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Does farm size matter for participation in a land fallowing policy? Evidence from China

Zhuanlin Wang[a], Mehdi Nemati [b], Jinxia Wang[a] and Ariel Dinar[b]

[a]China Centre for Agricultural Policy, School of Advanced Agricultural Sciences, Peking University, Beijing, People's Republic of China; [b]School of Public Policy, University of California, Riverside, CA, USA

ABSTRACT

Land fallowing policy reduces the negative resource-use externalities, including water resources. Previous studies of land fallowing policies identified different factors that explain the willingness of farmers to participate in these programmes. However, less attention was placed on farm size as an important explanatory variable. We develop a theoretical model to explain the role of farm size in decisions to participate in land fallowing programmes. We then apply the theory to the Seasonal Land Fallowing Policy (SLFP), enacted to reduce agricultural groundwater use by fallowing the cultivated land of winter wheat in Hebei Province, China. Both small- and large-scale farmers participate in the programme. Using survey data, we examined whether farm size matters in decisions to participate as part of a set of variables, including farm and farmer characteristics and government requirements. Our results indicate that farm size significantly affects participation in the programme— the larger the farm, the more likely it will participate. The results are robust to various specifications. We also find that government requirements largely impact the decisions of small-scale farmers to participate. The findings have important implications for policy formulation and distinction among small- and large- scale farms.

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1. Introduction

Land fallowing programmes have been used to manage environmental externalities related to and derived from agricultural production by governments for quite some time. In 1986 the United States began implementing the Conservation Reserve Program (CRP) to retire highly erodible and other environmentally sensitive cropland and pasture (Hendricks and Er 2018; Lim and Wachenheim 2022). In Europe, the Common Agricultural Policy (CAP) schemes subsidized farmers to abandon farmland from 1988 to 2008, aiming to reduce surpluses and the costs of storing excess products (Ustaoglu and Collier 2018). China initiated its 'Grain for Green' programme in 1999 for soil erosion control. With 25 provinces (out of 31) involved, China reforested about 33 million ha of cultivated land through the programme (Delang and Yuan 2014).

More recently, with the increased importance attached by the Chinese government to environment conservation, various pilot land fallowing programmes aimed at some environmental issues have been launched. For instance, the Seasonal Land Fallowing Policy (SLFP) for addressing groundwater overdraft was launched in 2014 (Deng et al. 2021), and a land fallowing policy for addressing heavy metal pollution was launched in Hunan Province in 2016 (Yu et al. 2019). A

CONTACT Jinxia Wang jxwang.ccap@pku.edu.cn

land fallowing policy for addressing stony desertification was launched in Guizhou and Yunnan provinces in 2016 (Wu and Xie 2017). Although these programmes are still in the pilot stage, their experience is of great importance for the Chinese government to further promote such land fallowing policies.

Land fallowing policies are expected to deal with agricultural and environmental problems. However, to achieve the goals of such policies, the first step is ensuring that stakeholders would like to participate in the programmes offered by the government (Engel, Pagiola, and Wunder 2008). Therefore, the participation motivations of farmers in land fallowing programmes have been discussed in literature. As pointed out by Monger et al. (2018), the programme must be attractive for targeted participants by providing enough financial incentives. Farmers are unlikely to voluntarily participate if their opportunity costs are not adequately compensated for (Suter, Poe, and Bills 2008; Zuo, Wang, and Huang 2020). Of course, not all farmers are eligible to enrol in the programme unless they can satisfy some requirements that are determined by various policy objectives (Fleming, Lichtenberg, and Newburn 2018). For example, Uchida, Xu, and Rozelle (2005) reported that the 'Grain for Green' programme attempts to retire plots that are susceptible to soil erosion. Therefore, the enrolled farmers should have land that their slop are larger than 15 degree.

One of the important factors that may influence farmers' decision to participate in such programmes is farm size. This inference is based on the assumption that farm size shapes many on-farm aspects, such as mechanization or labour allocation, which could lead to differences in production performance (Foster and Rosenzweig 2022; Rada and Fuglie 2019; Sheng, Ding, and Huang 2019). Consequently, the per land unit opportunity cost and the per land unit benefit of fallowing land may vary with farm size (Zuo, Wang, and Huang 2020). The size of farmland also largely determines the degree of farmers' dependence on agricultural production (Sauer, Davidova, and Latruffe 2012), the flexibility in production decisions, and the ability to handle the risk of decision-making failure (Vigani and Kathage 2019). These aspects of distinction caused by farm size have been used in part of the literature to explain why farm size matters in adopting some other payment-for-environmental-services (PES) programmes related to water, such as the Equitable Payments for Watershed Services (EPWS) programme in Tanzania (Kwayu, Sallu, and Paavola 2014) and watershed management programmes in Ethiopia (Amsalu and de Graaff 2007; Agidew and Singh 2018). The general findings of these studies indicate that farmers with larger farms are more likely to participate in the programmes.

However, only a few studies in the economic literature have shed light on the role of farm size in determining participation in land fallowing programmes. One of the reasons for such scant related literature might be that some previous works rely on either aggregate county-level data (e.g. Isik and Yang 2004) or spatial well-site data (e.g. Monger et al. 2018), which makes it difficult to explore the role of farm-level factors on the participation in the programmes. The limited number of articles that explore the impact of land fallowing programmes find inconclusive results. Some studies find that farm size positively correlates with farmers' decisions to participate in land fallowing programmes (McLean-Meyinsse, Hui, and Joseph 1994; Chang and Boisvert 2009). In contrast, some studies suggest that farm size is likely to adversely affect participation in land fallowing programmes (Konyar and Osborn 1990; Zhang et al. 2011; Xie, Cheng, and Lv 2017; Xie, Cheng, and Lu 2018). The inconsistent conclusions from these studies indicate that the relationship between farm size and participation in land fallowing programmes needs to be further studied with more detailed data and more specific measurements of farm size variables.

To address this question, we focus on one of China's new land fallowing programmes, the Seasonal Land Fallowing Policy (SLFP), initiated in 2014 to address the severe groundwater overdraft in the North China Plain. On average, about 60% of SLFP areas have been occupied by small-scale farms since the policy was enacted. To incorporate both small-scale and large-scale participants and non-participants in SLFP in one analysis framework, farmer-level field data were collected by means of a survey, which allows to comprehensively reveal the impact of farm size and other determinants on participation in SLFP.

This work contributes to the literature in several ways. To our knowledge, this is the first effort to specifically explore the role of farm size on participation in the land fallowing programmes that have mainly addressed groundwater overdraft. In addition, this article includes large-scale farmers in the participation behaviour analysis of environmental policies, which is usually neglected by other related studies in China (Xie, Cheng, and Lv 2017; Xie, Cheng, and Lu 2018). Finally, our study enriches the analysis of other factors, such as irrigation conditions and government requirements for participation in land fallowing programmes. Our findings are not only critical in the SLFP's expansion to other areas of North China Plain, but also could be used as a reference for other countries in order to promote seasonal or permanent land fallowing policies, especially those that pertain to groundwater resource problems.

The article is organized as follows: Section 2 presents the background of the development of farm size and SLFP in China; Section 3 describes the sampling process and contents of the data; Section 4 introduces the empirical models and variables used in the model; Section 5 analyzes the empirical results, emphasizing farm size and Section 6 provides conclusions and policy implications.

