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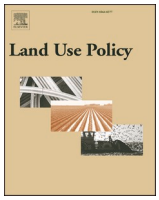

Effects of farmland use rights transfer on collective action in the commons: Evidence from rural China

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ABSTRACT

Although many studies have focused on the negative effects of the outflow of rural labor and insufficient land endowments on collective action related to irrigation, few have considered the effects of the farmland reallocation that accompanies this labor out-migration, especially at the household level. Using data from China, this paper sheds new lights on the internal structure of irrigation collective action by exploring the differentiation of famers' participation in collective action among farms, especially we explore how the reallocation of farmland affects the probability of successful collective action related to irrigation and how this effect varies among farms with different farmland use rights transfer behavior. Employing a two-stage approach, we deal with endogeneity problems and examine the effect from the perspective of behavior variation among small farms, based on survey data from 4917 households in 21 provinces in China. We find that the effect varies according to the type of transfer behavior. In particular, farmland transfer makes farmers who are expanding their production, and also farmers who are optimizing their land utilization, more likely to participate in collective action for irrigation, but the effect on farmers who are downsizing their agricultural production is not significant. Thus, farmland transfer influences the success of village collective action curvilinearly, and mainly through transfer-in and farm-adjustment farmers' decision to participate in collective action. Implications are drawn for land use policy as well as the governance of commons.

1. Introduction

While extensive research has considered rural–urban labor migration, suggesting that it reduces collective action (Liu and Li, 2017; Liu, 2018; Gao et al., 2020) and makes governance of the commons more difficult (Rudel, 2011), especially in irrigation commons (Baker, 1997; Wang et al., 2016), little attention has been paid to the effect of reallocation of resources such as farmland among farmers in rural society, which coincides with changes in the demand–supply ratio of arable land caused by that migration (Arimoto, 2011). We examine the effects of the reallocation of farmland on collective action related to the governance of irrigation commons in the context of rural labor outflow in China, where this reallocation is implemented through trading of farmland use rights under the "separating three property rights" system. Trading of farmland use rights is also known as farmland use rights transfer or farmland transfer, which refers to farmland lease among farmers without changing the collective ownership of farmland (Li et al., 2014, 2018b). Studies suggest that farmland transfer and the success of village collective action are nonlinearly related and hypothesize that the negative effects of labor out-migration can be alleviated by farmland transfer through the rise of large-scale producers, namely a new middle class of farmers and agricultural cooperatives (Su et al., 2020a, 2020b; Wang et al., 2022), emphasizing the benefits of enlarging operational area through farmland trading.

But this mechanism has not been tested empirically and is inadequate for explaining how farmland transfer affects collective action. Although the rising of large-scale producers is a certain trend in China agricultural production, small producers are still the main participants in agricultural production as well as collective action in rural society. At present, about 90 % of agricultural producers in China is small farmers and hundreds of millions of farmers will remain in the agricultural sector for a long time, and for most of them maintaining small-scale part-time agricultural production will be a rational choice (He, 2015). Thus, exploring how does farmland transfer affects these small-scale farmers'

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willingness to participate in collective action is important for policy making.

The impacts of farmland transfer on collective action at household level is far more complex than rising of larger producers. One of the outcomes of farmland trading at the household level is that an increase of farming scale for some farmers, and a decrease for others. Besides, farmland trading is also an effective way to reduce farmland fragmentation, given the cultivated-land endowments in China. Thus, in any analysis of the impacts of farmland use rights transfer on collective action, it is reasonable to consider variations in farmland transfer behavior.

In this paper we examine the heterogeneous impacts of farmland transfer on collective action related to the governance of irrigation commons at the household level. In particular, we focus on the variation in those impacts of farmland transfer on collective action related to the governance of irrigation commons as a result of variation of households' behavior in farmland transfer. Following Fujiie et al., (2005), collective action is taken as successfully organized collective activities related to public irrigation, which means the construction, operation and maintenance of irrigation facilities have been run by the village. Especially, we define collective action at the household level as farmers' participation in these activities.

Using survey data on 4917 households in 21 provinces throughout China, we find that farmers involved in farmland transfer can be divided into three groups, which we call transfer-in, farm-adjustment and transfer-out. And we find that the effect of farmland transfer on farmers' participation in the maintenance and construction of public irrigation facilities varies between these groups. In particular, farmers who are transferring farmland to expand their production scale or optimize land utilization are more likely to be encouraged by the transfer, compared to farmers who are reducing or eliminating agricultural production. The findings have policy implications for the governance and resilience of the rural commons worldwide, as well as for food security and agricultural development in China, where more than 30 million hectares of arable land (one-third of all the arable land in the country) has been transferred.

The main theoretical contribution of this paper is that we explore the internal structure of irrigation collective action associated with farmland use rights transfer, i.e. the variation in farmers' participation in collective action among small farms with different farmland use rights transfer behavior. In light of the lack of previous research focusing on the detailed inspection of the variation in farmers' participation in collective action, we identify the behavior differentiation among small farms when farmers are involved in farmland use rights transfer, and show how the farmland transfer affects the probability of successful collective action related to irrigation and how this effect varies among farms. These findings shed some new light on the internal structure of collective action in the commons, which suggest land use policy in China could be improved, if considering the variation of farmers' behavior.

This paper is organized in the following way. In Section 2, some of previous work on collective action in commons and farmland transfer is reviewed. In Section 3, a theoretical model adapted from the Institutional Analysis and Development framework is introduced and based on this framework, hypotheses are proposed. In Section 4, the data, variables and empirical models are introduced, and the results of the empirical analysis are presented in Section 5. The findings are discussed in Section 6, and Section 7 concludes.

2. Literature review

Previous work has studied the effects on collective action of two factors related to land use patterns: farm size and tenure rights. Regarding the effects of farm size, studies have had different results in different contexts (Olson, 1965). Some observe that farmers' willingness to participate in collective action related to irrigation increases with farm size, and this is plausible for four reasons. First, farmers with larger farms, which generally indicate more wealth, are usually more able to contribute financially to the maintenance of a common resource, such as irrigation facilities, despite the presence of free riders (Cai and Cai, 2013). Second, farmers with larger farms enjoy greater benefits from a well-maintained irrigation system, so they have a greater incentive to contribute (White and Runge, 1994; Nakano and Otsuka, 2011). Third, given that large cultivators benefit from economies of scale, they may find collective irrigation production more financially viable, so they are more likely to help support it (Meinzen-Dick et al., 2002; Martey et al., 2013). Fourth, because the demand for irrigation water increases with area, large farms require more efforts to maintain the irrigation infrastructure (Haji et al., 2013; Sharaunga and Mudhara, 2018).

On the other hand, some studies find that farm size can affect farmers' participation in irrigation maintenance in a negative way (Sheikh et al., 2016). And here we can see two plausible reasons. First, taking farm size as a proxy for wealth, a large farm provides exit options for farmers, making the formation of norms or enforcement in a community more difficult and collective action less likely (Ternström, 2003; Araral, 2008). Second, the owners of large farms have different priorities from landholders at the other end of the wealth scale, which could make agreements on collective action and local enforcement less likely (Bardhan and Dayton-Johnson, 2002; Bardhan et al., 2007).

Turning to tenure rights, insecure land tenure is seen as an obstacle to irrigation collective action. It is an accepted fact that security of land tenure increases cultivators' willingness to invest in the land (Besley, 1995; Brasselle et al., 2002). The construction and maintenance of irrigation facilities involves much investment of labor and money, and in a situation of unstable land tenure this is too risky, so farmers will invest their labor and money in short-term projects instead (Klümper and Theesfeld, 2017).

