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HOW TENURE SECURITY AND FARMLAND TRANSFER AFFECTED FARMLAND INVESTMENT: EVIDENCE FROM APPLE GROWERS IN CHINA

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Abstract. Tenure insecurity and thin land rental markets weakened the incentives to farmland investment in rural China, which was not conducive to improving agricultural productivity. Thus, impacts of tenure security and farmland transfer on farmland investment were analyzed by using the household fixed effect model, the IV method and a 762 household-level and 1163 plot-level data set. The results indicated that: (1) compared with owned plots, the number of farmyard manure in rented plots without stipulating rental time was significantly decreased by 64.0~66.9%; (2) each 1% increase in land rents led to a 1.7% rise in the input of farmyard manure; (3) each 1% increase in the size of farmland transfer resulted in a 0.1% rise in the input of farmyard manure. Our study contributed to boosting agricultural sustainable development from the perspectives of improving the systems of farmland property rights and developing farmland rental markets.

Keywords: farmyard manure, rented plots, rental time, land certificates, farmland rental markets, land rents.

JEL Classification: Q15, Q18, Q01.

Introduction

How to enhance farmland investment was still a big challenge for most of developing countries to increase agricultural productivity. Theoretically, the number of farmland investment relied mainly on the availability and size of revenues on farmland investment (Lyu et al., 2019; Burke et al., 2019). More importantly, the systems of farmland property rights determined tenure security and the development of farmland rental markets, which influenced the availability and size of revenues on farmland investment (Li et al., 2019; Fan et al., 2012). Specifically, tenure insecurity resulting from the Household Responsibility System (HRS) discouraged farmers to invest in land because farmers might not obtain the whole revenues on farmland investment in the context of high risk of losing rented land (Abdulai et al.,

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2011; Jacoby & Mansuri, 2008). However, when farmland rental contracts were perfect in practice, effective farmland rental contracts improved the expectation of tenure security, which weakened the negative impact of ambiguous systems of farmland property rights on the willingness to farmland investment (Li et al., 2021; Luo, 2019). And to weaken tenure insecurity, in 2013 the land certification program had been required to be accomplished within five years across China.

Meanwhile, land rental markets were commonly thin in the context of ambiguous systems of farmland property rights, which were not conducive to taking back the revenues on farmland investment in time through effective land rents (Carter & Yao, 2004). And farm size was a key factor to determine the amount of revenues on farmland investment, and when land rental markets were not well-developed, the cost of farmland investment had difficulty in being decreased by means of expanding farm size (Cao et al., 2020a; Li et al., 2019). Hence, the main aim of this paper was to analyze the impacts of tenure security and farmland transfer on farmland investment.

Previous literature focused on the impact of farmland property rights systems on agricultural investment, and two main influencing mechanisms were commonly emphasized. Firstly, tenure security conducive to improving the expectation of the risk of losing rented plots boosted agricultural investment in rented plots. In context of ambiguous systems of farmland property rights, the risk of farmland property rights in rented plots was relatively higher than that in owned plots, which resulted in lower amount of organic fertilizers in rented plots (Ma et al., 2013; Feng, 2008; Lyu et al., 2019). However, when property rights in rented plots became more secure, negative impact of rented plots on the input of organic fertilizers was weakened (Saint-Macary et al., 2010; Jacoby & Mansuri, 2008; Abdulai et al., 2011). Hong et al. (2020) analyzed the effect of land titling on farmland investment and found that the land titling program encouraged farmers to invest in land. Similarly, Cao et al. (2020b) studied the impact of the share of farmland retained on farmland investment and indicated that the share of farmland retained significantly affected land quality and changed use of plots. Notably, the endogenous issues and self-selection issues for impact of rented plots on agricultural investment were commonly ignored. Thus, the plot-level data and the household fixed effect model were used to avoid the endogenous issues, and the PSM model was used to avoid the self-selection issues.

Notably, when the systems of farmland property rights were ambiguous, perfect farmland rental contracts improved the expectation of tenure security (Li et al., 2021; Luo, 2019). A plausible reason is that perfect rental contracts could stipulated respective rights, responsibilities and obligations for both parties who participated in rental markets in advance, which stabilized considerably the expectation of the risk of farmland property rights (Hart, 2009; Hart & Moore, 2008; Besley, 1995). However, owing to bounded rationality, uncertainty and complexity of external environment, most of farmland rental contracts were not perfect in the actual world (Nie, 2017). Consequently, both parties who participated in farmland rental markets had incentives to violate rental contracts, which means that rental contracts were not stable in practice (Gao et al., 2019).

More importantly, the duration of farmland rental contracts was an important index to denote the stability of rental contracts (Li et al., 2019). Tian and Li (2013) studied the impacts of periodic land readjustments on rental contracts and agricultural investment and

demonstrated that tenure insecurity resulting from periodic land readjustments reduced the duration of rental contracts and consequently, decreased agricultural investment. Similarly, Kousar and Abdulai (2016) analyzed the impact of rental contracts on farmland investment and indicated that compared with production-sharing contracts, more chemical fertilizers and less organic fertilizers were used for farmers who used fixed-rent contracts because the average duration of fixed-rent contracts was shorter than that of production-sharing contracts, which resulted in more chemical fertilizers.

Secondly, effective land rental markets were conducive to diluting the cost of farmland investment and withdrawing the revenues on farmland investment in time (Jia & Lu, 2018; Wu et al., 2018; Cao et al., 2020a). Zhang et al. (2019) studied the impact of the patterns of farmland transfer on agricultural investment and demonstrated that larger size of farmland transfer organized by the village collectives enhanced significantly farmland investment. Meanwhile, Carter and Yao (2004) demonstrated that farmland transfer was conducive to obtaining the revenues on farmland investment in time, which boosted farmland investment.