2. Background

2.1. Development of farm size in China

Historically, China's main agricultural land holding was made up of small farms. The household-responsibility system, which began in 1979 and was essentially completed in 1983, equally allocated the rural arable land among all households in each village, resulting in small farm size was China's main type of agricultural land holding (on average, only 0.7 ha in 1985). After the reform, and driven by the emerging land-rental market and the rapid growth of rural-to-urban migration due to urbanization and industrialization, new types of agricultural business entities (i.e. large-scale farms), including farmer cooperatives, family farms, large grain growers, and agricultural companies, were rapidly developed (Ito, Bao, and Ni 2016; Huang and Ding 2016). Although the new types of agricultural business entities vary in their organizational structure, they are all characterized as large-scale, and intensive, with commercial production and management in the cropping sector (Zuo et al. 2015). According to the official definition used in the Third National Agricultural Census, the land holdings of a large-scale farmer is more than 3.33 ha (50 mu).[1] The size of these large-scale farms is still small compared with the size of farms in some other counties, such as the United States (Lowder, Skoet, and Raney 2016), but it is a marked change compared to the small farm size of households. Based on this standard, in 2016, about 30% of the total farmland in China was operated by large-scale farmers (NSBC 2017).

2.2. SLFP overview and farmers' participation in SLFP operations in Hebei

SLFP was designed to reduce agricultural groundwater use by adjusting farms' cropping patterns. The grain production area of Hebei Province is mainly characterized by a wheat-maize double-cropping pattern. In this cropping pattern, winter wheat grows in the dry season (from early October to late June), while summer maize grows in the wet season (from late June to early October). Precipitation is very low in the dry season (winter), resulting in a much higher water requirement for winter wheat, supplied by groundwater, than that of summer maize. Hence, winter wheat was targeted in SLFP. The term 'seasonal' SLFP emphasizes that only one crop is encouraged to be fallowed in this double-cropping pattern. It makes SLFP distinct from some other well-known land fallowing policies that refer to year-round or permanent fallowing (Wu and Xie 2017). The government provided a unified and time-invariant cash compensation for participation in SLFP. The amount of compensation was 7,500 CNY per ha per year.[2] The provincial government that designed the rate believed that participating in SLFP would not negatively affect farmers' income with this compensation. Small and large-scale farmers received the same compensation per ha, and there was no change in the compensation over time.

The provincial government was the primary agency responsible for selecting the pilot counties and arranged a quota of pilot areas (with allocated programme funds) for these counties annually. All farmers in the pilot counties could volunteer to participate in the programme. After farmers voluntarily apply to the SLFP, the local government selects the final participants based on additional conditions.

The government formulated several conditions to target potential applicants and select the final participants. The SLFP was established to target groundwater-dependent winter wheat growing areas located in the overdraft zone of the aquifer. Therefore, farmers in prefectures and counties in the targeted regions are eligible to participate in the programme.[3] In addition, the condition that plots to be selected should cover a contiguous area is emphasized to minimize the implementation cost and achieve a noticeable policy effect. In practice, the minimum contiguous areas set by the local government is 3.33 ha. However, small-scale farmers' total land areas are less than this requirement and their land are dispersed. Therefore, whether small farmers can successfully apply for the programme also depend on their neighbours' applications whose land are conjunctive with them. In order to meet this requirement, the local government has tried to encourage all farmers in the targeted villages to apply for the programme. The arable land of large-scale farmers is largely contiguous and exceeds 3.33 ha in general, so they can easily meet this condition.

The number of SLFP counties increased from 34 in 2014–47 in 2022, mainly located in four adjacent prefectures (Cangzhou, Handan, Hengshui, and Xingtai) of southern Hebei province. In a short time, the SLFP areas increased from 50,700 ha in 2014–131,300 ha in 2022. As of the pilot phase, the SLFP areas included only a small share (2%) of the total cultivated land areas and the total planted areas of winter wheat (5.7%) of Hebei province in 2018 (Deng et al. 2021).

Although much fewer in number than small-scale farmers, large-scale farmers have been increasingly important participants in SLFP, but the significance differs by region. The SLFP areas with large-scale farmer participants increased from 38% of the total SLFP areas in 2014–46% in 2015. After this, SLFP experienced some decline but still accounted for 41% in 2017 (Table 1). Among large-scale farmers, farmer cooperatives contributed the most significant proportion of the SLFP areas, followed by large grain growers and family farms. In addition, the participants of small and large-scale farmers differed significantly among regions in Hebei Province. For example, in 2017, both Handan and Hengshui prefectures showed that large-scale farmers were the main participants in SLFP. Handan's SLFP areas that were managed by larger-scale farmers were as high as 93% and 63% for Hengshui Prefecture. In contrast, small-scale farmers could be the main participants in areas such as Xingtai Prefecture, where the share of SLFP areas managed by large-scale farmers was only 24%, the lowest in the four SLFP major prefectures (Handan, Hengshui, Cangzhou and Xingtai prefectures) in Hebei Province. The SLFP areas of small- and large-scale were also equal in some regions, such as Cangzhou Prefecture where 49% of the SLFP areas were allocated to large-scale farmers, and 51% were small-scale farmers.

Table 1. The proportion of SLFP areas participated by small-scale and large-scale farmers (%).

Year	Small-scale farmers (%)	Large-scale farmers				
		Share (%)	Farmer cooperatives	Family farms	Large grain growers	Agricultural companies
2014	62	38	76	11	11	3
2015	54	46	59	9	28	4
2016	55	45	49	11	29	11
2017	59	41	51	15	27	7
Average	58	43	59	11	24	6

Notes: The authors collected the data from County Agriculture Bureaus in Hebei Province. On average, from 2014 to 2017, 68% of pilot counties' information is successfully collected to calculate the proportion.

3. Data

An extensive field survey collecting information for small and large-scale farmers was carried out in Hebei Province in 2019 (Deng et al. 2021). First, the researches site was narrowed down to the four prefectures (Xingtai, Cangzhou, Hengshui and Handan prefectures), which accounted for nearly 90% of the pilot areas due to their most severe groundwater overdraft in the aquifer (Figure 1). Then, a stratified random sampling method was used to sample farmers in these four prefectures.

In some SLFP counties, small-scale farmers are the dominant participants (occupied more than 50% of SLFP areas) while in some other SLFP counties, large-scale farmers are the dominant participants. Therefore, we classified SLFP counties into two types: dominated by small-scale or large-scale participants. Then we selected small-scale farmers in counties dominated by small-scale participants, and selected large-scale farmers in counties dominated by large-scale participants. Within the counties dominated by small-scale farmers, in principle, we randomly selected 2 counties in each prefecture. However, since the SLFP areas occupied with small-scale farmers in Cangzhou is almost the same as the SLFP areas occupied with large-scale farmers (as we introduced in section 2.2), we select 1 county in this prefecture. In total, 7 counties were sampled to survey small-scale farmers. Within the counties dominated by large-scale farmers, in principle, we randomly selected 1 county in each prefecture. Because the SLFP areas implemented by large-scale farmers in Handan was significantly larger than that in other prefectures, we selected only 1 more county in Handan. In total, 5 counties were sampled to survey large-scale farmers (Figure 1).

