Water scarcity and cooperation: evidence from rural China

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Abstract: This study examines the impact of long-term exposure to water scarcity on farmers' cooperation. A unique historically formed irrigation water quota system in western China provides an opportunity to exogenously measure variation of water scarcity within an otherwise homogenous region. Specifically, we use the ratio of the arable land to the irrigation water quota of each village as our measure of water scarcity. Moreover, we use both survey questions and economic experiment to measure cooperation. We find a positive and robust relationship between long-term water scarcity and cooperation measured by both the irrigation-related collective activities and contribution in the public goods game. The result suggests that long-term exposure to water scarcity does not only improve collective actions in irrigation-related activities, but also strengthen farmers' preference for cooperation. It implies that as water is more scarcity, the value of collective action increases and thus farmers work more closely together. This better collective action experience in agricultural activities fosters a stronger culture of cooperation, which then spill over to other aspects of life such as their behavior in our experiment.

Key words: Water scarcity; Irrigation; Cooperation; Public goods game; China

JEL codes: C92; C93; Q15; Q25

1.Introduction

Scarcity is one of the core conceptions of economics. Literature has shown that resource scarcity is related with more competition, conflicts, less pro-social behavior and more anti-social behavior. Long-term exposure to scarcity could induce anti-social behavior (Prediger, Vollan, & Herrmann, 2014). Negative climate and economic shocks that tighten resource constraints could also incite conflicts (Burke, Hsiang, & Miguel, 2015; Maystadt & Ecker, 2014; Miguel, Satyanath, & Sergenti, 2004). And in experiment settings, artificially created scarcity also undermines pro-social behavior (Blanco, Lopez, & Villamayor-Tomas, 2015; Gatiso, Vollan, & Nuppenau, 2015; Pfaff, Velez, Ramos, & Molina, 2015). Moreover, the experience of short-term scarcity could have profound long-term impact on people's behavior as well. For example, using a framed field experiment, Blanco et al. (2015) find that people who experienced a reduction in available resources extract more resources in later rounds when the amount of resources rebound to the initial level.

However, resource scarcity also has the potential to induce cooperation among people since there are incentives to use the limited resources efficiently and maximize the welfare for the society as a whole. In experimental settings, there are evidence suggesting that people could refrain themselves, at least to some extent, from over appropriating when facing increasing scarcity (Oses-Eraso, Udina, & Viladrich-Grau, 2008; Oses-Eraso & Viladrich-Grau, 2007). In the field studies, it has been shown that the common pools resources could be governed by self-organizing collective actions in developing countries (Ostrom & Gardner, 1993). Especially in the context of irrigation, utilizing water resource often demands large scale collective actions in building and maintaining irrigation infrastructures. Existing studies have found that irrigation system is able to foster collective actions and facilitate social capital among people through the collective efforts on constructing and maintaining local canals, regulating and monitoring water allocation and coordinating in crop types and plots arrangement to facilitate irrigation (Aoyagi, Sawada, & Shoji, 2014; Bardhan, 2000; Fujiie, Hayami, & Kikuchi, 2005; Tsusaka, Kajisa, Pede, & Aoyagi, 2015).

In this study, we investigate how water scarcity within a gravity irrigations system affects people's preference for cooperation. We hypothesize that as irrigation water is scarcer, farmers have stronger incentives to work collectively on the irrigation system and thus achieve better collective actions in irrigation activities. Furthermore, the experience of better collective actions fosters a stronger social norm or culture of cooperation within the community. Since farmers could have internalized such norms, we would be able to observe more cooperative behavior in settings beyond irrigation.

Instead of using experimental method and manipulating scarcity in endowment artificially(e.g. Pfaff et al., 2015), we examine the impact of long term exposure to water scarcity in real life using a unique irrigation water quota system in western China. The amount of water quota allocated to each village was based on the self-reported irrigated land areas by villages in the period of the construction of the reservoir and canals in 1960s. While, more self-reported irrigated land areas, more workload required on the villages to construct the reservoir and canals in 1960s. The tradeoff between the benefits (more irrigation water) and costs (more labor input in canal construction) thus resulted in the differences in the ratio of allocated water quota and actual arable land areas [1], which created variations in water scarcity in later agricultural activities. We use two indicators to measure farmers' cooperation: one is their cooperative actions in and attitudes toward irrigation activities based on household survey information; the other is their contribution in a public goods game as a measure of their general preference for cooperation based on a lab experiment in the field.

We find significant and positive correlation between water scarcity and irrigation-related activities: people living in more water scarce villages tend to have better coordination in crop-plot choices to facilitate irrigation and better attitude towards cleaning local canals. More water scarce villages also tend to have higher canal quality. Moreover, the impact of water scarcity goes beyond irrigation-related activates. The scarcity of irrigation water also improves villagers' propensity to cooperate in the abstract setting of public goods game.

This study contributes to two strands of literature. First, it contributes to the discussion of the impact of resource scarcity on social preferences. Some studies have linked moderate scarcity with better collective actions (Araral, 2009; Ito, 2012; Wang, Chen, & Araral, 2016).Yet better collective actions do not necessarily mean more cooperation, as contributing more to collective actions could also be a dominant strategy for people who only maximize their own payoffs instead of social/community

[1] See Section 2.1 for more detailed description on the history of irrigation water quota system.

payoffs when facing increasing resource scarcity. By looking at behavior in an abstract game setting, our study finds that the long-term exposure to resource scarcity does not only lead to better collective actions in irrigation activities, but also improve people's preference for cooperation.

Second, this study speaks to the literature on the influence of institutions on social preferences. Bowles (1998) has reviewed how markets as economic institutions could have shaped people's social preferences. People tend to generalize the successful strategies in performing economic tasks to other spheres of life. Work organizations that require people working together have been found to improve cooperation (Attanasio, Polania-Reyes, & Pellerano, 2015; Carpenter & Seki, 2011; Gneezy, Leibbrandt, & List, 2016). The gravity irrigation system per se as an institutional arrangement that requires collective efforts also improves the pro-social preferences of the users when compared with non-irrigation farmers (Tsusaka et al., 2015). Our findings further show that, within the gravity irrigation system, farmers who have strong incentive in collective actions became more cooperative than those with weak incentives.

The rest of this paper is organized as follows: Section 2 describes our empirical strategy and the data; Section 3 and 4 present empirical results and the discussion of the implication of the results respectively; Section 5 concludes the paper.