In sum, previous studies had discussed the impact of the systems of farmland property rights on agricultural investment in detail, which provided a reference for theoretical analysis and empirical test. Compared with the existing literature, the main contributions of this paper were that: (1) for research perspective, a more systemic conceptual framework for impacts of tenure security and farmland transfer on farmland investment had been established, which expanded and improved the research perspective of the existing literature; (2) for research content, impact of tenure security on farmland investment had been studied from the perspectives of the clarity level of the structure of farmland property rights and the stability of farmland rental contracts, which deepened the research conclusions of the existing literature. And the three variables for rented plots without stipulating rental time, rented plots with stipulating rental time and holding land certificates had been used to analyze the impact of tenure security on farmland investment. Meanwhile, impacts of land rents and the size of farmland transfer on farmland investment had been studied, which enriched the research conclusions of the existing literature. And the instrumental variable (IV) method had been used to ensure the accuracy of estimation results.

Moreover, apple growers were regarded as a typical case because (1) economic rents of agricultural production might have difficulty in motivating farmers to engage in farmland investment owing to small farm size and low revenues on agricultural production, while as a kind of high-value agricultural products, economic rents of apple production were relatively higher, which encouraged apple growers to invest in farmland; (2) compared with crop growers, governments had less incentives to interfere in apple production, so these concerns about distortions resulting from governments' behaviors were relatively less; (3) due to high ratio of apple income to household income, apple growers were typical specialized farmers, which represented the key agricultural operators in the future.

1. Conceptual framework

Notably, the systems of farmland property rights determined the risk of losing rented plots and the development of farmland rental markets, which affected the availability and size of revenues on farmland investment and consequently, influenced the amount of farmland

investment (Li et al., 2019; Fan et al., 2012). Specifically, tenure security depended on the clarity level of the structure of farmland property rights and the stability of farmland rental contracts. In the context of the Household Responsibility System (HRS), the risk of farmland property rights in rented plots was higher than that in owned plots, but as the land certification program had been executed, tenure security might be improved. When the systems of farmland property rights were imperfect, effective farmland rental contracts could weaken the risk of losing rented plots, which influenced the willingness to farmland investment. Meanwhile, when farmland rental markets had been gradually developed, effective land rents could obtain the revenues on farmland investment in time, and expanding farm size could reduce the cost of farmland investment, which influenced the willingness to farmland investment (Figure 1).

1.1. Impact of tenure security on farmland investment

Theoretically, the number of farmland investment depended on the availability and size of revenues on farmland investment. Notably, tenure security was considered to be a key factor that influenced the availability of revenues on farmland investment, which means that secure tenure encouraged rational farmers to invest in farmland (Abdulai et al., 2011). Specifically, part of farmland investment was commonly regarded as a typical kind of long-term investment because the investment recovery period for above farmland investment was relatively long. Therefore, farmers might not get the whole profits from farmland investment in the context of insecure tenure (Jacoby & Mansuri, 2008). If farmers could not obtain full residual claims to revenues on farmland investment, the amount of farmland investment would be decreased (Li et al., 2019).

Notably, tenure security consisted primarily of the clarity level of the structure of farmland property rights and the stability of farmland rental contracts (Luo, 2019; Li et al., 2021). Specifically, the Household Responsibility System (HRS) gave rise to uncertain structure of

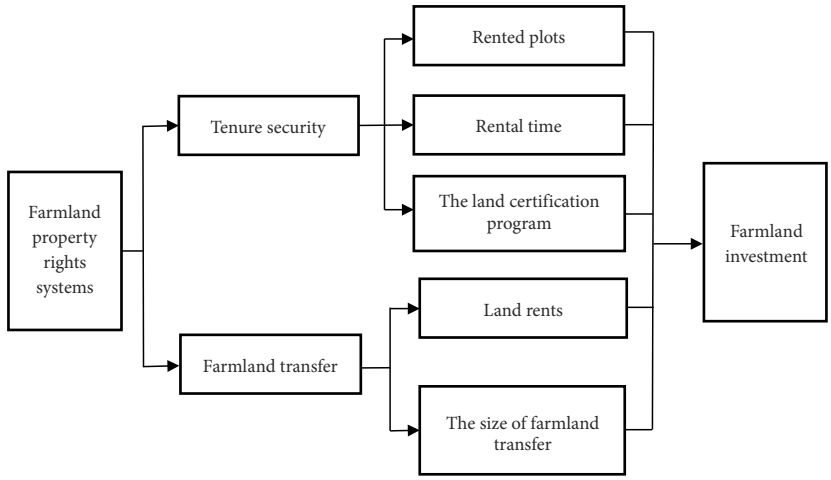

Figure 1. Conceptual framework

farmland property rights, which damaged tenure security in rented plots and resulted in obvious differences in tenure security between owned plots and rented plots (Feng, 2008). In other words, in the context of ambiguous systems of farmland property rights, the risk of losing rented plots was relatively high, suggesting that tenure in rented plots was not more secure than that in owned plots.

However, perfect farmland rental contracts were conducive to weakening the negative impact of ambiguous systems of farmland property rights on tenure security (Li et al., 2021). A reasonable explanation was that if farmers who participated in farmland rental markets were able to foresee all future possible situations and respective rights, responsibilities and obligations were stipulated in advance, tenure security would be considerably improved, which reduced the expectation of the risk of losing rented plots (Hart, 2009; Hart & Moore, 2008; Besley, 1995). Nevertheless, owing to bounded rationality, asset specificity and the inclination of opportunism, most of rental contracts were imperfect in practice (Nie, 2017). Thus, a key issue resulting from imperfect farmland rental contracts was that farmers who participated in farmland rental markets might be at risk of being "held-up" by other farmers afterwards, which reduced ex-ante specific investment (Nie, 2017). Notably, stipulating rental time significantly improved the stability of rental contracts and reduced the expectation of the risk of losing rented plots, which motivated farmers to invest in farmland. To decrease the possibility of losses, the stronger asset specificity, the longer the rental time (Masten & Crocker, 1985).