For the selection of small-scale farmers, in each sampled county, two SLFP townships were randomly selected, and one SLFP village and one non-SLFP village were selected by applying the matching approach in each sample township.[4] Finally, 20 small-scale farmers were randomly selected in each sampled village. This sampling process allowed us to acquire an effective sample of 558 small-scale household farms in 2019, with 226 participating in the SLFP and 332 not participating. Since some large-scale farmers will rent land from other villages and importantly, in one village, there are only a few large-scale farmers, we can't first sample village and township in the sampling for large-scale farmers. Instead, in each sample county, we randomly selected respondents

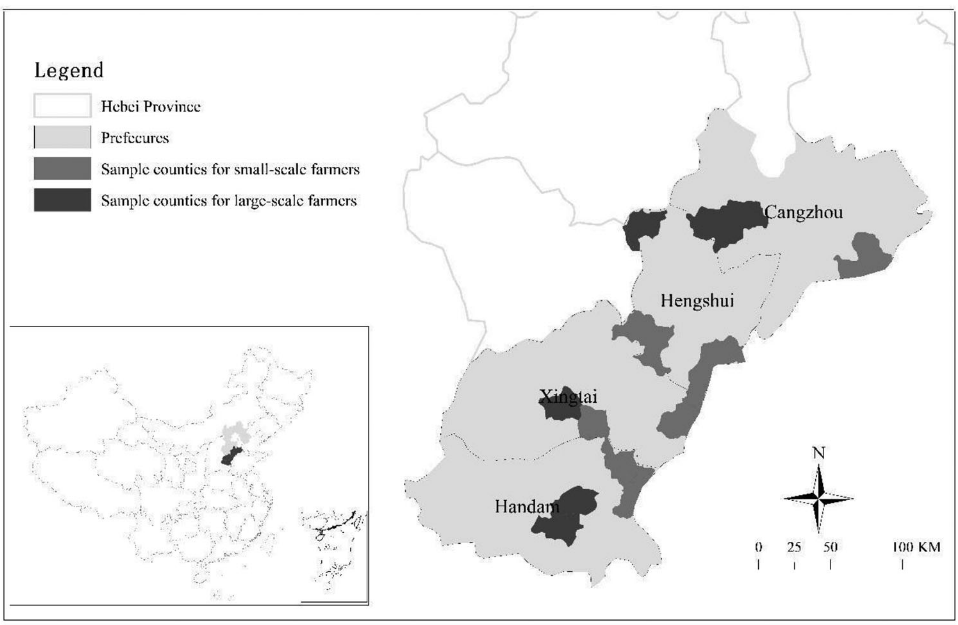

Figure 1. Location of sample counties.

from the participant group and non-participant group based on the list of large-scale farmers provided by the county government. Finally, we surveyed an effective sample of 158 large-scale farmers, including 101 participants and 57 non-participants in 2019.

During the survey, face-to-face interviews with representatives in the small-scale farms and managers of large-scale farms were carried out. Questionnaires for each group of farmers covered a wide range of common and unique issues. This study highlights the common information related to participation in the programme, including. (i) SLFP participation information; (ii) farm size, soil type, and other features of the cultivated land; (ii) irrigation conditions, including features of wells used by respondents and aquifer characteristics under their cultivated farmland; (iv) socio-economic characteristics of the head of the small-scale households or the managers of the large-scale farms. In addition, a survey with village leaders was conducted to capture factors that may affect the small-scale farmers' participation decision at the village level, such as the neighbour effect (which is introduced later).

4. Model of participation in the programme

4.1. Theoretical framework and research hypothesis

An eligible producer i participates in a government programme if the utility associated with participating in that programme that regulates the production of a given crop (e.g. not growing irrigated wheat) is larger than the utility associated with not being in the programme (growing irrigated wheat). The additional utility per ha associated with participation in the programme denoted by $U_{1i} = T_i + B_i(S_i)$, is equal to the per ha of cash compensation T_i offered by the government and other expected increases in income B_i resulting from the re-arrangement of labour and capital saved by retiring an additional one ha of farmland. T_i is fixed in this programme. B_i can be obtained either directly from farming or non-farming activities. B_i is determined by farm size S_i.

The additional utility per ha of non-participating in the programme U_{2i} is equal to the net returns from cultivating the crop regulated by the programme (e.g. irrigated winter wheat). Let p be the output price of wheat, y_i be the per ha yield of wheat as a function of farm size (S_i) of the cultivated land operated by farmer i. c_i are the per ha production costs, including irrigation costs. U_{2i} can be expressed as the total net benefit from winter wheat production so that $U_{2i} = py_i(S_i) - c_i$. Assuming that the dichotomous variable Y_i indexes the participation decision if U_{1i} is larger than U_{2i}, that is,

$$Y_i = 1 \quad if \quad U_{1i} - U_{2i} = T_i + B_i(S_i) - py_i(S_i) + c_i > 0$$

It is an empirical question how the utility of participating in the programme responds to farm size. However, we try to explore it intuitively. Farmers who operate larger cultivated land are supposed to have more space to rearrange their labour and capital to other areas not involved in the programme (Amsalu and de Graaff 2007; Agidew and Singh 2018). By doing so, their farming income in non-fallowed land may be positively impacted, resulting in higher utility from participating in the programme. Farm size may also affect farmers' non-farming income by affecting their non-farming employment. Farmers who operate smaller cultivated land can have more time to engage in a non-farming occupation, increasing their non-farming income. Still, their expected non-farming increase may depend much on their human capital rather than farm size. Hence, the utility associated with participating in the programme U_{1i} is supposed to increase with farm size S_i.

In addition, if we assume that the price of wheat and other production costs are given to the farmer, then the utility of non-participating in the programme depends on the relationship between farm size and wheat yield. We assume the yield of wheat decreases with farm size in China as some previous work indicated (Benjamin and Brandt 2002; Chen, Huffman, and Rozelle 2011; Li et al. 2013; Sheng, Ding, and Huang 2019), leading to the utility of non-participating in the programme

U_{2i} to decrease with the farm size S_i. As a result, as the increase with farm size S_i, farmers are more likely to participate in the programme. Based on this theoretical framework, we hypothesize that farm size positively affects farmers' participation decisions.

4.2. Empirical specification

A random utility framework is used to empirically estimate the parameters and verify the research hypothesis (Cameron and Trivedi 2005). The utility U_{1i} and U_{2i} are assumed to be composed of an observable component π_{1i}, π_{2i} and an unobservable component ε_{1i}, ε_{2i} respectively. Then the probability of participation $P(Y_i = 1)$ can be expressed as.

$$P(Y_i = 1) = P(U_{1i} > U_{2i}) = P_r(\pi_{1i} + \varepsilon_{1i} > \pi_{2i} + \varepsilon_{2i})$$
$$= P_r(\pi_{1i} - \pi_{2i} > \varepsilon_{2i} - \varepsilon_{1i})$$

Assuming that $\varepsilon_{2i} - \varepsilon_{1i}$ is normally distributed, and $\pi_{1i} - \pi_{2i}$ is a linear function, the probability of participation P in the programme can be estimated with a logit model:

$$P(Y_i = 1) = \Phi(\beta_1 S_i + \beta_2 X_i)$$

where $\Phi(.)$ represents the cumulative normal distribution, X_i is a set of physical and socioeconomic factors that are mainly related to the opportunity cost associated with participating in the programme. The requirements of the programme administrators should be controlled to separate the impact of the farm size S_i. β_1, β_2 are the parameters to be estimated. Table 2 presents the definition and expected direction of all variables used.

Participation in the SLFP programme is the dependent variable that measures whether a farmer participates (= 1) in the programme in 2019 and 0 otherwise. The farm size variable measures total cultivated areas, including farmer's land and rent-in land from other farmers or village committees. As a significant biophysical attribute of farms, soil type is included to reflect land quality. Soil type is

Table 2. Variables description and expected sign.

