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The influence of asset specificity on farmers' willingness to participate in fallow from the perspective of farmer differentiation

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Fallow is an important institutional guarantee for green agricultural development and an important measure to promote rural revitalization. Asset specificity is a crucial factor that affects farmers' willingness to participate in fallow. In order to improve farmers' willingness of to fallow and promote the long-term promotion of fallow system, based on the perspective of farmer differentiation, a total of 1,240 micro survey data in four cities of Gansu province was used to quantify the asset specificity by the entropy method. A multivariate ordered Logit model and a double-hurdle model were established to explore the effects of asset specificity on the willingness of farmers with different degrees of differentiation. The results show that: 1) There are differences in fallow willingness among different types of farmers. The fallow willingness of non-farmers and II part-time farmers is generally stronger than that of pure farmers and I part-time farmers. 2) Geographical location specificity has a significant negative impact on the fallow willingness of the four types of non-fallow farmers, and has significant negative impacts on the subsequent fallow willingness and fallow degree of the four types of fallow farmers. 3) Physical asset specificity has a significant negative effect on the fallow willingness of pure farmers, I part-time and II part-time farmers among non-fallow farmers, but has little effect on the subsequent fallow willingness of fallow farmers. 4) Human capital specificity has a significant negative impact on the fallow willingness of the four types of non-fallow farmers, and has a significant negative impact on the subsequent fallow willingness and fallow degree of the four types of fallow farmers.

KEYWORDS

fallow, asset specificity, farmer differentiation, double-hurdle model, multivariate ordered logit model

1 Introduction

Land is the basis for the survival and development of human society, but the *per capita* area of cultivated land in China is less than half of the world's *per capita* level, and the quality of cultivated land is also declining year by year, and the twin problems of decreasing quantity and declining quality of cultivated land need to be addressed urgently (Li et al., 2019). The fallow policy is not only an important measure for rest and recuperation of cultivated land, land restoration and ecological protection (Zhang et al., 2017), but also an effective measure to implement the strategy of "storing food in the land", guaranteeing food security, promoting ecological civilization and advancing structural reform on the supply side (Niu and Fang, 2019). China's President Xi Jinping first elevated the fallow system to the level of a national strategy in his Note on the Proposal of the Central

Committee of the Communist Party of China on the Formulation of the 13th Five-Year Plan for National Economic and Social Development. Subsequently, it was clearly stated in the 2019 Central Document No. 1 and in Communist Party of China The 20th Congress of the Communist Party of China in 2022 that fallow system should be established and a system of rest and recuperation of cultivated land should be improved. Thus, it can be seen that the fallow system for cultivated land has now become a key measure to promote the sustainable development of Chinese agriculture (Xie et al., 2021). At the same time, as participants and beneficiaries of the fallow policy, farmers' enthusiasm to participate in fallow is the main factor for the orderly promotion and rational extension of the fallow pilot project (Yu et al., 2019). Therefore, it is of practical significance to explore the factors influencing farmers' willingness to participate in fallow, in order to stimulate their endogenous motivation to participate in fallow and thus promote their participation in fallow.

Fallow is to guide farmers to withdraw the overused cultivated land from agricultural production in a certain period of time in the form of compensation, and implement protection for recuperation, so as to achieve the goal of promoting the improvement of agricultural ecology. Most existing research on fallow has focused on the macro level of fallow policies (Chen and Yang, 2017; Yang et al., 2018; Niu and Fang, 2019) and the determination of compensation standards for fallow (Xie and Cheng, 2017; Yu et al., 2018; Liu et al., 2019), but few scholars have studied the willingness and extent of farmers' participation in fallow from the perspective of micro farmers. As cultivated land is a highly exclusive asset (Dowall and Monkkonen, 2008), when farmers give up their cultivated land and transfer their agricultural assets, they incur high sunk costs, making the opportunity cost of fallow higher, which in turn leads to a reduction in their expected returns and a 'lock-in' (Feng et al., 2018). Specifically, in long-term agricultural production, farmers invest in and use assets that are dedicated to agriculture, and when they fallow, these assets face depreciation or even become worthless, creating barriers to exit (Xie et al., 2021), suggesting that asset dedication has a significant impact on farmers' willingness to fallow. Moreover, as rural capital continues to flow to the towns, purely productive farming farmers have gradually evolved into part-time farming farmers who work part-time and non-farmers who work full-time off-farm, and this has led to the coexistence of pure, part-time and non-farmers who continue to diverge (Su et al., 2016). Farmer differentiation has become a dominant trend in rural China (Liu et al., 2020), and it has led to differences in farming land use decisions between farmers with different levels of part-time employment (Liu and Niu, 2014), which has been widely recognised in the context of farmer differentiation (Lambert et al., 2007; Yu et al., 2017). Therefore, it is also of theoretical value to study the impact of asset specificity on farmers' willingness to fallow based on the perspective of farmer differentiation.

A summary of existing studies reveals the following shortcomings in the current research: firstly, most of the existing literature has studied how to motivate non-fallow farmers to participate in fallow, ignoring the subsequent willingness of fallow farmers to participate, which has important implications for the sustainable and stable promotion of fallow policies. Secondly, asset specificity is a crucial factor that affects farmers' willingness to participate in fallow, but few research has been conducted on the impact of asset specificity on farmers' willingness to fallow, and there is no uniform methodology for measuring asset specificity. Thirdly, when studying farmers' willingness to fallow, few scholars have considered the factor of farmer differentiation, ignoring the differences in farmers' willingness to fallow in different part-time divisions. Based on this, this study uses 1,240 micro-survey data from four cities in Gansu province to classify farming farmers into pure farming farmers, Ⅰ-part-time farming farmers, Ⅱ-part-time farming farmers and non-farmers based on the perspective of farmer differentiation, and then quantifies asset specificity using the entropy method. A multivariate ordered Logit model and a double-hurdle model were then developed to explore the effects of asset specificity on the willingness of non-fallow farmers to fallow and the subsequent fallow willingness and degree of fallow farmers with different degrees of part-time division, in the hope of providing a theoretical basis and decision-making reference for motivating farmers to actively participate in fallow.

