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Impact of land tenure policy on agricultural investments in China: Evidence from a panel data study

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ABSTRACT

The goal of this paper is to examine the impact of changes in China's rural land policy on agricultural investments. Dramatic changes occurred in China's rural land policies after 2000, including the extension of rural land contractual period, restriction of land reallocation among villages and villagers groups, elimination of agricultural taxes for responsibility land, and rapid development of rural land rental markets. These changes have given farmers more secure tenure on collectively controlled responsibility land and have strengthened farmers' income rights for responsibility lands, incentivizing them to increase their investments on responsibility lands. A panel data method was used to quantitatively investigate the impact of land policy changes on agricultural investment. We considered the application of organic fertilizer as an indicator for long-term agricultural investment, and compared the use of organic fertilizer between private plots and responsibility lands operated by the same household. The results showed that the difference in organic fertilizer use between private plots and responsibility land for the same household has become smaller from 2000 to 2008. Our findings suggest that recent changes in rural land policies have provided farmers incentives to increase land quality investment on their responsibility lands.

1. Introduction

A clearly defined land property right plays a critical role in agricultural production and economic growth. In general, secure property right is an important factor that can influence investment decisions by a rational agent (Alchian & Demsetz, 1972; Demsetz, 1967). Since land is one of the most important inputs for agricultural production, the tenure security of farm land has a significant impact on the utilization of the land. Farm land tenure policy can influence the risk of land expropriation and long-term investments that can improve land quality and farm productivity (Feder & Feeny, 1993). Moreover, as land right consists of a set of rights, different types of land property rights, such as the use rights, transfer rights and rights of alienation may have heterogeneous effects on land investments (Besley, 1995; Feder & Onchan, 1987; Jacoby, Li, & Rozelle, 2002). Today, insecurity of farm land property rights remains a major issue in transitive economies and many developing countries, where various land tenure policy reforms are ongoing.

Land tenure policy reform in China provides a good case study to understand the impact of land tenure insecurity on agricultural investments. China's Household Responsibility System (HRS) reform during 1979 to 1984 first defined the use rights and ownership of farm land. Under the HRS, collectively owned land was assigned to individual households with contracts of up to 15 years, providing farmers with greater incentives to increase agricultural production. This reform dramatically promoted the total factor

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productivity in China's agriculture and accounted for about half of the agricultural growth during 1979–1984 (Lin, 1992). After 1984, however, China experienced a slow increase in agricultural productivity and a sharp decline in collective agricultural investments (Wen, 1995). Several studies have argued that the insecurity of use rights for responsibility land may lead to a low level of investment by farmers (Li, Rozelle, & Brandt, 1998).

The current literature on land tenure policy and farm investments highlights the critical role that a clearly defined property right can play in land investment in China. A group of studies utilized the frequency of land reallocation within a village as an indicator for land insecurity to examine the effect of land tenure on farmer investments (Xu & Zhang, 2005; Zhong & Ji, 2009). However, those studies found different results.[1] Li et al. (1998), on the other hand, compared long-term land investment among private land (also called ziliu di), collective and responsibility land, assuming that the private land had more secure land right than collective and responsibility lands, to identify the impact of land tenure policy on agricultural investment. This study could have better dealt with household heterogeneity through a household fixed effect, resulting in a consistent estimate on the effect of land tenure policy on land investment. Unfortunately, their data obtained from a small sample size and outdated, hardly assessing the impact of recent changes in China's farm land tenure policy.

China's farm land tenure policy has dramatically changed since 2000. In 2002, China issued a new law for rural contracting land, and two years later, the Chinese central government further modified the law of land management. In 2008, China issued its first property law. Several important changes in farm land tenure policy are worth being highlighted here. First, under the new law for rural contracting land, the length of the contract has been extended from 15 years to 30 years, which provides farmers higher security of tenure on collectively controlled land. Second, farm land reallocation in rural China has been restricted since 2000. According to a survey conducted by Tao et al. (2009), land reallocation within villages or villagers' groups[2] has significantly declined. Restrictions on periodic land reallocation have reduced farmers' risk of losing their use rights of responsibility land. These policy changes would considerably affect the security of collectively controlled responsibility land, and consequently may influence farmer's investment on land in rural China.