Variables	Definition (unit)	Expected sign
Dependent variable		
Participation	Dummy: = 1 if a farmer participates in SLFP, 0 otherwise	
Characteristics of farm		+
Farm size	Total cultivated areas(ha)	
Sandy soil	Dummy: = 1 if the main soil type of cultivated land is sandy,0 otherwise	
Loam soil	Dummy: = 1 if the main soil type of cultivated land is loam,0 otherwise	–
Clay soil	Dummy: = 1 if the main soil type of cultivated land is clay,0 otherwise	–
Irrigation conditions		
Surface water	Share of cultivated land irrigated by surface water of total cultivated land (%)	–
Water-saving irrigation	Dummy: = 1 if water-saving irrigation is used in field irrigation,0 otherwise	–
Pipe delivery	Dummy: = 1 if the main water delivery method is the pipeline,0 otherwise	–
Charge	Electricity price for irrigation plus management fee (yuan/kilowatt-hour)	+
Well depth	Average depth of main wells used by the farmer (10^2 m)	?
Characteristics of farmers		
Age	A farmer's age (years)	–
Age squared	A farmer's age squared (years)	+
Education	Number of school years (years)	+
Non-farming experience	Dummy: = 1 if a farmer engaged in a non-farming job before participating in SLFP,0 otherwise	+
Risk attitude	Range from 0–10, the higher the value, the more risk-seeking	+
Number of cars	Number of cars owned by a farmer	+
Government Requirements		
Serious shallow overdraft	Dummy: = 1 if the township locates in serious shallow overdraft region	+
General deep overdraft	Dummy: = 1 if the township locates in general deep overdraft region	+
Serious deep overdraft	Dummy: = 1 if the township locates in serious deep overdraft region	+
Distance	Euclidian distance between county government offices and farmers' location (km)	–

represented by three dummy variables (sandy soil, loam soil, clay soil). Better soil type leads to higher land productivity, resulting in a higher opportunity cost to participate in the programme and a weak willingness to participate (Isik and Yang 2004). Compared to sandy soil, clay soils are more fertile but less well-drained than loam soil. Loam soils are more fertile but less well-drained than the sandy soils baseline (Ma et al. 2012). Therefore, farmers' participation in SLFP is expected to be negatively impacted if the primary soil type of their cultivated land is clay compared to sandy soil.

Since the SLFP aims to affect irrigation, the category of *irrigation conditions* is included. Irrigation water is an essential input factor in crop production. Better irrigation conditions, such as self-contained irrigation facilities, and availability and stability of irrigation are expected to result in higher yield and negatively affect participation (Suter, Poe, and Bills 2008; Zuo, Wang, and Huang 2020). We use five variables to represent irrigation conditions. Surface water represents the share of cultivated land irrigated by surface water of total cultivated land in percentage. Suppose farmers' cultivated land can also be irrigated by surface water. In that case, they may care less about the groundwater problems and be unwilling to participate in a programme that aims to protect groundwater. Water-saving irrigation is a dummy variable that equals 1 if water-saving irrigation technologies are used in field irrigation and 0 otherwise. Water-saving irrigation technologies include not only some traditional water-saving agronomic technologies (border irrigation and furrow irrigation), but also some relatively new techniques (pipeline irrigation, sprinkler irrigation, and drip irrigation) (Blanke et al. 2007). Water-saving field irrigation is more efficient than flood irrigation by reducing evaporation and runoff losses (Peterson and Ding 2005). Under more efficient use of irrigation water and higher fixed cost of investing in water-saving infrastructure, farmers who adopt water-saving irrigation are expected not to participate in a land-fallowing programme. Pipe delivery is also a dummy variable, which equals one if water conveyance is mainly through piping systems consistent with underground pipework and surface pipework (such as water hose), and 0 otherwise. Pipes can convey water more efficiently than earth or concrete canals.

Another set of two variables (charge and well depth) reflects the cost of pumping groundwater since groundwater is the main water source in our research region. The variable charge represents the charge for pumping water, which consists of electricity charges and management fees in this region, units in yuan/kilowatt-hour. Electricity charges usually are uniform in a village, but the management fee may vary from the manager (Wang et al. 2020). Electricity charges are found to significantly affect winter wheat abandonment in North China Plain because of the higher irrigation cost (Wang and Li 2018). Hence, we expect the charge to incentivise participation in the programme. Well depth is measured by the farmer's average depth of main wells. Deep wells may be better functioning for pumping water compared to shallow wells given the higher and newer investment.[5] However, pumping groundwater from the deeper wells also leads to higher irrigation costs because more electricity is used for pumping. Hence, well depth may positively or negatively affect farmers' participation decisions.

The characteristics of farmers are consistent with the respondents' socio-demographic characteristics, including their age, education, non-farming experience, risk attitude, and the number of cars. Compared with older farmers, young farmers may have more non-farming job opportunities. Participating in the programme allows them to pursue alternative non-farming employment. On the other hand, older farmers are more eager to retire, so they may join the programme to reduce farmed areas. The age squared is also included in this model to capture this variation, as previous studies did (Uchida et al. 2007; Wang and Li 2018). Education represents the number of school years. Farmers with higher levels of human capital (education) are more likely to increase their income through employment in the non-farming sector after fallowing part of their cultivated land in certain seasons. Therefore, following previous studies, it is hypothesized that well-educated farmers are more willing to participate in the programme (Wang and Li 2018; Xie, Cheng, and Lu 2018; Xie, Cheng, and Lv 2017). Non-farm experience will be an indicator variable equal to 1 if a farmer is engaged in a non-farm job before participating in SLFP and 0 otherwise. Compared to full-time farmers, those who had non-farming experience before participating in the programme are more likely to engage in non-farm jobs. Risk attitude was measured by asking farmers to rate their risk-taking attitude, with 0 representing completely unwilling to take risks and 10 representing very adventurous. Risk-averse farmers may prefer to maintain their planting patterns rather than participate in new programmes because of concerns about the uncertainty and irreversibility of the programme (Isik and Yang 2004). We include the number of cars as a proxy variable for income level since farms with higher incomes can afford to own cars. Richer farmers are likely to be less dependent on agriculture and more willing to participate in the policy.

Based on the enrolment process introduced in section 2.2, farmers' willingness and the programme administrators could determine participation in the programme. Programme administrators aim to enrol farmers to achieve high social benefits with minimal implementation costs. Therefore, programme administrators prefer farmers who can better achieve policy goals with less implementation cost to join the programme. Therefore, we include two variables to reflect the impact of the preferences of programme administrators. One is overdraft type dummies, a series of indicator variables representing four types of groundwater overdraft regions at the township level, which are the government zones (general shallow overdraft, serious shallow overdraft, general deep overdraft, serious deep overdraft). The government may preferentially target farmers located in the regions with the more severe groundwater overdraft. Another one is distance representing the Euclidian distance between county government offices and farmers' location in km. Programme administrators may prefer enrolling these applicants who are closer to them to reduce implementation costs.

Table 3 presents the summary statistics of the above variables. The average farm size of all sample farmers is 7.8 ha. As described in the background section, the average farm size of small-scale farmers (0.64 ha) is much smaller than that of large-scale farmers (33.07 ha).

5. Empirical results

5.1. Farm size and participation decision

The estimated marginal effects and the corresponding standard errors are given in Table 4. the unconditional relationship between farmers' participation decisions and farm size is estimated in column (1). The marginal effect of farm size is statistically significant at the 1% level. The result shows that the probability of farmers participating in the programme increases by 0.7% for 1 ha increase in farm size, given that other conditions are unchanged. Other independent variables except farm size are included in column (2). The inclusion of these variables does not change the significance of farm size. The prefecture-level dummy variables are included in column (3) to take into account of spatial heterogeneity, such as differences in weather conditions. The marginal effect of farm size barely changes when controlling the regional fixed effect compared to that in column (2). The results of these three regressions indicate that the probability of participating in the programme significantly increases with farm size. The results verify the hypothesis we have proposed.

We estimated a number of variations of our models to check the robustness of the results. A quadratic term for farm size is added in column (4) to explore if there exists a non-liner relationship between farmers' participation decision and their farm size. The results support the non-linearities, with the probability of participating in the programme showing diminishing rise with farm size. Furthermore, using the coefficients of equation (4), we obtained that the marginal impact of farm size is zero at 128 ha. Since farm size at present in our sample is far below 128 ha (only 0.15% of farms were larger than 13.33 ha in 2017), we can conclude that farm size will positively impact farmers' participation decision to join the programme.

In addition, a series of farm size dummies in place of a continuous farm size variable are estimated in Table 5. Three category methods are used to create the farm size dummies. The

Table 3. Summary statistics of variables.

