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Willingness to accept compensation for land fallowing: results from a survey of village representatives in Northern China*

Alec Zuo, Jinxia Wang and Qiuqiong Huang[†]

Economic instruments have been increasingly adopted by governments around the world to address water scarcity problems because of their potential to achieve environmental outcomes in more cost-effective ways. This is the first study to estimate the willingness to accept compensation for land fallowing in rural China. Using survey data collected from village representatives in Northern China (mainly village leaders, party secretaries and village accountants), our results suggest that in groundwater irrigated sample villages, at least 28 per cent of respondents have a compensation expectation lower than the standard level of 500 yuan/mu/year for one season of fallowing set by the Government. Water scarcity measures such as irrigation supply reliability and depth-to-groundwater within a village are found to have statistically significant effects on the likelihood of fallowing land in groundwater irrigated villages.

Key words: contingent valuation method, land fallowing, Northern China, willingness to accept.

1. Introduction

In recent decades, the over-exploitation of water resources has become an increasingly serious issue in Northern China. The region contains just 17 per cent of China's freshwater resources, while hosting 56 per cent of the nation's irrigated land (NBSC 2018; MWR 2019). In addition to low regional water endowment, growing demands from industrial, agricultural and residential sectors have led to an over-exploitation of water resources, exacerbated by recent below-average annual rainfall. Groundwater is the major source of irrigation, with pumping resulting in serious environmental consequences such as land subsidence and seawater intrusion of coastal areas. For example, large cones of depression have formed in Hebei province and severely undermined the safety of housing, roads and other infrastructure.

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[†]Alec Zuo is Associate Professor at Centre for Global Food and Resources, Faculty of the Professions, The University of Adelaide, Adelaide, Australia. Jinxia Wang (email: jxwang.ccap@pku.edu.cn) is a Professor at China Center for Agricultural Policy, School of Advanced Agricultural Sciences, Peking University, Beijing, China. Qiuqiong Huang is a Professor at the Department of Agricultural Economics and Agribusiness, University of Arkansas, Fayetteville, Arkansas, USA.

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In response, the Chinese Government has focused on water conservation by improving irrigation efficiency. For example, under ‘the Action Plan for Synchronous Control over the Total Amount and Intensity of Water Consumption in the 13th Five-Year Period’ (the Action Plan) issued by the Ministry of Water Resources and the National Development and Reform Commission in 2016, an irrigation efficiency of 0.55 by 2020 was set as one of the top policy priorities. Irrigation efficiency is defined as the ratio of the amount of water consumed by the crop to the amount of water supplied through irrigation infrastructure, and in 2018, China met the target, achieving an irrigation efficiency of 0.554 (MWR 2019). This was a significant improvement from 0.44 in 2004, while irrigation efficiency in developed countries is usually between 0.7 and 0.8 (Hu 2016). However, some scholars have found that higher irrigation efficiency, often achieved by using more efficient irrigation technologies, does not necessarily lead to reductions in the consumptive use of water (i.e. Pfeiffer and Lin 2014). Even if water is conserved through upgrading irrigation infrastructure, the price per unit of water saved is likely to be higher than other alternatives, for example buying water back from water users in Australia (Loch *et al.* 2014).

Within agriculture, one of the most effective ways to reduce consumptive water use is to fallow land. Many benefits, in addition to water conservation, can be realised when farmers fallow their land, such as soil moisture and conserving nutrients for subsequent growing seasons, re-establishment of soil biota and breaks from crop pest and disease cycles. Other countries (including the USA, EU and Japan) have implemented land fallowing projects to resolve resource and environmental issues. For example, in western United States, due to frequent droughts and increasing water demand from the municipal sector, land fallowing programs have been implemented, and water saved from fallowing is transferred for environmental or municipal uses. In China, in order to resolve the overdraft of groundwater issues, a seasonal land fallow project was launched in Hebei province in 2014 – being the most water-scarce province in Northern China. Farmers who participated in the project can obtain compensation of 500 yuan/mu/year.[1] The project aims to encourage farmers to stop growing winter wheat or replace winter wheat with non-water-intensive crops, such as green manure, rapeseeds or others. Initially, the project entailed 50,000 hectares (ha) of cultivated land (0.78 per cent of cultivated land in Hebei province), which increased to 133,000 ha (2.04 per cent of cultivated land in Hebei) by 2016. However after 2016, no more cultivated land has been added to the scope of the project and, to date, the project has not been extended to other provinces.

One key piece of information needed for successfully implementing land fallowing projects in a cost-effective way is the minimum level of compensation

[1] Fifteen mu is equal to 1 ha, and 500 yuan is equal to 104 AUD (given an average exchange rate of 1 AUD = 4.80 RMB in 2019), and therefore, the compensation is equal to 1,560 AUD per hectare.

required to encourage farmer participation (Rao 2016). Farmers are unlikely to voluntarily participate if their opportunity costs of fallowing (thereby forgoing crop incomes) are not adequately compensated for. The objective of this study was to provide empirical estimates of the willingness to accept (WTA) compensation for land fallowing, as well as identify factors that influence the decision to fallow land. Based on our knowledge, there are limited studies on estimating the WTA compensation for land fallowing in rural China using large-scale plot-level survey data. In particular, the data that have previously been collected within rural regions suffer from relatively homogenous regional-level characteristics, such as water supply reliability, groundwater availability, soil quality and socio-economic variables – making it impossible to identify the relationship between these characteristics and fallowing WTA. The extensive coverage of rural areas across Northern China within this study ensures there is sufficient heterogeneity among villages and helps investigate whether village-level characteristics affect fallowing WTA. Our findings may provide the Government with a new approach to revise levels of compensation, in order to reflect the high rate of heterogeneity among villages and farmers through better targeting and financial budgeting – thereby improving the cost-effectiveness of this large-scale national program.

The remainder of the paper is organised as follows. Section 2 provides a brief review of the literature on resource conservation by farmers, along with the factors influencing such practices. Section 3 presents information on the data collection, followed by methods of data analysis in Section 4. Section 5 presents the results and discusses the findings. The final section summarises key findings and provides recommendations for future research.

