
| Contributed only labor | Dummy variable, =1 if a farmer contributed labor to building surface water irrigation infrastructure in 2011 | 0.53 | 0.50 | 0 | 1 |
| Contributed cash [a] | Dummy variable, =1 if a farmer contributed cash to building surface water irrigation infrastructure in 2011 | 0.15 | 0.36 | 0 | 1 |
| % investment from farmers ¶ [b] | The share of total investment in building surface water irrigation infrastructure contributed by farmers during 2005-2015 | 0.15 | 0.30 | 0 | 1 |
| % maintenance expenditure from farmers ¶ | The share of irrigation system maintenance expenditure contributed by farmers during 2005-2015 | 0.39 | 0.44 | 0 | 1 |
| **Social capital variables** | | | | | |
| Strongly agree villagers can be trusted | Dummy variable indicating a farmer strongly agrees that most villagers can be trusted | 0.19 | 0.39 | 0 | 1 |
| Agree villagers can be trusted | Dummy variable indicating a farmer agrees that most villagers can be trusted | 0.77 | 0.42 | 0 | 1 |
| Strongly agree village leaders can be trusted | Dummy variable indicating a farmer strongly agrees that village leaders can be trusted | 0.13 | 0.34 | 0 | 1 |
| Agree village leaders can be trusted | Dummy variable indicating a farmer agrees that village leaders can be trusted | 0.71 | 0.45 | 0 | 1 |
| N relatives or friends for financial support | Number of relatives or friends that can provide support when a farmer has financial difficulties | 10.49 | 14.41 | 0 | 110 |
| Adjusted N non-water associations ¶ | Number of non-water associations in the village, adjusted by years of existence, participation rate, and frequency of activities | 2.24 | 1.86 | 0 | 8.38 |
| Governance quality ¶ | Quality of local irrigation systems governance | 0.54 | 0.21 | 0 | 0.85 |
| N O&M tasks managed by farmers ¶ | Number of canal operation and maintenance tasks managed by farmers | 0.41 | 0.80 | 0 | 3 |
| If your neighbors did not have access to irrigation water for a whole year, who would help them financially? | | | | | |
| *Relatives or friends* | Dummy variable, =1 if a farmer listed relatives or friends | 0.54 | 0.50 | 0 | 1 |
| *Neighbors* | Dummy variable, =1 if a farmer listed neighbors | 0.35 | 0.48 | 0 | 1 |

| Variable name | Description | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| *Village leaders or upper level government* | Dummy variable, =1 if a farmer listed village leaders or upper level government | 0.43 | 0.50 | 0 | 1 |
| Village leaders resolve water allocation conflicts | Dummy variable, =1 if village leaders resolve water allocation conflicts | 0.31 | 0.46 | 0 | 1 |
| Report rule-breaking behavior | Dummy variable, =1 if a farmer would report rule-breaking water use behavior if it were observed | 0.50 | 0.50 | 0 | 1 |
| Villagers mitigate extreme weather shocks on their own | Dummy variable | 0.39 | 0.49 | 0 | 1 |
| Villagers cooperate to mitigate extreme weather shocks | Dummy variable | 0.23 | 0.42 | 0 | 1 |
| **Household characteristics (N=189)** | | | | | |
| Age | Age of household head in 2007 | 49.03 | 10.83 | 15 | 72 |
| Years of schooling | Years of schooling of household head in 2007 | 6.51 | 3.23 | 0 | 12 |
| Household size | Number of household members in 2007 | 3.84 | 1.59 | 1 | 9 |
| % female | The share of household members that are female in 2007 | 0.48 | 0.15 | 0 | 1 |
| Total HH asset (100,000 yuan) | Total household asset in 100,000 yuan in 2007 | 0.17 | 0.25 | 0.01 | 2.28 |
| % off-farm | Average share of household members that worked off-farm during 2004-2010 (adjusted by percent of labor time allocated to off-farm activities) | 0.10 | 0.15 | 0 | 0.71 |
| % rice | Share of land allocated to rice production in 2007 | 0.21 | 0.33 | 0 | 1 |
| HH per capita land holding (mu) | Average land per capita in the household in mu in 2007 | 3.07 | 2.35 | 0.27 | 13 |
| Farmer has the most common last name | Dummy variable, =1 if a household has a last name shared by the most households in the village | 0.36 | 0.48 | 0 | 1 |
| Experienced disasters between 2001 and 2007 | Dummy variable, =1 if a household experienced natural disasters such as pests and wind, between 2001 and 2007 | 0.65 | 0.48 | 0 | 1 |
| **Village characteristics (N=52)** [a] | | | | | |
| Village per capita land holding (mu) [¶] | Average land per capita in village in 2007 | 2.09 | 1.40 | 0.48 | 7.20 |
| % lined canal in village [¶] | Share of total canal length in village that was lined in 2007 | 0.32 | 0.42 | 0 | 1 |
| % irrigated area in village [¶] | Share of canal command area that was actually irrigated in village in 2007 | 0.93 | 0.13 | 0.44 | 1 |
| Canals in village silt up easily [¶] | Dummy variable, =1 if canals in village silted up easily in 2007 | 0.77 | 0.43 | 0 | 1 |
| N HH per meter of canal, log and standardized [¶] | Number of households per meter of canal in 2007, log and standardized | 0 | 1 | -2.68 | 1.45 |
| % villagers with junior high or above education [¶] | Share of villagers with junior high or above education in 2007 | 0.57 | 0.23 | 0.10 | 0.95 |