	All samples (N = 716)				Small-scale farmers (N = 588)				Large-scale farmers (N = 158)			
Variables	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
Participation	0.46	0.5	0	1	0.41	0.49	0	1	0.64	0.48	0	1
Characteristics of farm												
Farm size	7.8	21.72	0.02	240	0.64	0.39	0.02	2.6	33.07	36.38	3.33	240
Sandy soil	0.26	0.44	0	1	0.29	0.45	0	1	0.15	0.36	0	1
Loam soil	0.4	0.49	0	1	0.42	0.49	0	1	0.33	0.47	0	1
Clay soil	0.34	0.47	0	1	0.29	0.45	0	1	0.52	0.5	0	1
Irrigation conditions												
Surface water	14.15	31.13	0	100	12.86	29.65	0	100	18.68	35.61	0	100
Water-saving irrigation	0.53	0.5	0	1	0.5	0.5	0	1	0.62	0.49	0	1
Pipe delivery	0.89	0.31	0	1	0.88	0.33	0	1	0.94	0.23	0	1
Charge for groundwater	0.78	0.42	0.3	3	0.81	0.46	0.45	3	0.69	0.24	0.3	1.86
Well depth	174.62	116.89	24.5	408	178.59	125.98	24.5	408	160.57	75.31	72.67	400
Characteristics of farmers												
Age	56.5	10.01	29	80	58.64	9.38	30	80	48.96	8.4	29	70
Education	7.38	3.02	0	18	6.95	3.05	0	18	8.91	2.37	2	16
Non-farming experience	0.46	0.5	0	1	0.45	0.5	0	1	0.47	0.5	0	1
Risk attitude	3.54	3.06	0	10	3.16	2.92	0	10	4.89	3.15	0	10
Number of cars	0.27	0.51	0	4	0.2	0.42	0	2	0.54	0.70	0	4
Government Requirements												
Serious shallow overdraft	0.06	0.24	0	1	0	0	0	0	0.28	0.45	0	1
General deep overdraft	0.04	0.21	0	1	0	0	0	0	0.2	0.4	0	1
Serious deep overdraft	0.5	0.5	0	1	0.57	0.5	0	1	0.25	0.44	0	1
Distance	25.1	25.45	0.84	115.71	28.65	27.51	0.84	115.71	12.55	7.82	1.08	63.12

Table 4. Regression results of the logit model using the continuous farm size variable.

	(1)	(2)	(3)	(4)
Farm size	0.007***	0.005**	0.006*	0.010***
	(0.002)	(0.002)	(0.003)	(0.002)
Farm size squared				−0.00004***
				(0.00001)
Loam soil		−0.027	−0.031	−0.032
		(0.043)	(0.043)	(0.043)
Clay soil		−0.087*	−0.094**	−0.100**
		(0.046)	(0.047)	(0.046)
Surface water share		0.001	0.001**	0.001**
		(0.001)	(0.001)	(0.001)
Water-saving irrigation		−0.106**	−0.117***	−0.123***
		(0.041)	(0.043)	(0.042)
Pipe delivery		−0.165***	−0.154***	−0.155***
		(0.058)	(0.058)	(0.058)
Charge for groundwater		0.155***	0.145***	0.144***
		(0.041)	(0.043)	(0.043)
Well depth		−0.004	−0.004	−0.003
		(0.014)	(0.016)	(0.016)
Age		−0.030**	−0.031**	−0.029*
		(0.015)	(0.015)	(0.015)
Age squared		0.0003**	0.0003**	0.0003**
		(0.0001)	(0.0001)	(0.0001)
Education		0.021***	0.021***	0.019***
		(0.006)	(0.006)	(0.006)
Non-farming experience		0.059	0.058	0.068*
		(0.038)	(0.038)	(0.038)
Risk attitude		−0.003	−0.003	−0.004
		(0.006)	(0.006)	(0.006)
Number of cars		0.043	0.044	0.040
		(0.036)	(0.037)	(0.035)
Serious shallow overdraft		0.252***	0.264***	0.221**
		(0.089)	(0.093)	(0.092)
General deep overdraft		0.268**	0.232**	0.176
		(0.107)	(0.117)	(0.112)
Serious deep overdraft		−0.030	−0.078	−0.071
		(0.038)	(0.063)	(0.063)
Distance		0.002***	0.003***	0.003***
		(0.001)	(0.001)	(0.001)
Prefecture dummies		No	Yes	Yes
Observations	716	716	716	716
Wald test	9.29	89.93	90.65	101.85

Notes: *10% significance, ** 5% significance, *** 1% significance.

first one divides farmers into small-scale farmers (smaller than 3.33ha) and large-scale farmers (larger than 3.33ha), which is in line with the definition of large-scale farmers in our paper, following the Chinese Government categories. The results will show whether participation decisions differ between small-scale and large- scale farmers. In the second one, farmers are categorized as small farmers (less than 0.5ha), median farmers (between 0.5ha and 1ha), and large farmers (larger than 1ha), which can bring out approximate frequency in each category. The third one refers to the category method used in the Statistical Database on Rural Operations and Management in China (Xie et al. 2020), in which the size of the farm is classified as less than 0.67ha, 0.67ha-2ha, 2ha-3.33ha, 3,33ha-6.25ha, 6.25ha-13.33ha and above 13.33ha. Columns of (1), (2), and (3) in Table 5 present the relative results using these three methods, respectively. The farm size dummy variable representing the smallest farm-size range is used as the benchmark group in each regression. The results indicate that no matter which category method is used, compared to the baseline group, farmers whose farm size is in the largest category are more likely to participate in the programme. In general, our research hypothesis passes our robustness tests.

Table 5. Regression results of the logit model using the variables of farm size dummies.

	(1)	(2)	(3)
Farm size[3.33ha-)	0.186***		
	(0.064)		
Farm size [0.5–1ha)		0.010	
		(0.044)	
Farm size[1ha-)		0.097**	
		(0.049)	
Farm size[0.67–2ha)			0.028
			(0.040)
Farm size[2–3.33ha)			0.200
			(0.185)
Farm size[3.33–6.67ha)			−0.357**
			(0.149)
Farm size[6.67–13.33ha)			0.029
			(0.111)
Farm size[13.33ha-)			0.267***
			(0.072)
Observations	716	716	716
Control variables	Yes	Yes	Yes
Prefecture dummies	Yes	Yes	Yes
Observations	716	716	716
Wald test	95.05	92.97	106.49

Notes: *10% significance, ** 5% significance, *** 1% significance. Control variables include all other variables except farm size in Table 4, column 2.

5.2. Control variables and participation decision

Apart from farm size, most other control variables meet our expectations of their directions and significance level. According to column (4) in Table 4, farmers whose main soil type of cultivated land is clay are more likely to participate in the programme than those whose main soil type is sandy, which means farms with better land quality are more likely to participate in the programme. Not surprisingly, irrigation conditions have a very significant impact on farmers' participation decisions in the programme. Farmers who use water-saving field irrigation technology and deliver water by pipes are less likely to participate in the programme since they are less affected by water scarcity. The higher the charge for groundwater, the larger the possibility of participating in the programme. The share of cultivated land irrigated by surface water positively impacts farmers' participation decision. This is inconsistent with our expectation; however, the marginal effect is very small compared to the other four irrigation-related variables. The average depth of groundwater has no significant impact since well depth may have either a positive or negative effect on farmers' participation decisions, as discussed in section 4.2.

As we expected, the older age of the farmer does not necessarily result in a greater likelihood of participation in the programme, presenting a U-shaped curve instead. In addition, farmers with higher education levels and non-farm experience are more likely to participate in the programme. Farmers' risk attitude has no significant impact on the results, which means risk is not considered when a farmer decides to enrol in the programme, probably because the SLFP is not very risky for farmers, given its simple enrolment and compensation mechanism. The results did not support the expectation that the number of cars owned by farmers (that is the income of farmers) has a significant effect.