2. Empirical strategy and data

2.1. Study site: irrigation water quota system in Minle

We carried out our study in Hongshui River Irrigation District in Minle County, Gansu Province in northwestern China. Minle County is an oasis located in the northern foothills of the Qilian Mountains and lies in the middle of the Hexi corridor, where is featured by semi-arid climate and the long history of irrigation agriculture.[2] The traditional and the main source of irrigation water is surface water from local rivers. Hongshui River is the largest of the five major rivers in Minle County and Hongshui River Irrigation District is the largest irrigation district in the county and one of the "large irrigation districts" at national level. We choose to focus on one irrigation district in one county in order to eliminate confounding factors such as different geo-climate conditions, different socio-economic histories,

[2] Zhang, Heerink, Dries, and Shi (2013) has provided a detailed introduction of the social-economic and geo-climate background of Minle County.

different irrigation cultures and traditions, and different local regulations and policies.

The current irrigation water quota system in Hongshui River Irrigation District was introduced in 1966, as a reform to the old irrigation water allocation system. The old system allocated irrigation water based on the actual sown areas reported by villages. In 1966, as the construction of the new canal which requested labor input from local villagers, the county authority introduced the water quota reform. Villages that would benefit from the new canal system were asked to report their irrigated land area. These self-reported irrigated land areas were then used as the sole criterion for the allocation of both irrigation water and the workload of irrigation infrastructure construction and maintenance across villages later. The villages that received more irrigation water also undertook larger obligation in the irrigation infrastructure construction. We will refer this self-reported irrigated area as "irrigation water quota" or "water quota" for simplicity in the rest of the paper.

Since the availability of irrigation water was tied with labor input obligations, when reporting the irrigated area, villages had to balance between the benefits (more irrigation water) and costs (more labor input in canal construction rather than in their own land). Such trade-off considerations resulted in differences between irrigation water quota and the actual land size across villages. Villages received relatively more water quota suffered less from water scarcity in later years and *vice versa*, which created variations in the relative water scarcity across villages. In this study, we take advantage of these historically formed variations in water scarcity to examine the impact of water scarcity on cooperation.

2.2 The measure of water scarcity

The measure of water scarcity is prominently crucial for our empirical model specification. The level of scarcity is determined by the demand for the resource compared to the availability of the resource. Therefore, we create our water scarcity indicator based on the ratios of the potential demand for water to the accessible irrigation water supply of each village. To be specific, we construct our water scarcity indicator at the village level as follow:

$$Scarcity = \frac{Village\ arable\ land\ areas}{Village\ irrigation\ water\ quota}.$$

The irrigation water quota of each village in the denominator represents the supply of irrigation water and arable land areas of each village in the numerator represents the potential demand for water.[3]The ratio represents how much arable land one unit of water quota has to irrigate.[4]Water is scarcer when the ratio is larger. In sampled villages, the arable land areas at village level have never been changed since the late 1970s. Changes in the water quota have been rare and on relatively small scale. Six out of the twenty-six villages in our sample reported that they r had experienced the changes in village water quota. The latest change can be traced back to 1997.We adjust the current water quota to these changes and use the numbers after adjustment to calculate the ratio. We believe that this ratio could to a large extent capture the differences in a relatively long-term water scarcity between villages.

It is crucial to our identification strategy that the variations in our water scarcity measure is exogenous to people's social preferences. There could have five potential sources of endogeneity. First, the water quota was decided by the older generation, rather than the villagers we interviewed. Even the oldest villager in our sample (66-year-old) was a teenager in 1966 when the water quota was determined. They might have been involved in the later construction of the canals and the reservoir, but they were certainly not involved in deciding how much irrigated land should be reported to the county authority. We can safely say that the irrigation water quota and hence the degree of water scarcity was imposed upon them, rather than determined by them.

Second, migration across villages with different degrees of water scarcity could also jeopardize the efficacy of our water scarcity measure. If water scarcity pushed people with certain features to move out villages, it then creates selection biases. However, because Chinese hukou system largely tied people to where they are registered, especially for the rural resident, migration is much less likely due

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[3]We use the potential demand for water (represented by arable land of each village) instead of actual demand measures such as sown area and crop portfolio, because the actual demand is likely to be endogenous to the availability of irrigation water. Besides, arable land sizes are stable over time while sown areas and crop portfolios vary every year. Using arable land sizes as numerator captures long term scarcity, on which this study is focused, better than using actual water demand measures in 2015.

[4] The ratio is used to compare the level of water scarcity among villages within Hongshui River Irrigation Districts. It is not an indicator that is comparable to water stress level in other regions. When comparing Minle with the rest of Gansu or China, we believe the extent of irrigation water scarcity can be seen as "moderate". Water resource is scarce as water is the single most binding resource to local agricultural production. We regard water resource in Minle as not being very scarce because irrigation agriculture in Minle is still very active and Minle and neighboring areas have been famous for their irrigation agriculture throughout the history.

to the insufficient water. Marriage has been a legitimate reason for inter-village migration, but it is much more common for women than for men. In our all male sample, only four subjects were not born in the villages they live in. Therefore, we do not believe that selection bias though migration is an important issue in our study.

Third, since our measure of water scarcity focus on surface water, groundwater availability could also affect the validity of our identification strategy. However, we believe the groundwater is not an important issue for two reasons. First, while we focus on the long-term exposure to water scarcity in this study, the use of groundwater is a recent phenomenon in Minle. The oldest well in the 26 villages we visited was dug in 1987, the second oldest one was dug in 1998 and there were only five wells before 2009. The boom of well digging occurred in 2011 and 2012, when 58%[5] of the wells were dug in these two years. The second reason is that despite the increasing access to groundwater in recent years, groundwater water is still not an important source for agricultural irrigation. The cost of pumping groundwater out of the deep wells is much higher than that of surface water. And the most importantly, the groundwater salinity is much higher than surface water, and salinity is harmful to yields and soil fertilit. Therefore, the groundwater is only used as a complementary to surface water. Irrigation water scarcity is mainly driven by the access to surface water.

Fourth, as each unit of water quota receives the same amount of water, the shocks and uncertainty in water supply affect all villages simultaneously in the same way. Therefore, the impact of water scarcity is this study is not confounded by variations and uncertainty in water supply. The quota system also limits the maximum amount of water that a village can use, so that unlike in a common pool resource situation, the water use of one village within its quota does not affect how much water that other villages can use. And as long as the irrigation district administration allocates water reasonably, water use today does not harm the availability of water tomorrow. Therefore, the typical intertemporal concern in a common pool resource plays very little role in determining the behavior of farmers in our case. Furthermore, as the water quota of each village and the time of irrigation are known to the whole

[5] There are 90 wells in total in the 26 villages, but we only have the information on which year they were dug for 79 wells. Two villages only reported when their first wells were dug (2002 and 2011).

irrigation district and irrigation is controlled by the sluices on the main canal, chances of stealing water from other villages are very low. Inter-village competition over water is very unlikely to affect people preferences within their villages.

