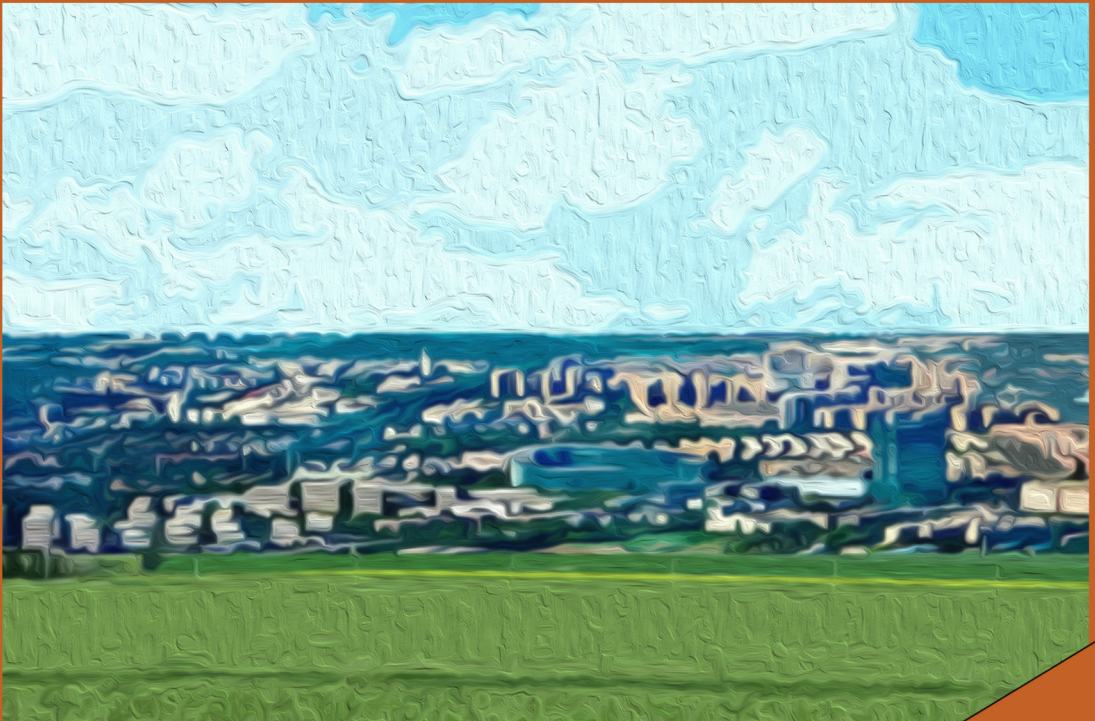


Arable Land Scarcity in China

-the Role of the Land Rental Market



>>>>>> 2024

Liang Tang

Propositions

1. Risk-averse farm households reduce fertilizer use with increasing farm size.
(this thesis)
2. Industrial agglomeration drives the expropriation of cultivated land.
(this thesis)
3. Climate change measures are most effective when they focus on innovators and early adopters.
4. Artificial intelligence in agriculture enhances yields and reduces pesticides applications.
5. It is better to adapt to viruses than to eradicate them.
6. Dialogue is the most cost-effective way to promote peace.

Arable Land Scarcity in China – the Role of the Land Rental Market

Liang Tang

Wageningen, 26 August 2024

Arable Land Scarcity in China – the Role of the Land Rental Market

Liang Tang

Thesis committee

Promotors

Prof. Dr N.B.M. Heerink
Personal chair, Development Economics Group
Wageningen University & Research

Dr J.H.M Peerlings
Associate professor, Agricultural Economics and Rural Policy Group
Wageningen University & Research

Co-promotor

Prof. Dr Xianlei Ma
Professor, College of Public Administration
Nanjing Agricultural University, Nanjing, P.R. China

Other members

Prof. Dr M.P.M Meuwissen, Wageningen University & Research
Prof. Dr T.J Herzfeld, Leibniz Institute of Agricultural Development in Transition Economies, Halle, Germany
Prof. X. Yu, Georg-August-Universität Göttingen, Germany
Dr X. Zhu, Wageningen University & Research

This research was conducted under the auspices of the Wageningen School of Social Sciences

Arable Land Scarcity in China – the Role of the Land Rental Market

Liang Tang

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Prof. Dr C. Kroeze,

in the presence of the

Thesis Committee appointed by the Academic Board

to be defended in public

on Monday 26 August 2024

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Liang Tang

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Chapter 1 General Introduction

1.1 Background and problem statement

Land resources are scarce, particularly in China. China struggles with the challenge of supporting 20% of the world's population with just 9% of its arable land (Wu *et al.*, 2018). It needs to feed a population exceeding 1.41 billion¹ with approximately 127.52 million hectares of arable land. This scarcity of land per capita stresses the importance of strict arable land protection, effective land governance, and advancements in agricultural technology to ensure national food security.