According to estimated results in columns (2) and (3) of Table 4, compared to the farms located in the regions of the general shallow overdraft, farmers located in the regions of serious shallow overdraft and general deep overdraft are more likely to participate in the programme. However, farmers in serious deep overdraft regions aren't more likely to participate in the programme. In addition, farmers geographically closer to the county government offices were not more likely to participate in the programme, but farmers farther away were more likely to participate in the programme. However, the direction of the two variables is not exactly the same as expected. The significance of the two variables verifies the inference that the government affects farmers' participation decisions.

5.3. Farmers' participation decision for each type of farm size

The effect of farm size on small-scale and large-scale farmers' participation may differ, and some unique factors for one type of farmers we did not include in previous regressions may also have an important impact. Therefore, we estimate the regression for each type of farm separately.

Models in which only small-scale farmers are considered, is estimated in Table 6. The results indicate that farm size is not a significant factor among small-scale farmers in column (1). A natural forthcoming question is which factors may play a vital role in the decision of small-scale farmers to participate. Based on the enrolment process of small-scale farmers, an additional factor that may have a significant effect on participation is the prerequisite of having contiguous areas of at least 3.33 ha for participation. This requires that a small farm's participation has to rely on other neighbour farmers' participation, using the endowment of cultivated land in the village. Therefore, we include two village-level variables to reflect the impact of the requirement of contiguous areas in

Table 6. Regression results of the logit model for small-scale farmers.

	(1)	(2)
Farm size	0.054	0.030
	(0.051)	(0.023)
Loam soil	−0.048	−0.024
	(0.047)	(0.018)
Clay soil	−0.153***	−0.015
	(0.052)	(0.018)
Surface water share	0.002***	0.00008
	(0.001)	(0.0004)
Water-saving irrigation	−0.118**	−0.006
	(0.047)	(0.023)
Pipe delivery	−0.179***	0.008
	(0.061)	(0.023)
Charge for groundwater	0.153***	−0.054*
	(0.047)	(0.032)
Well depth	−0.025	0.006
	(0.017)	(0.008)
Age	−0.021	−0.014*
	(0.019)	(0.007)
Age squared	0.0002	0.0001*
	(0.0002)	(0.00007)
Education	0.017***	−0.0001
	(0.006)	(0.003)
Non-farming experience	0.107**	0.013
	(0.044)	(0.015)
Risk attitude	−0.006	−0.002
	(0.006)	(0.003)
Number of cars	−0.019	0.009
	(0.046)	(0.018)
Serious shallow overdraft	–	–
General deep overdraft	–	–
Serious deep overdraft	−0.330***	−0.026
	(0.086)	(0.077)
Distance	0.005***	−0.001***
	(0.001)	(0.0004)
Neighbour effect		0.005***
		(0.001)
Village farmland		0.001***
		(0.0002)
Observations	558	558

Notes: *10% significance, ** 5% significance, *** 1% significance. '-' represents omitted variables.

column (2) of Table 6. One is the neighbour effect representing the percentage of the farmers participating in SLFP in the village group.[6] Some farmers may participate in the programme for the consistency and overall benefit of collective action, even if they may be unwilling to retire the land independently. The impact of the neighbour effect may also be caused by some farmers' perception and willingness to join SLFP as a result of communicating with their neighbour participants (Lambert 2007; Reimer and Prokopy 2014). Another variable is village farmland representing the village's total cultivated areas (ha). The larger the total farmland areas of the village, the easier it is to meet the requirements of contiguous areas. As we expected, the results of column (2) of table 6 indicate that both variables (neighbour effect and village farmland) positively affect small-scale farmers' participation decisions. Besides, we also found that the variable Distance negatively affects small-scale farmers' participation in column (2), which means government officers prefer farmers closer to their office location to join the programme. The results indicate that the preference of the government largely determines small-scale farmers' participation.

Models which only includes large-scale farmers, is estimated in Table 7. The results in column (1) show that firm size significantly affects large-scale farmers' participation. In column (2), we

Table 7. Regression results of the logit model for large-scale farmers.

	(1)	(2)
Farm size	0.004**	0.003*
	(0.002)	(0.002)
Farmer cooperatives		0.152*
		(0.086)
Agricultural companies		0.121
		(0.195)
Loam soil	0.047	0.057
	(0.103)	(0.102)
Clay soil	−0.013	−0.029
	(0.090)	(0.094)
Surface water share	−0.0004	−0.00002
	(0.001)	(0.001)
Water-saving irrigation	0.007	−0.010
	(0.096)	(0.094)
Pipe delivery	0.074	0.060
	(0.193)	(0.195)
Charge for groundwater	0.181	0.144
	(0.179)	(0.162)
Well depth	−0.007	−0.0004
	(0.056)	(0.056)
Age	−0.005	−0.007
	(0.037)	(0.037)
Age squared	0.00003	0.0004
	(0.0004)	(0.0004)
Education	0.030*	0.025
	(0.017)	(0.017)
Non-farming experience	−0.036	−0.035
	(0.073)	(0.069)
Risk attitude	0.013	0.011
	(0.010)	(0.010)
Number of cars	0.086	0.091
	(0.054)	(0.055)
Serious shallow overdraft	−0.018	−0.012
	(0.189)	(0.171)
General deep overdraft	0.370***	0.375***
	(0.118)	(0.116)
Serious deep overdraft	−0.165	−0.151
	(0.264)	(0.233)
Distance	0.005	0.006
	(0.004)	(0.004)
Observations	158	158

Notes: *10% significance, ** 5% significance, *** 1% significance.

include three dummy variables representing farm types (family farms, farmer cooperatives, agricultural companies) to explore if specific types of large-scale farmers are more likely to participate than others.[7] The regression results show that there is a significant difference in the probability of participating for farmer cooperatives compared to the benchmark group of family farms but not for agricultural companies.

6. Conclusion and policy implications

This study verifies the impact of farm size on participation in a new land fallowing policy—SLFP—in China, using comprehensive survey data including small- and large-scale farmers. Both baseline and robustness check results estimated by the logit model support our hypothesis that farm size positively affects farmers' participation decisions. Apart from farm size, other determinants we include in the regression also play an important role in the adoption of SLFP. Farmers with better soil quality, more advanced field-irrigation technologies, water-delivery technologies, and lower charges of pumping groundwater are less likely to participate in the programme. The probability of participation first falls and then rises with the farmers' age. Farmers who are more educated and with non-farming experience are more likely to participate in the programme. The requirements of the government largely determine small-scale farmers' participation decisions.

These factors that affect farmers' participation in the programme can be explained by the eligibility and opportunity cost given the fixed incentives. The programme targeted the farms located in groundwater overdraft zones and required the fallowed land to have contiguous areas. Hence, farmers' participation decisions are affected by choice of programme administrators to meet the eligibility. Then, eligible farmers decide to participate in this programme if they can acquire more expected utility from participating in the programme than from not participating. Joining the programme is a niche for a farmer if the subsidies make up for the direct agricultural economic losses resulting from the fallowing land due to participation in the programme. In contrast, their income can be improved by allocating their freed labour to off-farm employment or increasing input levels in other parts of their farmlands that are not part of the programme. As we illustrated in the analytical framework, a larger farm size enables farmers more flexibility in adjusting their cropping pattern after participating in the programme to maintain (or increase) their farming income. In contrast, the larger farm's net revenue to maintain the status quo (planting winter wheat) may be lower because of more extensive operation. Farmers are unwilling to set aside their farmland with better soil quality and irrigation conditions, which means higher land productivity since the compensation may not offset their losses. Farmers who have the ability to recruit into a non-farming occupation because of their higher education level, appropriate age, and non-farming experience may increase their non-farming income by participating in the programme, giving them the incentive to participate in the programme.