Meanwhile, the land certification program was conducive to making land size, land location and land boundary clearer, which decreased the negative impact of ambiguous systems of farmland property rights on tenure security and improved formal credit accessibility. Specifically, the land certification program could provide a legal protection for farmers' land rights, which increased the cost of violating farmers' land rights and consequently, improved the expectation of tenure security (Cheng et al., 2019; Li et al., 2021). And the land certification program could improve the effectiveness of land used as physical collateral, which provided a low-cost method to identify creditworthy borrowers (Li & Huo, 2021). As tenure security was gradually improved in the context of the reform of the systems of farmland property rights, the amount of farmland investment was increased in the actual world (Abdulai et al., 2011; Leight, 2016).

Thus, the following hypotheses were proposed:

H1. Compared with owned plots, the number of farmland investment for rented plots without stipulating rental time could be significantly reduced, but that for rented plots with stipulating rental time could not be significantly decreased.

H2. The land certification program could improve the expectation of tenure security and consequently, enhance the amount of farmland investment.

1.2. Impact of farmland transfer on farmland investment

The development of farmland rental markets influenced farmers' incentives to invest in farmland by means of affecting the availability and size of revenues on farmland investment. For the availability of revenues, farmland transfer was conducive to gaining the revenues on farmland investment in time through effective land rents for farmers who did not continue

to engage in agricultural production (Carter & Yao, 2004). In other words, in the context of well-developed farmland rental markets, effective land rents reflected the level of land quality, which helped farmers to get the revenues on farmland investment in time by participating in farmland rental markets (Li et al., 2019). For the size of revenues, farmland transfer conducive to expanding farm size diluted the cost of farmland investment, which obtained economies of size and as a consequence, boosted farmland investment (Lyu et al., 2019).

Thus, the following hypotheses were proposed:

H3. Land rents reflecting the level of land quality helped farmers to get the revenues on farmland investment in time and consequently, motivated farmers to invest in farmland.

H4. Farmland rental markets conducive to expanding farm size diluted the cost of farmland investment and consequently, motivated farmers to invest in farmland.

2. Materials and methodology

2.1. Data source

The data set used here was obtained in 2017 from an empirical investigation about tenure security and land rental markets implemented by the Center for Western Rural Development, Northwest A&F University. According to the "Dominant Regional Layout Planning of Apple Industry" issued by the Ministry of Agriculture, the main apple production areas located in the Loess Plateau area and the Surrounding Bohai Bay area in China. Specifically, Shandong province was a typical representative in the Surrounding Bohai Bay area and Shaanxi province was a typical representative in the Loess Plateau area. Based on the stratified random sampling method and the Probability Proportionate to Size (PPS) sampling method, Fengxiang, Fuxian, Baota in Shaanxi province and Yiyuan, Yishui, Muping in Shandong province were randomly selected.

Then, 2~3 townships were randomly selected from each sample county, and 2~3 villages were randomly selected from each sample township. And about 20 farmers were randomly selected from each sample village. Finally, the database which consisted of 762 effective respondents, 46 villages and 17 towns was obtained (Table 1). Moreover, 465 sample farmers rented in farmland. This survey was implemented by means of the face-to-face interviews using structured questionnaires. The contents of survey covered mainly the input and output of apple-planting activities, detailed information regarding participating in land rental markets and specific characteristics of farm households.

Table 1. Sample distribution

Provinces	Shaanxi			Shandong			Total
Counties	Fengxiang	Fuxian	Baota	Yiyuan	Yishui	Muping	
Towns	3	3	3	3	3	2	17
Villages	9	8	9	8	6	6	46
Respondents	141	132	132	122	119	116	762

Meanwhile, we also collected the plot-level data about input, output and plot characteristics. Specifically, a rented plot and an owned plot were randomly selected for farmers who rented in land, while an owned plot was randomly selected for farmers who did not participate in land rental markets. Finally, we got effective information of 1163 plots in this investigation because 64 farmers who rented in land did not grow apples in their owned plots owing to inappropriate conditions of climate or topography.

2.2. Variable selection and descriptive evidence

As for dependent variable, the variable for the input of farmyard manure was used to denote farmland investment, and farmyard manure used here included mainly sheep manure and cow dung. Notably, a major reason for using the input of farmyard manure as farmland investment was that farmyard manure was a typical kind of long-term agricultural investment related to specific plots (Jacoby & Mansuri, 2008; Burke et al., 2019). And most of small farmers were able to afford the cost of farmyard manure, which means that they needed not depend on collective action within the villages.

As for key independent variables, the two variables for rented plots without stipulating rental time and rented plots with stipulating rental time were used to denote tenure security, and the variable for holding land certificates was also used to denote tenure security. Meanwhile, the two variables for land rents and the size of farmland transfer were used to denote farmland transfer, which reflect the price and size of farmland transfer.

As for control variables, we used age, education and village cadres identity for household head to denote household head characteristics because these variables reflected the quality of human capital for household head. For household characteristics, we used the ratio of agricultural labors to household size to denote the amount of human capital for farm households. Whether or not there was hay mower and fertilizer ditching machine denoted the mechanization level of agricultural production. And the variable for the accessibility of Internet denoted the level of informationization. For plot characteristics, the distance from plot to the nearest town denoted the distance from home to markets. The input of chemical fertilizer denoted the substitution degree of the input of farmyard manure, and land quality was assessed by farmers' subjective cognition because farmers' subjective cognition affected directly their behaviors of agricultural production. The age of apple trees denoted biological needs for farmyard manure, and natural disasters denoted the suitability of agricultural production.