2. Literature review

Fallowing is well established as a practice used to conserve soil and water. Although resource conservation entails many private benefits for producers, the associated public benefits are often more substantial. Without Government regulation or intervention, the equilibrium at which the level of resource conservation is undertaken would be sub-optimal, as individual farmers often do not account for public benefits in their decision-making. Farmers' decisions on conservation practices' adoption or program participation can be explained by their behaviour in utility maximisation, subject to income and time constraints, and given the production technology employed. At the time of decision, farmers evaluate the expected future utility from adoption/participation (V_{ap}) versus non-adoption/participation (V_{nap}) and choose to adopt/participate if $V_{ap} > V_{nap}$. The utility functions of adoption/participation and non-adoption/participation can each be written as reduced-form equations, containing exogenous conditioning factors that determine current and future income from each decision, respectively.

The key component in most conservation programs, namely economic incentives (often provided as monetary compensation), has been widely studied in the literature. Rosegrant *et al.* (2009) pointed out that economic incentives are commonly used to encourage conservation by increasing V_{ap}. Van Kooten and Schmitz (1992) highlighted that while cultivating a positive attitude among farmers towards wetlands preservation is worthwhile, it must be accompanied by adequate monetary compensation. Ruto and Garrod (2009) found that farmers require greater financial incentives to participate in an agri-environment scheme.

The contingent valuation method (CVM) is commonly used in surveys to elicit farmers' WTA for a well-defined program (i.e. Cooper 1997). There are different formats for asking contingent valuation questions such as open-ended, payment card, single-bounded and double-bounded dichotomous choice. In their study of willingness to pay (WTP) for a watershed restoration project in rural China, Xu *et al.* (2006) found the median WTPs elicited using single-bounded and double-bounded referendum formats exceeded the median WTP using the payment card by factors of nine and seven, respectively. The differences here may arise because dichotomous choice questions are more susceptible to 'yea-saying' bias or 'acquiescence bias', which is the tendency of a respondent to agree with a statement when he/she is uncertain.

In addition to monetary compensation and program attributes, a number of farmer and farm characteristics also influence farmer decisions on participation within conservation programs. Results reveal that younger and higher educated farmers and farmers are more likely to participate in programs (Sidibé 2005). Off-farm employment may serve as a substitute for land and water, in terms of providing farmers with a livelihood, and farmers with easy access to off-farm employment can often afford to not use land or water for agricultural production. The opportunity cost of conservation on land with poor soil is lower than that on land with quality soil. Van Kooten and Schmitz (1992) found that participation in wetlands preservation increased with the size of available pastureland on farms.

3. Data

3.1 Study area

The study area includes six provinces in Northern China: Inner Mongolia; Hebei; Henan; Liaoning; Shanxi; and Shaanxi (Figure 1). Despite being the main agricultural production region, Northern China faces severe water shortages. The average annual precipitation in this study area ranges from 239 mm in Inner Mongolia to 736 mm in Henan province. Calculations using data from the National Bureau of Statistics of China (NBSC) show that water resource per capita in Northern China was <700 m^3 in 2015, well below the threshold of 1,000 m^3 used by the United Nations to define a water-scarce

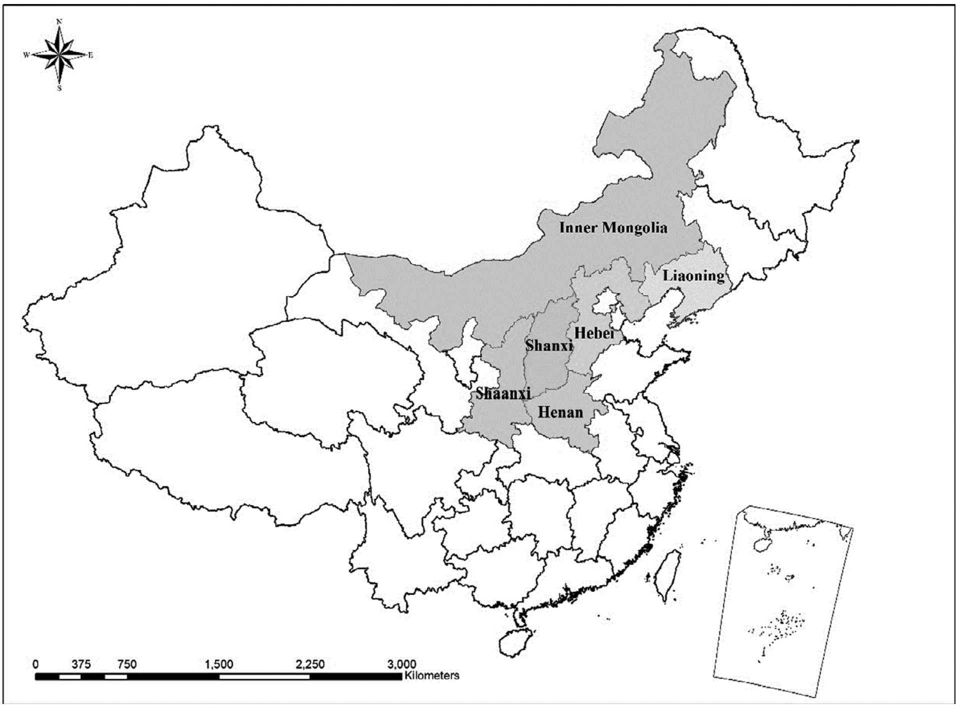

Figure 1 The location of study area.

society. The situation is most dire in Hebei province, where water resource per capita was only 182 m^3 in 2015.

3.2 Northern China Water Resource Survey

Data used in the study were generated from the *Northern China Water Resource Survey* (NCWRS), conducted in 2004 and 2016. A stratified random sampling process was used to generate a sample representative of Northern China. We organised counties in each sample province into one of four water scarcity categories according to the percentage of irrigated area as follows: very scarce (between 21 per cent and 40 per cent), somewhat scarce (between 41 per cent and 60 per cent), normal (more than 61 per cent), and mountain and desert (<20 per cent).[2] Within each of the scarcity strata, we randomly sampled two or three counties from the list of all counties in each strata; from all counties in the mountainous and desert counties, we chose one county. Then, we randomly selected two townships within each county (one with income above the median and one below) and four villages within each township (two with income above the median and two below). Under our

[2] In Hebei province, the scarcity categories were defined according to the degree of annual overdraft of groundwater resources since its irrigation mainly depends on groundwater resources.

sample design, there were four water scarcity stratum and 50 counties (primary sampling unit). At the end of both rounds of the NCWRS, one extra village was added in Shanxi province, making the final sample 401 villages. Since a probability proportional to size (PPS) sampling was not used, weights (equal to the inverse of the probability of being selected proportional to population) are used for each village to account for the sample design and to make our modelling results applicable outside of the sampled villages in the six provinces.