Fifth, the intergenerational transmission of social preferences could be a potential source of endogeneity. If the older generations were more pro-social and thus were willing to contribute more to the public projects in exchange for more water, or if they formed a more cooperative culture or social norm through working together on the public projects, and their pro-social preferences could be inherited by the younger generations, then either the water scarcity in terms of irrigation water quota is the result of certain social preferences or both the scarcity and the social preferences are results of some omitted factors. Although we cannot rule out this possibility, we believe that, as we will discuss later, even if such endogeneity exists, it does not jeopardize our main findings.

2.3 Measure of collective actions and cooperation

2.3.1. Collective activities in irrigation management

The higher level of water scarcity increases the equilibrium level of farmers' efforts into collective irrigation management. The most straightforward measure of such effort is the actual labor or monetary contribution to irrigation-related collective activities. For instance, Ito (2012) uses the household labor contribution to irrigation management as the measure of collective actions of farmers. However, such labor or monetary contribution in rural China is usually organized by local administration and hardly fully voluntary and it is often affected by many factors that we cannot observe. Alternatively, we turn to activities that are carried out more voluntaries and individually. Specifically, we focus on two aspects: coordination with other farmers when deciding what crops to grow and which plots to grow them on; and keeping the canals free of trashes. The farming coordination can improve irrigation efficiency because when the neighboring plots are growing the same type of crops, they can be irrigated at one time when water is most needed which thus can reduce the water loss from multiple rounds of irrigation. Keeping the canals and ditches clean is important as it helps to maintain the speed of the water flow so that farmers can get the amount of water they are entitled to. We asked three questions on either of these two aspects and the specific questions and how we construct the variables are listed in the following table 1. Besides, we also use the self-reported canal quality to measure the outcome of farmers' collective effort on irrigation management. If water scarcity can push farmers to work more on the canal maintenance, we expect to see that such efforts result in higher canal quality. The specific definition of this outcome measure is also listed in Table 1.[6] Table 1 also reports the means and standard deviations of these measures of collective actions. We can see that there exist much variations in our identified irrigation-related activities and the self-reported canal quality. We expect that higher level of water scarcity leads to better cooperation in irrigation related activities and better irrigation canal quality.

[Table 1 is here]

2.3.2. Public goods game[7]

To measure people's general preference for cooperation, we conducted a five rounds repeated linear public goods game with a stranger design. subjects were randomly divided into 3-person groups at the beginning of each round. Each subject received an initial endowment of ¥10 in each round. They were asked to decide how much to keep in a personal account and how much to contribute to a group account. The payoff function is described as follow:

$$\pi_i = 10 - g_i + 0.5\sum_{j=1}^{3} g_j.$$

$\pi_i$is subject i's payoff andg_i is his contribution to the group account. The size of the group account equals to the sum of the contribution from the three participants in the same group. The marginal payoff of the group account is 0.5, offering monetary incentives to free ride. After subjects made their contribution decisions they were informed about the total group contribution and their individual payoffs at the end of each round. We use the subjects' average contributions in this public goods game

[6] The maintenance of the third-tier canals is the responsibility of the irrigation district, not the village. The fourth and fifty tier canals together are often referred as "end level canal network (*Mo Ji Qu Xi*)". The first-tier canal is the single main canal that connected directly to the reservoir. The second-level canals are the branches stemming from the first-tier canal and carry irrigation water to multiple villages along it way. Both of these two higher level canals are governed by higher administrations and are not directly involved in village level irrigation. Thus, we didn't include them in the questions on canal quality.

[7] This public goods game is part of (the third stage) a five-stage experimental session. Before this stage of public goods game, everyone had played one risk choice game and three binary choice dictator games. The payoffs from these previous games were only revealed to the subjects after the whole session, so that the subjects would not be affected by these choices. After this stage of 5 round public goods game, subjects were asked about their preferences between a punishment and a reward institution and they then were randomly assigned to one of the institution for another 5 rounds of public goods game with punishment or reward. See Yang et al. (2017) for a full description for the whole experiment session.

and the contribution in the first round as our measure of people' preference for cooperation. On average, subjects contributed 5.95 *Yuan* into the public account.

We conducted the experiment in January 2016 along with a household survey. The experiment was computerized and programed with z-Tree (Fischbacher, 2007). We created a lab environment with tablets and paper boxes in the conference rooms of village administration buildings. We turned paper boxes into small cubicles with tablets inside so that subjects could make their decisions independently and anonymously. Communications among subjects were not allowed. Subjects received oral instructions from the experimenters at the beginning of each stage and were asked to answer practice questions on paper. The practice questions aimed to test whether the participants understood how to calculate the payoff from the contributions in public good game. The experiment only proceeded when all subjects were able to correctly answer the practice questions. The whole experiment lasted 60-90 minutes.[8] All subjects also participated in a household survey. The payment was done after the experiment and survey. The average payment to subjects was 166 *Yuan*[9], which equals approximately one and half day salary of a local full-time off-farm worker.

2.4 Recruitment and Subject Pool

We randomly selected 26 villages in in Hongshui River Irrigation District in Minle County and selected 12 men from each village as our experiment subjects and survey respondents. We chose male-only subjects for several reasons. Men are usually household decision makers and represent the family in most of the community events.[10] More importantly, compared to women, men are more involved in agricultural production and irrigation-related activities. In a way, men are more exposed to water scarcity and irrigation than women. Moreover, middle age women in rural Gansu mostly received little education and they had trouble understanding the setup of our experiment in our pilots. Therefore, we limit the subjects to male.

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8 Again, the experimental duration and the following payment are for the whole five –stage experiment.

9 1 USD=6.89 CNY.

10 It has been found that women on average have lower bargaining power than their husbands in context of rural western China (Bulte, Tu, & List, 2015; Yang & Carlsson, 2016).

Our targeting age range of subjects was from 40 to 65 years old.[11] We set the age range as we wanted to target at the people who had been exposed to irrigation water scarcity for an relatively long period and engaged in irrigation activities. We excluded older men as they were already gown up as adult when water quota system was established and they might have been influenced by the experience of canal and reservoir construction and might even have played a role in determining water quota. We excluded younger generation as they were less exposed water scarcity and less engaged in agricultural activities. The summary statistics of individual and household characteristics are presented in Table 2. We can see that 304 out of the 312 subjects are household heads[12]. The average age is 51 years old. The average education level is quite low (primary school education). All subjects are ethnic Han. Only two subjects reported to have urban hukou, while the rest all have rural hukou.[13] The subjects on average have spent more than 8 months at home and 96 days on farming in 2015. 39%of the subjects have been employed in off-farm activities. The average gross household income per capita is 22,060*Yuan*. 35% of the villages have non-farm enterprises and the average share of local off-farm labor in each village is 19%. As the key variable for our study, we can see that the water scarcity ratio is 1.38 with the quite big variation (range from 1 to 2.02).

