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Identifying the effects of the stability of farmland transfer management rights on the use of organic fertilizer with different farmland scales and crop types

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Encouraging farmers to protect the quality of arable land is a focus of the current Chinese government. Enhancing the stability of arable land property rights is considered by the academic community to be an effective way to do so. Based on the survey data of 723 households in the hilly area of Jiangxi Province and using the probit model and robustness test methods, this paper examines the effect of stable farmland transfer management rights on farmers' use of organic fertilizer and the differences in this effect with different management scales and crop types. The results show that stable management farmland transfer rights significantly encourage farmers to use organic fertilizer. Specifically, signing a written formal contract, increasing the contract registration rate, and extending contracts' duration can increase farmers' probability of using organic fertilizer, but whether there is a dispute in a farmland transfer has no significant impact on farmers using organic fertilizer. This study also finds that the impacts of stable arable land transfer management rights vary based on different characteristics of farmers using organic fertilizer. Stable arable land transfer management rights can encourage large-scale farmers and farmers planting grain crops to use organic fertilizer. To increase the stability of these rights, the local government should encourage farmers to sign formal written contracts, standardize their registration, and extend their duration.

KEYWORDS

cultivated land, organic fertilizer, land management right, farmland size, crop types

1 Introduction

As the most important and basic material input in agricultural production, chemical fertilizer is called "grain in grain". Using chemical fertilizer can not only improve soil fertility but also increase the yield per unit area of grain crops (Zhou, 2019; Shang et al., 2021). However, the excessive use of agricultural inputs such as chemical fertilizers will not only cause agricultural nonpoint pollution and damage the rural ecological

environment but also affect the quality of agricultural products, threaten food safety, and hinder the sustainable development of agricultural and rural areas in China. In 2022, a primary central document has been proposed to promote the green development of agricultural and rural areas, strengthen the comprehensive treatment of agricultural nonpoint pollution, and further promote the reduction of agricultural inputs. An effective way to reduce agricultural inputs, especially chemical fertilizers, is to gradually replace chemical fertilizers with organic fertilizers (Su et al., 2022; Wang and Li, 2022). Organic fertilizer has several ideal characteristics to improve soil quality and ensure the quality and safety of agricultural products (Ning et al., 2016). Its use plays an important role in alleviating the pressure on the rural ecological environment and promoting the sustainable development of agricultural and rural areas. As the main decision makers in agricultural production and management processes, farmers have the power to decide whether to use organic fertilizer. Therefore, encouraging farmers to replace chemical fertilizers with organic fertilizers and improve the soil and the quality and environment of cultivated land has become a key issue related to food security and sustainable agricultural development.

Property rights play an important role in encouraging economic subjects to invest. A focus of academic research is exploring the impact of stable property rights on farmers' behavior with respect to cultivated land protection (Coase, 1960; Besley, 1995; Ma et al., 2013; Zhao et al., 2022; Lu et al., 2019; Li and Shen, 2021; Shang et al., 2021). Using organic fertilizer is regarded by academia as a behavior that protects and improves the quality of cultivated land, but few studies have directly discussed the impact of stable cultivated land circulation management rights on its use. Since investment in cultivated land protection is not short term, investment of time, capital, labor and other factors in 1 year will be recovered in subsequent years (Li et al., 1998; Brasselle et al., 2002; Lu et al., 2022). If the property rights to cultivated land are unstable, they will affect farmers' investment expectations and reduce their investment in cultivated land protection. Empirical research in China and abroad has confirmed this theory. Li and Wang (2021) reviewed domestic and international research on the stability of land property rights and farmers' protection of their cultivated land quality and found that 82.5% of the sample literature supported the conclusion that stable land property rights can promote farmers' protection of their cultivated land quality. Of course, some studies have found that other factors (such as credit supply and technology) restrict the effect of stable land property rights on the protection of and investment in cultivated land quality (Li and Wang, 2021). Other studies have shown that instability in agricultural land property rights caused by agricultural land adjustments affects a farmer's long-term investment in a plot, affecting behaviors such as the use of farm manure, but the actual effect is not significant (Zhao et al., 2022). Still others have found that economic and social