In China, state and collective ownership distinguish urban and rural land, respectively. China's rapid industrialization and urbanization have led to significant expropriation of cultivated land, raising concerns about land quantity and quality decline (Tang *et al.*, 2020; Xiao and Ning, 2013). To address this, the government has enforced the "balance between occupation and compensation of cultivated land" policy since 1997. This policy requires that any cultivated land lost to urban expansion be compensated by developing an equivalent quantity and quality of land, aiming for no net loss in arable land. Despite its positive effects in maintaining the quantity and quality of China's arable land, this policy faces challenges. These include regional reductions in the quantity and quality of arable land that affect the rural land rental market's development and diminish farmers' motivation to invest in land improvement (Gyourko *et al.*, 2022; Jacoby *et al.*, 2002).

Moreover, agricultural production in China has been dominated by smallholders since the implementation of the Household Responsibility System (HRS) in the late of 1970s. This involved dividing arable land of varying quality into smaller, evenly distributed plots among villagers to maintain fairness. However, this has led to the fragmentation of arable land to some extent (Tan *et al.*, 2006). For instance, in the provinces of Zhejiang, Hubei, and Yunnan, the average farm size is only 0.32 hectares, with an average of 6.66 plots (Jia and Petrick, 2014). Land fragmentation has a significant detrimental effect on productivity and efficiency (Cholo *et al.*, 2019; Rahman and Rahman, 2009; Tan *et al.*, 2010). Undoubtedly, developing

¹ <https://www.ceicdata.com/en/indicator/china/population>

the land rental market, promoting land transfer, achieving increased farm size, and improving agricultural production efficiency are inevitable choices for China.

Although private sale of farmland is prohibited in China, the exchange of user rights through land rentals is possible. The land rental market emerged in China's rural areas in the late 1990s and has been developing gradually since (He *et al.*, 2016; Wang *et al.*, 2015). The rate of cultivated land transfer increased from 4.6% in 2005 to 40% in 2021 (see Table 1.A1 in the Appendix 1 for details). The land rental market, increases farmers' incomes (Chen and Zhai, 2015), agricultural investments (Gao *et al.*, 2012), and productivity (Jin and Deininger, 2009), and promotes efficiency and equity (Tang *et al.*, 2019). It enables the reallocation of land from less to more efficient households, facilitating specialized and profitable farming practices (Chamberlin and Ricker-Gilbert, 2016; Jin and Deininger, 2009).

The reform of the land tenure system has promoted the development of China's rural land market. Following the disbandment of the People's Commune System in 1978, the early 1980s saw the introduction of the HRS, leading to a notable increase in agricultural output. Initially, the transfer of farmland was strictly restricted; however, this changed in 1984 when land leasing within villages was permitted. The late 1990s witnessed the gradual emergence and development of the land rental market, further bolstered by a comprehensive land registration initiative in 2010 that clarified rural land ownership. The 2014 "Three Rights Separation" (TRS) reform, which delineated the distinctions between ownership, contracting, and operational rights of rural land, has been instrumental in facilitating the transfer of operational rights and, consequently, in the rapid expansion of the land rental market. Further details on government efforts to enhance the rural land rental market are in Table 1.1 and Table 1.A1.

Despite the fact that data from the Ministry of Agriculture and Rural Affairs (2021) suggests that the rate of arable land transfer was around 40% by the end of 2021, the rural land rental market is far from mature. Farmland rentals are still largely informal as Zhou *et al.* (2019) shows using 2015 field survey data. Moreover, a large proportion of the arable land rents are below the average formal market price, and a majority of the rental contracts are either short-term or open-ended. Therefore, the land rental market requires further research on its functionality in adjusting land transfer contract choices and regulating rental levels, in order to incentivize large-scale operations and improve agricultural production efficiency.