Table 2 illustrated descriptive evidence for dependent variable, key independent variables and control variables in this study. It can be seen from the Panel A that the input of farmyard manure in owned plots was significantly higher than that in rented plots at the 10% level. And the average number of farmyard manure used by sample farmers amounted to 1310.82 yuan per mu per year. For key independent variables, we found that 79% of sample farmers stipulated rental time in the context of farmland rental market participation, and the average duration of rental contracts was 15.48 years. And 78% of sample plots had been registered to improve tenure security. Meanwhile, the average size of farmland transfer was 4.26 mu, and the average number of land rents was 443.50 yuan per mu per year.

Table 2. Descriptive statistics

Variable name	Mean		
Panel A: Dependent variable	Owned plots	Rented plots	Differences (T-statistic)
Ln of the input of farmyard manure per mu	3.414 (0.128)	3.063 (0.157)	0.351* (0.203)
Panel B: Key independent variables			
Dummy variable for rented plots without stipulating rental time (yes = 1)	0.085(0.279)		
Dummy variable for rented plots with stipulating rental time (yes = 1)	0.315(0.465)		
Dummy variable for holding land certificates (yes = 1)	0.781(0.414)		
The size of farmland transfer (mu)	4.256(28.808)		
Land rents (yuan per mu)	443.504(598.199)		
Panel C: Control variables	Farmers without rented plots	Farmers with rented plots	Differences (T-statistic)
Household head characteristics			
Ln of age	3.983 (0.015)	3.900 (0.010)	0.083*** (0.017)
Ln of edu	1.865 (0.044)	2.012 (0.030)	–0.147*** (0.052)
Dummy variable for village cadres (yes = 1)	0.131 (0.020)	0.125 (0.015)	0.006 (0.025)
Household characteristics			
The ratio of agricultural labors to household size (%)	0.586 (0.015)	0.559 (0.010)	0.027 (0.017)
Dummy variable for hay mower (yes = 1)	0.319 (0.027)	0.455 (0.023)	–0.136*** (0.036)
Dummy variable for fertilizer ditching machine (yes = 1)	0.094 (0.017)	0.175 (0.018)	–0.081*** (0.026)
The accessibility of Internet (1 = very bad, 5 = very good)	4.124 (0.070)	4.265 (0.049)	–0.141* (0.083)
Plot characteristics			
Ln of the distance from plot to the nearest town	1.934 (0.037)	1.567 (0.040)	0.367*** (0.058)
Ln of the input of chemical fertilizer	5.361 (0.148)	5.772 (0.106)	–0.411** (0.178)
Subjective judgment for land quality (1 = very good, 5 = very bad)	2.332 (0.084)	2.015 (0.059)	0.317*** (0.100)
Ln of age of apple trees (year)	2.819 (0.030)	2.288 (0.052)	0.530*** (0.069)
Dummy variable for natural disasters such as frost (yes = 1)	0.248 (0.025)	0.244 (0.020)	0.004 (0.032)

Notes: Land quality and the accessibility of Internet were evaluated by using a five-point rating scale. Numbers in parentheses denoted standard deviation. ***, **, * denoted statistical significance at the 1%, 5% and 10% levels, respectively. One acre equaled 6 mu. Dummy variable for owned plots was considered to be a baseline of tenure security.

As shown in the Panel C of Table 2, in addition to these variables including dummy variable for village cadres, the ratio of agricultural labors to household size and dummy variable for natural disasters such as frost, the differences in most of control variables between farmers who rented in farmland and other farmers who did not rent in farmland were significant, which means that the self-selection issues of farmland transfer might be serious for sample farmers. Thus, the PSM model was used to check the robustness of estimation results.

2.3. Model specification and methods

To empirically test H1 and H2, the plot-level data was used and the econometric model was specified as follows:

$$\mathrm{Ln}\, m = \alpha_0 + \beta_1 \times R_1 + \beta_2 \times R_2 + \beta_3 \times C + \sum \alpha_i x_i + \psi + \varepsilon, \quad (1)$$

where m was dependent variable, which denoted the plot-level input of farmyard manure. R_1 and R_2 were key independent variables, which denoted rented plots without stipulating rental time and rented plots with stipulating rental time, respectively. C was also key independent variable, defined as 1 if land certificates had been issued and 0 otherwise. β_1, β_2 and β_3 were the coefficients of key independent variables. x_i was control variable including household head characteristics, household characteristics and plot characteristics, and α_i was the coefficient of control variable. ψ denoted household fixed effect. When the household fixed effect model was used, these variables for household head characteristics and household characteristics needed not be controlled (Li et al., 2021). Notably, the variable for the price of farmyard manure needed not be controlled according to the study from Muraoka et al. (2018). Moreover, α_0 and ε were intercept term and random error term, respectively.

To empirically test H3, the household-level data was used and the basic econometric model regarding impact of land rents on farmland investment was specified as follows:

$$\mathrm{Ln}\, M = \mu_0 + \rho \times \mathrm{Ln}\, D + \sum \mu_i X_i + \aleph + \tau, \quad (2)$$

where M was dependent variable, which denoted the household-level input of farmyard manure. D was a key independent variable, which denoted land rents, and ρ was the coefficient of key independent variable. X_i was control variable including household head characteristics, household characteristics and plot characteristics, and μ_i was the coefficient of control variable. $\aleph$ was village fixed effect to control for the impacts of village-level unobservable variables. Notably, when the village fixed effect model was used, the variable for the price of farmyard manure needed not be controlled, which was similar to the study of Qiu et al. (2017). Moreover, μ_0 and τ were intercept term and random error term, respectively.