During our survey, in order to maximise the villages covered, we chose to conduct face-to-face interviews with village cadres (village leaders, party secretaries or village accountants). Based on our experiences from the field survey, it was evident that village cadres could better answer the WTA questions than ordinary farmers in the villages. Compared with ordinary farmers, village cadres have a better understanding of local socio-economic and physical conditions. Furthermore, village cadres were generally (although not always) more familiar with programs run by the Government, particularly the seasonal land fallowing program. Importantly, village cadres are also farmers in the villages, so there was no significant difference in their opportunity cost of fallowing land compared with ordinary farmers, given cultivated land is equally distributed among households in terms of quantity and quality in rural China (Lin 1992).

Although our preference was to interview village cadres, if none were available within a village, we interviewed ordinary farmers. In 2004, ordinary farmers were interviewed in around 22 per cent of villages, while this proportion was 29 per cent in 2016. In order to test whether there was a significant difference in fallowing likelihood between village cadres and ordinary farmers, we conducted two-way association tests, two-sample equal mean tests and regression models. These checks demonstrated that village cadres were no different from ordinary farmers in the village, in terms of their fallowing decisions (see Appendix S1). Furthermore, two recent studies found no statistical difference in farmer conservation program participation between village cadres and ordinary farmers in China (e.g. Liu and Lan 2015; Zhu *et al.* 2018). Therefore, we do not expect any significant difference in land fallowing likelihood between village cadres and ordinary farmers.

The key component of the NCWRS is the CVM question section, in which respondents are presented with a hypothetical land fallowing program, and monetary compensation is the only program attribute that varies. Before the CVM question was raised, respondents were asked to answer a few questions regarding the largest plot they have, such as the size of the plot and crop mix. The wording of the CVM question is as follows:[3]

[3] The CVM question did not specify a starting year. During the survey, enumerators told farmers to assume that the land fallowing project will be implemented in the following year. Most pilot projects in China have a first phase that last several years. Whether a project will be continued after its first phase depends on the outcome of the program assessment. During the survey, enumerators also conveyed such information to farmers.

> Suppose that in order to conserve water resources, the Government is implementing a voluntary land fallowing project in your village. The first phase of the project is likely to last a few years. If you participate and fallow land for at least one year, you will get compensated. Please understand that participation means you will not earn any farm income on the land that you fallow but you are free to choose any work unrelated to the fallowed land.

> Please answer the following question for your largest plot, based on the previous questions. If you were offered X yuan/mu/year, are you willing to fallow this plot?

Five compensation levels were used as follows: 100, 300, 500, 800 and 1,000 yuan/mu/year. In 2004, the starting point was 500, while in 2016 the starting point was 100. Figure 2 displays the bidding processes in 2004 and 2016. The interviewers were trained to be impartial to farmers' answers in order to reduce social desirability bias (the tendency to give answers that the respondent considers socially acceptable or what they think the interviewer wants to hear). Note that only respondents with irrigated plots were included in the analysis. Respondents with only rain-fed plots were not included. In 2004, 264 respondents had irrigated plots, and this number dropped to 227 in 2016.

4. Empirical model

Given the sequential bid data format, the probit model[4] (Whitehead 2002) is often used to model how fallow decisions respond to compensation levels and other covariates such as geographic location, soil quality, crop mix and farm income.

Willingness to accept for fallow is revealed by n questions, and if follow-up questions are incentive compatible ($WTA_1 = WTA_2 = \ldots = WTA_n$) and if respondents do not anchor their follow-up responses to the starting-point offer amount, C_1, a 'yes' answer will be observed if $WTA_1 \leq C_1$, and a 'no' response will be observed if $WTA_1 > C_1$. Multiple bounded valuation questions will reduce the variance of WTA estimates without bias (Whitehead 2002). The formal empirical model is presented below:

[4] A random-effects panel probit model can be estimated as well, given the dataset pseudo-panel format. However, the random-effects model was calculated using quadrature, which is an approximation, and its accuracy partially depends on the number of integration points used. The results suggest that the models were not stable across an alternative number of quadrature points and hence cannot be trusted.