factors, such as population growth, life expectancy, per capita GDP, consumer perception, carbon emissions, climate change, and COVID-19, affect the use of arable land (Al-Sulaiti and Baker, 1998; Zaman et al., 2016; Anser et al., 2020; Farzadfar et al., 2022; Khan et al., 2022). In particular, the COVID-19 epidemic has affected people in all the above aspects. Research shows that COVID-19 has adversely affected the income of more than two-thirds (67%) of families (Wang et al., 2021; Geng et al., 2022). However, female entrepreneurship significantly promotes an increase in family income (Ge et al., 2022). To eliminate the impact of COVID-19, dissemination of accurate information is essential (Wang and Li, 2022). In addition, cultural tourism has a significant impact on environmental sustainability (Li et al., 2022), which may further affect the use of arable land. One study found that enterprise scale has a positive impact on operating efficiency, which means that scale is also an important factor in the use of arable land (Ismail et al., 2009); even cultural events and business organizations, which are easy to overlook (Al-Sulaiti and Almwajeh, 2007; Al-Sulaiti et al., 2021), may become important factors in the use of arable land. Therefore, there are many academic research results on the factors affecting the use of arable land and the use of organic fertilizer, especially on the impact of stable arable land property rights on farmers' investment behavior in protecting arable land. These studies have important reference significance for the government to formulate arable land protection policies according to local conditions.

However, researchers have differed on what indicators to use to measure the "stability of property rights". Some use indicators such as whether farmers have experienced an agricultural land adjustment, whether land is registered, or whether farmers have land certificates (Ji et al., 2014; Hong and Luo, 2018; Leonhardt et al., 2019). However, these researchers note that the concept of stable cultivated land property rights has rich connotations that are difficult to express comprehensively with a single indicator. Therefore, some later research has measured the stability of these rights from legal, factual and perceptual dimensions and taken a more representative point of view (Ma et al., 2013). Some empirical studies also support that stable property rights across these three dimensions greatly influence farmers' investment in cultivated land protection and their use of organic fertilizer. However, there are also problems with these three indicator dimensions. For example, the perception of property rights stability cannot be falsified because perception is a person's private psychological activity that "cannot be directly observed". Therefore, this dimension "cannot meet the falsifiability requirements of scientific research". In addition, to ascertain the stability of farmers' perceived property rights, a survey of farmers must ask relevant questions about farmers' wishes, but farmers' answers to these questions may not represent their real thoughts or behaviors. Therefore, it is necessary to create an index system for property rights

stability that can be observed, falsified and compared with the actual situation in rural China.

Accordingly, this paper investigates the impact of stable management rights to cultivated land transfer on farmers' use of organic fertilizer against the background of widespread cultivated land transfer in rural China. The purpose is to determine whether stabilizing these rights will encourage farmers to protect the quality of cultivated land. A review of the literature reveals few studies on the impact of such stability on farmers' investment behavior with respect to cultivated land protection, and the few relevant studies mostly focus on family farms, neglecting ordinary farmers, especially those in hilly areas. Because the income from farming is relatively low in hilly areas, due to the relatively small plots and large slopes, the stability of cultivated land transfer management rights deserves more attention. Second, because different crops and cultivated land management scales make different demands on farmers in terms of labor, capital and other factors, this paper explores whether different crop types and cultivated land scales affect farmers' decision to use organic fertilizer. Therefore, using the hilly area of Jiangxi Province as an example, based on constructing a stability index system of cultivated land transfer management rights, this paper uses a probit model to empirically test the impact of the stability of cultivated land transfer management rights on farmers' use of organic fertilizer and uses the supplementary variable and replacement variable methods to test the robustness of the regression results. At the same time, we consider the impact of the sample heterogeneity of farmers with different business scales and crops on the regression results to provide a reference for improving cultivated land transfer policies and sustainable agricultural development. The main contribution of this paper is based on the verifiable perspective, measuring the indicators of the stability of arable land transfer management rights and distinguishing the impact of different business scales and planting crops on farmers' use of organic fertilizer.