Moreover, several important changes in farm land policies occurred, which may influence the tenure rights of farm land in China. For instance, agricultural taxes for responsibility lands were abolished in 2006 nationally. The elimination of agricultural taxes, along with the introduction of agricultural subsidies since 2004, may strengthen the income rights of agricultural land, and consequently lead to more investment on responsibility land. Also, land rental markets in rural China have developed dramatically since 2000, strengthening the transfer rights of farm land (Ma, Heerink, Feng, & Shi, 2015). Chinese farmers now can cash their long term investment in farm land through rural land rental markets, increasing their incentive of land investment.

The overall goal of this paper is to understand the dynamic impact of China's land tenure policy on agricultural investments since 2000, which may in turn assist China's policymakers to better assess the effect of China's farm land policy reform and further improve China's farm land management. To meet this general goal, we compared the long-term investment between private and responsibility lands owned by the same rural household. This strategy can better control for the unobservables that may affect the land investment at the household level, and has been widely used in the study of institutional economics, such as Shaban (1987), which focused on productive efficiency of crop-sharing contracts.

To measure the impact of land rights on farm investment, we considered the application of organic fertilizer as an indicator for long term investment. Organic fertilizer mainly consists of animal wastes (pig manure, chicken manure, cow dung and so on) and straw, which can improve soil quality, and may sustain land quality for four or five years (Jacoby et al., 2002). Unlike other types of long term investments, such as irrigation, which are more likely to be invested by local governments or a group of farmers, the application of organic fertilizer mainly reflects investment choice of an individual farmer. Li et al. (1998) also used the application of organic manure as an index of long term investment.[3]

The rest of the paper is organized as follows. In the next section, we provide the institutional background on China's land policy and major changes after 2000. Section 3 discusses the data set we used in the empirical study. In Section 4, we present the econometric strategy, the basic results of estimation, and results from alternative estimating methods. Section 5 concludes the paper with a discussion of policy implications.

2. Land tenure policy and agricultural investment in China

2.1. China's land tenure policy

Before the household responsibility system was completed, China's agricultural production was organized in a collective-based production team system. A production team typically consisted of about 20–30 neighboring households and worked together on collectively owned land. Because of high costs in monitoring labor inputs among a team and rewards to individual farmers were not tied to their work directly, output growth was very low (Lin, 1988).

China's land policy reform began at the end of 1970s. After the implementation of the household responsibility system, essentially

[1] Xu and Zhang (2005) show that land security can significantly improve land related investments by farmers while Zhong and Ji (2009) find no evidence that secure land right can increase farm household investments in China.

[2] The village refers to the administrative village which is the lowest level rural administrative and land management unit in China. An administrative village is often consisted with several villagers' groups which have fewer administrative responsibilities and weaker organizational capability than the village.

[3] Li et al. (1998) examine the impact of property rights on China's agricultural production. Their results show that the right to use land for long periods of time encourages the use of land-saving investments in rural China.

completed by the end of 1983, the local governments were responsible for the allocation of the majority of farm land to farmers. Although there exist large regional differences in land tenure policy, farm land in rural China can be divided into four types: private plots (ziliu di), ration land (kouliang tian), responsibility land (zeren tian) and contract land (chengbao tian). Private plots are generally under the control of farm households while the other types of land are collectively controlled lands. Ration land is granted to farm households based on the size of families to meet their subsistence requirements. Responsibility land is allocated to farmers on the condition that they delivered low-priced grain quotas to the state. Contract land is rented out by village leaders to farmers for fees with an uncertain duration. In some areas, collective land includes only ration land and responsibility land, but in most regions, responsibility land is the major type of collective land.

Private plots in China enjoy a high degree of tenure security. In most villages, farmers manage their own private plots and village leaders do not intervene in their production decisions. Although farmers cannot sell their private plots, they can rent them out to other farmers or allocate them to their children (Brandt, Rozelle, & Turner, 2004). In some regions, local governments issue certificates for private plots to farmers, to further clarify the land property rights. In general, farmers treat their private plots as if they own them (Li, 1997).

During the collective period when villages controlled mainly the agricultural production, private plots were purposely maintained to supplement the collective agricultural production and to increase farmers' incentive (Zhu, 2009). Du (1998) found that the average productivity of private plots was more than twice that of the collective lands, during the collective period. After 1979, this policy continued and farmers still managed their own private plots.[4] Although the 2004 amended land management law states that “the collective” ultimately owns the private plots, farmers nearly always have all rights related to the land.