There are important policy implications that can be derived from the analysis in this paper. Firstly, since we find that farm size does matter for the adoption of land fallowing programmes that address groundwater overdrafts, we can infer that the expansion of farm size benefits the implementation of land fallowing programmes by making it easier to enrol the participants. Secondly, the finding that farms with better land productivity and irrigation conditions are less likely to participate in the programme coincides with the economic benefits that agriculture production will be less impacted by the programme. However, enrolling these farmers can't necessarily achieve higher ecological benefits since those farms may use less water for irrigation even if they don't participate in the programme. In order to achieve optimal enrolment, which brings out the highest effectiveness under a fixed cost, the water-saving effects of these farmers should be further considered before approving them for participation in the programme. Thirdly, although the government makes efforts to improve the effectiveness by targeting the farms located in groundwater overdraft regions, the participation of farmers located in the regions of a serious deep overdraft should be further promoted because the problem of groundwater overdraft in these areas needs to be solved more urgently or can bring higher effectiveness. In addition, although the requirements of the government, especially the requirement of the contiguous areas, help to enrol the small-scale farmers, they might be a chance that some plots with higher productivity targeted, but less effect on overdraft problem are enrolled to meet these requirements.

Notes

1. This standard is used in our survey to identify the large-scale farmers. In the following text, a large-scale farmer is a farmer with a farm size equal or greater than 3.33 ha. One ha equals 15 mu.
2. This compensation standard is equal to US$ 1,087 per ha per year (US$ 1 equals 6.9 CNY in 2019).
3. Prefecture is the main administrative unit in China, one rank below that of provinces (the highest non-national level administrative unit). They consist of several districts and counties.
4. The matching approach ensures similar physical characteristics between SLFP and non-SLFP villages within the same township. The characteristics include the scale of contiguous areas, cropping pattern, irrigation condition and distance from the village committee to highway or county government.
5. The aquifer in this region is separated into a shallow and a deep unit by a confining layer. Farmers usually exploit groundwater in the shallow unit firstly by drilling shallow wells. When the shallow groundwater is almost exhausted or the shallow wells cannot be used, they begin to drill deep wells to pump groundwater in the deep unit.
6. Village group is a smaller unit in the village, and farmers in the same village group tend to live closer to each other.
7. There are four types of large farmers in our survey (farmer cooperatives, family farms, large grain growers, and agricultural companies), we group large grain growers as family farms since both of these two types of large farms are operated by household and may only differ by name.

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ORCID

Mehdi Nemati http://orcid.org/0000-0002-4736-7489

References

Agidew, Alem-meta Assefa, and K. N. Singh. 2018. "Factors Affecting Farmers' Participation in Watershed Management Programs in the Northeastern Highlands of Ethiopia: A Case Study in the Teleyayen Sub-Watershed." *Ecological Processes* 7 (1): 1–15. doi:10.1186/s13717-018-0128-6.

Amsalu, Aklilu, and Jan de Graaff. 2007. "Determinants of Adoption and Continued use of Stone Terraces for Soil and Water Conservation in an Ethiopian Highland Watershed." *Ecological Economics* 61 (2): 294–302. doi:10.1016/j.ecolecon.2006.01.014.

Benjamin, Dwayne, and Loren Brandt. 2002. "Property Rights, Labour Markets, and Efficiency in a Transition Economy: The Case of Rural China." *The Canadian Journal of Economics* 35 (4): 689–716. doi:10.1111/1540-5982.00150.

Blanke, Amelia, Scott Rozelle, Bryan Lohmar, Jinxia Wang, and Jikun Huang. 2007. "Water Saving Technology and Saving Water in China." *Agricultural Water Management* 87 (2): 139–150. doi:10.1016/j.agwat.2006.06.025.

Cameron, A. Colin, and Pravin K. Trivedi. 2005. *Microeconometrics: Methods and Applications*. Cambridge, u.a: Cambridge University Press.

Chang, Hung-Hao, and Richard N. Boisvert. 2009. "Distinguishing between Whole-Farm Vs. Partial-Farm Participation in the Conservation Reserve Program." *Land Economics* 85 (1): 144–161. doi:10.3368/le.85.1.144.

Chen, Zhuo, Wallace E. Huffman, and Scott Rozelle. 2011. "inverse Relationship between Productivity and Farm Size: The Case of China." *Contemporary Economic Policy* 29 (4): 580–592. doi:10.1111/j.1465-7287.2010.00236.x.

Delang, Claudio O., and Zhen Yuan. 2014. *China's Grain for Green Program: A Review of the Largest Ecological Restoration and Rural Development Program in the World*. Cham: Springer International Publishing AG.

Deng, Hongbo, Baozhu Guan, Jinxia Wang, Alec Zuo, Zhuanlin Wang, and Tianhe Sun. 2021. "Seasonal Land Fallowing Policy in Response to Groundwater Overdraft in the North China Plain." *Water Alternatives* 14 (2): 371–394.

Engel, Stefanie, Stefano Pagiola, and Sven Wunder. 2008. "Designing Payments for Environmental Services in Theory and Practice: An Overview of the Issues." *Ecological Economics* 65 (4): 663–674. doi:https://doi.org/10.1016/j.ecolecon.2008.03.011.

Fleming, Patrick, Erik Lichtenberg, and David A. Newburn. 2018. "Evaluating Impacts of Agricultural Cost Sharing on Water Quality: Additionality, Crowding in, and Slippage. ." *Journal of Environmental Economics and Management* 92: 1–19. doi:10.1016/j.jeem.2018.08.007.

Foster, Andrew D., and Mark R. Rosenzweig. 2022. "Are There Too Many Farms in the World? Labor Market Transaction Costs, Machine Capacities, and Optimal Farm Size." *The Journal of Political Economy* 130 (3): 636–680. doi:10.1086/717890

Hendricks, Nathan P., and Emrah Er. 2018. "Changes in Cropland Area in the United States and the Role of CRP." *Food Policy* 75: 15–23. doi:10.1016/j.foodpol.2018.02.001.

Huang, Jikun, and Jiping Ding. 2016. "Institutional Innovation and Policy Support to Facilitate Small-Scale Farming Transformation in China." *Agricultural Economics* 47 (S1): 227–237. doi:10.1111/agec.12309.

Isik, M., and W. Yang. 2004. "An Analysis of the Effects of Uncertainty and Irreversibility on Farmer Participation in the Conservation Reserve Program." *Journal of Agricultural and Resource Economics* 29 (2): 242–259. doi:10.22004/ag.econ.31113.

Ito, Junichi, Zongshun Bao, and Jing Ni. 2016. "Land Rental Development Via Institutional Innovation in Rural Jiangsu, China." *Food Policy* 59: 1–11. doi:10.1016/j.foodpol.2015.12.005.

Konyar, K., and C. T. Osborn. 1990. "A National-Level Economic Analysis of Conservation Reserve Program Participation: A Discrete Choice Approach." *The Journal of Agricultural Economics Research* 42 (2): 5. doi:10.22004/ag.econ.139017.

Kwayu, Emmanuel J., Susannah M. Sallu, and Jouni Paavola. 2014. "Farmer Participation in the Equitable Payments for Watershed Services in Morogoro, Tanzania." *Ecosystem Services* 7: 1–9. doi:10.1016/j.ecoser.2013.12.006.

Lambert, Dayton M., Patrick Sullivan, Roger Claassen, and Linda Foreman. 2007. "Profiles of US Farm Households Adopting Conservation-Compatible Practices." *Land use Policy* 24 (1): 72–88. doi:10.1016/j.landusepol.2005.12.002.