| Variable name | Description | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| Income per capita in village (100,000 yuan)[¶] | Average income per capita in the village in 2007 | 0.033 | 0.021 | 0.0090 | 16. |
| % off-farm in village [¶] | Share of village labor force that worked off-farm in 2007 | 0.10 | 0.12 | 0.00 | 0.53 |
| Distance to township government (km) [¶] | Distance from village center to township government in km | 4.38 | 3.67 | 0 | 15 |
| Last name diversity index in village [¶] | | 1.50 | 0.28 | 1.02 | 2.33 |
| N villages merged [¶] | Number of villages merged into the current village | 2.10 | 2.66 | 1 | 14 |
| Number of years a village has been formed [¶] | | 43.92 | 26.31 | 4 | 62 |
| N people per mu [¶] | Number of people per unit of land | 0.71 | 0.49 | 0.15 | 2.38 |

Notes: [¶] These variables are constructed from questionnaires that collect village-level information.

[a] In total 52 villages are included. Since not every village had irrigation infrastructure projects, only 50 villages are included in the investment regressions.

Table 2. Individual-level regressions using sequential logit model, Average marginal effects (AME)

| | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| | Contributed [a] | | Contributed cash [b] | | Contributed [b] | | Contributed cash [b] | |
| Strongly agree villagers can be trusted | 0.106 | (0.213) | 2.286*** | (0.307) | -0.00244 | (0.205) | 2.553*** | (0.313) |
| Agree villagers can be trusted | -0.0146 | (0.201) | 2.308*** | (0.313) | -0.0959 | (0.188) | 2.532*** | (0.326) |
| Strongly agree village leaders can be trusted | -0.251* | (0.137) | -0.265 | (0.183) | -0.169 | (0.109) | -0.318** | (0.159) |
| Agree village leaders can be trusted | -0.114 | (0.0919) | 0.00364 | (0.115) | | | | |
| N relatives or friends for financial support | 0.00294 | (0.00210) | 0.00109 | (0.00199) | | | | |
| Adjusted N non-water associations | 0.0161 | (0.0237) | 0.0127 | (0.0215) | | | | |
| Governance quality | 0.343** | (0.166) | -0.195 | (0.246) | 0.352** | (0.163) | -0.181 | (0.235) |
| N canal O&M tasks managed by villagers | 0.0435 | (0.0399) | -0.00604 | (0.0527) | | | | |
| Villagers support financially when no irrigation | 0.0636** | (0.0319) | 0.0327 | (0.0405) | 0.0540* | (0.0317) | 0.0159 | (0.0357) |
| Village leaders resolve water allocation conflicts | 0.0301 | (0.0662) | 0.0430 | (0.0853) | | | | |
| Report rule-breaking behavior | -0.0510 | (0.0663) | 0.0796 | (0.0751) | | | | |
| Villagers mitigate extreme weather shocks on their own | 0.0512 | (0.0701) | 0.0827 | (0.0835) | | | | |
| Villagers cooperate to mitigate extreme weather shocks | 0.158* | (0.0855) | -0.0790 | (0.102) | 0.125 | (0.0790) | -0.119 | (0.0943) |
| Age | -0.00352 | (0.00346) | 0.00247 | (0.00427) | -0.00497 | (0.00317) | 0.00206 | (0.00385) |
| Years of schooling | -0.0102 | (0.0132) | -0.00642 | (0.0155) | -0.00940 | (0.0127) | -0.00378 | (0.0142) |
| Household size | 0.0236 | (0.0260) | 0.0455* | (0.0250) | 0.0166 | (0.0253) | 0.0455* | (0.0256) |
| % female | 0.131 | (0.194) | -0.209 | (0.248) | 0.0767 | (0.194) | -0.136 | (0.242) |
| Total HH asset (100000 yuan) | 0.385 | (0.257) | 0.106 | (0.109) | 0.439 | (0.291) | 0.121 | (0.102) |
| % off-farm | -0.0704 | (0.237) | -0.0299 | (0.264) | -0.110 | (0.226) | 0.00547 | (0.264) |
| % rice | 0.0285 | (0.109) | -0.0776 | (0.145) | 0.0636 | (0.108) | -0.109 | (0.138) |
| HH per capita land holding in mu | 0.00342 | (0.0182) | 0.0149 | (0.0214) | 0.00159 | (0.0189) | 0.0196 | (0.0208) |
| % lined canal in village | 0.0587 | (0.0981) | 0.100 | (0.122) | 0.0606 | (0.0928) | 0.0746 | (0.106) |
| % irrigated area in village | 0.611* | (0.318) | -0.451 | (0.573) | 0.635** | (0.274) | -0.590 | (0.534) |
| Canals in village silt up easily | 0.166* | (0.0916) | 0.0316 | (0.108) | 0.144* | (0.0818) | -0.0283 | (0.104) |
| N HH per meter of canal, log and standardized | 0.0870** | (0.0428) | 0.0139 | (0.0521) | 0.0746* | (0.0439) | -0.00181 | (0.0510) |
| Distance to township government in km | 0.0252*** | (0.00917) | -0.0134 | (0.0101) | 0.0260*** | (0.00939) | -0.0153 | (0.00963) |
| Observations | 189 | | 189 | | 189 | | 189 | |