Notably, to avoid the endogenous issues of land rents, the IV method was used here. These two variables for whether or not governments played the role of contract arbitration in the process of farmland transfer and whether or not there were anti-hail facilities before farmland transfer were used as instrumental variables of land rents. A main explanation was that contract arbitration improved the expectation of the risk of losing rented plots, which increased the intrinsic value of land. And anti-hail facilities reduced the negative impact of hail on agricultural output, which increased the revenues on agricultural production and consequently, raised land rents. Meanwhile, small farmers had difficulty in changing the two variables, which ensured the externality of instrumental variables.

To empirically test H4, the household-level data was used and the basic econometric model regarding impact of expanding farm size on farmland investment was specified as follows:

$$\mathrm{Ln}\, M = \gamma_0 + \theta \times \mathrm{Ln}\, T + \sum \gamma_i X_i + \aleph + \delta, \tag{3}$$

where M still denoted the household-level input of farmyard manure. T was a key independent variable, which denoted the size of farmland transfer, and θ was the coefficient of key independent variable. X_i was control variable including household head characteristics, household characteristics and plot characteristics, and γ_i was the coefficient of control variable. $\aleph$ was still village fixed effect to control for the impacts of village-level unobservable variables. Moreover, γ_0 and δ were intercept term and random error term, respectively.

Notably, to avoid the endogenous issues of the size of farmland transfer, the IV method was used here. The variable for the distance from home to nearest bank branches was used as instrumental variable because shorter distance from home to nearest bank branches reduced the borrowing cost of formal credits, which boosted the size of farmland transfer. Meanwhile, small farmers had difficulty in changing the location of bank branches, which ensured the externality of instrumental variables.

3. Estimation results

3.1. Impact of tenure security on farmland investment

According to the Eq. (1), Table 3 displayed the impact of tenure security on farmland investment. It can be seen from Table 3 that compared with owned plots, the number of farmyard manure in rented plots without stipulating rental time was significantly decreased by 64.0~66.9%[1] at the 5% level. A plausible reason is that tenure insecurity resulting from ambiguous systems of farmland property rights damaged full residual claims to revenues on farmland investment, and unstable farmland rental contracts could not improve land tenure security, which weakened the motivations for farmers to engage in farmland investment. However, compared with owned plots, impact of rented plots with stipulating rental time on farmland investment was not significant, which means that stable farmland rental contracts weakened the negative impact of rented plots on farmland investment. A plausible explanation was that stable farmland rental contracts were conducive to improving the expectation of the risk of losing rented plots. Thus, the number of farmyard manure in rented plots without stipulating rental time was significantly lower than that in owned plots, but stipulating rental time could reduce the negative impacts of ambiguous systems of farmland property rights on tenure security and farmland investment, which was consistent with H1.

However, as shown in the Table 3, land certificates could not significantly affect farmland investment. A plausible explanation was that although land certificates could clarify the structure of farmland property rights, there might be a lagged impact of land certificates on farmland investment. And due to low collateral value of farmland resulting from small farm size and low revenues on agricultural production, positive impact of land certificates on formal credit accessibility might be trivial as well.

[1] $\exp(-1.021) - 1 = -0.640$; $\exp(-1.105) - 1 = -0.669$.

Table 3. Tenure security and farmland investment

Variables	Ln of the number of farmyard manure	
R_1	–1.021(0.349)***	–1.105(0.537)**
R_2	–0.246(0.222)	–0.399(0.284)
C	–0.189(0.252)	0.204(0.454)
Ln of age	–0.980(0.578)*	
Ln of edu	–0.169(0.157)	
Dummy variable for village cadres	0.309(0.320)	
The ratio of agricultural labors to household size	–1.508(0.471)***	
Dummy variable for hay mower	0.206(0.226)	
Dummy variable for fertilizer ditching machine	0.866(0.305)***	
The accessibility of Internet	–0.061(0.099)	
Ln of the distance from plot to the nearest town	–0.382(0.167)**	–0.318(0.308)
Ln of the input of chemical fertilizer	–0.044(0.042)	–0.061(0.073)
Subjective judgment for land quality	0.213(0.079)***	0.072(0.144)
Ln of age of apple trees	0.003(0.154)	0.114(0.294)
Dummy variable for natural disasters such as frost	–0.071(0.238)	0.404(0.431)
Household fixed effect	No	Yes
R-squared	0.041	0.617
Number of observations	1163	1163

Notes: Numbers in parentheses denoted robust standard deviation. ***, **, * denoted statistical significance at the 1%, 5% and 10% levels, respectively. "Yes" denoted that these variables had been controlled, and "No" denoted that these variables had not been controlled.

3.2. Impact of farmland transfer on farmland investment

According to the Eq. (2), Table 4 presented the estimation results of the IV method for impact of land rents on farmland investment. Notably, the limited information maximum likelihood estimation (LIML) was used to avoid the issue of weak IV. As presented in the Table 4, higher land rents conducive to obtaining the revenues on the input of farmyard manure in time boosted significantly the number of farmyard manure at the 5% level, which was in line with H3. Specifically, each 1% increase in land rents led to a 1.7% rise in the input of farmyard manure. A plausible reason was that effective land rents could reflect the actual situation of land quality, which helped farmers to get the whole revenues on the input of farmyard manure and consequently, motivated farmers to engage in farmland investment.

Moreover, the first-stage estimation results indicated that the variable for whether or not governments played the role of contract arbitration in the process of farmland transfer could enhance significantly land rents at the 5% level because effective contract arbitration could improve land tenure security, which increased the actual value of farmland. Similarly, the variable for whether or not there were anti-hail facilities before farmland transfer could boost significantly land rents at the 1% level because anti-hail facilities could weaken the negative impact of natural disasters on agricultural output and increase the revenues on agricultural production, which raised land rents.