After the implementation of the household responsibility system in 1979, the majority of the collective lands constituted responsibility lands, and was controlled by local village leaders in China.[5] The land was granted to farmers based on the size of families or the number of laborers in the families and on the condition that farmers delivered grains to the state under a low price quota. Also, farmers needed to pay fees to the collective as public accumulation funds. Unlike private plots, farmers only have use rights on responsibility lands with little control of land related investments.

One concern that farmers were confronted with is the short contract duration of responsibility lands. Prior to 1984, responsibility lands often had a 2–3 year contract. The duration was extended to 15 years after the “No. 1 Central Document” of 1984. However, according to a detailed field survey of 1076 farm households conducted by Li et al. (1998) in Hebei and Liaoning provinces, the average length of land rental contract in 1995 was only 9 years.

Another concern for farmers is the risk of periodic reallocation of responsibility lands within villages. Village leaders were allowed to make necessary adjustments to household land holdings in order to maintain the egalitarian distribution of land among households in response to household demographic changes, such as the increase in rural population and generation of new families (Kung, 1995). Reallocation of land was common in poorly developed rural land rental markets (Benjamin & Brandt, 2000; Li, 1997). The high risk of land reallocation may lead to a significant reduction in farmers' incentives to invest in responsibility lands.

2.2. Land policy changes since 2000

Major changes in China's farm land policies have occurred since 2000. In this section, we focused on changes in the security of farmers' use right for responsibility land, the strengthening of the income rights of farm land due to the elimination of agricultural taxes and introduction of agricultural subsidies, and the improvement of transfer rights of responsibility land via rural land rental markets.[6]

First, farmers' use right for responsibility land has significantly improved. On one hand, the length of land lease contract has been extended in the second round of land contracting. In the first round of land contract reform initiated at the beginning of the 1980s, the length of the land lease contract was 15 years. However, in the second round, which ended nationally around 2000, the length of the land lease contract was extended to 30 years. In 2002, the new “law for rural land contract” explicitly set the length of the land lease contract to 30 years, providing a formal legal support for land right security (Ma et al., 2015). In addition, several central government documents and public speeches by former governmental leaders have reaffirmed that farmers need to be given “permanently unchanged” use right for contract lands. As such, it is believed that the extension of contract duration may lead to higher security of tenure on collectively controlled land.

On the other hand, the possibility of land reallocation within villages or villagers groups has decreased. Demographic changes in rural China have always led to frequent land reallocation among villages or villagers groups during the 1990s. The periodic reallocation of collective lands among households by village leaders, as authorized by the central government, placed farmers at the risk of losing their land use rights (Ma et al., 2015). However, since 2002, the new law for rural land contract has restricted land reallocations.

Moreover, nowadays the village leaders have less incentive to reallocate lands for two reasons. Firstly, as agricultural population in China constantly decreases, the egalitarian pressure on land reallocation reduces. For example, the ratio of agricultural population decreased significantly from 73.2% in 2000 to 48.65% in 2008. Secondly, the rapid development of rural land rental market helped

[4] According to surveys in Huang et al. (2012), private plots in China account for 2.4% of the total cultivated land in 1996. The share of private plots increased slightly to 2.7% in 2008.

[5] The responsibility land is a major component of Chinese farm lands, which accounts for 84% of total farm land in 1996 (Huang et al., 2012). In 2008, this share declined to 70%.

[6] Ma et al. (2015) provides a detailed discussion on China's land tenure policy and recent market-oriented reforms of farmland tenure system in China.

eliminate the inequality in land distribution across households (Deininger & Jin, 2005). Indeed, according to the field surveys conducted by authors in 2000 and 2009, in 2000, 40% of the households surveyed experienced land reallocation within villages, and 48% households experienced reallocation within villagers groups. These numbers declined to 10% and 18% in 2008, respectively.

Second, the income rights of responsibility land have been strengthened. Agricultural taxes for responsibility land were abolished in 2006, which has improved the income rights of responsibility land. A series of tax reforms for responsibility land occurred after 2000. In 2002, the Chinese central government conducted a pilot rural taxation reform in Anhui Province. Then in 2004, the government proposed to lower agricultural taxes for responsibility lands, reported in the "No. 1 Central Document" of that year. Later as a pilot program, the Chinese government eliminated agricultural taxes in Heilongjiang and Jilin provinces. In 2006, the agricultural taxes, historically collected in China for almost one thousand years, were abolished nationally. The agricultural tax reform has eliminated the tax linked to responsibility land and consequently strengthened the income rights of responsibility land. Not being required to pay taxes for responsibility lands, farmers are more willing to contract more land and probably invest more on responsibility land.