2 Theoretical analysis

Farmer differentiation is a process whereby, within a certain range, the more homogeneous operating agricultural farmers differentiate into more heterogeneous operating agribusiness farmers (Su et al., 2016). At present, the trend of farmer differentiation in China is becoming more and more obvious, but the willingness and behaviour towards fallow are more obviously different among different types of farmers (Liu et al., 2020). Therefore, it is necessary to classify farming farmers according to their degree of part-time employment. The classification of farmer types in this study is based on the proportion of agricultural income to net household income: pure farmers are those whose net household income is more than 95% from agriculture; I part-time farmers are those whose net household income is 50%–95% from agriculture; II part-time farmers are those whose net household income is 5%–50% from agriculture; and non-farmers are those whose net household income is less than 5% from agriculture (Yu et al., 2017; Zhang et al., 2019; Zhang et al., 2021).

Asset specificity is the extent to which an asset is allocated to other users and other uses based on the assumption that the value of the commodity does not decline (Williamson, 1991). This study argues that asset specificity affects farmers' fallow willingness from the following two aspects: First, the transaction cost. In the process of market transaction, due to the incompleteness of contract and opportunism tendency of people, the expected returns of asset holders are often reduced, which hinders farmers' withdrawal from agricultural production and inhibits their fallow willingness. Second, the sunk cost. High sunk costs associated with the conversion of assets to other uses can create a barrier to farmers' exit from agricultural production and thus inhibit their willingness to fallow. Cultivated land is eligible for geographic specificity, physical asset specificity and human capital specificity without considering the land use conversion (Li, 2009). Therefore, this study classifies farmers' asset specificity into three dimensions: human capital specificity, physical asset specificity and geographical location specificity, and theoretically elaborates the relationship between these three dimensions and farmers' willingness to fallow.

2.1 The impact of farmer differentiation on farmers' willingness to fallow

As the complex of economic and social "rational man", farmers' cultivated land utilization is the result of pursuing the balance of economic and social comprehensive benefits, rather than simply

pursuing the maximization of economic benefits (Liu et al., 2020). Farmer differentiation often affects the judgment of farmers' internal and external environment, the cost-benefit analysis of agricultural production, and the willingness of farmers to fallow (Yu et al., 2017). The higher the degree of part-time work of farmers, the higher their willingness to participate in fallow (Long et al., 2017). Under the stimulation of the current rapid economic development, the non-agriculturalization and part-time employment of farmers are gradually strengthened (Xie, 2019). How to increase the willingness of different types of farmers to participate in fallow and motivate them to participate in fallow is the primary measure to promote the orderly implementation of fallow policy and improve the effectiveness of fallow policy (Li and Shi, 2008). Accordingly, this study expects that farmer differentiation has an important effect on farmers' willingness to fallow.

2.2 The influence of asset specificity on farmers' willingness to fallow

(1) The influence of geographical location specificity on farmers' willingness to fallow. Geographical location specificity is the dependence of the asset value of land on its geographical location in agricultural production activities (Xie et al., 2021). As objective geographical factors such as location, transportation and markets directly affect the convenience of farmers in accessing agricultural market information, avoiding natural risk shocks and participating in market behaviour, in the process of agricultural production by farmers, the more superior the objective conditions such as climatic conditions, location and transportation of the land and the more dependent on the geographical location of the land (Dawkins, 2000), the stronger the geographical specialisation of the land. Studies have confirmed that the more geographically exclusive the land is, the higher the transaction costs, which in turn discourages farmers from transferring their land and promotes long-term land ownership and autonomous production. Therefore, the more geographically privileged the land is and the easier it is to participate in the market, the less likely the farmers choose to fallow. Accordingly, this study expects that geographical location specificity has a negative effect on farmers' willingness to fallow.

(2) The influence of physical asset specificity on farmers' willingness to fallow. Physical asset specificity means that facilities and machinery are designed to be used for a specific production activity, while being used in other ways will depreciate their value (Schnaider et al., 2022). In the case of farmers, physical asset specificity refers to the investment in physical assets (e.g. agricultural machinery) that farmers choose to purchase after making rational judgments in order to facilitate long-term production and improve agricultural productivity, this asset can only be of value if it is used in a specific production chain in agriculture (Smith and Shogren, 2002). The indivisibility of farm machinery leads to the fact that the higher the value of farm machinery, the more dedicated its asset, the more difficult it is for farmers to convert it to other uses and thus increase their autonomy in agricultural production (Cao et al., 2014). Therefore, the more physical asset specificity is in the agricultural production process, the more willing farmers are to participate in agricultural production and the less likely they choose to fallow. Accordingly, this study expects that physical asset specificity has a negative impact on farmers' willingness to fallow.

(3) The influence of human capital specificity on farmers' willingness to fallow. Human capital specificity is the accumulation of experience, technology and knowledge for a specific job, which can lead to devaluation if it is far away from the specific area where it is formed and applied (Takata and Parry, 2022). In long-term agricultural production, farmers increase their labour force to improve productivity, accumulate experience and skills in agricultural production through training and other forms, and learn agricultural knowledge and technology to increase their human capital specificity in both quality and quantity (Feng et al., 2018). The human capital specificity of farmers reflects their agricultural productivity, and also reflects the ease and opportunity cost of changing jobs. The higher the literacy level of farmers, the longer they have participated in training, and the longer they have worked in agriculture, the more specialized their agricultural knowledge and technologies are, and the higher the opportunity cost of transferring these knowledge and technologies to other uses will be (Luo et al., 2008; Lin et al., 2016), thus reducing the probability that the farmer choose to fallow. Accordingly, this study expects a negative effect of human capital specificity on farmers' willingness to fallow.