Table 4. Land rents and farmland investment

Variables	Ln of the number of farmyard manure
Ln of D	1.718(0.724)**
Ln of age	–1.128(1.417)
Ln of edu	0.295(0.357)
Dummy variable for village cadres	–0.280(0.724)
The ratio of agricultural labors to household size	–0.577(1.136)
Dummy variable for hay mower	–0.416(0.570)
Dummy variable for fertilizer ditching machine	1.457(0.670)**
The accessibility of Internet	0.135(0.217)
Ln of the size of farmland transfer	0.009(0.002)***
Ln of the distance from plot to the nearest town	0.390(0.292)
Ln of the input of chemical fertilizer	–0.079(0.110)
Subjective judgment for land quality	0.643(0.212)***
Dummy variable for natural disasters such as frost	–0.015(0.513)
Village fixed effect	Yes
Whether or not governments played the role of contract arbitration in the process of farmland transfer	0.549(0.257)**
Whether or not there were anti-hail facilities before farmland transfer	1.972(0.437)***
R-squared	0.297
Number of observations	465

Notes: Numbers in parentheses denoted robust standard deviation. ***, **, * denoted statistical significance at the 1%, 5% and 10% levels, respectively. "Yes" denoted that these variables had been controlled. To save space, the first-stage estimation results had not been given in detail.

According to the Eq. (3), Table 5 reported the impact of expanding farm size on farmland investment. Similarly, the limited information maximum likelihood estimation (LIML) was also used here to avoid the issue of weak IV. It can be seen from Table 5 that the size of farmland transfer significantly boosted the number of farmyard manure at the 10% level, which was consistent with H4. Specifically, each 1% increase in the size of farmland transfer resulted in a 0.1% rise in the input of farmyard manure. A plausible explanation was that expanding farm size diluted the cost of farmland investment and obtained economies of scale, which enhanced the amount of farmyard manure. Moreover, the first-stage estimation results demonstrated that the variable for the distance from home to nearest bank branches increased significantly the size of farmland transfer at the 5% level because shorter distance from home to nearest bank branches could decrease the cost of obtaining formal credits and as a consequence, encourage farmers to rent in farmland.

Table 5. The size of farmland transfer and farmland investment

Variables	Ln of the number of farmyard manure
Ln of T	0.120(0.068)*
Ln of age	–0.427(0.625)
Ln of edu	–0.248(0.230)
Dummy variable for village cadres	0.307(0.443)
The ratio of agricultural labors to household size	–1.256(0.647)*
Dummy variable for hay mower	–0.383(0.407)
Dummy variable for fertilizer ditching machine	–0.243(0.677)
The accessibility of Internet	0.178(0.127)
Ln of the distance from plot to the nearest town	0.706(0.319)**
Ln of the input of chemical fertilizer	0.009(0.073)
Subjective judgment for land quality	0.172(0.111)
Dummy variable for natural disasters such as frost	0.079(0.326)
Village fixed effect	Yes
The distance from home to nearest bank branches	4.291(1.887)**
R-squared	0.101
Number of observations	762

Notes: Numbers in parentheses denoted robust standard deviation. ***, **, * denoted statistical significance at the 1%, 5% and 10% levels, respectively. "Yes" denoted that these variables had been controlled. To avoid the issue of selection, the variable for land rents was not controlled here to include sample farmers who did not rent in land. To save space, the first-stage estimation results had not been given in detail.

4. Robustness and extensions

According to the results from the Panel C in the Table 2, the self-selection issue of farmland transfer might be serious in this paper. Similarly, part of plots might be selected by farmers according to some of plot characteristics, which means that farmland rental markets participation and sample plots were not randomly selected. Thus, the PSM model was used to analyze the impacts of farmland rental markets participation and rented plots on farmland investment. Before using the PSM model, the balance hypothesis and the common supporting hypothesis needed to be tested. Table 6 gave the estimation results of the balance hypothesis. And the results indicated that after matching, the differences in most of control variables between farmers who rented in land and farmers who did not rent in land were decreased or insignificant, suggesting that the balance hypothesis was satisfied. Similarly, the differences in most of control variables between rented plots and owned plots were also reduced or insignificant, suggesting that the balance hypothesis was satisfied as well.

Table 6. Estimation results of the balance hypothesis

Variables	Unmatched Matched	Household-level data		T-test	Plot-level data		T-test
		Treated	Control		Treated	Control	
Ln of age	U	3.900	3.983	–4.84***	3.900	3.934	–2.51**
	M	3.901	3.895	0.27	3.900	3.988	0.15
Ln of edu	U	2.012	1.865	2.85***	2.012	1.972	1.02
	M	2.012	2.049	–0.92	2.012	2.020	–0.18
Dummy variable for village cadres	U	0.125	0.131	–0.24	0.125	0.126	–0.07
	M	0.125	0.115	0.48	0.125	0.125	–0.03
The ratio of agricultural labors to household size	U	0.559	0.586	–1.55	0.559	0.567	–0.64
	M	0.560	0.551	0.56	0.559	0.558	0.02
Dummy variable for hay mower	U	0.455	0.319	3.77***	0.454	0.411	1.44
	M	0.454	0.436	0.54	0.454	0.452	0.06
Dummy variable for fertilizer ditching machine	U	0.175	0.094	3.12***	0.174	0.142	1.49
	M	0.173	0.163	0.41	0.174	0.167	0.27
The accessibility of Internet	U	4.265	4.124	1.69*	4.267	4.224	0.66
	M	4.264	4.317	–0.75	4.267	4.252	0.21
Ln of the distance from plot to the nearest town	U	1.566	1.934	–6.34***	1.849	1.869	–0.54
	M	1.568	1.605	-0.71	1.849	1.845	0.09
Ln of the input of chemical fertilizer	U	5.772	5.361	2.31**	5.636	5.612	0.16
	M	5.770	5.962	–1.32	5.636	5.634	0.01
Subjective judgment for land quality	U	2.015	2.332	–3.18***	2.148	2.106	0.53
	M	2.017	1.987	0.36	2.148	2.129	0.22
Dummy variable for natural disasters such as frost	U	0.244	0.248	–0.15	0.237	0.245	–0.33
	M	0.244	0.254	–0.36	0.237	0.242	–0.21
Ln of age of apple trees	U				2.519	2.728	–5.19***
	M				2.519	2.541	–0.44

Notes: ***, **, * denoted statistical significance at the 1%, 5% and 10% levels, respectively.