Beside the abolition of agricultural taxes, Chinese governments have provided farmers agricultural subsidies since 2004, which has also strengthened the income rights of agricultural land. The main component of agricultural subsidies, including the direct grain payments and the general input subsidy to grain producers, is area-based in practice and can partially influence the cost of grain production (Gale, 2013). Like the elimination of agricultural taxes, the introduction of agricultural subsidies has strengthened the income rights of responsibility land.

Third, the development of land rental markets in rural China has strengthened the transfer rights of responsibility land. Land transfers via rural land rental markets can increase the gains-from-trade of responsibility land. The rights for renting land can raise the value of responsibility land, and increase farmers' incentive to invest on these lands (Carter & Yao, 1999). Once the land rental market is functioning well in rural China, farmers can capitalize on their investment through rising land rental fees. Through land rental markets, farmers can reap their long term land investments without the fear of losing the benefits of their investments (Ma et al., 2015).

Since 2000, the Chinese central government issued a series of policies, including the "law for rural land contract" in 2002 and the "administrative method for rural contract land transfer" in 2005, to promote the development of rural land transfers. In 1990, only 0.9% of rural households experienced contract land transfers and 0.44% of rural lands was transferred (MOA, 1991). In 1998, about 3–4% of the rural lands were transferred (Chen & Han, 2002). According to a household survey, however, the ratio of transferred lands increased to 17.1% in 2008 (Huang, Gao, Ji, & Rozelle, 2012). As the private plots are small in size and often located near farmers' houses, they were seldom transferred. Therefore, the rapid development of rural land rental markets can mainly increase the gain-from-trade of responsibility land, rather than private plots, and consequently lead to an increase in land investment.

These changes in land policies mentioned above, have led to a higher degree of tenure security of collectively controlled responsibility land than before and the strengthening of the income rights of responsibility land. The farm land policy changes and the emergence of land rental market would significantly influence the value of rural responsibility lands, and consequently change farmers' incentive for long term land investments.[7]

3. Data and descriptive evidence

The data set used in the paper was obtained from two rounds of household surveys conducted by the Chinese Center for Agricultural Policy (CCAP), Chinese Academy of Science in 2000 and 2009. These surveys were questionnaire-based and carried out by face-to-face interviews between farm households and enumerators. The first round was conducted in November 2000. A stratified random sampling method was used. To obtain a nationally representative sample, six provinces, including Hebei, Liaoning, Shanxi, Zhejiang, Sichuan and Hubei, were selected. We then randomly selected five counties in each province, two townships in each county, and one village within each township. Finally, 20 households were selected for each sampled village. In total, there were 1200 farm households interviewed in our study. However, due to missing data and a few incomplete questionnaires, only 1189 households were included in our study.

Each household sampled in the 2000 survey was interviewed again in April 2009. However, because of massive labor migration which occurred in rural China, a few sample households were unavailable when the second round of the survey was carried out. Although we interviewed some of households through cellphone, we still had difficulty tracking all the households. Therefore, the second round survey only included 1046 households.

We gathered detailed information on grain output and inputs on each plot, including organic fertilizer, chemical fertilizer, seeds, machinery and labor. Information on the land tenure of each plot was collected. The survey also contained information on characteristics of each plot, including size, land quality, terrain, and irrigation condition as well as household's socioeconomic information.

In this study, the agricultural investment in soil quality refers to the application of organic fertilizer, which is a mixture of animal manure, straw and other farm-yard wastes. Unlike chemical fertilizer, such as nitrogen and phosphate, organic fertilizer can promote healthy crop growth, maintain soil structure, and can have an effect on the soil for four to five years (Jacoby et al., 2002). According to a World Bank Living Standards Measurement survey conducted in 1995, Chinese farmers can spend days in making the organic

[7] Using real option value theory, Ma, Wesseler, Heerink, and Qu (2013) show that China's land tenure reforms are more likely to elicit land conservation investments in areas where land markets are developing.

Table 1
Number of households and plots in the sample.
Source: Authors' surveys in 2000 and 2009.