3 Data sources and asset specificity measures

3.1 Data sources

The data in this study comes from household research conducted by the subject group on farmers in the second round of fallow in Gansu province from October to November 2019. Gansu province is an important main grain producing area in northwest China, carrying important ecological functions. It is a typical area with severe ecological degradation in China. Gansu province is one of the first three regions to implement the fallow policy, as well as a typical deep poverty area in China. In this study, Gansu province is selected as the research area to explore the farmers' fallow willingness in this area has representative and typical significance for testing the construction of China's fallow system. At the same time, it also has important practical significance for the coordinated development of agricultural economy and ecological protection in ecological degraded area. Based on consideration of the typicality of ecological degradation problems and the scale of the fallow pilot situation, the four pilot fallow counties in Yongjing county of Linxia autonomous prefecture, Jingning county of Pingliang city, Huan county of Qingyang city and Tongwei county of Dingxi city were finally selected as the research areas, and the above four pilots are all the second round of fallow in Gansu province. Firstly, one to three pilot towns were selected in each pilot county according to the scale of fallow implementation in each county, and three to four pilot villages were randomly selected in each pilot town; secondly, in order to ensure the homogeneity between the non-pilot villages and the pilot villages in terms of ecological environment, cultivated land quality and farming conditions, and socio-economic status, one to two non-pilot villages were selected near each pilot village based on the principle of geographical proximity. Three to four natural

TABLE 1 Results of the asset specificity measure.

Variable	Measuring item	Entropy value	Entropy weight	Mean value of variables
Geographical location specificity	The ecological environment of their cultivated land	0.990	0.037	0.889
	The distance between the village and the town seat	0.946	0.192	
	The traffic conditions of the village	0.986	0.050	
	The convenience of village mailing/receiving express parcels	0.932	0.243	
Physical asset specificity	Tractors owned by farmers	0.991	0.033	0.251
	A rotary tiller owned by a farmer	0.991	0.033	
	Farmer-owned irrigation pumps	0.990	0.037	
	A farm tricycle owned by a farmer	0.987	0.046	
Human capital specificity	Years of education	0.960	0.141	0.559
	The number of times a family member attends agricultural technical training each year	0.964	0.130	
	Number of times a family member attends off-farm employment skills training per year	0.991	0.034	
	Days of farming in a year	0.993	0.024	

villages were then randomly selected from each administrative village, and finally six to seven farmers were randomly selected from each natural village to conduct household research.

The research area involved a total of 48 administrative villages in seven townships in four cities and four counties in Gansu province. A total of 1,300 questionnaires were distributed and 1,240 valid questionnaires were collected, with an effective rate of 95.38%, of which 605 were from fallow farmers and 635 from non-fallow farmers.

3.2 Measure of asset specificity

Geographical location specificity refers to the natural advantages of areas with unique climatic conditions, good transportation conditions and obvious location advantages (Xiao, 2004). The ecological environment of the cultivated land, the distance from the village committee to the township government, the distance from the village committee to the agricultural supply point and the accessibility of the village are generally chosen as the measures of geographical location specificity (Li, 2009; Lin et al., 2016).

Physical asset specificity in agricultural production means that farmers will invest in farm machinery that is well matched to their agricultural products in order to increase productivity, but these farm machines are often only suitable for a single species or a specific production process and are more difficult to convert to other uses, resulting in asset specificity (Jin and Jayne, 2013; Lin et al., 2016). Physical asset specificity is generally measured by the ownership of farm machinery by the farmers (Li, 2009; Liu et al., 2020).

In agricultural production, human capital specificity is expressed as farmers spending more time on production, accumulating experience and learning knowledge through training and other means in order to improve returns, resulting in higher human capital specificity (Luo et al., 2008). Human capital specificity is usually measured by the number of years of education, the number of technical training sessions per year and the number of years spent in farming (Luo et al., 2008; Gottlieb et al., 2015).

3.3 Quantification of asset specificity

In order to confirm the validity and reliability of the scale, this study used SPSS 23.0 to conduct reliability and validity tests. The results showed that the Cronbach's α value for the total scale was 0.737 and the Cronbach's α values for the subscales were all greater than 0.6, and the reliability test was passed. The KMO values of the total scale and the subscales were all higher than 0.6, the Bartlett's spherical test was significant at the 0.1% significance level, and the factor loading coefficients were all higher than 0.6, and the validity test was passed (Ni et al., 2022). Subsequently, this study used the entropy value method to quantify asset specificity.

The specific measurement questions selected for this study and the quantification results are shown in Table 1.

4 An empirical analysis of asset specificity on non-fallow farmers' willingness to fallow

4.1 Model construction

Since there are five different degrees of farmers' willingness to fallow, and there is a certain order among different choices, we choose a multivariate ordered logit model to study non-fallow farmers' willingness to fallow. The functional expression is established is as follows:

$$ln\left[\frac{p(Y\le n)}{1-p(Y\le n)}\right]=\alpha_n+\sum_{m=1}^{k}\beta_m x_m \quad (1)$$

In equation Eq. 1: n denotes the five levels of willingness to fallow, Y is the degree of farmers' willingness to participate in fallow, x_m denotes the mth variable affecting farmers' willingness to fallow, α_n denotes the intercept term, and β_m denotes the regression coefficient.

TABLE 2 Meaning of non-fallow farmers variables and their descriptive statistics.