Figure 2 presented the estimation results of the common supporting hypothesis. And the results demonstrated that most of sample farmers and sample plots were within the scope of common support, which means that the common supporting hypothesis was satisfied. Therefore, the PSM model used here was appropriate in this study.

Table 7 displayed the estimation results of the PSM model. The results from the nearest neighbor matching method, caliper matching method and kernel matching method indicated that positive impact of farmland transfer on farmland investment was still significant, and negative impact of rented plots on farmland investment was still significant. Hence, above-mentioned estimation results were robust in this study.

To reduce the selection bias of land rents, the Heckman two-stage regression model was used to analyze the impact of land rents on farmland investment. Specifically, farmers could decide whether to participate in farmland rental markets in the first stage, and then farmers who participated in farmland transfer could choose the level of land rents in the second stage.

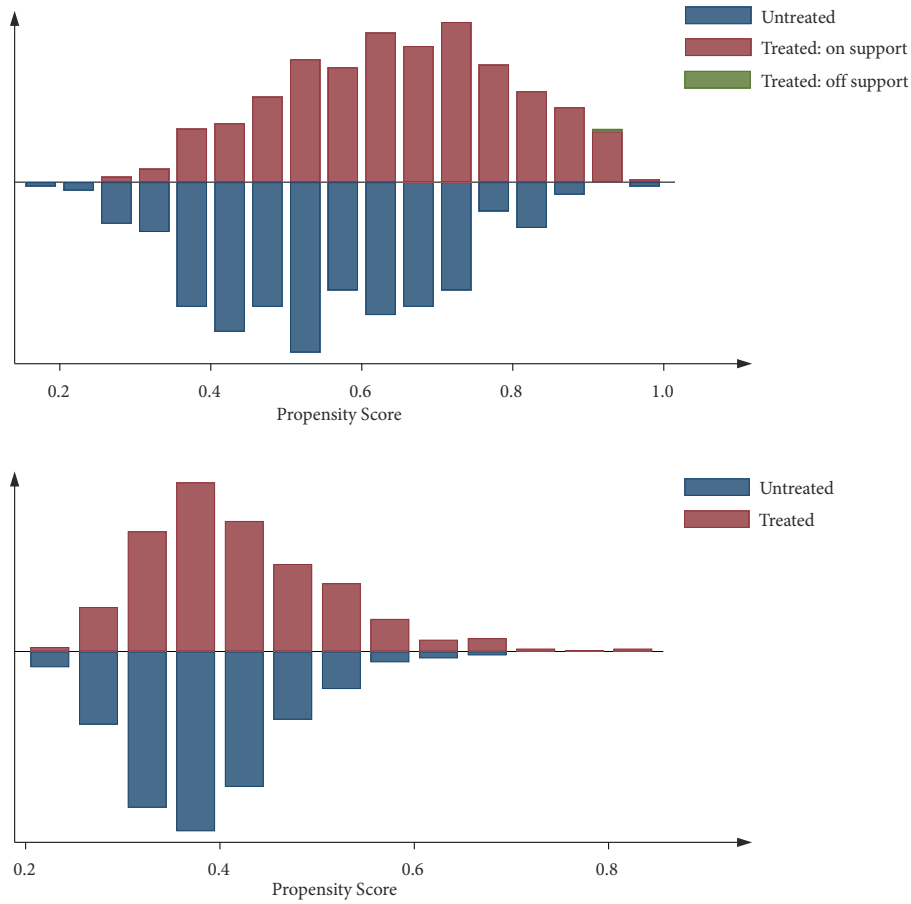

Figure 2. Distribution of propensity score

Table 7. Estimation results of the PSM model

The method of matching	Treated	Controls	Differences	S.E.	T-statistics
Farmland transfer					
The nearest neighbor matching method	4.301	3.218	1.084***	0.285	3.81
Caliper matching method	4.267	3.272	0.995***	0.301	3.30
Kernel matching method	4.306	3.197	1.109***	0.313	3.54
Rented plots					
The nearest neighbor matching method	3.063	3.427	–0.364*	0.223	–1.63
Caliper matching method	3.063	3.520	–0.457**	0.210	–2.18
Kernel matching method	3.063	3.519	–0.456**	0.210	–2.17

Notes: ***, **, * denoted statistical significance at the 1%, 5% and 10% levels, respectively.

Table 8 reported the estimation results of the Heckman two-stage regression model. The results indicated that higher land rents could significantly boost the number of farmyard manure at the 5% level, which means that above estimation result was robust in this study. Moreover, the result from the inverse mills ratio was not significant, suggesting that the selection bias of land rents was trivial here. Thus, the estimation result of the IV method was appropriate.