Although farmland use rights transfer is widely considered to be the main cause of alterations in farming patterns, land utilization and production structures in China (Zhang et al., 2018), little is known about its impact on the organization of community collective action. Overall, farmland use rights transfer could change farmland use and agricultural production in two ways. First, it allows farmers or organizations to lease farmland use rights from other farmers, which promotes the concentration of farmland and encourages the specialization of production. Second, it helps alleviate the problem of land fragmentation, which is common in Asia and in Central and Eastern Europe via farmland adjustment and consolidation (Li et al., 2018a; Zang et al., 2019).

These changes could promote collective action and improve the governance of rural commons in the context of labor outflow (Agrawal, 2001; Ostrom, 2009). However, farmers are motivated to participate in farmland transfer for various reasons (Zhong and Wang, 2003), which reflect variations in agricultural production. Therefore, a detailed inspection of the differing impacts of farmland use rights transfer on irrigation collective action in different groups of farmers may offer clues regarding the remedy for the decline in collective action in rural society, helping China and other developing countries craft targeted policies for different groups to counter rural decline during rapid urbanization.

3. Framework and hypotheses

3.1. Theoretical framework

As suggested by Ostrom et al. (1994), Araral (2009), collective action in the commons can be explained by internal factors, i.e. the physical attributes of the common pool resources, the attributes of the community and households, the micro-institutional context and exogenous factors. Following the substantial scholarship on governance of the commons, collective action and farmland use rights transfer, we organize our analysis based on an adapted version of Ostrom's (Ostrom et al., 1994)Institutional Analysis and Development (IAD) framework. The internal factors and exogenous factor, in this case farmland use rights transfer, can affect the outcomes of collective action through the

incentives of the players (Fig. 1).

3.2. Effects of farmland use rights transfer

In order to examine the effects of farmland use rights transfer on collective action in the commons in rural China, this paper focuses on irrigation collective action which is a typical manifestation collective action in rural China. According to Ostrom (1994) and Wang et al. (2016), irrigation system could generate various potential collective action problems such as appropriation, assignment, provision and monitoring, which makes irrigation systems a logical unit of analysis in studying collection action in the commons. In this paper, following Fujiie et al. (2005), irrigation collective action at the household level is defined as farmers' participation in collective activities related to public irrigation, for example construction, operation and maintenance of public irrigation facilities.

The existing literature about irrigation collective action has largely focused on the effects of farm size, tenure rights and formation of norms on irrigation collective action, but the effects of farmland use rights transfer on farmers' participation in irrigation collective action remain unclear. Based on previous literature around collective action and farmland transfer, we speculate that farmland use rights transfer affects irrigation collective action in two ways.

3.2.1. Concentration effect of farmland use rights transfer

Previous scholarship suggests that land concentration is the main goal (and outcome) of farmland use rights transfer (Wang et al., 2018). It enables active cultivators to operate at a larger scale and enables the development of a new type of cultivator that is more specialized and has more resources to invest in the maintenance of irrigation systems (Su et al., 2020a). On the other hand, some plausible negative effects can be identified as production scale increases. Contributions to the management of a common pool resource may decrease or even reverse, where negative factors such as free riding start to dominate (Bardhan and Dayton-Johnson, 2002; Adhikari, 2005; Araral, 2009). Also, such expansion of production scale through rights transfer is usually based on short-term contracts, which makes maintaining or constructing durable facilities on the transferred farmland a risky investment (Gaspart et al., 1998).

Furthermore, farmland use rights transfer is used by some farmers to shrink their production to small-scale and part-time farming, which limits their willingness and ability to increase any input in agricultural production (Yu et al., 2003; Gao et al., 2012), including public irrigation facilities. Nevertheless, small-scale producers are more likely to cooperate with others to realize economies of scale in infrastructure construction (Ternström, 2003; Araral, 2008).

3.2.2. Consolidation effect of farmland use rights transfer

Farmland use right transfer is an effective way to reduce land fragmentation under the "separating three property rights" system. As suggested in prior scholarship, reduction of land fragmentation encourages cultivators to participate in irrigation collective action (Zang et al., 2019; Wang et al., 2020). On the other hand, consolidation increases the cost of agricultural production and leads to alterations in cropping patterns (Wang et al., 2011). That is, as the cost of holding farmland rises, cultivators are more likely to grow cash crops rather than grain crops, due to higher profits; and a private system is more suitable for cash crops than a public one (de Fraiture and Giordano, 2014).

3.3. Variation in farmland use rights transfer behavior and hypotheses

Although prior investigations of the effects of farmland use rights transfer provide valuable clues, we believe none of these mechanisms is working alone. But, according to existing studies, changes in farmland holdings and land use patterns are the main factors through which farmland transfer affects farmers' participation in collective action related to irrigation. And as these changes are determined by farmers' behavior in the process of farmland transfer, it is reasonable to speculate that the impacts on irrigation collective action are different among farmers with different farmland transfer behavior.

Based on previous studies (Zhong and Wang, 2003), we consider that farmers make three kinds of transfer: transfer-in, farm-adjustment and transfer-out. Farmers in the first group transfer in more farmland than they transfer out, which indicates an expansion of their production scale. In the second group, the amounts are equal, and the farmer uses trading to optimize farmland allocation and address problems such as land fragmentation. Farmers in the third group are transferring more land out, suggesting that they are cutting back or quitting agricultural production. We speculate that the mechanism of the impact of transfers varies between these groups and put forward the following hypotheses for possible interactions between farmland use rights transfer and collective action related to irrigation in each group. By testing these hypotheses, the complex effects of farmer differentiation on collective action in rural commons are empirically explored.

Hypothesis 1. *For transfer-in farmers, a moderate scale of farmland use rights transfer increases the likelihood to participate in collective action related to irrigation.*

Farmers who obtained more farmland to expand their production scale tend to have larger farms and more specialized agricultural production. Farmers with larger farms usually need more irrigation water, which would plausibly increase their willingness to invest in construction and maintenance of public irrigation facilities (Haji et al., 2013; Sharaunga and Mudhara, 2018). Moreover, farmers with greater specialization tend to earn more money from agricultural production. This high reliance on farm income would seem to represent an incentive to invest in collective action for irrigation. Besides, land fragmentation will be reduced by transferring in farmland, and farmers prefer plots that

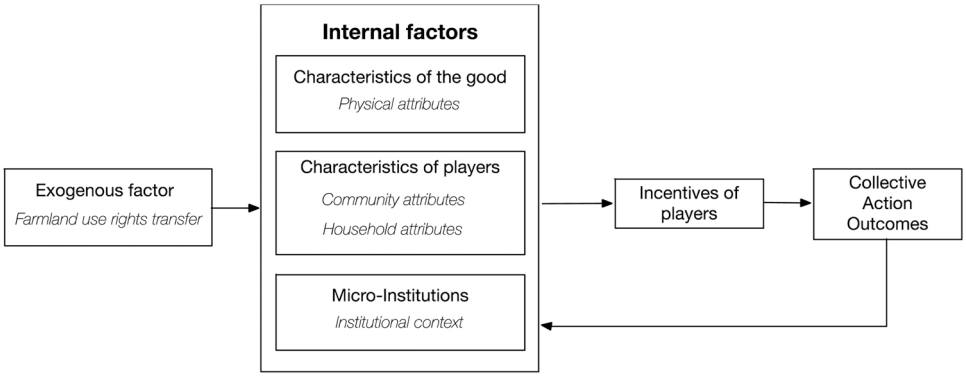

Fig. 1. Framework linking farmland use rights transfer to collective action in irrigation.

are concentrated and contiguous for the application of agricultural machinery.