Year	Total sample	Sample of households with both private plots and responsibility land					
	# of households	# of households	# of plots	Private plots (ziliu di)		Responsibility land (zeren tian)	
				Plots	Ratio	Plots	Ratio
2000	1189	305	1334	394	30%	940	70%
2008	1046	180	857	239	28%	618	72%
Total	2235	485	2191	633	29%	1558	71%

fertilizers; the average farm household spent about 8% of its annual labor days on organic fertilizer application. Values for organic fertilizer application for each plot were calculated from aggregation of different types of organic fertilizer.

To measure the degree of land tenure security, we relied on comparison between private plots and responsibility lands. As shown in Table 1, there were 305 households in the 2000 (25.7% of the total households surveyed) sample who owned both private plots and responsibility croplands, with a total of 1334 parcels of farmland. In 2008, the number of such peasant households decreased to 180 (about 17.2% of the total households surveyed in 2008) and the number of parcels reduced to 857. It was chiefly incurred by the reduction of plots. Generally, every household in our sample had four parcels of land during the two periods, a private plot and 3 parcels of responsibility lands.

To provide some descriptive evidence, we compared organic fertilizer use on private plots and responsibility lands under the assumption that private plots are generally held much longer and are considered more secure than collectively controlled responsibility lands. Firstly, as shown in Table 2, the organic fertilizer used on responsibility land was significantly lower than that on private plots, although there were some differences across regions. Secondly, the difference in organic fertilizer use between private plots and responsibility land decreased from 7.12 kg per hectare in 2000, to 2.67 kg per hectare in 2008 (see the last line of Table 2) which indicated that organic fertilizer use was higher on private lands, but the differences became smaller in 2008. It is worth noting that besides the land policy changes after 2000, there may be other factors that lead to greater organic fertilizer use on private plots. Thus, this descriptive evidence can only be considered as circumstantial at this point, however, the findings will be examined later in light of our estimation of the econometric model.

4. Econometric analysis

In this section, we provide an empirical investigation on the impact of land tenure policy on the use of organic fertilizer. We first specify our econometric model and discuss variables, then present our base results. Finally, we present our robustness checks to examine the findings through an alternative estimation method.

4.1. Model specification

Our estimation strategy to assess the importance of land rights for organic fertilizer use was to compare fertilizer use on private plots and collectively controlled responsibility lands cultivated by the same household. By comparing plots of the same household, we were able to control for household level factors, such as, education of farmers, farming experiences, land endowment, and other unobservable variables, which may have influenced the application of organic fertilizer.

Thus, we specify the empirical model as follows:

Table 2
Organic fertilizer use on private plots and responsibility land in China in 2000 and 2008 (tons/hectare).
Source: Calculation based on household surveys by authors.

Province	2000			2008		
	Private plots	Responsibility land	Difference	Private plots	Responsibility land	Difference
	(1)	(2)	(2)-(1)	(3)	(4)	(4)-(3)
Hebei	2.34	1.74	− 0.61	–	–	–
Shanxi	9.18	5.59	− 3.59	4.75	2.64	− 2.11
Liaoning	19.45	8.57	− 10.88	15.66	6.72	− 8.94
Zhejiang	11.37	5.33	− 6.05	3.04	1.07	− 1.97
Sichuan	22.16	12.72	− 9.44	8.18	4.55	− 3.63
Hubei	30.88	15.01	− 15.87	11.81	7.12	− 4.7
Average	16.4	9.28	− 7.12	6.74	4.08	− 2.67

Table 3
Summary statistics of variables.

Variable	Definition	Mean	Std. error	Min	Max
M	Amount of organic fertilizer, tons/hectare	8.82	14.99	0	100
R	Responsibility land = 1; private plot = 0	0.71	0.45	0	1
R^*D_{2008}	Interaction term between R and D_{2008}	0.39	0.49	0	1
D_{2008}	Yearly dummy, 2008 = 1; 2000 = 0	0.28	0.45	0	1
P-QM	Land quality, medium = 1, otherwise = 0	0.54	0.5	0	1
P-QH	Land quality, high = 1, otherwise = 0	0.24	0.43	0	1
P-Irrigation	Yes = 1; no = 0	0.64	0.48	0	1
P-Plain	Yes = 1; no = 0	0.29	0.46	0	1
P-Distance	Kilometer	0.57	0.98	0	35
P-Area	Hectare	0.07	0.11	0.001	3.33
P-Crop1-grain	Dummy for grain crop, yes = 1, no = 0	0.62	0.49	0	1
P-Crop2-cash	Dummy for cash crop, yes = 1, no = 0	0.22	0.42	0	1
P-Crop3-others	Dummy for other crop, yes = 1, no = 0	0.05	0.22	0	1