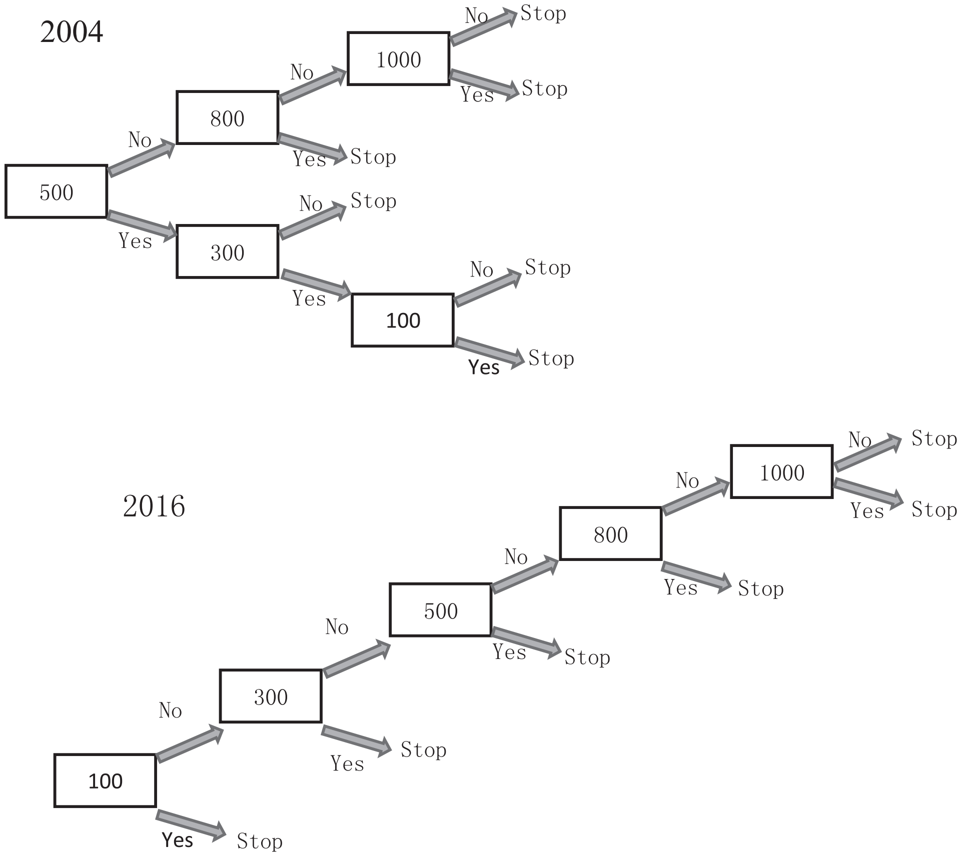

Figure 2 Bidding process in the 2004 and 2016 survey, respectively.

$$y^*_{in} = \beta * \text{compensation}_n + \boldsymbol{x}_i * \boldsymbol{\alpha} + \varepsilon_{in}, \tag{1}$$

where y^*_{in} is a latent variable ranging from $-\infty$ to ∞, Compensation$_n$ is the n different amounts offered to farmers for each mu of fallowed land per year, $\mathbf{x}_i$ is a vector of characteristics at the village and individual farmer level, β is a parameter and $\boldsymbol{\alpha}$ is a vector of parameters to be estimated, and ε_{in} is a random error term. The link between the observed binary variable for fallow y_{in} and the latent y^*_{in} is expressed as:

$$y_{in} = \begin{cases} 1 & \text{if } y^*_{in} > 0 \\ 0 & \text{if } y^*_{in} \leq 0, \end{cases} \tag{2}$$

where y_{in} = 1 if farmer i indicated he or she would fallow at compensation level n and y_{in} = 0 otherwise.

Table 1 Mean and standard error of variables, with design effects

Variable names	Definition	2004			2016		
		Mean	SE	DEFT	Mean	SE	DEFT
Dependent variable							
Fallow	Dummy: 1 if willing to accept the compensation and fallow; 0 otherwise	0.56	0.02	1.20	0.36	0.02	1.63
Independent variables							
ln compensation	Log of compensation level in current year yuan	6.02	N.A.	N.A.	6.02	N.A.	N.A.
Village-level variables							
Supply reliability of irrigation (%)†	Share of years in the past 4 years with sufficient surface or groundwater irrigation supply	59.47	4.17	1.59	60.24	4.73	1.69
Depth-to-groundwater (m)‡	Depth-to-groundwater (metre)	25.87	2.97	1.76	42.01	5.37	1.75
% migrant labour	Percentage of migrants in village labour force	16.10	1.63	1.45	21.49	2.10	1.46
% illiterate	Percentage of village labour force that are illiterate	6.20	0.96	1.53	5.89	0.90	1.15
% primary school	Percentage of village labour force with the highest education level at primary school	34.04	1.24	1.04	25.55	1.79	1.38
Net farm income per capita (1,000 yuan)	Net farm income per capita in 1,000 current year yuan	1.08	0.11	2.15	2.89	0.34	1.80
% irrigated land	Proportion of arable land that is irrigated	72.28	3.19	1.68	80.48	2.57	1.42
ln land rent (yuan/mu/year)	Log of average land rental rate per mu per year in current year yuan	4.54	0.10	2.20	5.78	0.09	1.86
% first-grade arable land§	Percentage of arable land with first-grade soil quality	46.04	2.70	1.39	49.36	2.74	1.33
Distance to county gov. (km)	Distance to county government (km)	20.80	2.94	1.92	20.90	2.62	1.91
Plot-level variables							
Plot size (mu)	Size of the largest plot (mu)	5.60	0.78	1.66	7.83	1.23	1.62
Maize plot¶	Dummy variable indicating maize is grown on the plot	0.28	0.06	2.19	0.39	0.07	2.17
Rice plot¶	Dummy variable indicating rice is grown on the plot	0.17	0.07	2.98	0.11	0.05	2.23
Other crops¶	Dummy variable indicating other crops are grown on the plot	0.18	0.04	1.66	0.11	0.04	1.81

Note: †For villages that use both surface water and groundwater for irrigation, the mean of surface water and groundwater supply reliability was used. ‡For villages that only use surface water for irrigation, depth-to-groundwater was set to 0. §There are four grades of land quality in China. The first grade means the highest soil quality. ¶Wheat is the reference category for crop dummies. DEFT, square root of design effect.

Although the same villages were sampled in 2004 and 2016, the respondents completing the survey were mostly different. In addition, compensation levels in 2004 and 2016 were of the same monetary amounts; however, the inflation-adjusted compensation levels differed across years. Both factors made the data unsuitable to be pooled; therefore, the two rounds of survey data were analysed separately. Variable definitions, mean estimations along with standard errors and the design effects are reported in Table 1.

Eight models are estimated in total, with the same specification of dependent and independent variables, but different groups of sample villages. The first two models use the full sample and are estimated for 2004 and 2016, respectively (columns 1 and 2). The next six models only use sub-samples. The third and fourth models use sample villages that use only surface water or surface and groundwater conjunctively for irrigation (columns 3 and 4). The fifth and sixth models use sample villages that use only groundwater or surface and groundwater conjunctively for irrigation (columns 5 and 6). The last two models use sample villages that only use groundwater for irrigation (columns 7 and 8). All regressions were estimated by Stata's svy prefix command (StataCorp 2017) to account for our multi-stage, clustered, stratified and weighted sample design. No multicollinearity was detected in either the full sample or the sub-samples. All models have a good overall fit and a reasonably high prediction accuracy of no <80 per cent.