On the other hand, problems of free riding and insecurity of farmland holding increase as the area of farmland increases. With farmland concentrated in the hands of those who actively farm, the variation among farmers in landholdings as well as production investment will become huge, and free riding will occur more frequently (Meidinger et al., 2003). But also, since farmland transfer contracts are usually for short terms – usually a year, and not automatically renewable (Gaspart et al., 1998) – the holders of transferred farmland would not seem to have much incentive to invest in durable public facilities. And on very large properties, it is more efficient to construct private irrigation facilities. In addition, enlarging farm scale through farmland trading will increase the cost of production. To make more profit, farmers often plant cash crops instead of grains, which is called non-grain utilization of arable land (Wang et al., 2011). Cash crops need more labor input, and make private irrigation more useful, because the optimal irrigation period varies between crops. Thus, farmland use rights transfer also reduces the propensity to cooperate in irrigation collective action.

The negative impacts of free riding, insecure farmland tenure and higher cost of production grow could sharply with production scale, which imply the general relationship between land use rights transfer and irrigation collective action presents an inverted-U shape. And this inverted-U relationship means that for transfer-in farmers, after certain size of farmland transfer the contributions of expanding production scale by farmland transfer to irrigation collective action might decrease, indicating a moderate scale of farmland transfer in could increase the likelihood to participate in collective action related to irrigation.

Hypothesis 2. *For farm-adjustment farmers, a moderate scale of farmland use rights transfer increases the likelihood to participate in collective action related to irrigation.*

Farmland holdings in China are highly fragmented, with an average of 4.1 plots per household. Farmland use rights transfer can promote land consolidation and therefore reduce labor input, as well as the risk of free riding (Zang et al., 2019). However, farm-adjustment farmers suffer from the uncertainty of short-term farmland contracts, which limit their willingness to invest in transferred land. And although their transfers do not change their total farmed size, the cost of farmland use could increase sharply due to higher rent for well-located plots. Thus, among these farmers, rights transfer also reduces the propensity to cooperate in irrigation collective action. Furthermore, increasing the area of transferred farmland could increase the uncertainty of contract and farmland cost as well as the negative impacts. In general, for these farmers farmland transfer might enhances their propensity to cooperate in irrigation collective action at the beginning until negative factors start to dominate, which indicates an inverted-U relationship between farmland transfer and success of irrigation collective action. Similar to transfer-in farmers, inverted-U relationship means for farm-adjustment farmers, a moderate scale of farmland use rights transfer might increase the likelihood to participate in collective action related to irrigation.

Hypothesis 3. *For transfer-out farmers, a moderate scale of farmland use rights transfer increases the likelihood to participate in collective action related to irrigation.*

Farmers who transfer out their contracted farmland but have not yet completely quit agricultural production are mostly part-time agricultural producers, working on a small farm but mainly relying on off-farm income. Using public irrigation might be cheaper for them, because it is hard for small farms to achieve economies of scale. Thus, farmland use rights transfer might also encourage these farmers to invest in public irrigation facilities. As the scale of farmland transferred out increases, farmers' willingness to invest in agricultural production would reduce, which include participating in maintenance or construction of irrigation facilities. Therefore, it is reasonable to propose hypothesis that for transfer-out farmers, farmland transfer increases the likelihood to participate in irrigation collective action until negative factors start to dominate, which means a moderate scale of farmland use rights transfer might increase the likelihood to participate in collective action related to irrigation.

4. Data, variables and method

4.1. Data

Our data were collected in a 2017 survey. The survey was designed to investigate the situation in rural China by collecting information on agricultural production, farmers' living, village development, and the construction and maintenance of public irrigation facilities. Nearly 1000 students from dozens of universities or academic institutes were recruited and trained by four experts at the institute from March to June 2017 and conducted the field survey from July to September 2017, when most of the students were on summer break.

The researchers first selected 40–50 representative villages in each province according to the economic development level and then assigned surveyors to the target villages, where they randomly selected 15–25 households in each village. Village-level and household-level data were collected through two different questionnaires; in total, 17,949 household questionnaires and 865 village questionnaires were collected.

Irrigation types vary widely in rural China due to varying water resource endowments and governance structures. As this paper deals with collective action related to public irrigation, we considered only households whose farmland is mainly irrigated by canals. We also dropped samples from villages with less than 10 sampled households due to concerns with data reliability and quality. We are left with data on 4917 households in 196 villages in 21 provinces or regions. Considering the relevance of the research topic, we regard this as a representative sample in the context of our study.

4.2. Variables

4.2.1. Dependent variable

Two approaches are commonly used to measure collective action in irrigation. The 'outcomes' approach considers its effects on common pool resource governance, for example the status of irrigation facilities (Su et al., 2020a), the frequency of conflicts and rule violations over resource allocation (Bardhan, 2001), the amount of free riding (Araral, 2009) or carbon sequestration (Beyene et al., 2016) The 'process' approach considers the collective action itself, for example collective lobbying and joint maintenance of canals and tanks (Meinzen-Dick et al., 2002; Fujiie et al., 2005). Informed by the studies of Wang et al. (2016), Zang et al. (2019) and Su et al. (2020a), we choose as indicators of collective action the frequency of participation in collective maintenance of public irrigation facilities and the frequency of attendance at village meetings on irrigation.

4.2.2. Core independent variables

The main purpose of this study is to find out how farmland use rights transfer affects collective action and explore the differences in that effect among farmers with different transfer behaviors. According to definition of three kinds of transfer, and considering farmers who do not transfer any farmland, it is reasonable to divide farmers into four groups: non-transfer, transfer-in, farm-adjustment and transfer-out. For all these groups, we use "the area of transferred farmland" as the measure of trading activity.

4.2.3. Control variables

Based on the theoretical framework mentioned earlier, we include variables to control for the effects of physical attributes of resources, community attributes, institutional context and household attributes.

4.2.3.1. Physical attributes. As suggested by Ostrom (2005), the attributes of the resource are important factors in the probability of successful collective action. We therefore include four physical variables representing village and farm water resource status to control for geographic factors.

4.2.3.2. Village water resources. It is generally agreed that collective action can hardly occur unless there is a common perception of moderate resource scarcity among the resource users. Bardhan (1993), Agrawal (2001) and Araral (2009), see a curvilinear (inverted-U-shaped) relation between water resource scarcity and the probability of successful collective action in irrigation: farmers are more likely to manage and maintain the irrigation system when the local water resources are moderately scarce.

4.2.3.3. Farmland location. Users' location within systems is crucial for resource availability (Meinzen-Dick et al., 2002; Chun, 2014). With canal irrigation, upstream farmland has a better chance than downstream farmland at getting enough water (Scott and Silva-Ochoa, 2002). Considering the inverted-U relationship of water scarcity and participation, we therefore expect the greatest participation from farmers in the midstream.

4.2.3.4. Village topography. Local topographic attributes can affect collective action for irrigation in two ways. First, spending on construction and maintenance of irrigation canals varies with landform. In particular, the cost in flat areas is much lower than in hilly areas. Second, as plain topography enables irrigation systems to extend for miles (Mody, 1997), it is easier to achieve economies of scale on farmland in flat areas.

4.2.3.5. Farmland water scarcity. Collective action is more likely to be successfully organized in the face of resource scarcity (Baland and Platteau, 1996; Nie et al., 2020). In regard to irrigation, successful collective action is more common in farmland where drought is frequent.

4.2.3.6. Community attributes. Previous scholarship has found that community attributes play a critical role in the success of collective action. The village is the basic unit of organization for collective action in China, so we include variables representing village size and collective economic condition to control for community attributes.