Variable categories	Variable name	Variable meaning and assignment	Mean	Standard deviation
Dependent variable	Fallow intent	Degree of willingness of non-fallow farmers to participate in future fallow. Very reluctant = 1, Relatively reluctant = 2, Generally = 3, Relatively willing = 4, Very willing = 5	3.501	1.236
Independent variable	Geographical location specificity	The location value formed by the different quality of cultivated land and traffic conditions. It is obtained by the entropy method	0.315	0.111
	Physical asset specificity	Sustained investments by specialist farmers are valuable only if they are linked to a specific use. It is obtained by the entropy method	0.513	0.175
	Human capital specificity	Agricultural production and management capacity of specialized farmers. It is obtained by the entropy method	0.064	0.071
Control variable	Fallow cognition	Whether or not you know about fallow. Not very familiar with = 1, not familiar with = 2, moderately familiar with = 3, quite familiar with = 4, very familiar with = 5	2.556	1.208
	Perceptions of cultivated land use behaviour	Uncultivated, endless use of cultivated land can lead to greater ecological degradation than before. Strongly disagree = 1, roughly disagree = 2, neutral = 3, roughly agree = 4, strongly agree = 5	3.570	1.015
	Effectiveness of fallow compensation	Can compensation funds help to increase the willingness to fallow. Not at all = 1, Basically not = 2, Generally = 3, Basically able = 4, Completely able = 5	3.564	1.099
	Agricultural acreage	Acreage of cultivated land actually owned by the family	20.811	11.199
	Degree of reliance on the land	Whether they can continue to live without farming. Not at all = 1, no = 2, neutral = 3, yes = 4, ideally at all = 5	2.263	1.201
	Labor force size	The number of people in their household who can work	4.606	1.753
	Family living standard	The living standard of the family. Poor = 1, below = 2, average = 3, high = 4, very high = 5	2.915	0.755
	Fallow attitude	To protect and enhance land productivity and achieve sustainable cultivated land use. I feel it is my responsibility to participate in fallow. Strongly disagree = 1, roughly disagree = 2, neutral = 3, roughly agree = 4, strongly agree = 5	3.458	0.936
	Gender	Interviewee gender. Female = 0, male = 1	0.751	0.433
	Age	Age of interviewee	54.345	11.544
	Education level	Number of years the interviewee has been in education	5.384	4.072
	Risk preference	Likelihood of interviewee to take risks. Never take risks = 1, Occasionally take risks = 2, Average = 3, Take more risks = 4, Take risks often = 5	1.823	2.192

4.2 Variable selection

Dependent variable: non-fallow farmers' willingness to fallow.

Independent variable: asset specificity.

Control variables: Among the existing studies on farmers' willingness to fallow, Li and Su (2021) argued that education level and household income have a significant impact on fallow, and that farmers with higher education level and more stable household income are more likely to choose to fallow; Xie et al. (2012) concluded from their research that factors such as household size, type of household part-time employment and farmers' awareness of cultivated land conservation affect farmers' willingness to preserve cultivated land; Chen et al. (2021) and Zuo et al. (2020) argued that different compensations for fallow are needed to encourage farmers to participate in fallow; Xie and Wu (2020) suggested that the area of cultivated land and the number of labourers are also the main factors affecting farmers' willingness to fallow; Liu and Gong (2020) previously found that farmers' own risk preferences have a positive effect on their willingness to fallow, and also found that farmers' perceptions of cultivated land use behaviour also affect farmers' willingness to fallow. Therefore, combining existing studies, this study selects fallow cognition, perceptions of cultivated land use behaviour, fallow attitude, agricultural acreage, degree of reliance on the land, labour force size, family living standard, effectiveness of fallow compensation, gender, age, education level and risk preference as control variables.

The meaning, assignment and descriptive statistics of each variable for non-fallow farmers are shown in Table 2.

4.3 Fallow farmers' willingness to fallow

This study conducted a statistical analysis on the willingness of different types of non-fallow farmers to fallow, and the results are shown in Table 3. Part-time farming accounts for 75.43% of the sample in the study area, which shows that part-time farming has become a common phenomenon in the study area, where II part-time farmer farming accounts for 34.17% of the total number of farmers in

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TABLE 3 Willingness of different types of non-fallow farmers to fallow.

Whether to participate in the fallow		Pure farmers		I part-time farmers		II part-time farmers		Non-farmers		Total
		Number of farmers	Proportion %	Number of farmers	Proportion %	Number of farmers	Proportion %	Number of farmers	Proportion %	Proportion %
Generally	Yes	84	53.85	75	58.59	145	66.82	391	64.92	61.57
	No	31	19.87	25	19.53	44	20.28	125	18.66	19.69
	Total	41	26.28	28	21.88	28	12.90	119	16.42	18.74
		156	100.00	128	100.00	217	100.00	635	100.00	100.00

the sample and is the most dominant type of farming in the study area. Overall, 61.57% of non-fallow farmers express willingness to participate in fallow, indicating a more optimistic outlook for promoting the fallow policy. At the same time, however, there are differences in the willingness of different types of farming farmers to fallow their land, with non-farmers and II-part-time farmers being more willing to fallow than I-part-time farmers and pure farmers.

4.4 Influence of asset specificity on non-fallow farmers' willingness to fallow

Before conducting the empirical analysis of the double-hurdle model, considering that there may be some internal correlation among the measurement variables of asset specificity, we conducted a multicollinearity test on the samples. The maximum value of the VIF for the four types of farmers' models was 1.89 (much smaller than 10), indicating that there was no significant multicollinearity among the explanatory variables.

In this study, the multivariate ordered logit model was used to regress the four types of non-fallow farmers in turn, and the regression results are shown in Table 4.

Geographical location specificity has a significant negative effect on the willingness to fallow of pure farmers, I part-time farmers and II part-time farmers, while there is no significant effect on the willingness to fallow of non-farmers. This is due to the fact that the higher the share of agricultural income in total household income, the more farmers rely on agriculture and the more they value the geographical location of their cultivated land. The more suitable the topography of the cultivated land is for agricultural production, the more fertile the soil, the more convenient the transportation, and the closer it is to the county, the higher the geographical superiority of the cultivated land, which will bring advantages such as higher yields, lower transaction costs and lower transportation costs, thus discouraging farmers from participating in fallow farming. For farmers whose total income is mostly derived from non-farm income, they are less dependent on agriculture and attach less importance to cultivated land, so differences in the quality of cultivated land do not affect whether they participate in fallow.

Physical asset specificity has a significant negative effect on the willingness to fallow of pure farmers, I part-time farmers and II part-time farmers, while there was no significant effect on the willingness of non-fallow farmers to fallow. When farming, farmers will purchase farm machinery to improve their productivity in order to increase their farm income. The more farm machinery a farmer owns and the higher its value, the better his or her material base of agricultural production, and the higher the transaction costs and sunk costs of converting farm machinery to other uses, the more likely he or she is to continue farming in the future, thus discouraging him or her from participating in fallow farming. Non-farmers, on the other hand, own less or no farm equipment compared to the other three categories of farmers, so the impact of physical asset specificity on them is smaller.