Table 1.1 Developments on land market

Year	Policies/Regulations/Laws	land property rights and land transfer
1949	Constitution Law	Socialist public ownership of land. Laws prohibit the sale or lease of land.
1978	Reform and Opening Up Household Responsibility System (HRS)	Collective ownership of rural land allows farmers to contract management but not buy, sell or rent land.
1986	Land Administration Law of China	The first officially promulgated land management law in China. It regulates many aspects of land ownership, land use, and land acquisition. This law has been revised four times, with the most recent revision being completed in 2019.
2002	Rural Land Contract Law of the People's Republic of China	Preserve farmers' land contracting rights and allows voluntary land transfer with compensation.
2018	Revised Land Contract Law of the People's Republic of China	The "three rights separation" further clarifies that rural land is collectively owned, and households enjoy contracting and management rights. Additionally, farmers are encouraged to transfer the management rights of their land.

Facing the challenge of limited arable land to support its large population, China intensified its land use, increasing grain production from 300 million tons in 1978 to 617 million tons in 2020 (NBS, 2020). This growth was achieved alongside significant increases in the use of nitrogen, phosphorus, potassium, and compound fertilizers (NBS, 2020). As a result, China has become the world's largest consumer of agricultural chemicals, accounting for over 30% of the global consumption of fertilizers and pesticides (Wu *et al.*, 2018). Data from the National Agricultural Cost Benefit Data Compilation (NACB, 2021) shows a continued rise in fertilizer use in cereal production, risking overuse and decreasing nutrient use efficiency (Liao *et al.*, 2023), highlighting the ongoing struggle to balance food security with sustainable agricultural practices amidst environmental concerns.

In summary, in light of China's low per capita land ratio and the imperative of achieving food self-sufficiency, the country faces significant challenges related to arable land scarcity. This scarcity manifests in three primary ways: **the limited availability of arable land, the efficiency of its use, and the intensity of its cultivation**. Addressing the pressing issue of land scarcity requires a multifaceted approach. Firstly, reducing the conversion of rural land to urban areas can help alleviate the pressure on available arable land. Secondly, enhancing the efficiency with which arable land is used is crucial. One effective strategy to achieve this is by improving the functionality of the land rental market, thereby optimizing land utilization. Thirdly, the intensive use of arable land, particularly the excessive application of fertilizers, poses a significant environmental and sustainability challenge. Figure 1.1 provides an overall framework of the macro (the local governments) and micro (the households) joint analysis in

this thesis, where land rental is related to production efficiency, and agrochemical use is related to input use intensity.

The current thesis aims to shed light on strategies for addressing the scarcity of arable land resources and reducing its pressure on sustainable agricultural production. It commences with an analysis of macroeconomic data to explore key factors influencing the rural-urban conversion of agricultural land in China, including industrial agglomeration, population concentration, and fiscal deficits. The phenomenon of land finance is widely recognized in China, where revenue from land leasing constitutes a significant portion of local governments' off-budget income (Liu *et al.*, 2023). This revenue is crucial for alleviating local fiscal deficits and serves as a primary motivation for local governments to expropriate and lease land (Shu *et al.*, 2018). This characteristic offers valuable insights for other developing countries with lower urbanization rates.

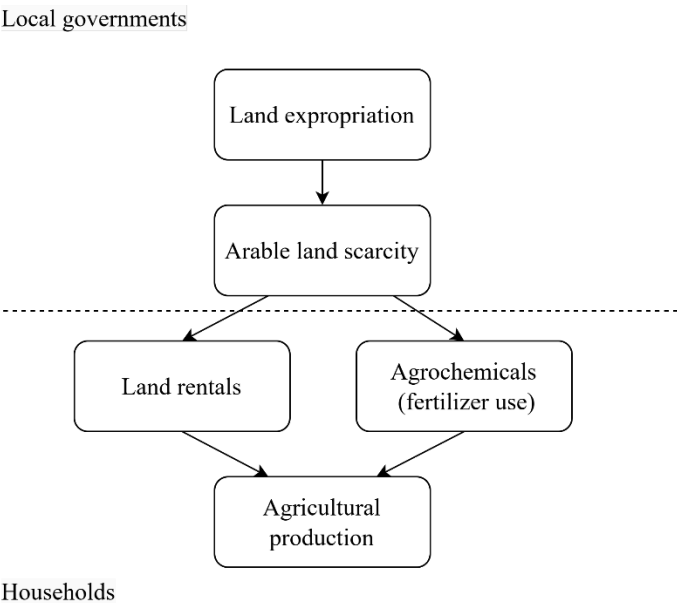


Figure 1.1 The overall framework of the macro and micro joint analysis in this thesis

Subsequent chapters focus on the role of smallholder farmers' participation in land transfers within networks of acquaintances in enhancing the functionality of the land rental market and promoting sustainable agricultural production. It is posited that a well-functioning land rental market, characterized by long-term leases at fixed rental rates, encourages sustainable investment by incoming farmers. Lastly, building on the foundation of an improved land rental market, this study further investigates the impact of farmers' participation in the land rental market and their risk preferences on the intensity of land use, using the use of fertilizer as an indicator.