2 Theoretical analysis and research hypothesis

2.1 Legal dimension

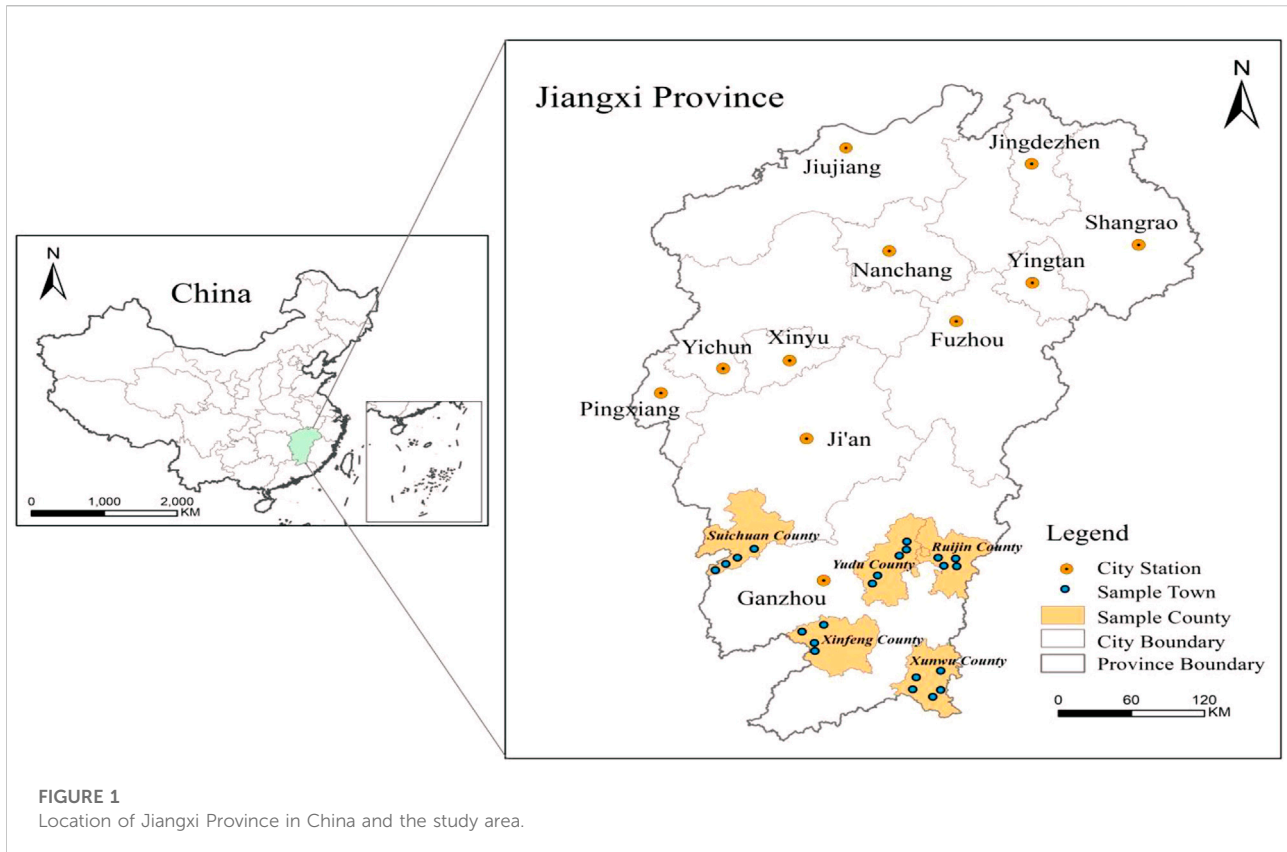
The legal dimension endows the property rights to cultivated land, which means legalizing these rights, reducing costs and risks in the process of cultivated land transactions, and stimulating farmers' enthusiasm to invest in cultivated land, especially to protect their long-term investment in it. A new round of agricultural land rights confirmation, registration and certification is currently occurring to confirm the area, scope and use of each land

type individually to give farmers more formal, clear and complete cultivated land rights (Jacoby et al., 2002; Abudharman et al., 2020; Zhao et al., 2022). From the perspective of property rights security, this new round of agricultural land ownership confirmation registration clearly defines the rights to cultivated land. Issuing land certificates ensures the property rights security of cultivated land, helps promote the circulation of cultivated land, and ensures the stability of cultivated land management rights (Cheng and Zou, 2022). From the perspective of the integrity of property rights, it gives mortgage and security rights to the transferred land and diversifies cultivated land transactions, which can also promote the circulation of cultivated land and encourage business entities to invest in and protect it (Qiu et al., 2017; Yue et al., 2021; Qian et al., 2022). Zhou and Wang (2019) found that land ownership confirmation can increase the input of organic fertilizer into the transferred land through the "collateral effect". In practical research, the legal dimension of property rights security is generally measured by the formation of contracts. Compared with oral agreements, written formal contracts can give cultivated land management entities a greater sense of stability and encourage them to make long-term investments in cultivated land. Some studies have also confirmed that signing a formal written contract is conducive cultivated land management entities' the adoption of cultivated land protection behaviors, such as planting green manure and using organic manure (Li et al., 2019; Li B. et al., 2021). Consequently, the following research hypothesis is proposed:

H1: From the legal dimension, encouraging farmers to sign formal written contracts and register them will encourage farmers to use organic fertilizer.

2.2 Factual dimension

The legal dimension may not always reflect the actual security of property rights. For example, the law clearly stipulates that land cannot be adjusted at will, but in fact, the possibility of land adjustment still exists for various subjective and objective reasons, which may make legally stable property rights unstable in reality (Li and Wang, 2021). In contrast, the actual control of property rights gives a better sense of their security, that is, the security of property rights in reality, which is generally measured by indicators such as the length of the holding period, whether there is an experience of land adjustment, and whether there are disputes in the process of circulation. If the duration of the cultivated land transfer is long, the business entity will make a long-term plan for agricultural production and management, and its long-term behavior will be more obvious. Research shows that long-term leasing contracts can increase the expected time and scale of farmers' adoption of relevant



protection technologies and their cultivated land quality protection behavior without technical and financial constraints (Myyra et al., 2005; Xin and Li, 2019). In addition, in the process of farmland transfer, a dispute between the parties will reduce the transferee's confidence in their property rights security, cause them to fear that the previous farmers may impact their production and operation, and shake their confidence in their ability to recover their investment, and thus, they will tend to adopt short-term investment behaviors. Therefore, whether there is a dispute in a farmland transfer will also impact farmers' use of organic fertilizer. Accordingly, the following research hypothesis is proposed:

H2: In reality, extending the duration of farmland transfer contracts and eliminating transfer disputes will encourage farmers to use organic fertilizer.