Human capital specificity has a significant negative effect on the willingness of all four types of non-fallow farmers to fallow, with a greater effect on pure farmers and I part-time farmers. In the course of long-term agricultural production, farmers invest more labour in order to increase their income, gain experience in farming by

TABLE 4 Multivariate ordered logit model regression results.

Variable		Pure farmers		I part-time farmers		II part-time farmers		Non-farmers	
		Fallow willingness	Standard error	Fallow willingness	Standard error	Fallow willingness	Standard error	Fallow willingness	Standard error
Asset specificity	Geographical location specificity	−1.909***	0.157	−0.318*	0.175	0.466**	0.200	0.247	0.207
	Physical asset specificity	−0.310**	0.149	−0.032**	0.014	−0.370*	0.213	−0.151	0.472
	Human capital specificity	−2.654***	0.310	−0.795**	0.361	−0.543*	0.287	−0.370*	0.213
Control variable	Fallow cognition	1.937***	0.270	0.161	0.216	0.428***	0.112	0.130**	0.062
	Perceptions of cultivated land use behaviour	−0.163	0.219	−0.149*	0.080	−0.083	0.134	−0.047***	0.013
	Effectiveness of fallow compensation	0.014	0.017	1.892***	0.285	0.017**	0.008	2.654***	0.310
	Agricultural acreage	0.116	0.266	0.051	0.034	0.013	0.012	0.020	0.027
	Degree of reliance on the land	−2.035***	0.675	−0.537***	0.207	−0.126	0.113	0.134	0.188
	Labor force size	0.126	0.149	0.187	0.158	2.150	1.808	0.344*	0.208
	Family living standard	−0.255	0.268	0.976**	0.383	0.330	0.226	0.137	0.404
	Fallow attitude	1.116**	0.520	0.122	0.238	0.338***	0.127	0.197	0.244
	Gender	0.413	0.562	0.314	0.530	0.038	0.372	1.941***	0.590
	Age	−0.018	0.022	−0.049**	0.026	−0.044**	0.017	−0.053**	0.026
	Education level	0.266**	0.121	0.012	0.016	0.027	0.023	0.055***	0.017
	Risk preference	0.118	0.431	0.071**	0.095	0.190	0.330	−0.174	0.133

Note: *, **, and *** indicate significant at the 10%, 5% and 1% levels respectively.

"learning by doing", and participate in technical training to learn more and acquire more expertise. Human capital is not only an expression of a farmer's agricultural productivity, but also of the difficulty and opportunity cost of leaving agriculture. The higher the proportion of agricultural labour in a household and the more knowledge and experience it has accumulated in agricultural production, the higher the sunk costs and the greater the risks faced by farmers in choosing to switch to other occupations through farming fallow, thus discouraging their willingness to participate in farming fallow. For both pure and I-part-time farmers, in order to maintain their livelihoods, they develop a stronger quantitative and qualitative human capital specificity, which has a greater impact on their willingness to fallow.

To test the robustness of the above estimates, the dependent variable was replaced with "I plan to participate in the state-promoted fallow", with fully disagree = 1, largely disagree = 2, generally = 3, largely agree = 4 and fully agree = 5. The multivariate ordered logit regression was conducted again. The regression results were highly consistent with the original model results, and the coefficients did not change significantly[1], indicating that they passed the robustness test.

5 A empirical analysis of asset specificity on fallow farmers' willingness and degree to subsequent fallow

5.1 Model construction

This study adopts the double-hurdle model to study the willingness and extent of subsequent fallow by fallow farmers. The double-hurdle model divides the decision-making process of individuals into two stages: "whether to participate" and "the degree of participation", and the two stages are established simultaneously to constitute a complete decision-making process. In the double-hurdle model, the equations of the two decision stages are estimated independently of each other, without the assumption of correlation between the two stages, effectively avoiding the problem of endogeneity between the equations of the two stages. The specific model is constructed as follows:

$$P\left(y_i = 0 \middle| x_{1i}\right) = 1 - \phi\left(x_{1i}\alpha\right) \tag{2}$$

$$P\left(y_i > 0 \middle| x_{1i}\right) = \phi\left(x_{1i}\alpha\right) \tag{3}$$

TABLE 5 Meaning of variables and their descriptive statistics for fallow farmers.

Variable categories	Variable name	Variable meaning and assignment	Mean	Standard deviation
Dependent variable	Fallow intent	After the fallow pilot, whether they are willing to participate in long-term fallow. No = 0, yes = 1	0.838	0.369
	Degree of fallow	If willing to continue fallow, the number of acres of cultivated land available for fallow	16.733	16.596
Independent variable	Geographical location specificity	The location value formed by the different quality of cultivated land and traffic conditions. It is obtained by the entropy method	0.313	0.107
	Physical asset specificity	Sustained investments by specialist farmers are valuable only if they are linked to a specific use. It is obtained by the entropy method	0.541	0.160
	Human capital specificity	Agricultural production and management capacity of specialized farmers. It is obtained by the entropy method	0.059	0.062
Control variable	Cultivated land cognition	Whether they familiar the quality of their cultivated land. Not very familiar with = 1, not familiar with = 2, moderately familiar with = 3, quite familiar with = 4, very familiar with = 5	3.344	0.984
	Fallow compensation satisfaction	Satisfaction with the fallow compensation standard (amount of compensation). Very dissatisfied = 1, not very satisfied = 2, neutral = 3, relatively satisfied = 4, very satisfied = 5	4.036	0.866
	Fallow policy satisfaction	Satisfaction with the overall fallow policies (farmers' participation, management, protection policies, ecological effects, etc.). Very dissatisfied = 1, not very satisfied = 2, generally = 3, relatively satisfied = 4, very satisfied = 5	3.810	0.918
	Fallow policy trust	The current fallow policy as a whole is in the collective interest of long-term existence. Strongly disagree = 1, somewhat disagree = 2, neutral = 3, somewhat agree = 4, strongly agree = 5	3.906	0.971
	Agricultural acreage	Acreage of cultivated land actually owned by the family	28.882	18.221
	Degree of reliance on the land	Whether they can continue to live without farming. Not at all = 1, no = 2, neutral = 3, yes = 4, ideally at all = 5	2.413	1.209
	Labor force size	The number of people in their household who can work	4.643	1.868
	Family living standard	The living standard of the family. Poor = 1, below = 2, average = 3, high = 4, very high = 5	2.899	0.845
	Social connection	Relationship between migrant/employed members and their friends/colleagues in the migrant/off-farm employment area. Never contact = 1, occasionally contact = 2, generally = 3, contact more = 4, often contact = 5	3.365	1.013
	Social opportunities	Satisfaction with local job opportunities. Very dissatisfied = 1, not very satisfied = 2, neutral = 3, relatively satisfied = 4, very satisfied = 5	2.474	1.027
	Non-farm employment willingness	After the land recovery is over, whether the main household labor force intends to be outside for a long time (more than 5 years) for off-farm employment. Never = 1, unlikely = 2, maybe = 3, mostly = 4, definitely = 5	3.104	1.361
	Fallow attitude	To protect and enhance land productivity and achieve sustainable cultivated land use. I feel it is my responsibility to participate in fallow. Strongly disagree = 1, roughly disagree = 2, neutral = 3, roughly agree = 4, strongly agree = 5	2.904	1.326
	Gender	Interviewee gender. Female = 0, male = 1	0.716	0.451
	Age	Age of interviewees	54.106	11.497
	Village cadres' satisfaction	Interviewees' satisfaction with the work of village cadres. Very dissatisfied = 1, relatively dissatisfied = 2, neutral = 3, relatively satisfied = 4, very satisfied = 5	3.403	0.913