4.2.3.7. Village size. Many studies consider the effects of group size on the likelihood of successful collective action (Olson, 1965; Poteete and Ostrom, 2004). It has been shown both empirically and theoretically that the organization and maintenance of irrigation collective action is more likely to succeed in smaller groups (Tang, 1992; Fujiie et al., 2005), where there are fewer free riders and the transaction costs of organization and maintenance are lower. Some scholars argue that group size is a consequence of the trade-off between transaction costs and economies of scale (Meinzen-Dick et al., 1997), and its impacts depend on other variables (Frohlich and Oppenheimer, 1970; Sandler, 1992; Kamei, 2018). However, in the case of China, group size refers to the size of the village, which is the administrative unit and thus considered exogenous. Therefore, we expect a negative effect of village size on the likelihood of successful irrigation collective action.

4.2.3.8. Village development. Although less discussed, conventional wisdom suggests that wealth has a strong effect on successful collective action. Studies have considered the topic from the aspects of income level and inequality of wealth at the micro-level (Agrawal and Gibson, 1999; Araral, 2008). However, besides individual wealth, the collective economic condition of the village is also important (Xu et al., 2015). If a village is relatively well-off, it is more likely to provide essential services and investment to guarantee the success of irrigation collective action. We therefore expect that irrigation collective action increases with the economic development of the village.

4.2.3.9. Institutional context. There is strong evidence that governance structure is of great importance to the success of collective action (Ostrom, 1990; Araral, 2009). To control for the effects of governance structure, we use a few village-level institutional variables.

4.2.3.10. Tenure stability. There is agreement on the positive effect of stable land property on participation in collective action related to irrigation (Hanemann, 2014). Although the central government promised that farmers' land contract rights (the rights to use farmland owned by communities) would be unchanged unless they gave up their membership in the rural collective since 1978 when the household responsibility system was instituted, when, there are still problems of unstable tenure for specific cultivated plots. Contracted farmland can be adjusted among farmers at predefined intervals due to changes in collective membership, causing tenure insecurity (Ma et al., 2015). Thus, frequent adjustment of contracted farmland is expected to have negative effects.

4.2.3.11. Rule formation and village governance. A well-functioning collective organization is the foundation of successful collective action. Firm rules for collective action for the commons lower transaction costs and can increase the likelihood of proportional water allocation in a system (Dayton-Johnson, 2000). In collective action system, well-established and consistently enforced rules can reduce free riding and encourage investment in public facilities. On the other hand, conflicts in collective action signal mistrust among members of the community and reflect ineffectiveness in the collective organization. Therefore, the variables for our measurement of the effectiveness of collective organization are (a) *rule formation* representing there are formal irrigation rules in the village; (b) *village governance failure* representing Farmer thinks that conflicts over irrigation arrangement happen a lot in the village. For each variable, yes is recorded as 1 and no as 0.

4.2.3.12. Household attributes. Studies also find that household attributes influence farmers' propensity to participate in collective action. In this study, we include farm area, and the age and education level of the household head as control variables to represent household-level heterogeneities. Although there is no consensus on the effects of age or education in the current literature (Huang et al., 2009; Khalkheili and Zamani, 2009), here, in the context of the aging population and the low average level of education in rural China, we expect a negative effect of age and a positive effect of education. Also, as farmers' land endowment varies greatly across regions in China, it is necessary to control for the size of the farm.

4.3. Methods

In our empirical analysis, we analyze the impact of land transfer on collective action from the perspective of farmers' varying behavior. But there is a problem here of selection bias, because farmers' decisions to transfer farmland may not be random; and of endogeneity, because land trading may be influenced by other economic factors also related to participation in collective action.

To deal with selection bias, we use a two-stage approach, following Lee (1982) and Hamilton and Nickerson (2003). In the first stage, we include a set of explanatory variables that affect both decisions: to transfer farmland and to participate in collective action. In the second stage, we develop a multinomial endogenous switching ordered probit model, where the multinomial treatment variable is assumed to follow a multinomial logistic choice model structure and the outcome variable follows an ordered probit choice model structure. Our regression

strategy is a variant of the instrumental approach to instrument the endogeneity of decision to transfer farmland using the inverse Mills ratio.

The multinomial treatment variable comes from farmers' choice of farmland transfer. As introduced above, farmers can be taken as of four types: non-transfer, transfer-in, farm-adjustment and transfer-out. We can use $j = 0, 1, 2,$ or 3, respectively, for these four. As the occurrence of one event (here, the decision to transfer farmland) does not alter the probability of another event, we use a multinomial logit model to estimate the selection process.

Consider that farmer i has four unordered strategy choices, $C_{ij}, \quad j = 0, 1, 2, 3$. Then, in the first-stage analysis, the farmer's decision to transfer farmland depends on a set of variables:

$$\Pr(C_{ij} = j) = \Pr(R_{ij} > R_{ik}), \text{for} k \neq j, j = 0, \quad 1, \quad 2, \quad 3$$

$$R_{ij} = X_i\beta_j + Z_i\delta_j + u_j$$

where R_{ij} is the maximum return attainable for farmer i choosing strategy j; X_i are the independent variables, which affect the farmer's decision to transfer farmland as well as their participation in collective action; Z_i are instrumental variables that only affect the selection process; β_j and δ_j are parameters to be estimated; and β_0 and δ_0 are normalized to zero.

The closed-form solution of the multinomial logit model can be constructed as:

$$\Pr(C_{ij} = j) = \exp(X_i\beta_j + Z_i\delta_j) / \sum_{j=0}^{3} \exp(X_i\beta_j + Z_i\delta_j) \quad .$$

Following the approach proposed by Lee (1982), the non-normal unobservables implied by the multinomial logit model can be transformed into normal random variables:

$$J_{ij} = \Phi^{-1}(\Pr(C_{ij} = j))$$

where $\Phi^{-1}()$ is the inverse normal distribution function, which transforms $\Pr(C_{ij} = j)$ into a standard normal random variable, J_{ij}. Thus, the inverse Mills ratio terms can be constructed for selection-bias-correction:

$$Mills_{ij} = \phi[J_{ij}] \Big/ \Pr(C_{ij} = j)$$

where $\phi[J_{ij}]$ denotes the standard normal density of J_{ij}.

Given this bias-correction term, we can construct the performance equation in our second-stage analysis. A multinomial endogenous switching ordered probit model is employed here because the dependent variables are taken to be multivariate discrete variables ranging from 1 to 5 (with a larger number indicating greater individual propensity to participate in collective action; see Table 1). We use

$$y_j^* = X_i\beta_j + E_i\alpha_j + \lambda_j Mills_{ij} + \varepsilon_j$$

where y_j^* is the propensity to cooperate in collective action (which cannot be observed directly) of farmers who choose strategy j, E_i are the core independent variables referring to farmland transfer activity, α_j and β_j are parameters to be estimated, ε is a random error term, and

Table 1
Definition of variables and expected impacts on collective action related to irrigation.