3 Model and data

3.1 Model

In agricultural production and management, farmers face two choices for using organic fertilizer, to "use" and "not use", so farmers' use of organic fertilizer is a binary

choice. We used quantitative data with a descriptive approach. Moreover, the study employed econometric methods (Abbasi et al., 2021), such as using a probit regression model for analysis, and the basic model is set as follows:

$$p = \alpha_0 + \alpha_1 X_1 + \sum_{i=2}^n \alpha_i X_i + \varepsilon \quad (1)$$

In the formula, p refers to the probability of farmers using organic fertilizer, α_0 represents the intercept term, X_1 represents a series of variables representing the stability of cultivated land transfer management rights, α_1 represents the regression coefficient of the stability variable of cultivated land transfer management rights, X_i represents a series of control variables, α_i represents the regression coefficient of control variables, and ε is random interference.

3.2 Data sources

In contrast to research using online review data, this paper uses offline survey data (Abaalzat et al., 2021). These data come from surveys of farmers in five counties and cities (Suichuan, Yudu, Ruijin, Xinfeng and Xunwu) in the Gannan region of Jiangxi Province in July 2021 (Figure 1). These counties

are very similar in culture but vary in their degrees of economic development (Sulaiti, et al., 2006). The terrain of the Gannan region is complex, mainly comprising mountains, hills and basins, with great regional differences. The average household cultivated land in this area is generally fragmented, scattered, small-scale, and mostly terraced, and the terrain is rugged. Therefore, using the hilly area of Jiangxi Province as an example, we can significantly observe the impact of the stability of cultivated land transfer management rights on farmers' use of organic fertilizer. This study collected the desired information through a questionnaire based on previous studies (Yu et al., 2022). The survey focuses on new rounds of land ownership registration, and the data cover the basic characteristics of the farmers, agricultural land circulation, agricultural production and management, land property rights and other factors. Following the principle of random sampling (Zeidabadi et al., 2022), four villages and towns in each county and city and 3–5 natural villages in each township were randomly selected, and then, the number of respondents was determined according to the resource endowment of the natural villages (such as population, land area, and regional characteristics). After deleting some invalid questionnaires, a total of 723 farmer data points were obtained in this survey.

3.3 Variable selection

3.3.1 Dependent variable

Farmers' use of organic fertilizer (whether farmers use organic fertilizer on the transferred cultivated land) is used as the explanatory variable, with yes = 1 and no = 0.

3.3.2 Explanatory variables

As mentioned above, this paper measures the stability of cultivated land circulation management rights from legal and factual dimensions. "Contract form" and "whether the contract should be filed" were selected to represent the stability of farmland circulation management rights in the legal dimension; "the duration of the circulation contract" and "whether there is a dispute in the farmland circulation" were selected to represent stability of these rights in the factual dimension.

3.3.3 Control variables

Combining the relevant studies, farmers' use of organic fertilizer is found to also be affected by the personal characteristics of the heads of household, household characteristics of the farmers and production and management characteristics. Therefore, the gender and age of

the head of household, whether the head of household is a party member, and whether the head of household receives planting and breeding training are considered the personal characteristic variables of the head of household. The household labor force (number of working-aged household members) and nonagricultural employment (number of household members who are employed off the farm) are considered household characteristic variables. The distance between the family and the government and the scale of cultivated land are considered characteristic variables of production and management. The definitions and descriptive statistical analysis of the above variables are presented in Table 1.