Notes: Robust standard errors are reported in parentheses. *, **, *** indicate levels of statistical significance at 10%, 5%, and 1%, respectively. [a] Base outcome: Did not contribute in 2011. [b] Base outcome: Contributed labor in 2011.

Table 3. Individual-level regressions, Reduced model with county fixed effects

| | County fixed effects model | | 2SLS model [c] | |
|---|---|---|---|---|
| | (1) Contributed [a] | (2) Contributed cash [b] | (3) Contributed [a] | (4) Contributed cash [b] |
| Strongly agree villagers can be trusted [c] | -0.00625 | 0.205* | -2.129 | 0.294 |
| | (0.237) | (0.105) | (6.032) | (1.222) |
| Agree villagers can be trusted [c] | 0.00507 | 0.188** | -1.698 | -0.291 |
| | (0.165) | (0.0843) | (8.188) | (2.684) |
| Strongly agree village leaders can be trusted [c] | -0.0267 | -0.281** | 2.764 | -1.370 |
| | (0.0630) | (0.121) | (8.497) | (1.122) |
| Governance quality [c] | 0.0727** | -0.224 | 1.477 | -1.073 |
| | (0.0262) | (0.315) | (2.988) | (1.198) |
| Villagers support financially when no irrigation [c] | 0.427* | 0.0227 | 0.858 | -0.231 |
| | (0.237) | (0.0409) | (6.260) | (0.319) |
| Villagers cooperate to mitigate extreme weather | 0.0704 | -0.147 | 0.497 | -0.892 |
| shocks [c] | (0.0635) | (0.111) | (2.450) | (0.882) |
| Age | -0.00275 | 0.000960 | -0.0121 | 0.0158 |
| | (0.00293) | (0.00661) | (0.0406) | (0.0154) |
| Years of schooling | -0.0131 | -0.00840 | -0.157 | 0.0846 |
| | (0.00870) | (0.0149) | (0.392) | (0.0618) |
| Household size | 0.0213 | 0.0207 | 0.208 | -0.0684 |
| | (0.0222) | (0.0424) | (0.352) | (0.0871) |
| % female | -0.00994 | -0.221 | -1.616 | 0.264 |
| | (0.215) | (0.326) | (6.096) | (0.588) |
| Total HH asset (100,000 yuan) | 0.251*** | 0.103 | 0.515 | -0.629 |
| | (0.0298) | (0.144) | (1.545) | (0.438) |
| % off-farm | -0.0995 | -0.0210 | 0.0509 | 0.429 |
| | (0.208) | (0.222) | (1.986) | (0.555) |
| % rice | 0.0250 | | -0.0449 | |
| | (0.0863) | | (1.904) | |
| HH per capita land holding (mu) | 0.00468 | -0.00174 | 0.00692 | 0.00513 |
| | (0.0171) | (0.0314) | (0.126) | (0.0468) |
| % lined canal in village | 0.321** | 0.177 | 1.100 | -0.478 |
| | (0.114) | (0.187) | (3.289) | (0.345) |
| % irrigated area in village | 0.666* | -0.0693 | 0.175 | -0.520 |
| | (0.346) | (1.912) | (5.671) | (1.569) |
| Canals in village silt up easily | 0.170** | -0.0786 | 0.358 | -0.546* |
| | (0.0632) | (0.121) | (1.476) | (0.307) |
| N HH per meter of canal, log and standardized | 0.145*** | 0.0261 | 0.285 | -0.288 |
| | (0.0291) | (0.102) | (0.704) | (0.205) |
| Distance to township government (km) | 0.0199 | -0.0437* | 0.0342 | -0.0977*** |
| | (0.0152) | (0.0224) | (0.0608) | (0.0359) |
| Inverse Mills Ratio | | -0.0730 | | -1.574** |
| | | (0.360) | | (0.780) |
| Constant | -0.418 | 0.573 | 2.252 | 2.732 |
| | (0.383) | (2.337) | (6.603) | (2.417) |
| Observations | 189 | 129 | 189 | 129 |