In the following sections, I provide a general research objective of this thesis. I will also formulate and specify research questions based on the aforementioned issues. Additionally, I will outline the methods and datasets utilized to address these questions.

1.2 Objective and research questions

Given the previous, the general objective of the thesis is to support the development of strategies for managing scarce arable land resources and promoting sustainable agriculture by analyzing the rural-urban land conversion in China, understanding the dynamics of the land rental market, and obtaining deeper insights into the functioning, driving forces and environmental effects of the land rental market in rural China. Figure 1.2 shows the framework of this thesis. To reach this objective four research questions will be answered.

- (1) How are industrial and population agglomeration affecting the expropriation of cultivated land in China, and what role do government fiscal deficits play during the land expropriation process?
- (2) What is the relationship between land tenure security, social relations and contract choice in rural land rentals?
- (3) What is the impact of social relations and public interventions on the land rent deviation in China's rural land rental market?

(4) To what extent and how does land renting-in and individual risk preferences impact fertilizer use?

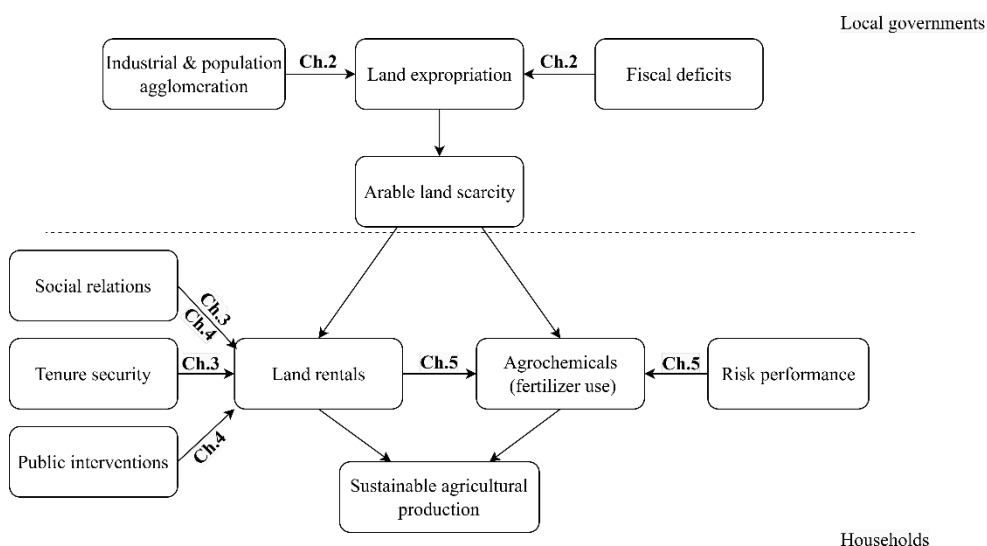


Figure 1.2 Conceptual framework of this thesis

1.3 Conceptual framework

Enhancing agricultural productivity emerges as a pivotal strategy for reinforcing national food security in the context of limited arable land resources. The extent to which agricultural productivity can be increased is determined by the **availability, efficiency, and intensity of arable land utilization**. Firstly, the conversion of rural land to urban areas has led to a reduction in the availability of regional arable land, especially as urban expansion encroaches upon highly fertile lands. The process of industrial and population agglomeration requires expansive spaces for production and living, leading to competition with the preservation of arable lands, exacerbating scarcity. Local governmental strategies aimed at fiscal alleviation through the relaxation of land protection policies further escalate the expropriation of arable land. Therefore, these issues require analysis at the level of local government. The theoretical underpinnings of agglomeration economies, public finance, and public land monopoly provide a robust framework for dissecting these dynamics and offer empirical insights that could guide effective policy interventions (Chapter 2).

Secondly, land use efficiency has been affected by land fragmentation and insecure property rights of land, hindering the transfer of arable land, thereby suppressing the improvement of agricultural productivity. The development of the land rental market is the main way to circumvent these obstacles and thus enhance agricultural productivity. Land rental issues require analysis at the farm household level because households are the relevant decision-makers. Existing research on the functioning of the land rental market is still insufficient, especially under the high dependency on informal social relations in rural areas, which affects the development and functioning of the land rental market. The complex social relationship and the pursuit of property rights security pose significant challenges to optimizing land transfer, contractual arrangements, and rent levels in this context. By applying theories such as the principal-agent theory, which examines relationships between delegators and those acting on their behalf, and transaction cost theory, which looks at the costs related to conducting transactions, both derived from the field of new institutional economics, this study seeks to uncover the interplay between social connections, the assurance of land tenure rights, and the selection of contracts. The research also aims to evaluate the capacity for government intervention to mitigate differences between actual and shadow rents, thereby enhancing overall market efficiency. The measurement of the shadow rents is based on micro-economic theory.