5. Results and discussions

In 2004, only 2 per cent of respondents were willing to accept a compensation of 100 yuan/mu/year. The share increases to 21 per cent, 71 per cent, 88 per cent and 95 per cent when the compensation is raised to 300, 500, 800 and 1,000 yuan/mu/year, respectively. In 2016, 5 per cent of respondents were willing to accept a compensation of 100 yuan/mu/year. The share increases to 12 per cent, 32 per cent, 52 per cent and 85 per cent when the compensation is raised to 300, 500, 800 and 1,000 yuan/mu/year, respectively. In both surveys, the minimum offer amount is low enough that most respondents (at least 95 per cent) will not accept it, and the maximum offer amount is high enough that most respondents (at least 85 per cent) will accept it. This indicates that the range of compensation values used was appropriate (Whittington 1998). If a considerable proportion of respondents accept the minimum offer amount or do not accept the maximum offer amount, the data are more likely to suffer from hypothetical bias.

5.1 Regression results for the full sample

Table 2 reports the marginal effects of independent variables on the probability of land fallowing, computed using estimation results from a set

Table 2 Probit regression (weighted) results, marginal effects on the probability of land fallowing

Dependent variable is fallow	Full Sample		Surface water and conjunctive		Groundwater and conjunctive		Groundwater only	
	(1) 2004	(2) 2016	(3) 2004	(4) 2016	(5) 2004	(6) 2016	(7) 2004	(8) 2016
ln compensation (yuan/mu/year)†	0.37***	0.36***	0.38***	0.38***	0.37***	0.35***	0.37***	0.35***
Village-level variables								
Supply reliability of irrigation (%)‡	0.0001	0.001	0.0002	0.0003	0.0003	−0.001††	0.0001	−0.001**‡‡
Depth-to-groundwater (m)†	−0.0002	−0.0001	−0.001**	0.001	0.0004	−0.001**	0.001	−0.002**
% migrant labour‡	0.001*	−0.0004	0.001	−0.001	0.002***	0.0001	0.001	0.001
% illiterate‡	−0.004***	0.0002	−0.005***	0.001	−0.004***	0.0003	−0.003**	0.0003
% primary school‡	0.002***	0.001	0.002**	0.001	0.002***	0.002*	0.002*	0.001
Net farm income per capita(1,000 yuan)†	−0.05***	−0.01	−0.07**	−0.01	−0.06***	−0.01	−0.02	−0.01
% irrigated land‡	−0.001***	−0.0003	−0.002***	−0.001	−0.001***	−0.0001	−0.001***	0.0004
ln land rent (yuan/mu/year)†	−0.01	−0.05	−0.04*	−0.07*	−0.001	−0.08**	0.01	−0.02
% first-grade arable land‡	−0.001***	−0.001	−0.0005	0.001	−0.001***	−0.001**	−0.002***	−0.002***
Distance to county gov. (km)†	−0.0004	0.001	−0.001	0.001	−0.001	0.0001	−0.00005	−0.0003
Plot-level variables								
Plot size†	0.01***	0.002**	0.01*	0.002*	0.01**	0.004***	0.01**	0.005***
Maize plot§	0.02	0.11*	0.03	0.21***	0.04	0.07	0.04	−0.003

Table 2 (*Continued*)

Dependent variable is fallow	Full Sample		Surface water and conjunctive		Groundwater and conjunctive		Groundwater only	
	(1) 2004	(2) 2016	(3) 2004	(4) 2016	(5) 2004	(6) 2016	(7) 2004	(8) 2016
Rice plot§	−0.16***	−0.01	−0.13*	0.08	−0.12**	−0.21**	−0.14	N.A.
Other crops§	0.05	−0.03	−0.02	0.03	0.07*	−0.07	0.10*	−0.01
Province dummy variables								
Henan¶	0.10*	0.09	0.07	0.32**	0.11*	0.03	0.09	−0.02
Shaanxi¶	0.02	0.08	−0.01	0.14	−0.02	0.03	0.04	0.09
Shanxi¶	−0.05	0.11	−0.07	0.26**	−0.09*	0.13*	−0.08*	0.17***
Inner Mongolia¶	−0.01	−0.12*	0.05	0.02	−0.01	−0.18***	−0.06	−0.12
Liaoning¶	0.20***	0.01	0.15**	0.06	0.17***	0.02	0.18**	0.10
Observations	1,275	1,115	635	490	1005	910	640	625
Number of respondents	255	223	127	98	201	182	128	125
% of correctly predicted	87	79	86	83	87	80	88	82
Pseudo R^2	0.59	0.37	0.61	0.45	0.59	0.38	0.60	0.40

Note: *, ** and *** indicate levels of statistical significance at 10%, 5% and 1%, respectively. N.A. since the sub-sample contains no rice plots. †Marginal effect of a one-unit increase from the sample mean of the independent variable is computed. ‡Marginal effect of a one-percentage-point increase from the sample mean of the independent variable is computed. §Wheat is the reference category for crop dummies. Marginal effect of a switch from wheat to the crop is computed. ¶Hebei is the reference category for province dummies. Marginal effect of moving a plot from Hebei to the province is computed. ††The square term of supply reliability is significant at the 1% level. The marginal effect is insignificant at the 10% level only when supply reliability is between 47% and 58%. ‡‡The square term of supply reliability is significant at the 1% level. The marginal effect is insignificant at the 10% level only when supply reliability is between 48% and 57%.