[Table 2 is here]

3.Results

3.1 Water scarcity and cooperation in irrigation/farming actives

First, we test whether the higher level of irrigation water scarcity leads to better cooperation in irrigation management. Table 3 displays the probit regressions results of the impact of water scarcity on actions in and attitudes towards irrigation-related activities. The variable of interest is the water scarcity indicator constructed as described above. The other control variables are individual characteristics (age, schooling, no. of siblings and non-farm activity), household characteristic(household size, contracted

11 However, during the process of survey implementation, there were actually two men younger than 40 years old (35 and 37 years old) and two men older than 65 years old (66 years old) who were also included in the survey. But we don't believe this is a serious issue, and this does not affect our main results.

12 One subject is the son of household head and seven are the father of the household heads.

13 Hukou is a record in a Chinese government system of household registration and determines where citizens are allowed to live (Wikipedia).

and size, whether the subject has the majority family name and gross income per capita) and community features (village arable land size, distance to town seat, distance to county seat, whether village have non-farm enterprise and the share of labor in non-farm sector) that might influence one's attitude and actions in irrigation related collective activities according to literature(Araral, 2009; Wang et al., 2016). The results show that the coefficients of water scarcity indicators all have positive signs that are consistent with our expectation, although only three of them are statistically significant.

If higher degree of water scarcity affects collective actions in irrigation management, it should reflect on the quality of different canals (the result of collective actions) as well. Since the maintenance of the third-tier canals is the responsibility of the irrigation district, not the village, we do not expect any significant impact; as the fourth-tier canals and fifth-tier canals are often shared and managed by local farmers as local public goods, we expect to see the water scarcity improves their quality. To test this, we run an ordered probit regression of self-reported canal quality (1-5 scale, 5 as best quality) on water scarcity. The results are shown in Table 4 and they confirm our expectations. To sum up, we do find that water scarcity increased farmers' effort on collective irrigation management.

[Table 3 is here]

[Table 4 is here]

3.2 Water scarcity and Contributions in the PGG

We have shown that water scarcity improves collective actions in irrigation activities. However, the results do not necessarily mean that water scarcity could affect people's willingness to cooperate in any other situation. When water is scarcer, the value of collective action increases so that self-interest people could also contribute more to the collective actions in irrigation activities. It maybe still of their best interests to free ride in a different setting where free-riding is the dominant strategy for self-interest people. Therefore, we further examine whether water scarcity improve cooperation in a more abstract setting such as in a public goods game.

As introduced in the previous section, we use contributions in a public goods game as our measure of general willingness to cooperate. Specifically, we use two variables, average contribution over five rounds and the contribution in the first round in the PGG, as our measure for subjects' preference for cooperation.

As we are interested in the relation between water scarcity and preference for cooperation, we first show the relationship between the water scarcity indicator and the average contributions in the public goods game (PGG) in Figure 1. Despite the large variations in average contribution level at different degree of water scarcity, there is a positive correlation between scarcity and cooperation (the fitted line in red). Replacing the average contribution over five rounds with contribution in the first round gives very similar result.

[Figure 1 is here]

We then formally tested this relationship with OLS regression as shown in Table 5. As we find that water scarcity makes farmers achieve better irrigation management though collective effort, we expect such effects can be generalized to other spheres of life and result in higher contribution in PGG.

[Table 5 is here]

The first column of Table 5 confirms the positive correlation between water scarcity and average contribution over the five rounds of the public goods game. Larger degree of water scarcity has a positive effect on cooperation among local villagers, although the positive coefficient is only significant at 10% level. In column (2) we added household and village level characteristics that may affect one's willingness to cooperate. The effect of water scarcity gets even larger and more significant than in column (1), while the characteristics are not good predictors of villagers' contributions in PGG, except for the number of siblings and the arable land size of the villages. Both the number of siblings and the logarithmic of the village arable land size have a significant and negative effect on contributions. This result is consistent with our expectation since the difficulties of coordination among farmers increase with the scale of irrigation.

As mentioned before, groundwater availability is another factor that might affect our measure of water scarcity. Despite that we don't believe that the recent availability of groundwater could have an impact on people's preferences, we formally tested this in column (3).We include the number of wells per hundred-hectare arable land to control for the availability of ground water. The result confirms our previous argument. Access to groundwater does not affect average contribution in the game and the significance of water scarcity keeps unchanged.

So far, we focus on the village level water scarcity since we believe that the impact of water scarcity works through the interaction among people and shape the people's preferences at community level rather than at individual or household level. In column (4), we added household level water scarcity indicator constructed in a similar way as the village level indicator. The result shows that household level scarcity doesn't affect people's contribution in the public goods game. This finding supports our previous argument that the effect of water scarcity works through fostering a more cooperative norm by the whole community, not by any individual farmer. From column (5) to (8), we replicate the same regression as column from (1) to (4), but with contribution in the first round of PGG as the dependent variable. The results are very similar. As the contribution in PGG is limited to the range from 0 to 10, we also run tobit regressions for this censored-type data and the results are very close to the OLS results as we show here.[14]

3.3 IV estimated results

Although we have discussed the exogeneity of our water scarcity measure in Section 2, we cannot completely rule out the potential endogeneity problem. Our measure is endogenous if the water quota and thus relative water scarcity was affected by older generations' attitude towards public goods, and such cultural, norm or social preferences are inherited by the younger generation. The villages that valued public goods more and thus were more willing to contribute to the canal and reservoir construction would tent to acquire more water quota than the villages that valued public goods less. This relation holds for the younger generation as well if their attitudes toward public goods are influenced by the older generation, which implies a negative relation between water scarcity and contribution to the public goods game. Therefore, if this possible channel of endogeneity exists, then we will expect to find that the effect of water scarcity on cooperation is even stronger than the OLS results in Table 5.