Thirdly, enhancing land use intensity is a necessary choice for improving agricultural productivity. However, the excessive use of agrochemicals not only reduces agricultural productivity but also pollutes the agricultural environment. Participation in the land rental market, along with addressing farmers' risk preferences, may encourage farmers to improve their cultivation methods. This, in turn, can mitigate the overuse of agricultural chemicals and promote sustainable agricultural practices. Farmers' risk preferences include two aspects: their general risk aversion and their decision-making preference for coping with external natural shocks such as rainfall. Conducting critical research on how participation in the land rental market and risk preferences affect the application of fertilizers by households cannot only enrich the discourse on sustainably enhancing land use intensity to improve agricultural productivity but also provide references for policymakers. Theories and approaches from (agricultural) production economics are needed to analyze these production decisions.

1.4 Methodology

1.4.1 Study area, sampling, and data collection

The empirical analysis of the thesis is based on data from both macro (the local governments) and micro (households) dimensions. The macro data consists of provincial-level balanced panel data compiled by the author from different yearbooks, while the micro data comes from two waves of field surveys in three provinces of China. The data used in Chapter 2 is derived from provincial and prefectural-level data published in various Chinese statistical yearbooks. The data sample includes 29 provinces (autonomous regions, municipalities) of P.R. China from 2007 to 2021, excluding Shanghai, Tibet, Hong Kong, and Macao due to missing core variable data.

The data used in Chapters 3, 4, and 5 were collected from a household survey conducted in the Jiangsu, Jiangxi, and Liaoning provinces in 2014/2015 for the year 2014, and in January 2019 for 2018. Jiangsu Province, which is located in the Jianghuai Plain in eastern China; Jiangxi Province, situated in the Poyang Lake plain in central-south China; and Liaoning Province, found in the Songnen Plain in northeast China, were selected to reflect geographical and economic diversity (see Figure 1.3 for their locations). These three provinces are significant bases for commercial grain production in China. The main information collected in this data set includes household location information, assets, and very detailed agricultural input and output information. Other information such as risk preferences of the respondent was also obtained in the survey.

This survey used a multistage sampling procedure to select sample households for the first survey in 2014/2015. China has four levels of administrative regions: provincial, county, township, and village. The survey was designed by selecting six counties based on the size of the county (two from each province), with four to seven townships chosen per county. Then, a certain number of villages were randomly selected from each township. In the final step, 20-40 households were randomly chosen in each village, resulting in a total of 95 villages and a sample size of 2,538 households. In the second survey in January 2019 obtaining 2018 data, 12 households from each village's 2014/2015 household sample list were randomly selected.

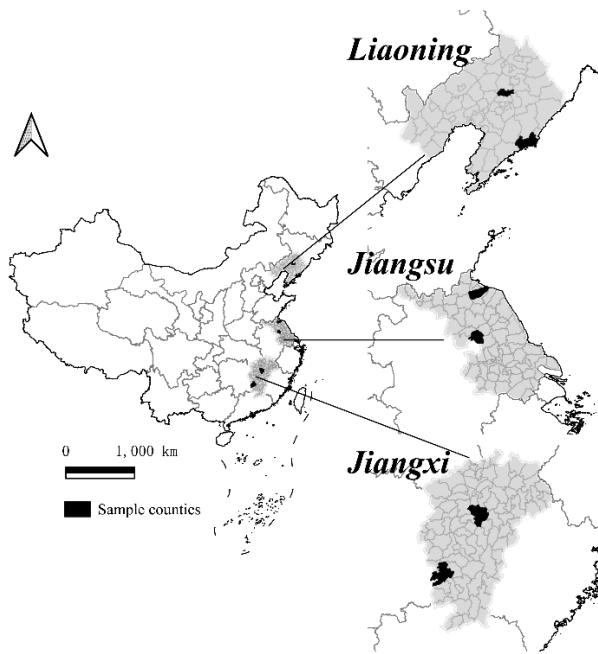


Figure 1.3 Locations of the Liaoning, Jiangsu, and Jiangxi provinces

In Chapters 3 to 5 I used different subsamples from the established dataset. This was necessary due to discrepancies arising from adjustments made to the questionnaire during the survey implementation in Jiangxi and Liaoning in 2015, following the initial implementation in Jiangsu Province in 2014. The introduction of new questions and adjustments to existing ones led to inconsistencies in the definition of some of the variables. Consequently, the data from Jiangsu, Jiangxi, and Liaoning became partially non-comparable, highlighting the imperative need to draw on distinct subsamples to ensure reliable and consistent analyses in the subsequent chapters.