Table 1 shows that 1) the average value of the farmers' organic fertilizer use rate is 0.25, indicating that less than 1/3 of farmers use organic fertilizer, which is a low proportion. 2) From the legal perspective of the stability of the management rights of cultivated land transfers, the average contract formation rate is 2.88, indicating that most of the cultivated land transfers tend to be oral agreements, which have relatively close rates to those of written informal contracts, and the average rate of contract filing is low at only 0.07. From the factual perspective, the average duration of the circulation contract is 1.62 years, indicating that the contracts are mainly short-term, and the variance of this indicator is 3.40, indicating that the duration varies greatly among farmers and that there are few disputes. 3) With respect to heads of household, the average rate of household heads who receive planting and breeding training is only 0.08, indicating that only a small number of farmers have received training. The age of the head of household of the transferred cultivated land is approximately 55 years old, indicating that most of the agricultural production and management in the hilly areas of Jiangxi Province is conducted by middle-aged and elderly individuals. 4) In terms of family characteristics, combined with its two indicators, almost half of the labor force in each family has nonagricultural employment. 5) In terms of the production and management characteristics, farmers' families are generally located far away from the township government, with an average distance of 5.67 km. However, the standard deviation of this index is 4.44 km, indicating great differences among farmers in different regions. The scale of cultivated land managed by farmers is less than 2 ha, indicating that the sample area is mainly small-scale. However, the standard deviation of this index is 4.89, indicating that the scale of cultivated land managed by farmers varies greatly.

4 Results

To further verify the impact of the stability of cultivated land transfer management rights on farmers' use of organic fertilizer, this paper first uses a probit model to carry out

TABLE 1 Variable definitions and statistical descriptions.

Variable	Definition	Mean	Sd
Whether organic fertilizer is used	Yes = 1, No = 0	0.25	0.43
Contract form	1 = Written formal contract 2 = Written informal contract, 3 = Oral agreement	2.88	0.42
Whether the contract is filed	Yes = 1, No = 0	0.07	0.25
Term of circulation contract	Unit: year	1.62	3.40
Whether there are disputes in circulation	1 = No dispute, 2 = Dispute with the land's previous farmers, 3 = Dispute with other farmers, 4 = Collective dispute with villages, 5 = Other	1.03	0.23
Age of head of household	Unit: years old	54.47	9.16
Whether the head of household is a party member	Yes = 1, No = 0	0.17	0.38
Whether the head of household receives planting and breeding training	Yes = 1, No = 0	0.08	0.26
Total household labor force	Refers to the number of people aged 16–65 in the family	3.62	1.35
Household nonagricultural employment	Refers to the number of people who have worked off the farm for more than 6 months	1.32	1.49
Distance from home to government	Unit: km	5.67	4.44
Cultivated land scale	Unit: ha	1.43	4.89

benchmark regression on the relationship between them and then uses the supplementary variable sand replacement variable methods to verify the robustness of the benchmark model regression.

4.1 Benchmark regression results

Before the model estimation, we first determine whether there is multicollinearity between variables. The average value of the variance inflation factor (VIF) is 1.38, and the maximum value is 1.80, so there is no multicollinearity problem. The regression results are shown in Table 2, which shows that the variable coefficients and significant differences between eqn(1) and eqn(2) are relatively small, and the goodness of fit of the model is high, indicating that the model setting is more optimal. Because the probit model is nonlinear, the variable coefficient is not the marginal effect, so the marginal transformation is carried out, and the marginal effect of the regression model is reported in the last column of Table 2. The regression results are analyzed as follows.

First, from the legal dimension, we discuss the relationship between the stability of farmland circulation management rights and farmers' organic fertilizer use behavior. The results show that the "contract form" increases the farmers' enthusiasm for using organic fertilizer at a significance level of 10%. Its marginal effect shows that compared with farmers who transfer cultivated land by oral agreements and informal written contracts, the probability of using organic fertilizer increases by 17.5% for farmers who sign a written formal contract. Moreover, contract filing can also improve farmers' enthusiasm for increasing the use of organic fertilizer. Compared with farmers who have not filed a contract, the probability of

increasing organic fertilizer use increases by 21.3% for farmers who have filed a contract. The above results show that improving the stability of the management right of cultivated land circulation in the legal dimension, such as by encouraging farmers to sign formal written contracts for cultivated land circulation and register contracts, can significantly improve the farmers' enthusiasm for using organic fertilizer, which confirms research hypothesis 1.

Second, from the factual dimension, we discuss the relationship between the stability of farmland transfer management rights and farmers' organic fertilizer use. The "circulation contract period" plays a significant role in incentivizing farmers to use organic fertilizer. In terms of marginal effect, compared with farmers who transfer cultivated land in the short term (the average circulation period is less than 1.62 years), the probability of using organic fertilizer increases by 2.3% for farmers who transfer cultivated land in the long term. The "whether there is a dispute in the circulation" factor fails to pass the significance test. The possible reason is that the number of farmers with circulation disputes in the sample is very small. Descriptive statistics show that the average value of cultivated land circulation disputes is only 1.03, which is close to the value without disputes. On the other hand, it shows that the cultivated land circulation relationship in the sample area is very stable, which partially confirms research hypothesis 2.

Third, the control variables and farmers' organic fertilizer use behavior are considered. In terms of the characteristics of the head of household, age, party membership and whether a farmer has received planting and breeding training fail to pass the significance test at the 10% level. In terms of family characteristics, the number of working family members and the number of family members with nonagricultural

TABLE 2 Benchmark regression.