Variable	Definition	Expected sign
Dependent variables		
Collective maintenance	Frequency of participation in collective maintenance (1 = never, 2 = seldom, 3 = sometimes, 4 = often, 5 = usually)	n/a
Attending meetings	Frequency of attendance at meetings on collective irrigation (1 = never, 2 = seldom, 3 = sometimes, 4 = often, 5 = usually)	n/a
Independent variables		
Farmland use rights transfer		
Participation in farmland use rights transfer	Participation in farmland use rights transfer (1 = yes, 0 = no)	+
Area of transferred land	Area of farmland transferred, in hectares	±
Physical attributes		
Village water resources	Water resources are moderately scarce at the village level (1 = yes, 0 = no)	+
Farmland location	The farm is in the midstream of the canal (1 = yes, 0 = no)	+
Village topography	The village is in a flat area (1 = yes, 0 = no)	±
Farmland water scarcity	Frequency of water scarcity on the farm (1 = never, 2 = seldom, 3 = sometimes, 4 = often, 5 = usually)	+
Community attributes		
Village size	Number of households in the village	–
Village development	Collective income of the village (in 2016, in US$)	+
Institutional context		
Rule formation	There are formal irrigation rules in the village (1 = yes, 0 = no)	+
Village governance failure	Farmer thinks that conflicts over irrigation arrangement happen a lot in the village (1 = yes, 0 = no)	–
Tenure stability	In the last five years, the contracted farmland in village has been massively adjusted (1 = yes, 0 = no)	–
Household attributes		
Farm size	Area of farm, in hectares	–
Age	Age of household head	–
Education	Education level of household head (1 = never attended school, 6 = graduate level)	+
Instrumental variables		
Distance to county	Distance from village to county, in kilometers	n/a
Volume of farmland transfer at village level	Ratio of the area of transferred farmland to the total area of farmland in the village	n/a

λ_j is the parameter of the bias-correction term, whose size is a measure of selection bias. Then y is the observed dependent variable of y^*, with

$$y_j = s \text{if and only if} \quad r_{j,s-1} < y_j^* \leq \quad r_{j,s}$$

where $s = 1, 2, 3, 4, 5$ and $r_{j,s}$ are threshold values, satisfying $r_0 = -\infty$, $r_{j,s} > \quad r_{j,s-1} \forall k$. Unlike in an ordinary ordered probit model, the probability of $y_j = s$ depends on the selection variables. We have

$$\begin{aligned}
\Pr(y_j = s, \quad j = j|x,z|) &= \Pr\Big(\quad r_{j,s-1} < y_j^* \leq \quad r_{j,s}, \Pr(C_{ij} = j) > \Pr(C_{ij} = 0)|x,z| \Big) = \Pr(\quad r_{j,s-1} - (X_i\beta_j + E_i\alpha_j + \sigma_j Mills_{ij}) \langle \varepsilon_j \\
&\leq \quad r_{j,s} - (X_i\beta_j + E_i\alpha_j + \sigma_j Mills_{ij}), u_j > -(X_i\beta_j + Z_i\delta_j +)|x,z|) = \Pr(\quad r_{j,s} - (X_i\beta_j + E_i\alpha_j + \sigma_j Mills_{ij}) \langle \varepsilon_j, \quad u_j \\
&> -(X_i\beta_j + Z_i\delta_j)|x,z|) - \Pr(r_{j,s-1} - (X_i\beta_j + E_i\alpha_j + \sigma_j Mills_{ij}) \langle \varepsilon_j, \quad u_j > -(X_i\beta_j + Z_i\delta_j)|x,z|) \\
&= \Phi(\quad r_{j,s} - (X_i\beta_j + E_i\alpha_j + \sigma_j Mills_{ij}, X_i\beta_j + Z_i\delta_j, \quad -corr(\varepsilon_j, \quad u_j)) - \quad \Phi(\quad r_{j,s-1} - (X_i\beta_j + E_i\alpha_j + \sigma_j Mills_{ij}, X_i\beta_j + Z_i\delta_j, \quad -corr(\varepsilon_j, \quad u_j))
\end{aligned}$$

where $\Phi()$ is the standard bivariate normal cumulative distribution function. Thus, maximum likelihood estimation can be used to obtain constant estimators and parameters.

Two-stage estimation has a potential identification problem when we use the same set of explanatory variables in both stages. Thus, the literature, we include two additional instrumental variables in the first-stage selection model. The first is the distance from village to county center. We choose this variable because it is an exogenous geographical characteristic of the village, and the county center is usually the center of regional economic activities. Thus, the closer the village is to the county center, the more active the non-agricultural economy is, which increases the likelihood of farmers' participation in farmland transfer. The second instrumental variable is the volume of farmland transfer at the village level. It is a common strategy to use aggregated data as an instrumental variable to solve the endogeneity (Card and Krueger, 1996; Li and Song, 2016). A large volume of farmland transfer in a village indicates a supportive policy environment (Gao et al., 2014) and a low cost of finding out about farmland trading (Yang, 2015), which can increase farmers' propensity to transfer farmland through peer effects. In addition, many studies have verified the exogeneity of community-level instrumental variables with respect to individual or family behavior (Yang et al., 2011, 2020; Ren et al., 2018). Therefore, the volume of farmland transfer at the village level can be taken as having no direct impact on farmers' participation in collective action.

Another challenge in this estimation is that household farmland transfer activity could be endogenous because it is influenced by other economic factors that are also related to participation in collective action, such as institutional environment, or household attributes. Hence in the second stage of analysis, an instrumental ordered probit model with the instrumental variables introduced above is constructed for a robustness check.

Based on the theoretical framework and the econometric models introduced above, the variables chosen for the empirical analysis are shown in Table 1, along with their definition and their expected sign.

5. Results

5.1. Descriptive statistics

The statistical results are shown in Table 2, and results by group in Table 3. Participation in collective action is moderate, with the mean frequency of participation in collective maintenance and frequency of attendance at village meetings on irrigation both at 3.1, and the mode of each at 3. For farmland use rights transfer, we use two indicators. One is participation in farmland use rights trading; its average is 0.33, meaning that 33 % of the sampled farmers participate. The other is the area of transferred farmland; it ranges from 0 to 34 ha, exhibiting great heterogeneity.

In terms of physical attributes of resources, about 33 % of the sampled villages are in a plain area, and 69 % have moderate water scarcity. At the household level, 49 % of the farms are in the midstream of the canals, and most of the farmers report that their farmland has moderate water scarcity (mode 3, average 2.9). Village population has a huge range, from 25 to 5010, with an average of 585; as does village economic development, with annual village income ranging from zero to USD 5.27 million, with an average of USD 32,500. As to institutional context, 55 % of the villages had formal regulations on irrigation management, while 13.2 % of the farmers report that there are frequent conflicts over irrigation arrangement, and 17.6 % report that their village has reallocated farmland plots in the last five years. The area of farmland held by each family ranges from 0.1 to 34.4 ha, again a very wide range. The average household head is 52, and most have a primary or middle-school education (mode 3, average 2.7).

Looking at key variables by group, the means of the dependent variables of the three groups are close to the value of whole sample. But there are large differences in area of transferred farmland. The averages in Group 1 and Group 3 are 0.407 and 0.229 ha, respectively, while in Group 2 it is only 0.053 ha, suggesting smaller transfers to optimize the utilization of farmland.

Table 2
Descriptive statistics of the main variables.

	Mean	Std. Dev.	Min.	Max.	Mode
Dependent variables					
Collective maintenance	3.128	1.090	1	5	3
Attending meetings	3.108	1.044	1	5	3
Independent variables					
Farmland use rights transfer					
Participation in farmland use rights transfer	0.331	0.471	0	1	0
Area of transferred land	0.061	0.722	0	34.133	0
Physical attributes					
Village water resources	0.690	0.463	0	1	1
Farmland location	0.494	0.500	0	1	0
Village topography	0.330	0.470	0	1	0
Farmland water scarcity	2.876	1.082	1	5	3
Community attributes					
Village size	584.953	446.733	25	5010	–
Log (village size)	6.145	0.698	3.219	8.519	–
Village development	32,513.41	23,0794.1	0.181	5,269,262	–
Log (village development)	7.339	2.304	0.182	17.371	–
Institutional context					
Rule formation	0.550	0.498	0	1	1
Village governance failure	0.132	0.339	0	1	0
Tenure stability	0.176	0.381	0	1	0
Household attributes					
Farm area	0.191	0.785	0.1	34.367	–
Age	52.324	12.404	19	94	–
Education	2.712	0.947	1	6	3
Instrumental variables					
Distance to county	21.737	19.233	0	130	–
Volume of farmland transfer at village level	0.306	0.171	0	1	–

Table 3
Descriptive statistics of key variables by group.