1.4.2 Empirical strategies

To answer the research questions state-of-the-art econometric models are employed in this thesis. These are discussed next for each research question separately.

In Chapter 2, I will estimate the impact of a variety of economic and urban infrastructure indicators of cities, industrial and population agglomeration and fiscal deficits on cultivated land expropriation by cities. Specifically, I emphasize the characteristics of industrial and population agglomeration using industrial value added and urban population density as proxies, respectively (McCann, 2013; Paul and Siegel, 1999; Peng *et al.*, 2022). I adopt the ratio of government fiscal deficits to general public budget revenue as an indicator of local government fiscal pressure. A two-way fixed effects model based on panel data will be employed for the empirical analysis to account for city-specific characteristics. This approach can capture unobserved heterogeneities and provide more accurate estimates of the model parameters (Wooldridge, 2021).

In Chapter 3, first, I assume that the relationship between landlords and tenants is characterized by endogenous matching. When a potential landlord decides to rent out his land, he has to decide whom he wants as a tenant and between a fixed rent contract and an interlinked land-labour contract. Then, a landlord has to make a joint decision about the tenant and contract type. Next, I hypothesize that partner choice will be less important for formal contracts since legal rather than informal rules mostly enforce these. Finally, household-level data will be used to test these hypotheses econometrically. The empirical analysis will utilize a nested logit model recommended by Macours (2014) for modelling the key features of joint decisions made by landlords.

In Chapter 4, I will quantify and explain the ratio between the actual land value for a farmer (*i.e.*, shadow rent) and the land rent he or she actually pays. It is hypothesized that this ratio will be close to one in the case of a formal well-functioning land rental market. I first derive the household-level land shadow rent or the value of the marginal product of land using a production function and assuming profit maximization (Abdulai and Tietje, 2007). Next, the ratio of the rent paid to the shadow rent is determined. Finally, I use household-level data to empirically analyse the impacts of social relations between rental partners and public interventions imposed by local governments or village collectives on the ratio and discuss efficiency and equity impacts. The Tobit model will be used for the empirical analysis.

In Chapter 5, I will derive a measure of fertilizer overuse/underuse. For this grain production functions will be estimated. Next, assuming profit maximization the shadow price of fertilizer

use will be determined. The difference between this shadow price and actual fertilizer price is an indicator of fertilizer overuse or underuse. The difference will be explained by means of a regression. One of the variables to be included is the share of land rented-in by households as an indicator of their participation in the rural land rental market. Risk preferences are measured using a general risk response category/dummy variable. Natural risks (shocks) are captured by rainfall levels and the deviation from the average rainfall over a 5-year period. Ordinary least squares (OLS) regression was employed for the empirical analysis.

Each of the research questions will be answered in a separate chapter (2-5). The final chapter concludes and provides a general discussion.

Appendix 1

Table 1.A1 “No.1 document” (2005-2023): changes in land transfer rate and policy guidance of rural land management