$$E\left(y_i \middle| y_i > 0, x_{2i}\right) = x_{2i}\beta + \sigma\lambda\left(\frac{x_{2i}\beta}{\sigma}\right) \tag{4}$$

Eq. 2 indicates that fallow farmers are not willing to continue to fallow subsequently; equation Eq. 3 indicates that fallow farmers are willing to continue to fallow subsequently, $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution, y_i is the number of fallow farmers willing to continue to fallow subsequently, x_{1i} is the independent variable, α is the corresponding parameter to be estimated, and i is the ith observation sample; in equation Eq. 4, $E(\cdot)$ is the conditional expectation, which indicates the extent to which fallow farmers are willing to continue to fallow subsequently $\lambda(\cdot) = \Psi(\cdot)/\Phi(\cdot)$ is the inverse Mills ratio, $\Psi(\cdot)$ represents the density function of the standard normal distribution, x_{2i} is another set of independent variables, β is the corresponding coefficient to be estimated, and σ is the standard deviation of the intercepted normal distribution.

Based on equations Eqs. 2–4, the log-likelihood function can be established as follows:

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TABLE 6 Willingness of different types of fallow farmers to subsequent fallow.

Whether to participate in the subsequent fallow	Pure farmers		I part-time farmers		II part-time farmers		Non-farmers		Total	
	Number of farmers	Proportion %	Number of farmers	Proportion %	Number of farmers	Proportion %	Number of farmers	Proportion %	Number of farmers	Proportion %
Yes	91	73.39	117	82.39	257	87.41	42	93.33	507	83.80
No	33	26.61	25	17.61	37	12.59	3	6.67	98	16.20
Total	124	100.00	142	100.00	294	100.00	45	100.00	605	100.00

$$lnL = \sum_{y_i=0}\{ln[1-\phi(x_{1i}\alpha)]\} + \sum_{y_i>0} ln\,\phi(x_{1i}\alpha) - ln\,\phi\left(\frac{x_{2i}\beta}{\sigma}\right) - ln\,\sigma + \ln\left\{\phi\left[\frac{y_i - x_{2i}\beta}{\sigma}\right]\right\} \tag{5}$$

In equation Eq. 5: *lnL* represents the value of the log-likelihood function, and the relevant parameters required for this study can be found using the maximum likelihood estimation.

5.2 Variable selection

Dependent variable: fallow farmers' willingness to follow up fallow and the degree of fallow.

Independent variable: asset specificity.

Control variables: Li et al. (2015) found that cultivated land awareness, literacy, labour force size, farmers' trust in fallow policies, cultivated land area and farmers' own attitudes towards fallow were important factors influencing farmers' willingness to fallow; Liu and Hu (2021) argued that farmers' willingness to fallow is affected by their subjective perceptions and the living environment they live in. Ti et al. (2022) put forward that increasing farmers' awareness of fallow compensation policies and farmers' trust in the local government can increase farmers' fallow willingness. Yu et al. (2017) found that the smaller the number of plots, the higher the satisfaction with the policy, the more social ties and the stronger the inclination to urban employment, the higher the farmers' willingness to participate in fallow; Liu et al. (2019) concluded that age and gender are the main factors influencing farmers' willingness to fallow, and suggested that the government's provision of off-farm employment opportunities to farmers would facilitate the effective implementation of the fallow policy, while the reduction of social opportunities would increase the economic pressure on farmers' livelihoods, further prompting them to go out for employment to earn more income. Long et al. (2017) suggested that because of the low education level of farmers in rural China, the ability of farmers of understanding and implementing policies is not strong, and therefore the ability of village cadres may, to a certain extent, affect farmers' willingness to make decisions on the fallow policy. Based on existing research findings, this study selects cultivated land cognition, fallow compensation satisfaction, fallow policy satisfaction, fallow policy trust, agricultural acreage, degree of reliance on the land, labor force size, family living standard, social connection, social opportunities, non-farm employment willingness, fallow attitude, gender, age and village cadres' satisfaction as control variables.

The meanings, assigned values and descriptive statistics of each variable for fallow farmers are shown in Table 5.

5.3 Subsequent fallow willingness of fallow farmers

As shown in Table 6, similar to non-fallow farmers, part-time farmers are the mainstay of fallow farmers, accounting for 79.50%

TABLE 7 Double-hurdle model regression results.