Groups	Samples	Mean of dependent variables		Mean of independent variables
		Collective maintenance	Attending meetings	Area of transferred land
Group 1 (transfer-in)	321	3.199	3.059	0.407
Group 2 (farm-adjustment)	731	3.114	3.088	0.053
Group 3 (transfer-out)	586	3.147	3.167	0.229

5.2. Empirical results

Results of the two-stage empirical analysis, employing the multinomial endogenous switching ordered probit model introduced above, are presented in Tables 4–6. The first-stage analysis on the decision to transfer farmland (Table 4) suggests that some variables that affect farmers' participation in collective action are also crucial in determining their decision to transfer farmland. Furthermore, farmers are more likely

Table 4
Factors that affect farmers' decision to transfer farmland.

		Selection Model		
		Transfer-in	Farm-adjustment	Transfer-out
Physical attributes	Village water resource	0.097	0.095	0.072
		(0.148)	(0.117)	(0.121)
	Farmland location	0.002	-1.08***	0.311**
		(0.155)	(0.204)	(0.138)
	Village topography	-0.091	0.095	0.028
		(0.149)	(0.121)	(0.121)
	Farmland water scarcity	-0.104	0.158***	-0.114**
		(0.069)	(0.056)	(0.057)
Community attributes	Village size	-0.326***	0.32***	0.102
		(0.093)	(0.082)	(0.081)
	Village development	-0.006	0.025	0.012
		(0.031)	(0.022)	(0.023)
Institutional context	Rule formation	0.668***	-0.599***	0.239**
		(0.146)	(0.134)	(0.122)
	Village governance failure	-0.336*	-1.453***	-0.477**
		(0.21)	(0.287)	(0.193)
	Tenure stability	-0.264	0.008	-0.032
		(0.185)	(0.145)	(0.14)
Household attributes	Farm area	0.223	-0.967	-3.756***
		(0.147)	(1.474)	(0.645)
	Age	-0.004	0.006	-0.001
		(0.006)	(0.005)	(0.005)
	Education	0.045	0.418***	0.194***
		(0.082)	(0.076)	(0.064)
Instruments	Distance to county	-0.009**	-0.007**	-0.005*
		(0.004)	(0.003)	(0.003)
	Extend of farmland transfer at village level	3.802***	6.358***	4.97***
		(0.477)	(0.383)	(0.375)
	Province	-0.032***	0.02**	0.014
		(0.012)	(0.009)	(0.01)
	Constant	-0.84	-7.426***	-4.083***
		(0.784)	(0.789)	(0.652)
	Sample	4917		
	Prob>chi2	0.000		
	R2_P (Pseudo R2)	0.1804		

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, same for the tables below.

to transfer farmland when transfer activities are more active in their village. We also find that farmers in villages farther from the county center are less likely to make transfers.

Tables 5 and 6 show the results of the second-stage analysis, in which the effects of farmland transfer on collective action related to public irrigation are estimated. The coefficients of λ are significant, suggesting that selection bias has been corrected. Guided by previous research (Zheng and Zheng, 2017; Su et al., 2020b), we regress endogenous variables on instrumental variables to check for weak instrumental variable. And we regress residual of instrumental ordered probit model on instrumental variables to check for the validity of instrumental variables. These tests say that the instrumental variables are valid and not weak (bottom of Tables 5 and 6). The results of the ordinary ordered probit model with correction of selection bias are presented in the first three columns of each table, and the results of the ordered probit model with instrumental variables in the last three columns. There are group-specific differences in the effect of farmland transfer.

For transfer-in farmers, the positive linear term and negative quadratic term suggest an inverted-U relationship between farmland use rights transfer and probability of cooperation in collective action for maintenance of public irrigation facilities (Table 5, columns 1 and 4). According to the coefficients of these terms, the probability of participation in collective maintenance is highest with an area of transferred farmland of around 7.52 ha (8.5 ha in the instrumental ordered probit model). This is much larger than the average area of transferred farmland in our data (0.407 ha), indicating an overall positive effect of farmland transfer on participation in maintenance of public irrigation facilities. In regard to attendance at meetings on collective irrigation, only the linear term is significantly positive in the baseline model, but the results of the instrumental ordered probit suggest an inverted-U relationship with the turning point at about 10.5 ha (Table 6, columns 1 and 4). We therefore can infer that farmers who transfer in more farmland have a higher propensity to cooperate in collective action related to irrigation.

The results for farmers who transfer farmland only to optimize land utilization show a similar inverted-U relationship between area of transferred land and collective action (Tables 5 and 6, columns 2 and 4). The turning point is around 3.35 ha for attendance at meetings on collective irrigation (3.12 ha in the instrumental ordered probit model) and 3.59 ha for participation in construction and maintenance of public irrigation, which again is much larger than average area of transferred farmland in this group (0.053 ha). Thus, farmland transfer is a positive factor in promoting collective action among farmers who are transferring farmland for better utilization.

For transfer-out farmers, the coefficients of area of transferred farmland and its quadratic term are both insignificant, so we see no significant effect of farmland transfer on collective action among these farmers.

Looking at control variables, the physical attributes of location, topography and farmland water scarcity have statistically significant positive effects on collective action, which is consistent with our expectations. That is, farmers whose farm is in a flat area and in the midstream of the canal are more likely to invest in public irrigation facilities, as are farmers with more severe water scarcity. The coefficient of village size is negative and statically significant, indicating a lower probability of successful organization of collective action on irrigation in larger villages. Institutional context also shows a significant effect, as the coefficients of formal regulations, conflicts over irrigation management, and instability of tenure are statistically significant in all models. Formal regulations have positive effects, while frequent conflicts and unstable tenure have negative effects. Thus, efficient formal arrangements can improve the likelihood of agreements on collective action, while unstable land tenure is a significant institutional obstacle to such action. The coefficient of the area of farmland held by the family is significantly negative, suggesting that better-off families are less likely to cooperate in irrigation collective action.

6. Discussion

In the 1950s, China's central government implemented a series of projects to strengthen infrastructure construction in rural areas, of which irrigation facilities were the most important in the agricultural sector. Under the People's Commune System, production costs and benefits, as well as the inputs including labor to construct and maintain public facilities such as irrigation, were shared equally by commune members. Irrigation facilities were well maintained by collective work assignments until 2003, when the reform of rural taxes and administrative charges relieved farmers of the duty of collective action for public facilities. Since then, small-scale communal irrigation facilities were supposed to be maintained by voluntary collective action in the village, but this had led to widespread failures. The outflow of agricultural labor exacerbated the problem, and canal irrigation was widely replaced by pump or groundwater irrigation operated by individuals (Wang et al., 2016, 2021).

Meanwhile, land reallocation among farmers occurred, along with reform of rural society and labor out-migration. Under China's collective land tenure system, rural communities own the farmland. The household responsibility system reform of the late 1970s and early 1980s gave community members the right to contract farmland, or rather use rights for farmland. In 1991, the government enacted the Provisional Regulation on the Granting and Transferring of the Land Rights over State-owned Land in Cities and Towns, which empowered farmers to transfer these use rights (Liu et al., 2014). Such transfer then became much more common. By the end of 2016, 35 % of the contracted farmland was

Table 5
Effects of farmland use rights transfer on participation in construction and maintenance of public irrigation.