Note: The sample size is 2191.

$$M_{ipt} = \alpha + \beta R_{ipt} + \theta(R_{ipt}{}^*\mathrm{D}_{2008}) + \sum_{j=1}^{7} \delta_j P_{ipt}^j + \mu_i + \epsilon_{ipt} \quad (1)$$

where subscript i represents i^{th} household, p denotes p^{th} plot, and t denotes t^{th} year. The dependent variable, M_{ipt} is organic fertilizer use by i^{th} household on her p^{th} plot in t^{th} year (tons/ha).

The key explanatory variable in Eq. (1) is R_{ipt}, which is a dummy variable indicating whether the plot is the private type ($R_{ipt} = 1$, if the plot is collectively controlled responsibility land, and $R_{ipt} = 0$, if the plot is privately owned). The coefficient of this variable captures the impact of land tenure policy on organic fertilizer use on private plots vs. responsibility land. We anticipate a negative coefficient if the household uses more organic fertilizer on the private plots. D_{2008} is a dummy variable, which equals 1 in 2008 and 0 in 2000. The second variable in the right hand side of Eq. (1) is a variable that controls for the interaction of R_{ipt} and D_{2008}. This interaction term is included to measure the changes in the difference of organic fertilizer use between private plots and collectively controlled responsibility land in 2000 and 2008. If changes in land policy since 2000 enhanced the security of collectively controlled land and consequently increased farmers' organic fertilizer use on responsibility lands, we would expect a positive coefficient of the variable.

We also included a set of plot-specific variables ($\Sigma_{j=1}{}^{7} P_{ipt}{}^{j}$) that may potentially influence the use of organic fertilizer by households, such as soil quality, the terrain of the plot, access to irrigation, the size of the plot, the distance of the plot from the home and crop produced in the plot. The soil quality might affect the application of organic fertilizer as farmers are likely to use more organic fertilizer on low quality land. As the use of organic fertilizer is a labor-intensive work, the terrain and location of the plot might influence the transportation of organic fertilizer, and consequently restrict its use. Crop choice is also an important factor that may influence the use of organic fertilizer by households. In addition, a household fixed effect is included to control for unobservable household level characteristics in order to obtain consistent estimates. The last term in Eq. (1) is a plot specific error term. Table 3 provides a summary of the statistics of the dependent variable and all explanatory variables.

4.2. Base results

We estimated Eq. (1) with a fixed effect (FE) model, using a panel data set of 857 plots in 2000 and 2008. As a benchmark, we also report the results from an ordinary least squares (OLS) with pooled data of both 2000 and 2008. However, our discussion is mainly based on the results from the fixed effect estimation.

Table 4 reports our base results. As previously indicated, private plots generally enjoy a high degree of land tenure security and farmers are willing to apply more organic fertilizer on private plots. Our results confirm this prediction. The estimates showed that on average farmers used 5.66 tons per hectare less on collectively controlled lands than private plots in 2000. The OLS estimates (in column 2 in Table 4) show a remarkable similarity to the private plot dummy coefficients.

Although the use of organic fertilizer on private plots was higher than on responsibility lands, our results showed a smaller difference in organic fertilizer use between private plots and responsibility lands for 2008. Indeed, our estimates in Table 4 show a statistically significantly positive coefficient for the interaction term of the land type (R_{ipt}) and the year dummy (D_{2008}). On average, the difference in organic fertilizer use between private plots and responsibility lands was about 0.59 ton per hectare in 2008, a dramatic reduction compared to that in 2000. An F-test shows that this difference is statistically indifferent from zero,[8] indicating that the impacts of land tenure on fertilizer use in 2008 are fairly small. The findings indicated that the land policy changes since 2000, especially the extension of land contract, restriction of land reallocation, the elimination of agricultural taxes, the introduction of agricultural subsidy, and the development of rural land rental markets, which more likely influence responsibility lands rather than

[8] An F-test was conducted to test if the sum of the estimated coefficients of R and R^*D_{2008} is zero. The Prob > F = 0.4978. We fail to reject the null hypothesis that the sum of the estimated coefficients of R and R^*D_{2008} equals zero.