Year	land property rights	land transfer	Land transfer rate
2005	Conscientiously implement rural land contract policy and properly handle land contract disputes.	Legally develop, legally carry out land transfer and develop moderate-scale operation based on farmer's voluntary and providing reasonable compensation.	4.6%
2006	Protect farmers' land contractual right and management right	Improve the land transfer mechanism and develop various forms of moderate-scale operation in appropriate places.	4.6%
2007	Persist in the basic rural management system and stabilize land contractual relationship.	Regulate land transfer and encourage appropriately contiguous planting in appropriate conditions.	5.2%
2008	Stabilize and improve the basic rural management system and stabilize the contractual relationship of rural land. Strictly implement the legal provisions of not adjusting land and forbidding to retract farmers' contracted land during contractual period.	Improve land rental market according to the principle voluntary and compensable legal principles. Cultivate and develop the market environment, allowing various moderate-scale operation forms.	8.8%
2009	Endow farmers with more sufficient and guaranteed land contractual management rights, keep the existing land contract relationship stable and unchanged for long term, and promote land titling, registration and certification.	Develop various forms of moderate-scale operation. Develop large-scale business entities such as leading specialized famers, family farms and farmers' cooperatives in appropriate places.	12.1%
2010	Improve the rural land contractual laws and policies, keep the existing land contract relationship stable and long-term unchanged. Fully implement policies to ensure that land entities (plots and areas) are distributed to households, and that relevant contracts and certificates are issued to the households.	Improve the land rental market, develop various forms of moderate-scale management under the legalization voluntary and compensable legal principles, and improve the organization degree of agricultural production and management.	14.7%
2012	Speed up to revise and improve relevant laws and implement the policy of keeping the existing land contract relationship stable and in the long-term unchanged.	Guide the transfer of land management rights, develop various forms of moderate-scale operation, promote the innovation of agricultural production and management modes, cultivate and support the new social organization of agricultural service.	21.2%
2013	Keep the existing land contract relationship stable and long-term unchanged, improve the relevant legal system and complete titling, registration and certification work of rural contracted management rights within 5 years.	Guide land transfer orderly, encourage and support the contracted land transferring to leading specialized famers, family farms and farmers' cooperatives and develop various forms of moderate-scale management to solve the fragmentation problem of contracted land.	25.7%
2014	Endow farmers with more property rights. Stabilize farmers' contractual rights, liberalize land management rights and allow land management rights to be mortgaged to financial institutions	Develop various forms of scale management, support and develop new agricultural business entities and improve the social system of agricultural service.	30.4%
2015	Persist in and improve the basic rural management system and persist in the main dominant position of farmers' family management.	Innovate the modes of land transfer and scale management, actively develop various forms of moderate-scale operation and improve the organizational degree of farmers.	33.3%
2016	Stabilize the contractual relationship of rural land, implement collective ownership, stabilize farmers' contractual rights, liberalize land management rights and improve the “three rights separation”	Actively cultivate new agricultural business entities, guide farmers farming conjoint lots, encourage farmers to join the stock cooperative with land management rights. Support professional scale service, such as	35.1%

Year	land property rights	land transfer	Land transfer rate
	approach.	helping to cultivate, tillage and cultivation collaborate and land trusts, etc.	
2017	Implement "three rights separation" approach of rural land collective ownership, farmers' contractual rights and land management rights. Accelerate the registration and certification of rural contracted land.	Accelerate and develop various forms of scale management, such as modes like land transferring and service driven and so on.	36.9%
2018	Improve the system of "three rights separation" for contracted rural land, which entails legally protecting the collective land ownership and farmers' contractual rights, while equally safeguarding the right to land operation.	Rural land rights can be used as collateral for financing and equity participation in agriculture. Foster new agricultural entities like family farms, cooperatives, enterprises, and service organizations to promote diverse moderate-scale operations.	-
2019	Maintain the stability and long-term continuity of rural land contracting relationships. Improve the implementation of laws, regulations, and policy systems that ensure collective ownership, stable farmers' contractual rights, and flexible land operation rights.	Establish a sound system for regulating land circulation and management, promote various forms of moderate-scale agricultural operations, and allow the use of contracted land operating rights as collateral for financing.	37%
2020	Improve the basic rural operating system, initiate the second round of land contracting, and extend it by another 30 years after the expiration period as a pilot project. Based on the pilot project, research and formulate specific methods for contract extension.	Encourage the development of various forms of moderate-scale operations and improve the agricultural socialized service system targeting small farmers.	-
2021	Adhere to the collective ownership of rural land by farmers and the fundamental status of household contract management. Maintain the stability and long-term unchanged nature of rural land contract relationships.	Improve the land management right transfer service system.	40%
2022	Conduct a second round of pilot programs for extending the land contract period by 30 years after expiration at the county level.	Initiate a pilot program for the standardized development of rural property transfer and trading markets.	-
2023	Research and formulate guidelines for the second round of pilot programs for extending the land contract period by 30 years after expiration.	Safeguard the legitimate land rights and interests of rural migrant workers who settle down in cities, and encourage them to voluntarily and legally transfer their land use rights for compensation.	-

Note: The policy compilation data from 2005 to 2017 comes from Table 2 in Luo (2018), while the data from 2018 to 2023 is compiled by the author. The land transfer rate is calculated by the author based on the total cultivated land area and the total area of transferred cultivated land from "China Agricultural Statistical Data" (2011-2017). Data for other years' land transfer rates comes from government reports of different years.