		Baseline Model			IV-oprobit		
		Transfer-in	Farm-adjustment	Transfer-out	Transfer-in	Farm-adjustment	Transfer-out
Farmland use rights transfer	Area of transferred farmland	0.647*	0.567	0.163	0.797***	0.553***	-1.604
		(0.36)	(0.659)	(0.146)	(0.286)	(0.119)	(1.856)
	Square of transferred farmland area	-0.043*	-0.12	-0.006	-0.045***	-0.077**	0.069
		(0.026)	(0.096)	(0.007)	(0.013)	(0.03)	(0.147)
Physical attributes	Village water resource	0.117	-0.19	0.102	-0.037	-0.046	0.122
		(0.156)	(0.118)	(0.122)	(0.075)	(0.065)	(0.114)
	Farmland location	0.419**	0.184	0.233*	0.173	0.13	0.181
		(0.182)	(0.351)	(0.137)	(0.115)	(0.103)	(0.179)
	Village topography	0.359**	-0.012	-0.085	0.253**	-0.035	-0.137
		(0.151)	(0.114)	(0.11)	(0.123)	(0.06)	(0.1)
	Farmland water scarcity	0.168**	0.264***	0.184***	0.117**	0.079	0.196***
		(0.083)	(0.095)	(0.065)	(0.054)	(0.058)	(0.075)
Community attributes	Village size	-0.107	-0.14**	0.008	0.076	-0.117**	0.025
		(0.144)	(0.069)	(0.068)	(0.067)	(0.059)	(0.066)
	Village development	0.008	-0.015	0.03	0.005	-0.005	0.029
		(0.031)	(0.02)	(0.023)	(0.014)	(0.013)	(0.023)
Institutional context	Rule formation	0.311	0.698***	0.417***	-0.12	0.412**	0.328*
		(0.237)	(0.188)	(0.111)	(0.111)	(0.2)	(0.197)
	Village governance failure	-0.335	-0.437	-0.853***	-0.022	-0.201	-0.655**
		(0.283)	(0.452)	(0.204)	(0.085)	(0.202)	(0.314)
	Tenure stability	0.143	0.163	0.138	0.215*	0.082	0.059
		(0.187)	(0.14)	(0.135)	(0.112)	(0.086)	(0.114)
Household attributes	Farm area	-0.064	0.144	-0.659	-0.226*	0.117**	-0.231
		(0.304)	(0.113)	(0.555)	(0.136)	(0.059)	(0.734)
	Age	0.008	0.004	-0.007	0.001	0.002	-0.002
		(0.007)	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)
	Education	-0.145*	0.075	0.029	-0.037	0.011	0.055
		(0.083)	(0.07)	(0.066)	(0.041)	(0.042)	(0.059)
Province		-0.021	-0.009	0.008	0.003	0.001	0.01
		(0.016)	(0.009)	(0.009)	(0.007)	(0.004)	(0.01)
λ		-0.027	-0.154	0.2	-0.93**	-0.265**	0.07
		(0.655)	(0.144)	(0.24)	(0.39)	(0.116)	(0.451)
Sample		321	731	586	321	731	586
Prob>chi2		0.000	0.000	0.000	0.000	0.000	0.000
F-test statistic of instruments and endogenous variable						21.66	
Distance to county (p-value)					0.935	0.783	0.290
Extend of farmland transfer at village level (p-value)					0.693	0.817	0.189

transferred, which has led to great changes in land use.

6.1. The effects of farmland use rights transfer on farmers' participation in collective action

This study has conducted a detailed inspection of the internal structure of collective action organization by investigating how farmland transfer affects irrigation collective action and the variation of this effect among small farms with different farmland use rights transfer behavior at the household level. We characterized three types of farmland transfer and examined the variation in the impact of farmland transfer among these groups (Table 7). According to empirical analysis results, among transfer-in and farm-adjustment farmers there is a clear inverted-U relationship between the scale of transferred farmland and individuals' participation in collective action, in accord with Hypothesis 1 and Hypothesis 2. However, a corresponding effect is not seen among transfer-out farmers, which implies the negative and positive effects might more or less balance out and leaving no significant net impact on participation in collective action for public irrigation.

6.2. The aggregated effect of farmland use rights transfer on collective action

Prior analysis shows that farmland use rights transfer affects the success of collective action by influencing the transfer-in and farm-adjustment farmers' participation in collective action. Thus, we plotted three groups of farmer's collective action participation function on the same abscissa axis (top of Fig. 2). The horizontal axis shows the land transfer at the village level, where right part of the axis represents transfer in and left part represents transfer out. The vertical axis is the individual's propensity to participate in collective action. The inverted-U relationship between farmland transfer and collective action among transfer-in and farm-adjustment farmers (with turning points around X_1* and X_2* respectively) as well as the insignificant relationship for transfer-out farmers are plotted.

According to group-specific results, we infer there is an inverted U relationship between land transfer and village collective action (bottom of Fig. 2). With increase of land transfer, transfer-in and farm-adjustment farmers are more likely to participate in collective action, which indicates an improvement of village collective action; when both transfer-in and farm-adjustment farmers' probability of participation in collective action is highest (at turning points around X_2* and X_1* respectively), village collective action is most likely to succeed (with aggregated area of transferred land X_1* + X_2*); but village collective action will decrease with greater areas of transferred farmland, as the positive effect of farmland transfer flips to negative for both transfer-in and farm-adjustment farmers.

Given the total amount of cultivated farmland in a village, our deduction is consistent with prior literatures (Su et al., 2020a, 2020b), which suggest the village collective action increases curvilinearly with the volume of land transfer in the village.

7. Conclusions

With its rapid industrialization and mass labor migration away from agriculture, failed maintenance of irrigation facilities is widespread in rural China. Although much scholarship has focused on the negative effects of the outflow of rural labor and insufficient land endowments on

Table 6
Effects of farmland use rights transfer on attendance at meetings on collective irrigation.