Variable	Organic fertilizer use			
	Equation 1	Equation 2	Marginal effect	
Core explanatory variables	Contract form	-0.778 (0.370)	-0.659 (0.375)	-0.175
	Whether the contract is filed	0.836 (0.496)	0.805 (0.486)	0.213
	Term of circulation contract	0.097 (0.047)	0.088 (0.035)	0.023
	Whether there are disputes in circulation	0.355 (0.402)	0.423 (0.407)	0.112
	Age of head of household	—	0.352 (0.594)	0.093
Control variable	Whether the head of household is a party member	—	-0.063 (0.274)	-0.016
	Whether the head of household receives planting and breeding training	—	-0.462 (0.382)	-0.123
	Total household labor force	—	-0.039 (0.089)	-0.010
	Household nonagricultural employment	—	-0.046 (0.083)	-0.012
	Distance from home to government	—	0.023 (0.022)	-0.006
	Cultivated land scale	—	0.179 (0.088)	0.048
		Log likelihood	-116.76	-113.18
	Prob > chi2	0.000	0.000	—
	Pseudo R2	0.133	0.159	—

Note: * * *, ** *, * represent significance levels of 1%, 5% and 10%, respectively, and the robust standard error is in brackets.

TABLE 3 Robustness test based on the multiple regression model.

Variable	Amount of organic fertilizer used	
Core explanatory variables	Contract form	-0.234(0.924)
	Whether the contract is filed	1.784(0.825)
	Term of circulation contract	0.094(0.104)
	Whether there are disputes in circulation	0.701(0.297)
Control variable	YES	YES
	Prob > F	0.000
	R-squared	0.711

Note: * * *, ** *, * represent significance levels of 1%, 5% and 10%, respectively, and the robust standard error is in brackets.

employment also fail to pass the significance test. Only the “cultivated land scale” in the production and management characteristics passes the significance test at the significance level

of 10%, which may be because the sample area is hilly, the cultivated land management scale is generally small, and the household characteristics and household characteristics have no significant

TABLE 4 Regression results after incorporating perception-related explanatory variables.

Variable	Benchmark regression model	Multiple regression model
Core explanatory variables		
Contract form	-0.653(0.371)	-0.240(0.933)
Whether the contract is filed	0.827(0.478)	1.829(0.841)
Term of circulation contract	0.087(0.035)	0.095(0.106)
Whether there are disputes in circulation	0.395(0.412)	0.652(0.349)
Are you satisfied with the current situation of land circulation	0.061(0.159)	0.104(0.417)
Control variable	YES	YES
Prob > chi2/Prob > F	0.000	0.005
Pseudo R2/R-squared	0.160	0.728

Note: ** *, ** *, * represent significance levels of 1%, 5% and 10%, respectively, and the robust standard error is in brackets.

impact on farmers' use of organic fertilizer, which is different from the findings of previous studies. Only when large-scale cultivated land is flowed into and the appropriate scale management is formed can farmers be encouraged to use more organic fertilizer.

4.2 Robustness test

To verify the robustness of the results, this paper replaces the dependent variable of "whether farmers use organic fertilizer" in the existing model with "the number of farmers using organic fertilizer" and adopts the ordinary multiple regression model. The results are as follows:

Table 3 shows that even if the dependent variables are replaced, the fitting results show that "contract form", "contract filing or not" and "circulation contract period" still significantly affect the farmers' organic fertilizer use, and their coefficient symbols and significance are not significantly different from those of the benchmark regression, which further verifies the robustness of the benchmark regression.

In addition, according to academic researchers, using legal, factual and perception dimensions is a more comprehensive and effective way to measure the impact of the stability of farmland circulation management rights on farmers' use of organic fertilizer. However, this view is revised in the "theoretical analysis and research hypothesis" part of this paper. To verify previous research and avoid the impact of missing variables (mainly within the perception dimension) on the regression results, we further verify the robustness of the benchmark regression results. This paper introduces the variable "whether you are satisfied with the current situation of land transfer" to characterize the perception dimension of the stability of cultivated land transfer management rights in the benchmark regression and multiple regression models. The regression results are as follows.

Table 4 shows that regardless of which model includes the explanatory variables of the perception dimension, the difference

in the symbol and significance of the regression coefficient is small. This indicates that the benchmark regression result is relatively robust, which confirms this paper's research hypothesis.

4.3 Heterogeneity analysis

According to previous research results, the stability of cultivated land transfer management rights will have a differentiated impact on the use of organic fertilizer by different cultivated land management entities. This paper classifies these entities according to their differences in management scale and cultivated crops to observe the heterogeneous impact on them of the stability of cultivated land circulation management rights.