Table 4
Estimates of the impact of land security on organic fertilizer use in China.

	Dependent variable: organic fertilizer use (M, tons/hectare)	
	OLS	Fixed effect model
	(1)	(2)
Land type (R) (1 = responsibility land; 0 = private plot)	− 6.61*** (1.19)	− 5.66*** (1.16)
Year dummy (D_{2008}) (2008 = 1; 2000 = 0)	− 10.80*** (1.40)	
$R*D_{2008}$	4.93*** (1.46)	5.07*** (1.31)
Land quality-medium (P-QM) (medium = 1, otherwise = 0)	0.86 (0.76)	1.7 (1.15)
Land quality-high (P-QH) (high = 1, otherwise = 0)	2.88*** (0.98)	3.65*** (1.28)
P-Irrigation (yes = 1; no = 0)	1.49*** (0.71)	− 0.15 (1.33)
P-Plain (yes = 1; no = 0)	− 4.06*** (0.63)	− 3.38** (1.72)
P-Distance (kilometers)	− 1.39** (0.68)	− 1.19** (0.50)
P-Area (hectare)	− 8.02*** (3.01)	− 11.88*** (4.43)
P-Crop1-grain (yes = 1; no = 0)	2.95** (1.19)	0.15 (1.31)
P-Crop2-cash (yes = 1; no = 0)	7.21*** (1.42)	5.40*** (1.50)
P-Crop3-others (yes = 1; no = 0)	− 1.94 (1.36)	− 2.01 (1.63)
Constant	13.52*** (1.38)	11.08*** (1.68)
Number of obs.	2191	2191
Number of groups		485
R-squared	0.14	0.14
F	22.99	10.84
Prob > F	0	0

Note: All numbers in parentheses are robust standard errors. ***, **, * represent statistically significance at 1%, 5%, and 10%, respectively.

private plots, might have led to a higher degree of tenure security of collectively controlled responsibility lands and improvement in income rights of responsibility lands, providing incentives for farmers to invest in land quality.

4.3. Alternative estimation

One potential problem with the organic fertilizer demand estimation in Table 4 arises from the zero values for fertilizer use. Since organic fertilizer was not applied to approximately 48% of the plots in our sample, the data on household fertilizer use were censored at zero. Thus, failing to account for these zero values could lead to a serious inconsistent estimation of the impact of land tenure security on organic fertilizer use.

To address this econometric issue, we used a Tobit model, which assumed that the unobservable for each household was drawn from the same normal distribution. We also included a set of household level dummy variables to control for household level fixed effects (Wooldridge, 2002).

Table 5
Tobit fixed effects estimates of the impact of land security on organic fertilizer use in China.

	Tobit	AME (average marginal effect)		
		P(M > 0)	E(M)	E(M|M > 0)
	(1)	(2)	(3)	(4)
Land type (R): (1 = responsibility land; 0 = private plots)	− 6.05*** (1.20)	− 0.09*** (0.02)	− 2.37*** (0.47)	− 2.87*** (0.57)
$R*D_{2008}$	4.53** (1.82)	0.07** (0.03)	1.78** (0.71)	2.15** (0.86)
Land quality-medium (P-QM) (medium = 1, otherwise = 0)	4.00*** (1.57)	0.06** (0.02)	1.57** (0.62)	1.90** (0.74)
Land quality-high (P-QH) (high = 1, otherwise = 0)	6.25*** (1.72)	0.09*** (0.02)	2.45*** (0.67)	2.97*** (0.82)
P-Irrigation (yes = 1; no = 0)	− 0.86 (1.65)	− 0.01 (0.02)	− 0.34 (0.65)	− 0.41 (0.78)
P-Plain (yes = 1; no = 0)	− 12.27*** (2.53)	− 0.18*** (0.04)	− 4.81*** (0.99)	− 5.82*** (1.20)
P-Distance (kilometers)	− 7.10*** (1.04)	− 0.10*** (0.01)	− 2.78*** (0.41)	− 3.37*** (0.49)
P-Area (hectare)	− 39.23*** (6.86)	− 0.57*** (0.10)	− 15.37*** (2.69)	− 18.61*** (3.25)
P-Crop1-grain (yes = 1; no = 0)	2.83 (1.79)	0.04 (0.03)	1.11 (0.7)	1.34 (0.85)
P-Crop2-cash (yes = 1; no = 0)	11.20*** (1.97)	0.16*** (0.03)	4.39*** (0.77)	5.31*** (0.93)
P-Crop3-others (yes = 1; no = 0)	− 9.93*** (3.12)	− 0.14*** (0.04)	− 3.89*** (1.22)	− 4.71*** (1.48)
Constant	13.59*** (0.30)			
Number of obs.	2191			
Number of groups	485			
Pseudo R^2	0.19			
LR chi^2	2233.83			
Prob > chi^2	0			