Notes: Robust standard errors are reported in parentheses.*, **, *** indicate levels of statistical significance at 10%, 5%, and 1%, respectively.

[a] Base outcome: Did not contribute in 2011.

[b] Base outcome: Contributed labor in 2011.

[c]. These variables are used as instruments for potentially endogenous variables (strongly trust in village leaders, strong trust in villagers, trust in villagers, villagers support financially when no irrigation, villagers cooperate to mitigate extreme weather shocks governance quality): The number of years that village is founded. Last name diversity index in village, N people per mu, N nature villages merged, have largest last name, and experienced disasters between 2001 and 2007.

Table 4. Village level regressions, County fixed effects model

| | (1) | | (2) | | (3) | | (4) | |
|---|---|---|---|---|---|---|---|---|
| | % investment from farmers | | % maintenance expenditure from farmers | | % investment from farmers | | % maintenance expenditure from farmers | |
| Strongly agree villagers can be trusted | 1.551* | (0.715) | 0.220 | (0.633) | 1.520* | (0.795) | 0.240 | (0.645) |
| Agree villagers can be trusted | 1.422** | (0.612) | -0.670 | (0.594) | 1.466** | (0.659) | -0.614 | (0.641) |
| Strongly agree village leaders can be trusted | 0.517 | (0.625) | -1.348* | (0.626) | 0.411 | (0.533) | -1.357** | (0.528) |
| Agree village leaders can be trusted | 0.226 | (0.348) | -0.557** | (0.219) | 0.239 | (0.264) | -0.554*** | (0.159) |
| N relatives or friends for financial support | -0.00865 | (0.00559) | 0.0131** | (0.00513) | -0.0108 | (0.00646) | 0.0132** | (0.00478) |
| Adjusted N non-water associations | 0.0157 | (0.0259) | 0.00404 | (0.0232) | | | | |
| Governance quality | -0.0732 | (0.603) | 0.394 | (0.235) | -0.169 | (0.520) | 0.383 | (0.236) |
| N canal O&M tasks managed by villagers | -0.0945** | (0.0422) | -0.0288 | (0.138) | -0.0368 | (0.0418) | -0.0145 | (0.121) |
| Villagers support financially when no irrigation | -0.0815 | (0.131) | 0.110 | (0.172) | -0.101 | (0.115) | 0.110 | (0.146) |
| Village leaders resolve water allocation conflicts | -0.207 | (0.202) | -0.134 | (0.164) | | | | |
| Report rule-breaking behavior | -0.117 | (0.172) | 0.0102 | (0.162) | | | | |
| Villagers mitigate extreme weather shocks on their own | -0.385 | (0.281) | -0.196 | (0.162) | | | | |
| Villagers cooperate to mitigate extreme weather shocks | -0.549 | (0.367) | -0.0812 | (0.394) | -0.208 | (0.283) | 0.0724 | (0.401) |
| Village per capita land holding in mu 2007 | -0.0388 | (0.0523) | -0.137** | (0.0607) | -0.0293 | (0.0544) | -0.127* | (0.0633) |
| % lined canal in village | 0.112 | (0.201) | 0.212 | (0.195) | -0.0435 | (0.147) | 0.150 | (0.213) |
| % irrigated area in village | 0.704 | (0.821) | -1.114 | (0.966) | 0.771 | (0.788) | -1.102 | (0.825) |
| Canals in village silt up easily | 0.0112 | (0.183) | -0.263** | (0.111) | 0.0353 | (0.166) | -0.237** | (0.0919) |
| N HH per meter of canal, log and standardized | 0.0449 | (0.0401) | -0.121* | (0.0652) | 0.0485 | (0.0414) | -0.108 | (0.0645) |
| % villagers with junior high or above education in 2007 | 0.265 | (0.235) | 0.236 | (0.296) | 0.326 | (0.242) | 0.274 | (0.275) |
| Income per capita(1000 yuan) in village 2007 | -1.40 | (3.38) | 2.04 | (3.46) | -1.60 | (3.11) | 1.99 | (3.44) |
| % off-farm in village 2007 | -0.929 | (0.570) | 2.040*** | (0.386) | -0.952 | (0.564) | 2.027*** | (0.327) |
| Distance to town government in km | -0.0216 | (0.0213) | -0.00400 | (0.0258) | -0.00931 | (0.0191) | 0.00248 | (0.0267) |
| Constant | -1.477 | (1.103) | 2.272 | (1.498) | -1.892 | (1.266) | 2.009 | (1.409) |
| Observations | 50 | | 52 | | 50 | | 52 | |