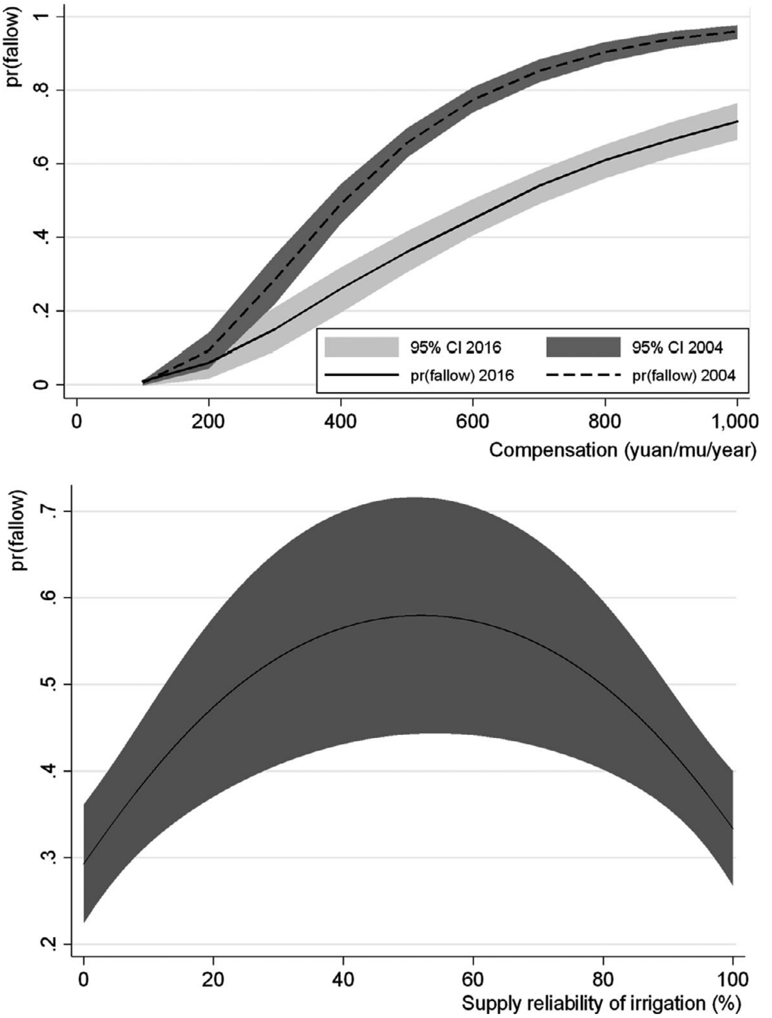

Figure 3 Predicted probabilities of fallowing against nominal compensation levels (2004 and 2016, full sample, top panel) and against supply reliability of irrigation (2016, groundwater-only sample, bottom panel). (Note: Shaded area is the 95 per cent confidence interval (CI)).

of probit models.[5] Across the eight models, the marginal effect of a one-unit increase in compensation is consistently positive and statistically significant, which is as expected. The average level of compensation is 412 yuan (ln412 = 6.02). The increments in the probability of fallowing, due to a one-unit increase from the mean to 1,119 yuan (or 7.02 = ln1,119), range from 0.35 to 0.38. Estimation results of the full sample are also used to generate both point estimates and interval estimates (confidence interval) of the

[5] In an alternative specification, a dummy variable indicating the respondent was a leader, party sectary or village accountant (versus others) was included as a control variable, and the result indicated no statistically significant impact of this variable on the probability of land fallowing.

probability of fallowing over the entire range of compensation levels, while other variables are held constant at their means. Figure 3 (top panel) shows that the line connecting all point estimates of predicted fallow probabilities is steeper in 2004 compared with 2016, over a large range of the compensation amounts. This indicates respondents were generally more receptive to changes in compensation in 2004 than in 2016. The slope of the line peaks around 407 yuan in 2004 and around 659 yuan in 2016, indicating respondents would be most receptive to a change in the compensation level at these points. The higher responsiveness in 2004 is plausible since compensation is measured in yuan of the current year. To induce the same rise in fallow probability, a bigger increase in the nominal compensation level (not inflation adjusted) would have been required in 2016 compared with 2004. This may also be explained by the income effect. The nominal net farm income per capita increased from 1,080 yuan in 2004 to 2,890 yuan in 2016 (Table 1). Thus, a one-yuan change would have had more influencing power in 2004 than in 2016, given the bigger impact on budget constraints.

The marginal effects of plot size are positive and statistically significant. Results from the full sample suggest that at the mean values of plot size, one additional mu would increase the probability of fallowing by 0.01 in 2004 and 0.002 in 2016. The positive relationship can be explained by two factors specific to rural China. Firstly, the per mu opportunity cost of fallowing a larger plot may be smaller. This is because the egalitarian principle that guides the land distribution process in rural China means that higher quality land is likely to be divided more often and allocated among households (Chen *et al.* 2011). This results in a negative relationship between land area and land quality, which means average profit per mu (the per mu opportunity cost of fallowing) is smaller on larger plots. Secondly, the benefit of fallowing may be higher for a larger plot than for a smaller plot. In most Chinese provinces, agriculture is still labour-intensive. Most studies found that the agricultural labour market is still imperfect (e.g. Wang *et al.* 2014) and therefore could not relieve family labour from farm work. Fallowing can free up family labour for other profit opportunities such as off-farm employment. A larger plot may result in a greater benefit of fallowing because more family labour can be reallocated to other profit opportunities.

A number of village-level characteristics significantly affect the probability of fallowing in 2004 but not in 2016, such as net farm income per capita, the share of arable land with first-grade soil quality, education levels of labour force in a village and percentage of irrigated land. This may suggest the village-level variables in 2004 were important in influencing rural household opportunity costs of land fallowing, while in 2016, village-level variables became largely insignificant, signalling heterogeneous development paths among rural households within villages – due to, for example, land consolidation and rural-to-urban migration.

5.2 Regression results of models using sub-samples

While the results of models using the three sub-samples are generally consistent with those of the full sample models, two noticeable variations are worth mentioning. Firstly, although neither supply reliability of irrigation nor depth-to-groundwater had a statistically significant coefficient in the 2004 or 2016 models using the full sample, their coefficients were statistically significant in two 2016 models using sub-samples, particularly the groundwater-only sample. A statistically significant relationship between supply reliability of irrigation and fallowing was only present when its squared term[6,7] was included in the model, suggesting the presence of both positive and negative effects. Figure 3 (bottom panel) displays the predicted probability of fallowing against supply reliability for the 2016 model with the groundwater-only sample. It is suggested that predicted probability of fallowing reached the maximum (0.58) when supply reliability was around 0.50. Given that the quantity of available water supply is controlled for through the inclusion of depth-to-groundwater, supply reliability primarily measures the probability of receiving sufficient quantity of groundwater for irrigation in a given year. A high value of supply reliability indicates an increased certainty of getting a sufficient quantity, while a low value indicates higher certainty of not getting a sufficient quantity. In either case, water users are more certain about what to expect during the irrigation season, and can plan their on-farm and off-farm activities accordingly. A 50 per cent chance (the middle point of supply reliability), on the other hand, indicates the highest level of uncertainty. Figure 3 (bottom panel) highlights that such uncertainty associated with groundwater supply will increase the likelihood of fallowing, when other factors such as quantity of water supply and level of compensation are held constant.