We formally deal with this endogeneity concern with an instrument variable approach. We believe that,

[14] The tobit results are available upon the request.

in the context of Minle County and Hongshui River Irrigation District, the geographic location of the villages could serve as an IV for the relative water scarcity. The underlying logic is that since the reservoir was built on the upstream of Hongshui River to the south of all the villages in our sample, the cost of working on the construction project was lower for the villagers that lived closer to the reservoir; therefore, villages located in the south could be more willing to contribute than those in the north, thus received more water quota given their land size and became less water scarce since then. We use latitude information as a proxy for villages' proximity to the reservoir and as our IV for the 2SLS regression. Since higher latitude means farther away from the reservoir, we expect to see a positive relationship between latitude and our water scarcity indicator in the first stage regression. The 2SLS results are shown in Table 6, where all other explanatory variables are the same as in Table 5. Similarly, we employ the 2SLS by using both average contribution over the five rounds and the contribution in the first round in PGG. The second stage regression results are shown in column (1) and column (2) respectively. Since the first stage is the same, we only report it once in column (3).

As we can see, latitude is a strong predictor for the scarcity ratio in the first stage regression, and it does not affect the dependent variable if we include it along with the water scarcity indicator in the regression. Results from the second stage regression shows that when taking possible endogeneity of water scarcity into consideration, the effect of water scarcity on the contribution in PGG is even stronger. Our finding that higher level of water scarcity improves people's preference for cooperation still holds.

[Table 6 is here]

4. Discussion

The results in the previous section have shown that water scarcity has a positive and significant impact on public goods provision in the context of irrigation. Farmers in villages entitled to relatively less irrigation water quota are more likely to coordinate their farming decisions with each other and more willing to improve the quality of the local canal system. Moreover, water scarcity not only affects farmers' irrigation-related activities, but also influence the social preferences of the farmers. Farmers with less irrigation water are more cooperative than famers with more water in the public goods game. And this relation holds even after we take individual, household and community characteristics and the potential endogeneity into consideration.

Our findings seem to contradict with many studies on similar topics, which have found that resource scarcity often incite conflicts and competition instead of cooperation. For example, Prediger et al. (2014) finds that pastoralists in area with lower quality graze land are more likely to engage in anti-social behavior in an artefactual field experiment. Our explanation to this discrepancy lies in the different nature of irrigation water as a common pool resource from other well-documented resources. Unlike common pool resources such as pastoral land and fishery, which can be appropriated by individual or a small group of users, irrigation requires monetary and labor inputs at a much larger scale, that usually cannot be undertaken by any individual or a small group of users. Therefore, such requirements demand collective actions from local communities, and these collective actions in irrigation activities may foster cooperation among local people. As water is scarcer, the value of collective actions increases and farmers have incentives to work more closely with each other on the irrigation system. The stronger interdependence then shapes a more cooperative culture among the farmers, as discussed in Carpenter and Seki (2011) and Gneezy et al. (2016). Furthermore, our explanation is also consistent with the literature on self-governing resource management, where successful cases are often found in irrigation systems (e.g. Ostrom, 1990; Ostrom and Gardner, 1993).

Our findings also underlie the importance of institutions in shaping social preferences. An irrigation system is not only an agricultural technology, but also exerts its own set of institutional arrangements on the users as it requires users to act in a certain way in order to benefit from it. An irrigation system could foster cooperation as it requires the community to work together. Then, other technological or institutional arrangement with similar features should also help to build cooperation among farmers. This point is particularly pertinent in many communities with rural development or common pool resource management projects. The crucial element of the success of these projects is farmers' voluntary participation and contribution, which to a large extent dependent on farmers' preference for cooperation. If a project could include certain elements that require farmers to regularly work together, there may be a better outcome in the long term as the project could obtain additional benefit from the more cooperative culture that it helps to foster.

Although we believe that this study has some important policy implications for common pool resource management, we have to admit that we do not provide any direct analysis on how to manage the common pool resources efficiently. Our data only allow us to identify the causal relationship from water scarcity to social preferences, but not the other way around. Ideally, we would like to have a valid instrument variable for social preferences so that we could model and identify the two-way relationship between resource scarcity and social preferences. This has to be left for future studies.

Our current design only allows us to study the inner-group cooperation. While our findings in this study emphasize on the positive effects of resource scarcity on the inner-group cooperation, we cannot claim the same effects of resource scarcity on inter-group cooperation. People tend to act differently when interacting with people from their own group from with outsiders(Chen & Li, 2009).When facing higher level of resource scarcity, inter-community competition over the scarce resource could lead to less cooperation and more conflicts. It is not clear that how resource scarcity affects the overall preference for cooperation at a larger scale.

The scale and size of our sample also limited our ability to test the heterogeneous impacts of water scarcity on cooperation. Collecting data from one irrigation district in one county rules out differences in factors such as water distribution rules, agricultural policies and social-economic history. Although we could reach a more convincing causal relationship without variations in these factors, we also lose the confidence in generalizing our findings to other regions with different social, economic and institutional backgrounds. Moreover, since we only have 26 villages in our sample, we don’t have enough statistic power to test village level heterogeneity effects. Studies on a larger scale is needed to answer these questions.

Another limitation of this study is that we only study the impact of water scarcity in the context of moderate water scarcity in semi-arid area. We have to be cautious if we want to generalize the findings to different settings. When water is very scarce, the positive relationship between water scarcity and cooperation we find in this study may not hold. Literature has recorded a curvilinear relation between water scarcity and collective action in irrigation system (Araral, 2009; Bardhan, 2000; Wang et al., 2016). Collective action is more difficult when water is very scarce or abundant, but easier when scarcity is moderate. This means that if we apply the same analysis to a more water scarce area, we might find the opposite relationship between scarcity and cooperation. Again, a larger scale research with a wider spectrum of scarcity is needed to fully reveal the relationship between water scarcity and cooperation.

5. Conclusion

As resource scarcity is often related with competition, conflicts, anti-social behavior as shown in many macro and experimental studies, this study proposes that under proper institutional arrangement, scarcity could help foster cooperation. As scarcity means that resources are more valuable to the users, and if utilizing the resources require certain collective efforts in certain ways, people would work more closely with each other when facing higher degree of scarcity and this working experience provides the possibility that people develop a more cooperative culture.

We test this idea using experimental and survey data from an irrigation district with a unique historically formed irrigation water quota system. This irrigation water quota system formed about 50 years ago when facing the construction of the new irrigation canals and the reservoir. When balancing the labor contribution to the construction site (cost) and the right to use water (benefit), some villages get relative more water than other. This differences in water quota creates variations in water scarcity across villages and these variations formed the base of our water scarcity indicator.

We find that water scarcity does help improve individual contribution to collective efforts in irrigation-related activities. And more interestingly, the effect of water scarcity goes beyond irrigation activities and spills over to a more general preference for cooperation, which is measured by subjects' contributions in a public goods game. This relationship between water scarcity and preference for cooperation holds even if we take potential endogenous into consideration.