Note: All numbers in parentheses are robust standard errors. ***, **, * represent statistically significance at 1%, 5%, and 10%, respectively.

Table 5 presents the estimated results of the Tobit model. In general, after accounting for the zero values for organic fertilizer use, the results further confirmed the key findings in Table 4. As expected, the signs of the coefficients on land security variable and the interaction term between land type variable and the year dummy are the same as in the fixed effect model, although the sizes of the coefficients are different (see column 1 in Table 5). The estimation results for other control variables are also similar to that in Table 4.

More interestingly, estimations of the Tobit model provided not only the effect of land tenure policy on the amount of organic fertilizer used, but also information on the impact of land tenure policy on propensity to use organic fertilizer. First, farmers are more likely to apply organic fertilizer on their private plots than collectively controlled responsibility lands. On average, the difference in the probability of applying organic fertilizer between private plots and responsibility land was about 9% in 2000. However, stemming from a series of land tenure policy changes since 2000, this number fell by 2% (the sum of the estimated coefficients of land type R and the interaction term R*2008 in column 2 in Table 5). Second, given the fact that farmers applied organic fertilizer, they were likely to use about 2.87 ton per hectare more organic fertilizer on private plots than on responsibility lands in 2000 while in 2008, the difference decreased to 0.72 ton per hectare. These declines in differences in both propensity to use organic fertilizer and the amount of fertilizer used between private plots and responsibility lands suggest that land policy changes from 2000 has incentivized farmers to increase their land quality investments.

5. Conclusions and policy implications

In this paper, we examined the effect of land tenure polices changes since 2000 on the agricultural investment in China. These changes included the extension of rural land contract period, the restriction of land reallocation, the elimination of agricultural taxes, the introduction of agricultural subsidy, and rapid development of rural land rental markets. We argued that extending farmland contract period and restricting land reallocation may have reduced the degree of insecurity of collectively controlled responsibility land. The abolition of agricultural taxes along with the introduction of agricultural subsidy can strengthen income rights of responsibility land. The development of rural land rental markets has improved transfer rights of farmlands, especially the responsibility lands. Those policy changes would provide farmers with incentives to increase their long term investments on responsibility lands. Using organic fertilizer use as an indicator for land investment, our empirical results showed that the difference in organic fertilizer use between private plots and responsibility lands became smaller.

The above findings have helped to improve the understanding of China's land tenure policy reforms. Our findings suggested that recent rural land tenure changes in China have reduced the tenure insecurity of responsibility lands, and consequently influenced agricultural production decisions of farmers. If farmers are given more secure rights on responsibility land or their existing rights are enforced, they would be encouraged to increase their long term investments in collectively controlled lands. Thus, many policymakers and scholars in China have considered land entitling an attractive method for further securing the contractual rights of famers in order to promote the development of China's agriculture.

It is worth noting that this paper measured only the potential impact of land policy changes on agricultural investment. These policy changes, however, might also improve farmers' incentive to adopt new technology and thus be expected to improve productivity and output growth. On the other hand, the improved land tenure security may encourage part time farming (Ma, Heerink, Feng, & Shi, 2017), which imposes negative effects on agricultural productivity. Therefore, enhancing the security of responsibility lands would also have a dynamic impact on growth of agricultural productivity, which is not examined in this paper.

This study also suffers from a limitation. Organic fertilizer use may not be a perfect indicator for long term investment. It was selected to make our analysis compatible with previous studies, but we do recognize that organic fertilizer is not an important enough input in China's agricultural production. In addition, as labor costs in agricultural production increase, the actual use of organic fertilizer is gradually decreasing in rural China. While other capital-intensive investments, such as irrigation are not undertaken by individual farmers, finding a better measure for plot-specific long term investment will certainly deepen our understanding of the impact of contractual land security on long term investments. This is therefore left for future studies.

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