Secondly, a statistically significant and negative relationship is found between depth-to-groundwater and the probability of fallowing in the 2016 model with the groundwater and conjunctive and groundwater-only sub-samples. Our estimate suggests that for a one-metre increase in depth-to-groundwater, the probability of land fallowing decreases by 0.002 for the groundwater-only sample. If the change is for one standard deviation (46 m), the probability changes by 0.09. This is consistent with economic theory on the value of most natural resources, including water, in that the value of the resource in situ equals the marginal cost of extraction and scarcity rent of drawing down the available stock (Fisher 1981, 17–18). When water becomes

[6] In alternative specifications, a squared term of supply reliability of irrigation was also added in models that use the full sample, surface water and conjunctive sub-sample, and groundwater and conjunctive sub-samples for 2004. However, no statistically significant result was found in these models.

[7] The way supply reliability of irrigation is measured in this research may reflect water shortages caused by infrastructure constraints and management institutions, in addition to physical scarcity. However, main reasons for unreliable irrigation supply were problems such as groundwater decline and less precipitation.

Table 3 Mean willingness to accept (WTA) estimates (yuan/mu/year)

Mean WTA Measured in	2004 full sample		2016 full sample	2016 groundwater only sample
	2004 yuan	2016 yuan	2016 yuan	2016 yuan
2004 model	406† [391, 423]	572 † [551, 596]	553† [523, 585]	–
2016 model	528‡ [506, 551]	744‡ [713, 776]	644‡ [615, 674]	675§ [621, 733]

Note: 95% confidence intervals (CIs) are reported in square brackets. †WTA is computed using estimation results of the 2004 model with full sample. ‡WTA is computed using estimation results of the 2016 model with full sample. §WTA is computed using estimation results of the 2016 model with groundwater-only sample.

scarcer, its value will increase as a result of either an increase in marginal extraction cost or the scarcity rent (Moncur and Pollock 1988). Fenichel *et al.* (2016) also found that the marginal value of an additional acre-foot of water increases with declines in water stock, within a study measuring the value of groundwater in the High Plains region in Kansas, USA. As the depth-to-groundwater increases, the cost of pumping groundwater also increases. In agricultural production, the rational response of a farmer who maximises profit is to irrigate higher value crops so that the value marginal product of an input reflects its cost. Using a sample that covered a range of provinces in Northern China, Wang *et al.* (2019) found a positive correlation between depth-to-groundwater and the share of cultivated land allocated to high-value crops, such as fruits and vegetables. As a result, land that grows higher value crops, in response to a rise in depth-to-groundwater, would require higher levels of compensation to induce fallowing.

The above findings may suggest two things. Firstly, over time the economic value of water due to scarcity is increasingly recognised by respondents between 2004 and 2016. Secondly, respondents in groundwater irrigated villages are more likely to consider the economic value of water in their decisions, compared to those in surface water irrigated villages. This is consistent with the status quo whereby, in most surface water irrigated villages, water users still pay for surface water on a per unit of land basis. Therefore, the amount paid for surface water is not tied to the volume of water delivered to the fields.

5.3 WTA compensation estimates for land fallowing

Each individual's WTA compensation for land fallowing can be computed using the estimation results and the actual values of the covariates for each individual. The mean WTA compensation of the full sample or a sub-sample is calculated by averaging individual WTAs over the respective sample. Table 3 displays mean WTA estimates along with the respective 95 per cent confidence intervals (CIs). The nominal mean WTA compensation was 406 and 644 yuan in 2004 and 2016, respectively. The rural resident consumer price index in China increased by 40.9 per cent between 2004 and 2016 (NBSC n.d.). After adjusting for inflation, 386 yuan in 2004 is the equivalent of 572 yuan in 2016. Therefore, mean WTA compensation, in real terms, was 12.6 per cent higher in 2016 compared with 2004. The difference is also statistically significant, with no overlapping range between the respective 95 per cent CIs. The difference in mean WTA compensation between the 2 years could be due to the difference in the parameter estimates between the 2004 and 2016 models, as shown in the full sample columns in Table 2, as well as the changing values of independent variables between the 2 years shown in Table 1. When using the 2016 sample and 2016 model coefficients, mean WTA compensation estimate is 644 yuan, which is 17 per cent higher than that of using the 2016 sample and 2004 model coefficients. When using the 2004 sample and 2016 model coefficients, mean WTA compensation estimate is 528 yuan, which is 30 per cent higher than that of using the 2004 sample and 2004 model coefficients. The difference in percentages here further supports the explanation that both model estimates and sample characteristics are different between the 2 years.

Willingness to accept compensation is also calculated for the 2016 groundwater-only sample. It should be noted however that the 95 per cent CI for mean WTA compensation of the groundwater sample is wider than that of the full sample, due to a larger estimated error within the groundwater sample model. The mean WTA compensation is 675 yuan, with a 95 per cent CI range from 621 to 733 yuan, not significantly different from that of the full sample (644 yuan).

It is difficult to assess whether respondents in groundwater irrigated villages would be financially better or worse off under the official compensation of 500 yuan/mu/year for one season of fallowing in the groundwater funnel areas of Hebei (Xinhua News Agency 2016). This is because our WTA compensation estimates are for whole-year fallowing, and two seasons of crops are usually planted within 1 year in the groundwater irrigated counties. However, a further examination of the distribution of WTA compensation for the groundwater-only sample reveals that 28 per cent of the 125 respondents have a WTA compensation smaller than 500 yuan. This means that the compensation expectations of these respondents are lower than the level of Government compensation. Potentially, this indicates that these respondents are happy to accept the compensation of 500 yuan for land fallowing and would consider themselves better off if such a policy was implemented. The remaining 72 per cent have a WTA compensation for one-year land fallowing higher than 500 yuan. However, it is unclear from the results whether their WTA compensation for one season of land fallowing within a year is still higher than 500 yuan. Of course, if the remaining are able to find other job opportunities or income sources to offset any potential losses resulting from land fallowing, they will be less affected financially.