Li, Gucheng, Zhongchao Feng, Liangzhi You, and Lixia Fan. 2013. "Re-Examining the Inverse Relationship Between Farm Size and Efficiency: The Empirical Evidence in China." *China Agricultural Economic Review* 5 (4): 473–488. doi:10.1016/j.landusepol.2022.106090.

Lim, Siew, and Cheryl Wachenheim. 2022. "Predicted Enrollment in Alternative Attribute Conservation Reserve Program Contracts." *Land Use Policy* 117: 106090. doi:10.1016/j.landusepol.2022.106090.

Lowder, Sarah K., Jakob Skoet, and Terri Raney. 2016. "The Number, Size, and Distribution of Farms, Smallholder Farms, and Family Farms Worldwide." *World Development* 87: 16–29. doi:10.1016/j.worlddev.2015.10.041.

Ma, Shan, Scott M. Swinton, Frank Lupi, and Christina Jolejole-Foreman. 2012. "Farmers' Willingness to Participate in Payment-for-Environmental-Services Programmes." *Journal of Agricultural Economics* 63 (3): 604–626. doi:10.1111/j.1477-9552.2012.00358.x.

McLean-Meyinsse, Patricia E., Jianguo Hui, and Randolph Joseph. 1994. "An Empirical Analysis of Louisiana Small Farmers' Involvement in the Conservation Reserve Program." *Journal of Agricultural and Applied Economics* 26 (2): 379–385. doi:10.1017/S1074070800026304.

Monger, Randall G., Jordan F. Suter, Dale T. Manning, and Joel P. Schneekloth. 2018. "Retiring Land to Save Water: Participation in Colorado's Republican River Conservation Reserve Enhancement Program." *Land Economics* 94 (1): 36–51. doi:10.3368/le.94.1.36.

NSBC (National Bureau of Statistics of China). 2017. Bulletin of the main data of the third national agricultural census.

Peterson, Jeffrey M., and Ya Ding. 2005. "Economic Adjustments to Groundwater Depletion in the High Plains: Do Water-Saving Irrigation Systems Save Water?" *American Journal of Agricultural Economics* 87 (1): 147–159. doi:10.1111/j.0002-9092.2005.00708.x.

Rada, Nicholas E., and Keith O. Fuglie. 2019. "New Perspectives on Farm Size and Productivity." *Food Policy* 84: 147–152. doi:10.1016/j.foodpol.2018.03.015.

Reimer, Adam P., and Linda S. Prokopy. 2014. "Farmer Participation in U.S. Farm Bill Conservation Programs." *Environmental Management (New York)* 53 (2): 318–332. doi:10.1007/s00267-013-0184-8.

Sauer, Johannes, Sophia Davidova, and Laure Latruffe. 2012. “Determinants of Smallholders’ Decisions to Leave Land Fallow: The Case of Kosovo.” *Journal of Agricultural Economics* 63 (1): 119–141. doi:https://doi.org/10.1111/j.1477-9552.2011.00321.x.

Sheng, Yu, Jiping Ding, and Jikun Huang. 2019. “The Relationship between Farm Size and Productivity in Agriculture: Evidence from Maize Production in Northern China.” *American Journal of Agricultural Economics* 101 (3): 790–806. doi:https://doi.org/10.1093/ajae/aay104.

Suter, Jordan F., Gregory L. Poe, and Nelson L. Bills. 2008. “Do Landowners Respond to Land Retirement Incentives? Evidence from the Conservation Reserve Enhancement Program.” *Land Economics* 84 (1): 17–30. doi:10.3368/le.84.1.17.

Uchida, Emi, Jintao Xu, and Scott Rozelle. 2005. “Grain for Green: Cost-Effectiveness and Sustainability of China’s Conservation set-Aside Program..” *Land Economics* 81 (2): 247–264. doi:10.3368/le.81.2.247.

Uchida, Emi, Jintao Xu, Zhigang Xu, and Scott Rozelle. 2007. “Are the Poor Benefiting from China’s Land Conservation Program?” *Environment and Development Economics* 12 (4): 593–620. doi:10.1017/S1355770X07003713.

Ustaoglu, Eda, and Marcus J. Collier. 2018. “Farmland Abandonment in Europe: An Overview of Drivers, Consequences, and Assessment of the Sustainability Implications.” *Environmental Reviews* 26 (4): 396–416. doi:10.1139/er-2018-0001.

Vigani, Mauro, and Jonas Kathage. 2019. “To Risk Or Not to Risk? Risk Management and Farm Productivity.” *American Journal of Agricultural Economics* 101 (5): 1432–1454. doi:10.1093/ajae/aaz020.

Wang, Xue, and Xiubin Li. 2018. “Irrigation Water Availability and Winter Wheat Abandonment in the North China Plain (NCP): Findings from a Case Study in Cangxian County of Hebei Province.” *Sustainability (Basel, Switzerland)* 10 (2): 354. doi:10.3390/su10020354.

Wang, Jinxia, Yunyun Zhu, Tianhe Sun, Jikun Huang, Lijuan Zhang, Baozhu Guan, and Qiuqiong Huang. 2020. “Forty Years of Irrigation Development and Reform in China.” *The Australian Journal of Agricultural and Resource Economics* 64 (1): 126–149. doi:10.1111/1467-8489.12334.

Wu, Qing, and Hualin Xie. 2017. “A Review and Implication of Land Fallow System Research.” *Journal of Resources and Ecology* 8 (3): 223–231. doi:10.5814/j.issn.1674-764x.2017.03.002.

Xie, Hualin, Lingjuan Cheng, and Hua Lu. 2018. “Farmers’ Responses to the Winter Wheat Fallow Policy in the Groundwater Funnel Area of China.” *Land use Policy* 73: 195–204. doi:https://doi.org/10.1016/j.landusepol.2018.02.003.

Xie, Hualin, Lingjuan Cheng, and Tiangui Lv. 2017. “Factors Influencing Farmer Willingness to Fallow Winter Wheat and Ecological Compensation Standards in a Groundwater Funnel Area in Hengshui, Hebei Province, China.” *Sustainability (Basel, Switzerland)* 9 (5): 839. doi:10.3390/su9050839.

Xie, Lin, Zeyuan Qiu, Liangzhi You, and Yang Kang. 2020. “A Macro Perspective on the Relationship Between Farm Size and Agrochemicals use in China.” *Sustainability (Basel, Switzerland)* 12 (21): 9299. doi:10.3390/su12219299.

Yu, Zhenning, Yongzhong Tan, Cifang Wu, Mingzhi Mao, and Xiaoling Zhang. 2019. “Alternatives Or Status Quo? Improving Fallow Compensation Policy in Heavy Metal Polluted Regions in Chaling County, China.” *Journal of Cleaner Production* 210: 287–297. doi:10.1016/j.jclepro.2018.10.314.

Zhang, Chunli, Daniel Robinson, Jing Wang, Jibin Liu, Xiaohui Liu, and Lianjun Tong. 2011. “Factors Influencing Farmers’ Willingness to Participate in the Conversion of Cultivated Land to Wetland Program in Sanjiang National Nature Reserve, China.” *Environmental Management (New York)* 47 (1): 107–120. doi:10.1007/s00267-010-9586-z.

Zuo, Yonghong, Ling Ma, Hailong Cai, Tianlong Wu, and Xian Xin. 2015. “China’s on-Going Debates Over Large-Scale Farming: What are the Pros and Cons?” *China Agricultural Economic Review* 7 (3): 338–343. doi:10.1108/CAER-06-2015-0072.

Zuo, Alec, Jinxia Wang, and Qiuqiong Huang. 2020. “Willingness to Accept Compensation for Land Fallowing: Results from a Survey of Village Representatives in Northern China.” *The Australian Journal of Agricultural and Resource Economics* 64 (3): 845–866. doi:10.1111/1467-8489.12379.