Our findings underlie the importance of institutions in shaping social preferences. A gravity irrigation system is not simply an agricultural technology, but also a whole set of institutional arrangements that necessitate collective action. This technological or institutional necessity could shape people's social preferences through the daily activities. Therefore, the policy implications of this study is very pertinent in resource management and environmental governance programs as these activities often rely on the voluntary participation and contribution from local people. Policy interventions that provide proper incentives for people to work together, or simply bring people together could help to foster a more cooperative atmosphere and thus facilitate the policy goals.

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Tables:

Table 1. Questions and indicators of farmers' effort on irrigation-related collective activities

Variable	Survey question		Mean (SD)	N
A: Coordination in farming				
Crop decide	How did you decide what crops to grow in 2015?	Dummy variable: 0, decide on their own; 1, decide with coordination.	0.41 (0.49)	279
Crop discuss	Do you discuss with neighboring farmers about which crop to grow on which plot every year before sowing?	Dummy variable: 1, discuss; 0, never discuss.	0.83 (0.37)	309
Reach agreement	Do you think it is easy to reach an agreement if you were to coordinate with other farmers?	Dummy variable converted from 1-5 scale: 1, very easy; 0. otherwise	0.46 (0.50)	290
B: Keep the canal clean				
Throw trash	Do people dump trash in the canal?	Dummy variable converted: 1, never or rarely; 0, often;	0.72 (0.45)	309
Stop villager	If you see other villagers damp trash in the canal, will you stop him?	Dummy variable, converted from 1-5 scale: 1, definitely will stop him; 0 otherwise.	0.83 (0.38)	312
Stop stranger	If you see a stranger damp trash in the canal, will you stop him?	Dummy variable, converted from 1-5 scale: 1, definitely will stop him; 0 otherwise.	0.88 (0.32)	312
C: Self-reported canal quality				
Canal quality: third tier	How is the condition of the third-tier canal?	1-5 scale, 1 as the worst condition and 5 as the best	3.38 (1.37)	281
Canal quality: fourth tier	How is the condition of the fourth-tier canal?	1-5 scale, 1 as the worst condition and 5 as the best	2.50 (1.26)	216
Canal quality: fifth tier	How is the condition of the fifth-tier canal?	1-5 scale, 1 as the worst condition and 5 as the best	1.89 (1.23)	219

Table 2. Summary Statistics

Variable name	Mean	SD	Min	Max	N
Individual characteristics					
Household head (dummy)	0.97	0.16	0	1	312
Age	51.4	4.96	35	66	312
Years of schooling	6.63	2.62	0	15	312
Ethnic dummy (han=1)	1	0	1	1	312
Hukou dummy (rural=1)	0.99	0.08	0	1	312
Off-farm job dummy (have any=1)	0.39	0.49	0	1	312
Time at home in 2015 (month)	8.24	3.45	1	12	312
Time spent on farming in 2015 (days)	95.7	81.4	0	365	312
Household characteristics					
No. of siblings	4.07	1.97	0	11	312
Dominant Family name dummy (yes=1)	0.83	0.38	0	1	312
Household size (person)	4.09	1.35	1	8	312
Farm size (mu)	18.36	10.94	2.5	72	312
Gross income per capita (1000 yuan)	22.06	56.23	0.06	753.41	312
Village characteristics					
Village arable land size (mu)	4959	2265	1500	11200	312
Distance to town seat (km)	5.17	2.58	1	11	312
Distance to county seat (km)	13.79	99.51	0	40	312
Village enterprise dummy	0.35	0.48	0	1	312
Share of local nonfarm labor (%)	19.01	11.54	0.75	50.61	312
Village water quota (mu)	3807	1708	1064	9520	312
Scarcity (ratio)	1.38	0.28	1	2.02	312

Table 3. Water scarcity on irrigation-related activities, probit

	(1) Crop decide	(2) Crop discuss	(3) Reach agreement	(4) Throw trash	(5) Stop villager	(6) Stop stranger
Water scarcity	0.190	0.0444	0.168*	0.238**	0.168*	0.0834
	(0.130)	(0.106)	(0.0949)	(0.101)	(0.0903)	(0.0834)
Age	0.00314	-0.00465	0.00751	-0.000529	0.0117***	0.00833*
	(0.00505)	(0.00414)	(0.00641)	(0.00448)	(0.00410)	(0.00433)
Years of schooling	-0.00821	0.00982	-0.000850	-0.00704	0.00765	0.00301
	(0.0116)	(0.0105)	(0.0117)	(0.00950)	(0.00808)	(0.00724)
Nonfarm dummy	0.0528	0.109***	-0.0231	0.00201	0.0457	0.0212
	(0.0672)	(0.0377)	(0.0563)	(0.0562)	(0.0583)	(0.0344)
Contract land (mu)	-0.00386	-0.000556	-0.00376	-0.00456	-0.000698	-0.00187
	(0.00354)	(0.00177)	(0.00244)	(0.00342)	(0.00209)	(0.00189)
No. of siblings	0.00856	0.0166	0.00263	-0.00630	-0.00569	0.00120
	(0.0142)	(0.0114)	(0.0134)	(0.0156)	(0.00905)	(0.0104)
Household size	0.00209	0.0262*	-0.00315	0.00404	0.000434	0.0125
	(0.0282)	(0.0135)	(0.0239)	(0.0163)	(0.0154)	(0.0133)
Majority family name dummy	-0.0504	-0.0153	-0.150*	0.00242	0.0572	0.0851
	(0.0760)	(0.0673)	(0.0786)	(0.0602)	(0.0887)	(0.0580)
ln(Gross household income)	0.0137	-0.0486*	-0.00891	-0.00938	-0.00370	0.0167
	(0.0356)	(0.0241)	(0.0304)	(0.0301)	(0.0218)	(0.0187)
ln(village arable land)	0.0369	0.111*	0.0994*	0.0186	-0.0654	0.0148
	(0.0741)	(0.0582)	(0.0554)	(0.0843)	(0.0694)	(0.0652)
Distance to town seat	0.0453***	-0.000261	-0.0270***	0.00161	0.0120	0.00714
	(0.0105)	(0.0121)	(0.00847)	(0.00862)	(0.00823)	(0.00765)
Distance to county seat	0.000729	0.000588	-0.00345	-0.00314	0.00106	-0.000570
	(0.00272)	(0.00365)	(0.00284)	(0.00353)	(0.00286)	(0.00275)
Village enterprise dummy	-0.0462	0.0622	-0.0122	0.0982*	0.0244	0.0263
	(0.0649)	(0.0559)	(0.0504)	(0.0557)	(0.0521)	(0.0415)
Share of local nonfarm labor	0.700**	0.414*	0.203	-0.253	0.0393	-0.105
	(0.262)	(0.204)	(0.165)	(0.199)	(0.182)	(0.188)
Constant	-0.395	0.684*	0.120	0.687**	-0.103	0.144
	(0.355)	(0.333)	(0.390)	(0.302)	(0.303)	(0.252)
Observations	279	309	290	309	312	312
R-squared	0.114	0.081	0.064	0.043	0.047	0.037