4.3.1 Comparative analysis of farmers managing different scales of cultivated land

The research shows that the factor endowments matching the scale of cultivated land management vary greatly with the scale, so there are also differences in the mechanism of the stability of the cultivated land transfer management rights^[5]. Because the sample area is hilly, cultivated land is generally fragmented and small-scale, and the surveyed farmers are divided into large-scale farmers (≥ 5 mu) and small-scale farmers (≤ 5 mu) based on the median cultivated land management scale. The regression results in Table 5 show that the "duration of the transfer contract" of farmland transfer management rights has a significant impact on both types of farmers' organic fertilizer use; large-scale farmland transfer farmers are also significantly affected by the form of the contract and whether the contract is filed. This shows that large-scale farmers' organic fertilizer use is more affected by the stability of cultivated land transfer management rights. This may be because most of the large-scale farmers in the sample area transfer their cultivated land by signing formal written

TABLE 5 Comparative analysis of farmers managing different scales of cultivated land.

Variable		Organic fertilizer use	
		Large scale	Small scale
Core explanatory variables	Contract form	-0.273(0.763)	-0.065(0.527)
	Whether the contract is filed	0.785(0.283)	0.547(0.326)
	Term of circulation contract	0.077(0.093)	0.091(0.035)
	Whether there are disputes in circulation	0.315(0.727)	0.381(0.415)
Control variable	YES	YES	YES
	Log likelihood	-110.25	-112.72
	Prob > chi2	0.000	0.003
	Pseudo R2	0.179	0.173

Note: ***, **, * represent significance levels of 1%, 5% and 10%, respectively, and the robust standard error is in brackets.

TABLE 6 Comparative analysis of farmers who plant different crops.

Variable		Organic fertilizer use	
		Grain crops	Nongrain crops
Core explanatory variables	Contract form	-0.037(0.439)	-0.248(0.653)
	Whether the contract is filed	0.206(0.457)	0.224(0.389)
	Term of circulation contract	0.105(0.082)	0.045(0.035)
	Whether there are disputes in circulation	0.907(0.438)	0.872(0.386)
Control variable	YES	YES	YES
	Log likelihood	-84.13	-87.36
	Prob > chi2	0.013	0.012
	Pseudo R2	0.221	0.209

Note: , , represent significance levels of 1%, 5% and 10%, respectively, and the robust standard error is in brackets.

contracts and registering those contracts for the public record, which ensures their enthusiasm for transferring cultivated land and agricultural management and makes them more willing to use organic fertilizer to protect their cultivated land.

4.3.2 Comparative analysis of farmers who plant different crops

Different crops have different demands for labor, capital and technology, so the stability of cultivated land circulation management rights may also result in different organic fertilizer use behaviors by farmers who grow different crops. Farmers in the sample area are divided into two categories: farmers who grow grain crops (mainly rice, corn, and wheat) and nongrain crops (mainly vegetables, and fruits). The regression results, presented in Table 6, show that the contract form and whether the contract is

filed have no significant impact on organic fertilizer use behavior between farmers of the two kinds of crops; the duration of the circulation contract and whether there are disputes in the circulation have a significant positive impact on the behavior of grain crop farmers but no significant impact on the behavior of nongrain crop farmers. This shows that the stability of cultivated land circulation management rights has different effects on the organic fertilizer use behavior of farmers who grow different crops.

5 Discussion

The research conclusion of this paper is that the legal and factual dimensions of the stability of cultivated land circulation management rights significantly encourage farmers to use

organic fertilizer to protect their cultivated land. Although cultivated land in these hilly areas is fragmented, small-scale, rugged and unequal, and the income from farming land there is lower than that in plains areas, we still find that cultivated land transfer is widespread there and that the stability of cultivated land transfer management rights encourages farmers to use organic fertilizer. This contrasts with previous studies' conclusion that after family farmers rent land for large-scale cultivation, they can easily derive short-term benefits by using short-term effective chemical fertilizers instead of organic fertilizers. There are two possible reasons for these different conclusions. First, the choice of research objects is different. For example, many studies focus on large-scale family farms, analyze the impact of cultivated land circulation management rights on their use of organic fertilizer, and find that these family farmers use organic fertilizer less. Second, there may be many factors affecting farmers' use of organic fertilizer, and the key influencing factors may differ in different sample areas. In our sample area, the stability of cultivated land circulation management rights is a key factor. However, in other regions of China, such as the middle and upper reaches of the Yellow River, social status has a significant impact on farmers' use of organic fertilizer. In plains areas such as Hubei and Shandong, the endowment characteristics of farmers' families (such as the scale of cultivated land) have a significant impact on their use of organic fertilizer.