Notes: Robust standard errors are reported in parentheses.
*, **, *** indicate levels of statistical significance at 10%, 5%, and 1%, respectively.

## Appendix

Appendix 1. Factors loadings of social capital measures

| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 |
|---|---|---|---|---|---|---|
| Do you agree village leaders can be trusted? | **0.8223** | -0.0236 | 0.044 | 0.153 | 0.0065 | 0.1193 |
| Do you agree villagers can be trusted? | **0.8489** | -0.0665 | -0.018 | -0.0402 | 0.0988 | -0.0351 |
| N relatives or friends for financial support | -0.1042 | -0.0725 | 0.3767 | **0.4844** | **0.5307** | -0.2175 |
| Adjusted N non-water associations | -0.0218 | **0.7908** | -0.1367 | -0.0284 | -0.0399 | 0.0607 |
| Governance quality | -0.0525 | **0.8229** | 0.0915 | 0.1026 | 0.0224 | -0.0612 |
| N O&M tasks managed by farmers | 0.0196 | -0.0327 | **0.931** | -0.0766 | -0.118 | 0.0455 |
| Relatives or friends help financially when no irrigation | 0.0262 | 0.0886 | -0.1165 | **0.728** | 0.0403 | 0.1217 |
| Neighbors help financially when no irrigation | 0.0854 | 0.0165 | 0.0535 | **0.6778** | -0.2222 | 0.2208 |
| Village leaders help financially when no irrigation | 0.1065 | 0.2934 | 0.1246 | -0.3849 | **0.4155** | 0.3484 |
| Village leaders resolve water allocation conflicts | 0.0286 | -0.0673 | -0.138 | -0.048 | **0.7594** | 0.0975 |
| Report rule-breaking behavior | **0.4123** | 0.0788 | -0.0716 | -0.18 | **0.5216** | -0.0564 |
| Villagers mitigate extreme weather shocks on their own (reverse coded) | 0.0848 | 0.0741 | 0.0508 | 0.0612 | 0.1219 | **0.8607** |
| Villagers cooperate to mitigate extreme weather shocks | -0.0318 | -0.0777 | -0.0354 | 0.2027 | -0.0681 | **0.72** |

Notes: Bold figures are used to emphasize the variables that were highly correlated with extracted factors.
*, **, *** indicate levels of statistical significance at 10%, 5%, and 1%, respectively.
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Appendix 2. Individual-level regressions, reduced model
First stage regression of 2SLS model