It is also worth noting from the literature that WTA estimates were often found to be higher than WTP regarding the same product (i.e. Kahneman *et al*. 1990). This is due to the endowment effect, which states that people ascribe more value to things merely because they own them. In the context of rural China, the endowment effect is likely to be insignificant since farmers do not have land ownership. Farmers have the right to use the land for up to 30 years, after which there can be an extension of another 30 years. Hypothetical bias may cause our WTA estimate to be higher than respondents' true value, if they believed that the results could influence the Government to set higher compensation levels for land fallowing programs – whereby respondents strategically chose to accept at a compensation level higher than the true level. If this was the case, our estimate of 675 yuan from the groundwater village only model may be over-estimated and respondents' true WTA compensation may be even closer to the official compensation level of 500 yuan.

An additional checking process is to compare net crop income at the plot level with the WTA compensation estimate. We found that the mean net plot income was 737 yuan/mu in 2016, which is 14 per cent higher than the mean WTA compensation estimate in 2016 (644 yuan/mu). The difference arises because when answering the CVM question, respondents accounted for the alternative profit opportunities they could pursue once fallowing freed up some or all of the family labour. Depending on each household's circumstance and village's context, off-farm work can either be readily available or completely unobtainable during the period of land fallowing. In the context of rural China, farmers now have increased access to local off-farm employment and they do not need to migrate to cities to earn higher wages (Yang *et al*. 2016). It is therefore likely that respondents factor in off-farm employment when making fallowing decisions, which lowers their compensation expectations to be below net crop income. Subsequently, we expect WTA compensation generally to be smaller than or equal to net crop income, although in rare circumstances WTA compensation higher than net crop income may be necessary for some. For example, non-pecuniary considerations (such as a preference for a farming lifestyle) may increase WTA compensation. Additionally, if farmers have supply contracts with buyers it would be costly to stop producing for a year and break an existing contract, again requiring higher compensation.

6. Conclusion

This is the first study to investigate WTA compensation in exchange for land fallowing in rural China. Due to the positive externalities of land fallowing, such as reduced pressure on water resources and fewer adverse environmental consequences, it is often undertaken at a sub-optimal level when farmers only consider its private benefits. Economic instruments such as financial payment are popular means used to encourage more farmers to fallow their land, particularly when public benefits from land fallowing are substantial.

The findings from this study provide timely policy advice. The compensation principle of the national land fallowing scheme, launched in 2016, was that land fallowing participants' net income should not be negatively affected. In the sample of villages that only use groundwater for irrigation, our result suggests the compensation expectation of at least 28 per cent of respondents is lower than the current level of Government compensation. That is, if the Government were to implement the land fallowing program and offer a compensation of 500 yuan/mu/year to retire land for one season, it is likely farmers in these villages would willingly accept. However, to assess whether the current amounts set by the Government over- or under-compensate farmers, more information needs to be collected under future studies to better measure individual farmers' opportunity costs of fallowing land.

Our findings also indicate land fallowing programs that target a selected group of farmers and certain villages may be more successful. Adjusting compensation based on certain village-level characteristics or broad farmer-level characteristics, without discouraging participation in land fallowing, may be more cost-effective for the Government, Farmers with larger plots are more likely to fallow. Likewise maize and wheat farmers are more likely to fallow than rice farmers. Farmers in groundwater irrigation villages facing a more uncertain water supply are also more likely to fallow. However, participants still need to balance their agricultural practices and income-generating activities so that they are not dependent on compensation payments in the longer term. Complementary Government programs should be set up to assist farmers in making such transitions.

It is more costly, on a per/unit of land basis, to conserve water through land fallowing in severely depleted groundwater areas. Given these regions are high-priority areas for implementing fallowing programs, it is critical to allocate a sufficient compensation budget. Policymakers should take into account both the extent of water scarcity and other local characteristics that will affect how producers have adjusted to the rising water scarcity. A fallowing program to replenish groundwater from producers who switch to higher value crops will cost more in these areas. It would therefore be more cost-effective to target producers who have not switched crops in these areas.

Furthermore, the Government should not take a set and forget approach when implementing land fallowing programs. Given the NCWRS data are not longitudinal in nature, we used data from two discrete years, under two separate regressions. Estimation results revealed differences across the 2 years. When all other variables remained constant, the levels of compensation increased over time. The effects of some covariates also differed across the 2 years. The Government needs to periodically re-evaluate the program, at least every few years, and vary program components (e.g. levels of compensation and targeted groups) to maintain program effectiveness.

Although not directly implied by our findings, the influence of land fallowing on farmer livelihood should also be considered when the Government implements the program, particularly the influence on the broader rural community. When water is taken away from production within irrigation-dependent communities, it may negatively affect other community members such as suppliers of seeds, fertiliser and other agricultural service providers. Downstream sectors such as retail and services may also be negatively impacted, depending on how much compensation payment is spent within local communities. Therefore, the Government needs to establish a broad assistance program in those rural communities where large-scale land fallowing is implemented, to minimise any negative impacts on livelihoods within the community.

A couple of limitations within the current study are worth mentioning. Firstly, village representatives, largely comprising village leaders, party secretaries or village accountants, may have different living circumstances compared with fellow villagers. Therefore, many variables are measured at the village level based on average characteristics within each village, rather than the characteristics of village representatives. Although the results are mostly consistent with expectations, it would be ideal to also collect more data on farmer individuals and use variables at the individual level. Secondly, although we have used some ex ante and ex post approaches to assess the potential of any hypothetical bias (such as 'yea-saying' bias and social desirability bias), we are not able to examine all types of hypothetical biases from the CVM, such as the starting-point bias. Future research addressing these limitations will be able to achieve more accurate and robust estimates for WTA compensation for land fallowing in China and will be of great value. Exploring farmer preferences for other program attributes, such as program timeframe and extent of participation (whole farm versus part of a farm), are also important next steps for future research in this area.

Data availability statement

The data that support the findings of this study are available in the Supporting Information (Appendix S1) of this article.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Comparisons between village leader, party secretary or village accountant and ordinary farmers.