Table 8. Estimation results of the Heckman two-stage regression model

Variables	Ln of the number of farmyard manure	Dummy variable for farmland transfer
Ln of D	0.182(0.077)**	
Ln of age	–0.905(2.326)	–0.784(0.204)***
Ln of edu	–0.332(0.402)	0.080(0.072)
Dummy variable for village cadres	0.399(0.574)	0.008(0.145)
The ratio of agricultural labors to household size	–1.272(0.903)	–0.009(0.206)
Dummy variable for hay mower	–0.955(0.979)	0.296(0.104)***
Dummy variable for fertilizer ditching machine	0.664(0.797)	0.247(0.149)*
The accessibility of Internet	0.038(0.189)	–0.018(0.045)
Ln of the size of farmland transfer	0.011(0.005)**	
Ln of the distance from plot to the nearest town	0.808(1.133)	–0.395(0.066)***
Ln of the input of chemical fertilizer	–0.050(0.075)	
Subjective judgment for land quality	0.554(0.263)**	–0.070(0.036)*
Dummy variable for natural disasters such as frost	–0.132(0.475)	–0.074(0.113)
Inverse mills ratio	–3.270(5.466)	
Prob > chi2	0.004	
Number of observations	762	

Notes: Numbers in parentheses denoted robust standard deviation. ***, **, * denoted statistical significance at the 1%, 5% and 10% levels, respectively.

5. Discussions

Impacts of tenure security and farmland transfer on farmland investment were analyzed by using 1163 plot-level and 762 household-level data. Different from the previous literature, a more systematic theoretical framework had been established here. From the perspective of tenure security, impacts of the clarity level of the structure of farmland property rights and the stability of farmland rental contracts on farmland investment were studied, and the plot-level data and the household fixed effect model were used to avoid the endogenous issues. From the perspective of farmland transfer, impacts of land rents and the size of farmland transfer on farmland investment were analyzed, and the household-level data and the IV method were used to avoid the endogenous issues. The specific results were as follows:

Firstly, compared with owned plots, the amount of farmland investment for rented plots without stipulating rental time could be significantly reduced, but stipulating rental time

could weaken the negative impacts of ambiguous systems of farmland property rights on land tenure security and the amount of farmland investment, which deepened the research conclusions of the existing literature. Specifically, compared with owned plots, the number of farmyard manure in rented plots without stipulating rental time was significantly decreased by 64.0~66.9%, which was similar to the results from Ma et al. (2013) and Lyu et al. (2019), but impact of rented plots with stipulating rental time on the number of farmyard manure was not significant. A plausible reason was that ambiguous systems of farmland property rights resulted in land tenure insecurity in rented plots, but stable farmland rental contracts could improve tenure security, which obtained the whole revenues on farmland investment in time and as a result, increased the willingness to engage in farmland investment. However, as a vital reform of farmland property rights systems, positive impact of land certificates on farmland investment was not obvious, which was different from the studies of Hong et al. (2020) and Abdulai et al. (2011). A plausible reason was that there might be a lagged impact of land certificates on farmland investment, and low collateral value of farmland weakened the positive impact of land certificates on formal credit accessibility, which led to insignificant impact of land certificates on farmland investment.

Secondly, higher land rents motivated significantly farmers to invest in farmland, and expanding farm size increased significantly the number of farmland investment, which enriched and improved the research conclusions of the previous studies. Specifically, each 1% increase in land rents resulted in a 1.7% rise in the input of farmyard manure because effective land rents could help farmers to obtain full residual claims to revenues on farmland investment and as a result, raised the quantity of farmyard manure. Meanwhile, each 1% increase in the size of farmland transfer resulted in a 0.1% rise in the input of farmyard manure, which was in line with the studies of Zhang et al. (2019) and Cao et al. (2020a). A plausible explanation was that expanding farm size could dilute the cost of farmland investment, which enhanced the willingness to raise the amount of farmland investment.

In sum, tenure security and farmland transfer were considered to be two key factors that affected the amount of farmland investment. And tenure security consisted of the clarity level of the structure of farmland property rights and the stability of farmland rental contracts. Specifically, ambiguous systems of farmland property rights led to high risk of losing rented plots, but stable farmland rental contracts could weaken the expectation of the risk of farmland property rights, which improved the availability of revenues on farmland investment and consequently, increased the number of farmland investment. Moreover, the effectiveness of reform of farmland property rights systems should be strengthened. Meanwhile, land rents and the size of farmland transfer denoted the price and size of farmland rental markets, which raised the availability and size of revenues on farmland investment and consequently, boosted the number of farmland investment.

Conclusions and policy implications

According to above estimation results, the quantity of farmland investment relied on the availability and size of revenues on farmland investment, and secure tenure and well-developed farmland rental markets affected significantly the availability and size of revenues on farmland investment, suggesting that tenure security and farmland transfer were two key

factors that determined the willingness to farmland investment. Thus, several policy suggestions were proposed in this paper: (1) ambiguous systems of farmland property rights should be improved to make the structure of farmland property rights clearer, and the reform of systems of farmland property rights should be continually deepened, which strengthened the expectation of land tenure security. Moreover, the relevant supporting measures should be implemented such as loan supporting policy; (2) farmland rental contracts should be inclined to be more formal and standardized. And smooth implementation of long-term farmland rental contracts should be strictly protected by local governments, so it was necessary to improve the effectiveness of relevant laws and regulations; (3) the role of price mechanism should be fully played to obtain the whole revenues on farmland investment in time, and all kinds of digital platforms should be fully used to release information about land rents; (4) farmland rental markets should be vigorously developed, and a great number of intermediary organizations with goals of enhancing farmland transfer should be established.

Although some robustness tests had been used to ensure the precision of estimation results, the main limitations of this study were that (1) some variables for plot characteristics were used to control the impact of plot-level factors on farmland investment as much as possible, but plot-level omitted variables could not be controlled here; (2) as apple was a kind of perennial crops, whether above conclusions were applicable to annual crops or not still needed be empirically examined.

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