Note: 1.Probit regression of behavior in and attitude toward irrigation related activities. Dependent variables are all dummy variables: *crop decide* equals 1 if there is coordination in determine crop structure; *crop discuss*, 1 as discuss with neighbors about what to grow; *reach agree*, equals 1 if one reports he feels it could be very easy to reach an agreement on what crops to grow; *throw trash*, 1 if one reports people never or rarely throw trash in the irrigation canal; *stop village*, 1 if he claims he would certainly stop a villager from throwing trash in the canal; *stop village*, 1 if he claims he would certainly stop a stranger from throwing trash in the canal.
2.Standard errors clustered at village level are reported in the parentheses.
3.***, ** and * stand for significant level 1%, 5% and 10%, respectively.

Table 4. Water scarcity on canal quality, ordered probit

VARIABLES	(1) Canal quality: Third tier	(2) Canal quality: Fourth tier	(3) Canal quality: Fifth tier
Water scarcity	0.133	0.942**	0.622*
	(0.341)	(0.397)	(0.331)
Age	0.00460	0.00879	0.0327
	(0.0110)	(0.0153)	(0.0210)
Years of schooling	-0.00702	-0.0207	-0.0359
	(0.0372)	(0.0330)	(0.0307)
Nonfarm dummy	0.199*	0.420***	-0.0244
	(0.120)	(0.159)	(0.191)
Contract land (mu)	-0.00549	0.0161	0.0131
	(0.00914)	(0.0106)	(0.0115)
No. of siblings	0.000393	0.00700	-0.0353
	(0.0319)	(0.0369)	(0.0428)
Household size	0.00808	0.00525	0.000329
	(0.0518)	(0.0703)	(0.0668)
Majority family name dummy	0.195	-0.198	0.242
	(0.173)	(0.294)	(0.247)
ln(Gross household income)	0.170*	0.200**	0.153
	(0.0915)	(0.0849)	(0.0931)
ln(village arable land)	-0.184	-0.550	-0.144
	(0.335)	(0.340)	(0.232)
Distance to town seat	0.0330	0.114***	0.0204
	(0.0299)	(0.0347)	(0.0361)
Distance to county seat	0.00317	0.0351**	0.0146
	(0.0111)	(0.0155)	(0.0129)
Village enterprise dummy	-0.210	0.144	0.144
	(0.267)	(0.318)	(0.228)
Share of local nonfarm labor	-0.819	-1.343	-0.554
	(0.687)	(0.938)	(0.689)
Constant cut1	-0.305	1.948	3.256**
	(0.985)	(1.410)	(1.475)
Constant cut2	0.0268	2.706*	3.603**
	(0.984)	(1.438)	(1.472)
Constant cut3	0.700	3.572**	4.307***
	(1.006)	(1.461)	(1.441)
Constant cut4	1.398	4.112***	4.745***
	(0.985)	(1.445)	(1.526)
Observations	281	216	219

Note: 1.Ordered probit results for reported canal quality. Canal quality variables are 1-5 scale variables, where 1 stands for the worst quality and 5 is the best quality. We asked each villager about the quality of the part of canals that irrigate their lands. Not all household use all three tiers of canals to irrigate their lands, which leads to relative large attrition in the sample size, especially for the fourth and fifth tier canals.

2.Standard errors clustered at village level are reported in the parentheses.

3.***, ** and * stand for significant level 1%, 5% and 10%, respectively.

Table 5. Water Scarcity and Contribution in PGG

	(1) Av. Con.	(2) Av. Con.	(3) Av. Con.	(4) Av. Con.	(5) First Con.	(6) First Con.	(7) First Con.	(8) First Con.
Water scarcity	1.159*	1.548**	1.379**	1.483**	1.156*	1.946**	1.846**	1.817**
	(0.613)	(0.649)	(0.605)	(0.601)	(0.677)	(0.732)	(0.741)	(0.677)
No. of Wells			-0.217				-0.129	
			(0.171)				(0.210)	
Water scarcity, household level				0.108				0.210
				(0.280)				(0.523)
Age		-0.00512	-0.00391	-0.00508		-0.0218	-0.0211	-0.0216
		(0.0295)	(0.0294)	(0.0294)		(0.0341)	(0.0343)	(0.0343)
Years of schooling		0.0392	0.0446	0.0365		0.0967*	0.0999*	0.0909
		(0.0471)	(0.0453)	(0.0470)		(0.0525)	(0.0526)	(0.0535)
Non-farm dummy		-0.123	-0.121	-0.110		-0.174	-0.173	-0.141
		(0.328)	(0.325)	(0.330)		(0.426)	(0.426)	(0.427)
Contracted land (mu)		-0.00295	-0.00303	-0.00388		-0.0239	-0.0239	-0.0258
		(0.0125)	(0.0128)	(0.0129)		(0.0167)	(0.0170)	(0.0169)
No. of siblings		-0.141**	-0.139**	-0.139**		-0.161*	-0.159*	-0.156*
		(0.0641)	(0.0640)	(0.0649)		(0.0795)	(0.0794)	(0.0820)
Household size		0.164	0.160	0.174		0.278*	0.276*	0.302*
		(0.117)	(0.115)	(0.121)		(0.152)	(0.149)	(0.160)
Majority family name dummy		0.454	0.477	0.416		0.379	0.393	0.292
		(0.305)	(0.306)	(0.318)		(0.497)	(0.500)	(0.520)
ln(Gross income per capita)		-0.00368	-0.00258	-0.00642		0.163	0.164	0.157
		(0.123)	(0.127)	(0.123)		(0.181)	(0.183)	(0.180)
ln(village arable land)		-0.855**	-0.825**	-0.843**		-1.156**	-1.138**	-1.135**
		(0.355)	(0.358)	(0.350)		(0.437)	(0.424)	(0.439)
Distance to town seat		0.0326	0.0110	0.0307		0.0647	0.0519	0.0608
		(0.0669)	(0.0666)	(0.0664)		(0.0836)	(0.0862)	(0.0826)
Distance to county seat		-0.0176	-0.00705	-0.0180		-0.0398**	-0.0335	-0.0407**
		(0.0159)	(0.0135)	(0.0161)		(0.0189)	(0.0214)	(0.0189)
Dummy for enterprise in village		0.341	0.306	0.346		0.507	0.486	0.521
		(0.348)	(0.333)	(0.347)		(0.422)	(0.424)	(0.417)
Share of non-farm labor in village		-0.188	0.134	-0.192		-0.924	-0.733	-0.942
		(1.410)	(1.391)	(1.413)		(1.341)	(1.347)	(1.312)
Constant	4.346***	4.379**	4.606**	4.353*	4.399***	4.575*	4.711*	4.536
	(0.910)	(2.108)	(2.069)	(2.141)	(1.004)	(2.614)	(2.574)	(2.661)
Observations	312	312	312	311	312	312	312	311
Adjusted R2	0.015	0.036	0.037	0.033	0.007	0.048	0.046	0.047