		Baseline Model			IV-oprobit		
		Transfer-in	Farm-adjustment	Transfer-out	Transfer-in	Farm-adjustment	Transfer-out
Farmland use rights transfer	Area of transferred farmland	0.485*	0.964*	0.496	0.735**	0.549*	0.032
		(0.278)	(0.572)	(0.319)	(0.364)	(0.330)	(1.755)
	Square of transferred farmland area	-0.009	-0.144*	-0.072	-0.035**	-0.088***	0.036
		(0.011)	(0.081)	(0.047)	(0.018)	(0.034)	(0.076)
Physical attributes	Village water resource	0.126	-0.158	0.095	0.079	-0.071	0.088
		(0.164)	(0.116)	(0.128)	(0.144)	(0.084)	(0.083)
	Farmland location	0.064	0.119	0.383***	0.138	0.241*	0.237**
		(0.179)	(0.366)	(0.138)	(0.157)	(0.141)	(0.113)
	Village topography	0.319**	-0.004	-0.1	0.334*	-0.003	-0.069
		(0.152)	(0.114)	(0.11)	(0.173)	(0.068)	(0.088)
	Farmland water scarcity	0.188**	0.362***	0.133**	0.089*	0.198	0.078
		(0.092)	(0.094)	(0.063)	(0.054)	(0.129)	(0.071)
Community attributes	Village size	-0.029	0.006	0.001	-0.101	-0.014	-0.002
		(0.153)	(0.074)	(0.073)	(0.183)	(0.065)	(0.05)
	Village development	0.017	-0.006	0.02	0.01	-0.001	0.018
		(0.031)	(0.02)	(0.025)	(0.025)	(0.016)	(0.017)
Institutional context	Rule formation	0.401*	0.439**	0.545***	0.321	0.337**	0.362*
		(0.231)	(0.184)	(0.11)	(0.371)	(0.169)	(0.19)
	Village governance failure	-0.215	-0.069	-0.667***	-0.361	-0.239	-0.421*
		(0.255)	(0.514)	(0.211)	(0.243)	(0.262)	(0.255)
	Tenure stability	0.168	-0.142	-0.014	0.233	-0.099	-0.006
		(0.189)	(0.139)	(0.126)	(0.168)	(0.104)	(0.084)
Household attributes	Farm area	-0.41	-0.175*	-0.799	-0.206	-0.098	-0.88**
		(0.282)	(0.098)	(0.532)	(0.213)	(0.119)	(0.359)
	Age	0.007	0.006	-0.004	0.002	0.004	0.000
		(0.007)	(0.005)	(0.005)	(0.005)	(0.004)	(0.003)
	Education	-0.039	0.077	0.043	-0.029	0.045	0.04
		(0.613)	(0.076)	(0.064)	(0.068)	(0.065)	(0.041)
Province		-0.018	-0.014	0.02**	-0.01	-0.003	0.014
		(0.016)	(0.009)	(0.009)	(0.017)	(0.005)	(0.009)
λ		-0.333	0.02	0.459*	-0.133	-0.11	0.458***
		(0.66)	(0.148)	(0.238)	(0.775)	(0.218)	(0.157)
Sample		321	731	586	321	731	586
Prob>chi2		0.000	0.001	0.000	0.000	0.000	0.001
F-test statistic of instruments and endogenous variable						21.66	
Distance to county (p-value)					0.624	0.896	0.751
Extend of farmland transfer at village level (p-value)					0.691	0.208	0.376

collective action for irrigation, the combined effects of farmland reallocation and rural labor out-migration have rarely been studied, especially at the household level.

In this study we explored the internal structure of collective action organization, especially we focused on the variation effect of farmland use rights transfer on irrigation collective action, considering variations in land transfer behavior among small farms, using a two-stage approach and survey data from 4917 households across 21 provinces of China. Based on previous studies that found significant positive impacts from farmland transfer in general, we further find that the impact differs among farmers with different land transfer behavior. Farmers who expand their production through land transfer and farmers who transfer land to optimize its utilization (without changing the total area) are more likely to participate in collective action for public irrigation. But this positive effect flips to negative with greater areas of transferred farmland. We speculate that demand for irrigation water, reliance on farm income, free riding, economies of scale in the construction of irrigation facilities, cropping patterns, and stability of tenure of transferred farmland help explain the variation among the three groups.

Our findings provide evidence for possible inferences related to farmland transfer, collective action and the governance of commons. Variation in the effects of farmland transfer reveals that both farmers who transfer land use rights to expand their production and farmers who do it to optimize land use (without changing scale of production) are likely to cooperate in collective action for public irrigation. This could benefit agricultural production in China, where about two-thirds of the farmland requires irrigation water from public irrigation facilities.

Beyond the question of irrigation, the substantive policy implication of our findings in the context of labor out-migration can be summarized. Although flexible resources markets in the agricultural sector are beneficial for collective action in rural commons, the variation of farmers' behavior should be carefully considered in the process of resources reallocation. To counter the negative effects of rural labor outflow and deal with the variation in land transfer behavior among farmers, we suggest three lines of improvement of land use policy in China.

First, land use policies should clearly stipulate the obligations and rights of both contractors and subcontractors, to strengthen the stability of the use rights of transferred farmland. And rural village governance should include formal irrigation rules to limit the free riding that occurs with the rural-household differentiation. Promotion of the One Village One Product movement could also encourage investment in public irrigation facilities, because it could increase regional agricultural specialization and therefore help non-grain producers achieve economies of scale in public irrigation systems.

Second, policies should aim to strengthen the supply of rural public services and encourage farmers to cooperate in collective action. Since for transfer-out farmers, their willingness to cooperate and realize economies of scale mitigates the negative effects from decreasing farming scale, one possible method to further enhance their likelihood to participation in collective action is to encourage the development of agricultural socialization of service organizations and combine collective action with services provided by these organizations.

Third, policies should also aim to establish a flexible farmland market which can aggregate vacant farmland to increase land use efficiency (Liu et al., 2014). One possible method here is to encourage the development of large-scale farming, such as the emerging Farmer Professional Cooperatives. Concentrating farmland and increasing the

Table 7
Impact mechanisms of farmland use rights transfer on farmers' participation in collective action.

Farmland use rights transfer behavior	Mechanisms	Expected sign	Expected total effect on collective action	Findings
Transfer-in farmers	Increase of farm scale	+	Inverted-U relationship	Inverted-U relationship
	Reduction of land fragmentation			
	Free rider problems	–		
	Uncertainty of short-term contract			
	Higher production costs			
Farm-adjustment farmers	Reduction of land fragmentation	+	Inverted-U relationship	Inverted-U relationship
	Uncertainty of short-term contract	–		
	Higher production costs			
Transfer-out farmers	Willingness to cooperate and realize economies of scale	+	Inverted-U relationship	Insignificant effects
	Smaller farm scale	–		

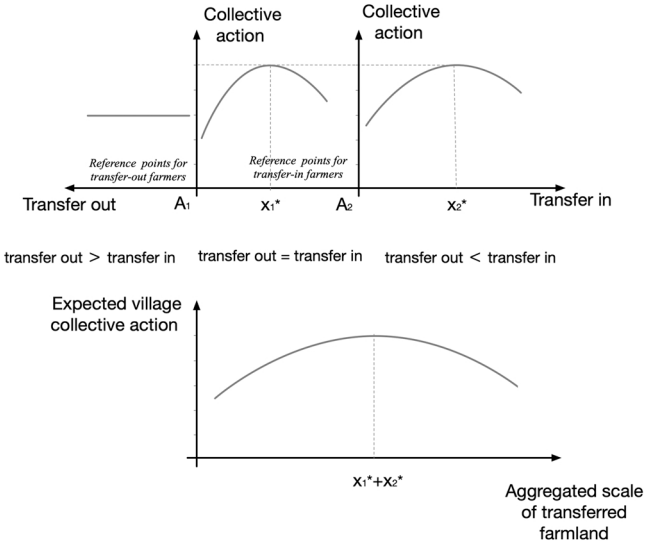

Fig. 2. Aggregated effects of farmland use rights transfer on collective action. Notes: A_1 and A_2 are farmland transfer behavior reference points for transfer-out and transfer-in farmers respectively. The left side of A_1 represents transfer-out farmers, and rights side of A_2 represents transfer-in farmers, while A_1 to A_2 represents farm-adjustment farmers.

average scale of agricultural production is expected to improve production efficiency (Liu et al., 2018) and mitigate the free riding caused by the variation in landholding size that results from the reallocation of farmland.

Although the empirical results are robust and reliable, this study has some potential limitations. First, beyond collective irrigation in rural society, more types of commons in both agricultural and non-agricultural sector need to be examined to enrich collective action theory. Second, larger sample could be used for further robustness check of our findings, and the accumulation of time series with timing variations will provide more convincing evidence for the impact of farmland transfer on collective action in the commons. Third, under the rapid transformation of rural sector in China, macro transformation could change some key contextual variables which may be important factors that affect success of collective action in the commons (Wang et al., 2019). Thus, in future analysis, more attention could be paid to the roles of key contextual variables in rapid transformation context.

Declaration of Competing Interest

None.

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