Variable		Pure farmers		I part-time farmers		II part-time farmers		Non-farmers	
		Fallow willingness	Fallow degree	Fallow willingness	Fallow degree	Fallow willingness	Fallow degree	Fallow willingness	Fallow degree
Asset specificity	Geographical location specificity	−1.029*** (0.328)	−2.829*** (0.820)	−2.676* (1.449)	−3.517* (1.864)	−0.310** (0.149)	−0.448* (0.262)	−0.644** (0.272)	−0.713*** (0.071)
	Physical asset specificity	−0.162 (0.264)	−1.436* (0.863)	−0.094** (0.047)	−0.233** (0.101)	−0.135 (0.115)	−0.505 (0.502)	−0.264* (0.137)	−0.123* (0.064)
	Human capital specificity	−1.160*** (0.392)	−3.542** (1.701)	−0.617* (0.339)	−1.894** (0.942)	−0.109* (0.064)	−0.381* (0.222)	−1.419** (0.621)	−2.472* (1.410)
Control variable	Cultivated land cognition	−0.337 (0.231)	0.390 (0.967)	−1.193** (0.471)	−3.333** (1.544)	0.151 (0.129)	−0.455 (0.884)	−0.234 (0.263)	−1.568 (1.047)
	Fallow compensation satisfaction	0.089 (0.296)	0.292*** (0.102)	0.155 (0.308)	1.712 (1.483)	0.452*** (0.145)	2.285** (1.141)	0.920** (0.411)	0.120 (1.464)
	Fallow policy satisfaction	0.637** (0.307)	3.088*** (1.039)	0.152 (0.347)	2.352 (1.890)	0.315** (0.143)	0.511 (1.130)	0.047 (0.378)	0.691 (1.483)
	Fallow policy trust	0.409* (0.245)	1.734 (1.414)	0.408 (0.349)	0.692*** (0.078)	0.274* (0.160)	0.909*** (0.048)	0.011 (0.030)	0.421 (0.878)
	Agricultural acreage	0.004 (0.011)	−0.292*** (0.102)	−0.015 (0.029)	−0.284** (0.144)	0.026 (0.020)	−0.423*** (0.102)	0.063 (0.057)	−0.292** (0.115)
	Degree of reliance on the land	−0.277 (0.353)	1.112 (0.680)	−0.071 (0.304)	−4.783** (2.083)	0.077 (0.112)	−1.639** (0.688)	−0.902*** (0.325)	−1.284 (0.848)
	Labor force size	0.007 (0.147)	1.693 (1.425)	1.005** (0.453)	2.664* (1.456)	0.112 (0.108)	0.067 (0.739)	0.519** (0.259)	0.714 (0.828)
	Family living standard	0.509 (0.352)	0.823 (1.440)	1.107* (0.577)	3.666* (1.988)	0.101 (0.190)	1.416 (1.322)	1.062** (0.513)	−0.426 (1.474)
	Social connection	0.247 (0.214)	1.737** (0.722)	0.146 (0.320)	2.297* (1.376)	0.294** (0.124)	1.382* (0.820)	0.230 (0.326)	0.765 (1.003)
	Social opportunities	0.107 (0.170)	0.991 (1.442)	−0.245 (0.391)	−0.553 (1.427)	−0.015 (0.097)	−1.162* (0.693)	−0.013 (0.257)	−0.641 (0.881)
	Non-farm employment willingness	1.169*** (0.449)	1.004 (1.513)	0.664** (0.317)	0.499 (1.489)	0.335** (0.165)	1.310 (0.920)	0.328*** (0.078)	0.131 (0.934)
	Fallow attitude	0.885** (0.432)	0.965 (1.395)	1.286*** (0.463)	1.453 (1.465)	0.176 (0.163)	0.639 (0.906)	0.117 (0.290)	0.999 (0.966)
	Gender	0.663 (0.631)	−0.706 (2.741)	1.619* (0.973)	3.176 (2.994)	0.034 (0.263)	0.577 (2.025)	−0.346 (0.679)	0.827 (2.253)
	Age	−0.049** (0.023)	−0.203** (0.087)	−0.040 (0.046)	0.165 (0.158)	−0.012 (0.011)	−0.047 (0.074)	0.024 (0.027)	−0.242*** (0.090)
	Village cadres' satisfaction	0.352 (0.273)	0.681 (1.114)	0.891 (0.565)	3.977*** (1.547)	−0.119 (0.126)	1.071 (0.856)	0.258 (0.311)	0.775 (1.094)

Note: The number in parentheses is the standard error. *, **, and *** indicate significant at the 10%, 5% and 1% levels respectively.

of the total sample of fallow farmers, with II part-time farmers accounting for the largest proportion at 48.60%. Compared with non-fallow farmers, fallow farmers' willingness of to actively participate in subsequent fallow increased significantly, reaching 83.80%, indicating that the current fallow policy is more effective and should be continually carried out in the future. At the same time, the willingness of different types of fallow farmers to participate in subsequent fallow also varies, from strong to weak: non-farmers, II part-time farmers, I part-time farmers and pure farmers.

5.4 Influence of asset specificity on fallow farmers' willingness and degree to continue fallow

Before conducting the empirical analysis of the double-hurdle model, a multiple cointegration test was conducted on the sample of fallow farmers using the variance inflation factor method. The maximum value of the VIF for the four types of farmers' models was 2.16, which was much smaller than 10, indicating that there was no significant cointegration between the explanatory variables.

In this study, double-hurdle model was used to analyse the subsequent willingness and extent of fallow farmers, and regressions were carried out for each of the four categories in turn, and the results are shown in Table 7.

Geographic location specificity has a significant negative effect on the subsequent willingness to fallow and the extent of fallow for all four types of fallow farmers, and the effect is significantly smaller for II part-farmers and non-farmers than for pure farmers and I part-farmers. The fallow of cultivated land may result in the loss of use of cultivated land by farmers who have been relying on it for their livelihood. The geographical exclusivity of cultivated land makes farmers more inclined to continue to hold cultivated land that is ecologically sound, easily accessible, and prone to large-scale management and mechanization, thus discouraging them from participating in fallow. For part-time farmers and non-farmers, agricultural income accounts for a relatively small proportion of total income, and their dependence on cultivated land is low, making the choice to fallow less influential.