The legal and factual dimensions of the stability of cultivated land circulation management rights show that a clear and stable definition of property rights is not only the basis of market transactions but also an important way to stabilize the expectations of economic subjects and enhance their investment activity. In particular, the legal dimension of signing and registering formal contracts stipulates farmers' rights and obligations. Specifically, such contracts stipulate what can and cannot be done on rented cultivated land and how to resolve disputes, which stabilizes farmers' expectations and helps them make planting decisions. In addition, we find that farmers who grow food crops tend to use organic fertilizer because in China, not only are farmers growing food crops guaranteed a minimum purchase price by the government but they also receive government subsidies, which further encourages them to plan to grow food crops long term, so they are more inclined to use organic fertilizer.

In addition, indicators to measure the stability of cultivated land transfer management rights or property rights are a focus of academic debate. Early research tended to use a single indicator to measure the stability of cultivated land property rights, such as the cultivated land adjustment frequency, whether the land was registered, and whether the land had a land certificate (Ji et al., 2014). However, subsequent research has found that the concept of the stability of property rights has rich connotations that cannot be easily reflected by a single index. Therefore, the subsequent, more representative measurement indicators

include legal, factual and perceptual dimensions. However, as noted in the Introduction, perception is a human psychological activity that cannot be observed and verified, so it does not meet the requirements of scientific fallibility and should be discarded. Only legal and factual indicators of the management rights of cultivated land circulation can be directly observed.

Of course, many factors affect farmers' use of organic fertilizer. In addition to the stability of the transfer of arable land management rights, there are social, economic and unexpected factors. For example, the COVID-19 epidemic has had a great impact on the global economy, especially human economic activities such as tourism, carbon dioxide emissions, food production and farmland utilization (Abbas et al., 2021; Abbasi and Tufail, 2021; Li Z, et al., 2021; Zhou et al., 2022). Regarding the use of arable land, COVID-19 has led to a sharp reduction in people's outdoor activities, thus directly affecting short- and long-term investment in arable land and thereby grain production. Therefore, farmers' organic fertilizer use behavior is not the result of only the stability of the management rights of arable land transfer but also other variables. This is a limitation of this paper and a future research direction.

6 Conclusion

This paper assesses the stability of farmland transfer management rights from legal and factual dimensions and uses the survey data of 723 farmers in the Jiangxi hills to assess its impact on farmers' use of organic fertilizer and its heterogeneity. The results show that 1) the legal dimension of the stability of farmland circulation management rights significantly encourages farmers to use organic fertilizer. Specifically, compared with farmers using informal contracts, such as oral agreements, farmers who sign formal written contracts are 17.5% more likely to use organic fertilizer. Farmers who have filed contracts are 21.3% more likely to use organic fertilizer than farmers who have not done so. 2) In fact, the stability of farmland circulation management rights can also significantly encourage farmers to use organic fertilizer. Compared with farmers who transfer cultivated land for the short term (the average transfer period is less than 1.62 years), farmers who transfer cultivated land for the long term are 2.3% more likely to use organic fertilizer, but whether there is a dispute in the land transfer process has no significant impact on the farmers' use of organic fertilizer. 3) The impact of the stability of cultivated land transfer management rights on farmers' use of organic fertilizer depends on the farmers' characteristics. For large-scale farmers and those who plant food crops, the stability of cultivated land management rights has a more significant impact on their use of organic fertilizer.

7 Implications

From the results above, we can draw the following implications: 1) the village collective or township government should play an intermediary role in the cultivated land transfer process and enhance the stability of cultivated land management rights by encouraging farmers to sign formal written contracts, increasing the contract registration rate, and extending the duration of such contracts. Specific recommendations include establishing and improving a land circulation trading platform, providing guidance for family farmers on signing formal written contracts with the land's previous farmers; and actively supervising, reviewing, authenticating and filing circulation contracts. 2) The village collective or township government should take the initiative to reduce the costs for both parties in the transaction process, such as by formulating standard circulation contract text that stipulates the key land rights in the transfer and fully endows family farms with more land rights. Constructing a farmland transfer security system that ensures the priority renewal rights of the transfer subjects will increase their willingness to invest in long-term land management. 3) In promoting the circulation of cultivated land, we should consider the responses of different groups, including farmers operating at different cultivated land management scales and those planting different crops, and explore more targeted cultivated land protection practices with different emphases at different levels.

8 Limitations

There are many factors affecting farmers' use of organic fertilizer; we only pay attention to the stability of arable land transfer management rights, which is a limitation of this paper. In the future, we can explore the impact of COVID-19 and social and economic factors, such as population growth and per capita GDP, on farmers' use of organic fertilizer.

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Data availability statement

The raw data supporting the conclusion of this article will be made available by the authors, without undue reservation.

Author contributions

LZ had the original idea and data collecting, HL, BW carried out the analyses for the study, the authors drafted the manuscript and the approved the 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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