| | (1) Strongly trust in village leaders | (1) Strong trust in villagers | (2) Trust in villagers | (5) Governance quality | (3) Villagers support financially when no irrigation | (4) Villagers cooperate to mitigate extreme weather shocks |
|---|---|---|---|---|---|---|
| Last name diversity index in village | 0.460 | -0.232 | -0.203 | 0.147 | 1.468 | -0.351 |
| | (0.506) | (0.575) | (0.514) | (0.157) | (1.207) | (0.540) |
| Farmer has the most common last name | -0.0485 | 0.0562 | 0.0188 | -0.0273 | -0.0515 | 0.121* |
| | (0.0624) | (0.0681) | (0.0544) | (0.0228) | (0.156) | (0.0635) |
| N villages merged | -0.00721 | 0.0160 | 0.00300 | -0.0313*** | 0.0200 | 0.00460 |
| | (0.0142) | (0.0154) | (0.0137) | (0.00436) | (0.0381) | (0.0169) |
| Number of years a village has been formed | 0.00220 | -0.00271 | 0.00384** | 0.000595 | -0.00715 | -0.00353* |
| | (0.00226) | (0.00235) | (0.00183) | (0.000723) | (0.00575) | (0.00211) |
| N people per mu | -0.0363 | 0.0829 | 0.0682 | -0.0794 | -0.190 | -0.0626 |
| | (0.0994) | (0.116) | (0.0921) | (0.0487) | (0.310) | (0.141) |
| Experienced disasters between 2001 and 2007 | -0.123* | 0.0670 | -0.0562 | 0.00388 | 0.0248 | 0.0714 |
| | (0.0684) | (0.0740) | (0.0540) | (0.0228) | (0.166) | (0.0735) |
| Age | -0.00131 | 0.00202 | -0.000692 | 0.00288** | 0.00720 | 0.00126 |
| | (0.00288) | (0.00327) | (0.00258) | (0.00111) | (0.00708) | (0.00345) |
| Years of schooling | -0.00887 | 0.0119 | 0.00831 | 0.00628 | 0.0811*** | 0.0104 |
| | (0.0115) | (0.0125) | (0.00975) | (0.00405) | (0.0265) | (0.0119) |
| Household size | -0.0331 | 0.0299 | -0.0353 | 0.00498 | -0.0808 | -0.0325 |
| | (0.0228) | (0.0270) | (0.0213) | (0.00861) | (0.0534) | (0.0258) |
| % female | -0.273 | 0.289 | 0.0994 | 0.193*** | 0.832 | 0.0588 |
| | (0.223) | (0.222) | (0.192) | (0.0729) | (0.577) | (0.211) |
| Total HH asset (100,000 yuan) | 0.0737 | -0.119 | 0.0325 | -0.00316 | -0.299 | 0.0744 |
| | (0.0935) | (0.1000) | (0.0747) | (0.0271) | (0.361) | (0.135) |
| % off-farm | 0.00706 | 0.0618 | 0.0486 | 0.0827 | -0.0267 | -0.418* |
| | (0.223) | (0.221) | (0.213) | (0.0740) | (0.470) | (0.214) |
| % rice | -0.106 | 0.159 | -0.0515 | 0.136*** | 0.100 | -0.0618 |
| | (0.0938) | (0.103) | (0.0765) | (0.0321) | (0.263) | (0.114) |
| HH per capita land holding (mu) | -0.00500 | 0.0187 | -0.0200 | -0.00857 | 0.0514 | -0.0213 |
| | (0.0151) | (0.0168) | (0.0121) | (0.00636) | (0.0453) | (0.0194) |
| % lined canal in village | 0.0399 | 0.0444 | -0.0658 | -0.322*** | -0.244 | 0.151 |
| | (0.114) | (0.124) | (0.0797) | (0.0399) | (0.297) | (0.135) |
| % irrigated area in village | -1.024*** | 1.085*** | -0.921*** | -0.204 | 1.979** | -0.0342 |
| | (0.379) | (0.379) | (0.322) | (0.157) | (0.886) | (0.478) |
| Canals in village silt up easily | 0.0326 | -0.0222 | -0.000602 | -0.108*** | -0.140 | 0.134 |
| | (0.0937) | (0.0969) | (0.0972) | (0.0293) | (0.225) | (0.0989) |
| N HH per meter of canal, log and standardized | 0.0287 | -0.0225 | -0.0613* | -0.0317** | 0.0505 | -0.0474 |
| | (0.0437) | (0.0478) | (0.0362) | (0.0152) | (0.110) | (0.0476) |
| Distance to township government (km) | 0.00231 | -0.000343 | 0.00133 | 0.00864** | -0.0192 | -0.00413 |
| | (0.0119) | (0.0130) | (0.0103) | (0.00411) | (0.0334) | (0.0146) |
| Partial *F* statistics | 0.92 | 0.65 | 1.19 | 0.65 | 10.06*** | 1.28 |
| Observations | 189 | 189 | 189 | 189 | 189 | 189 |

Notes: Robust standard errors are reported in parentheses
*, **, *** indicate levels of statistical significance at 10%, 5%, and 1%, respectively.