Physical asset specificity has a negative effect on fallow farmers' subsequent willingness to fallow, but to the least extent of the three dimensions of asset dedication. Farmers' investments in physical assets tend to be concentrated in two areas: investments in agricultural production that are attached to the cultivated land, such as irrigation facilities; and investments in agricultural production tools and equipment that match the objective conditions of the cultivated land, such as farm machinery. These agricultural investments are inseparable from the cultivated land, and once a farmer goes into fallow, the original investment in physical assets is greatly devalued, thus discouraging the willingness of the fallow farmer to follow through. One possible explanation for the minimal impact effect is that farmers are constrained by their income and do not have a wide range of large farm machinery and farm tools, so they take them less into account in their fallow decisions. For part-time farmers, even if they have some farm tools at home, they are more likely to transfer and sell farm equipment and choose to outsource services as they become more non-farmed, so the effect of physical asset specificity on farmers' willingness to fallow is smaller.

Human capital specificity has a significant negative effect on the willingness to fallow and the degree of fallow for all four types of fallow farmers, and the effect is greater for pure and non-farmers. Pure farmers and non-farmers have a single income structure and are more concerned about whether they can maintain their current income level through their own ability after the fallow period. The greater the capital specificity, the higher the sunk cost and the greater the difficulty of changing jobs. For pure farmers, the choice of farming will continue even after the end of the fallow pilot, thus influencing their continued participation in fallow. For non-farmers, they are already able to meet their livelihood needs through non-farm work, and are therefore more likely to rent out their cultivated land for rent if compensation for fallow does not meet their expected returns.

To check the robustness of the above estimates, this study replaces the regression method to retest the empirical results. The Heckman sample selection model was used to re-estimate the results and the results were found to be consistent with the double-hurdle model in terms of the magnitude and significance level of the regression coefficients[2], indicating that they passed the robustness test.

6 Conclusion

6.1 Study Conclusion

This study focuses on the effects of three dimensions of asset specificity on the willingness of fallow farmers to fallow from the perspective of farmer differentiation, and draws the following conclusions.

(1) Part-time farming has become a common phenomenon in rural China, and a higher proportion of fallow farmers are willing to participate in subsequent fallow compared to non-fallow farmers. At the same time, there are differences in the willingness of different types of farming farmers to fallow their land, with non-farmers and II-part-time farmers being more willing to fallow than pure and I-part-time farmers.
(2) Geographical location specificity has a significant negative effect on the willingness to fallow among the four types of non-fallow farmers: pure farmers, I-part-time farmers and II-part-time farmers, but has no significant effect on the willingness of non-farmers to fallow. Geographical location specificity has a significant adverse effect on the intent and willingness to participate in subsequent land recuperation of the four types of farmers. The impact on non-farmers and II part-time farmers are significantly smaller than that on pure farmers and part-time farmers.
(3) Physical asset specificity has a significant negative effect on the willingness of non-fallow farmers to fallow, while there is no significant effect on the willingness of non-farmers to fallow. Physical asset specificity has the most negligible influence on willingness to participate in subsequent land recuperations, especially on pure farmers and II part-time farmers.
(4) Human capital specificity has a significant negative effect on the willingness to fallow of all four types of non-fallow farmers, and the effect is greater for pure farmers and I part-time farmers. Human capital specificity has a significant negative impact on the willingness and degree of land recuperation among the four types of farmers. The effect is more pronounced for pure farmers and non-farmers.

6.2 Suggestions

(1) Implement a differentiated compensation policy. The current policy of compensation for fallow has effectively increased the willingness of farmers to fallow. However, for pure farmers, who have been engaged in agricultural production for a long time and have more asset specificity, the guidance and support for them to choose to fallow is still insufficient. In the future, compensation policies can be implemented to increase subsidies for pure farmers, thereby increasing their internal motivation to participate in fallow.
(2) Determine the priority of fallow cultivated land. When the government implements fallow, priority will be given to cultivated land with low geographical location specificity such as ecological fragility and inconvenient transportation, and farmers will be more willing to participate in fallow. Through

the fallow of this part of the cultivated land to form a demonstration effect, increasing the willingness of farmers to participate in fallow.

(3) The subsidies should take into account the depreciation of agricultural fixed assets. When farmers invest in agricultural fixed assets (farm machinery, irrigation facilities, etc.), it will be a large amounts of physical capital, the physical asset specificity is more difficult to convert them to other uses. Therefore, when setting the subsidies for fallow, it is important to take into account not only the direct reduction in agricultural output due to fallow, but also the depreciation of agricultural fixed assets.

(4) Actively organize skills training for farmers. While calling on farmers to fallow, the government should also actively organize skills training for farmers to strengthen the frequency and coverage of technical training, reduce their human capital specificity, so as to promote their willingness to participate in fallow.

6.3 Study Limitations

Based on the micro survey data of 1,240 farmers in Gansu province in China, this study empirically evaluates the impact of asset specificity on farmers' fallow willingness, which makes up for the shortcomings of existing literature and has strong practical significance. However, this study still has some limitations, specifically as follows:

(1) Asset specificity in different economic development areas has differences in the farmers' fallow willingness. However, due to financial constraints, this study does not consider the regional heterogeneity of its policy effect in other typical fallow pilot areas in China, which is worth further study.

(2) At present, this study only focuses on the study of farmers' willingness to fallow, but does not study the actual occurrence of fallow behavior. However, farmers' willingness and behaviors are sometimes not completely consistent. In general, how to encourage farmers to participate in fallow in the long term is a complex issue that needs longer-term investigation and deeper studies.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Materials, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Conceptualization, SZ and XX; Data curation, SZ and XX; Formal analysis, SZ; Funding acquisition, MZ; Investigation, SZ, XX and YL; Methodology, YL; Project administration, MZ; Software, SZ and YL; Supervision, MZ; Writing-original draft, SZ; Writing-review and editing, XL and MZ. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Publisher's note

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