Note: 1.OLS results for average contribution over the five rounds and the contribution in the first round.
2.Standard errors clustered at village level are reported in the parentheses.
3.***, ** and * stand for significant level 1%, 5% and 10%, respectively.

Table 6. Water scarcity on Contribution in PGG, 2SLS

VARIABLES	(1) Second stage Av. Con.	(2) Second stage First Con.	(3) First stage Water scarcity
Water scarcity	2.674**	3.796***	
	(1.093)	(1.211)	
Age	-0.00605	-0.0233	0.00113
	(0.0282)	(0.0323)	(0.000998)
Years of schooling	0.0307	0.0828	0.00410
	(0.0455)	(0.0509)	(0.00290)
Nonfarm dummy	-0.0841	-0.110	-0.0369*
	(0.329)	(0.422)	(0.0193)
Contract land (mu)	-0.0119	-0.0385**	0.00811***
	(0.0143)	(0.0171)	(0.00137)
No. of siblings	-0.142**	-0.161**	-0.000946
	(0.0605)	(0.0742)	(0.00549)
Household size	0.162	0.274*	-0.00892
	(0.112)	(0.144)	(0.00754)
Majority family name dummy	0.422	0.327	-0.0268
	(0.304)	(0.481)	(0.0312)
ln(Gross household income)	-0.00355	0.164	-0.00675
	(0.122)	(0.184)	(0.00921)
ln(village arable land)	-1.013***	-1.415***	0.157**
	(0.391)	(0.431)	(0.0748)
Distance to town seat	0.0240	0.0506	0.0106
	(0.0832)	(0.117)	(0.0230)
Distance to county seat	-0.0180	-0.0405	-0.00996**
	(0.0185)	(0.0248)	(0.00372)
Village enterprise dummy	0.454	0.692	-0.0518
	(0.386)	(0.490)	(0.0721)
Share of local nonfarm labor	-0.543	-1.507	0.0941
	(1.394)	(1.529)	(0.404)
IV: Latitude			1.790***
			(0.387)
Constant	3.362	2.906	-67.79***
	(2.301)	(2.763)	(14.85)
Observations	312	312	312
R-squared	0.067	0.073	0.472

Note: 1.2SLS results for average contribution over the five rounds and the contribution in the first round. The first stage regressions for the both outcome variables are the same, and thus we only report it once in column (3).
2.Standard errors clustered at village level are reported in the parentheses.
3.***, ** and * stand for significant level 1%, 5% and 10%, respectively.

Figures:

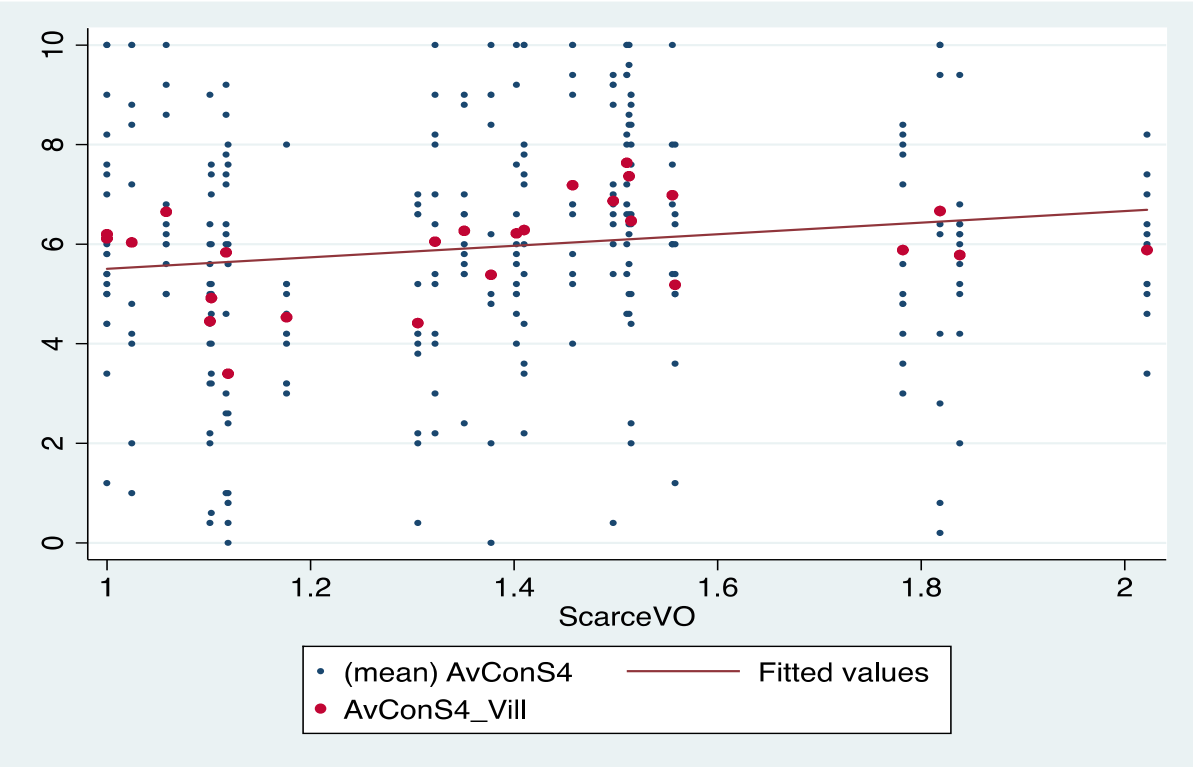

Figure 1 The relationship between the water scarcity indicator and the average contributions in the public goods game (PGG)