Chapter 2 Cultivated land expropriation in China — the roles of agglomeration and government fiscal deficits²

Abstract: Land occupation for construction has become the primary driving force behind the reduction of cultivated land in rural areas of China during the rapid industrialization and urbanization stage, leading to a decline in both the quantity and quality of the country's cultivated land. This study utilizes provincial data from the period 2006-2021 to investigate the impact of (industrial and population) agglomeration and local government fiscal deficits on cultivated land expropriation in China. The findings reveal that industrial agglomeration has a significant and positive impact on the expropriation of cultivated land. Although population agglomeration does not directly affect the rate of cultivated land expropriation, it significantly increases the ratio of cultivated land being converted into residential land. The local fiscal deficits (primarily at the provincial level) significantly increase the cultivated land expropriation rate.

Keywords: Industrial agglomeration; population agglomeration; fiscal deficits; cultivated land; China

² This chapter has been submitted to an international scientific journal.

2.1. Introduction

Urbanization is a common feature of economic development, which is experienced or will be experienced by most parts of the world (Deng *et al.*, 2010). Almost by definition urbanization leads to an increase in urban land use. This increase is primarily driven by agglomeration economies, which are external economies of scale resulting from the clustering of firms and production factors. A study by Gao and O'Neill (2020) shows that in the 21st century urban land is expected to increase by a factor 1.8-5.9 worldwide. This generally implies that a large amount of agricultural land (*i.e.* crop, pasture and forest land) and land occupied by homesteads will be converted to urban land. Land conversion is not only the result of economic growth but also acts as one of its driving forces (Ding and Lichtenberg, 2011; He *et al.*, 2014).

Cultivated land is a crucial production factor required for sustainable agricultural development and national food security (Chen *et al.*, 2022). Many developed and developing countries, have therefore implemented policies to protect the quantity and quality of cultivated land. In China specifically, a number of regulations have significantly contributed to cultivated land protection (Liu *et al.*, 2023; Tang *et al.*, 2021). However, despite the "no reduction" rule for total cultivated land (Ho and Lin, 2003), there has been an overall decline in the amount of cultivated land by 8.47 million hectares from 1989 to 2021 (MLR, 2000-2018; MNR, 2019-2022; Qu *et al.*, 2011). To mitigate this decline, policies were introduced to maintain a sustainable and stable level of cultivated land in the long run.

Apart from the threat to the quantity of cultivated land, there is the problem of diminished land quality that arises from land expropriation. For instance, land taken into cultivation in China to compensate for the loss cultivated land due to urban expansion is generally two to three grades out of 15 lower in quality than expropriated cultivated land, and is mostly located in areas with poor infrastructure and irrigation systems (Tang *et al.*, 2020; Xiao and Ning, 2013). Acquiring cultivated land also diminishes farmers' incentives to invest in their remaining fields when they fear further expropriations, further jeopardizing overall land quality (Gyourko *et al.*, 2022; Jacoby *et al.*, 2002).

The conversion of cultivated land into urban land primarily occurs through the expropriation of cultivated land. When governments sell the converted cultivated land to urban users for residential, commercial, or industrial purposes, they generate revenue in the short run and in the long run. This revenue can be substantial and has become known as ‘land finance’ in China. When faced with fiscal deficits, local governments need this revenue to fund various public projects and services such as infrastructure, education facilities, and health care (Shu *et al.*, 2018; Wu and Heerink, 2016).

Previous studies have explored various perspectives regarding issues associated with cultivated land expropriation, such as conflicts and investment (Jacoby *et al.*, 2002; Lin *et al.*, 2018; Wu and Heerink, 2016), violence (Sargeson, 2013), livelihoods and welfare of displaced farmers and national food security (Chen *et al.*, 2022; Liu *et al.*, 2023; McCarthy *et al.*, 2012; Qu *et al.*, 2018; Wang *et al.*, 2020; Xie, 2019), and negative environmental impacts (Kusiluka *et al.*, 2011). The causes of cultivated land expropriation, particularly agglomeration and fiscal incentives, have received less attention so far. Insights into these causes and the underlying mechanisms can provide useful inputs into central and local government policies aimed at promoting balanced economic development and securing national-level food security.

This paper therefore aims to investigate the impact of agglomeration and local government fiscal deficits on the expropriation of cultivated land in China. To reach this aim, an empirical analysis is conducted using a panel data set for 29 provinces covering the period 2006 to 2021. This study has two main contributions to the available literature. First, it examines the impact of agglomeration on cultivated land expropriation and thereby distinguishes between industrial and population agglomeration and between the expropriation of cultivated land for residential purposes. Second, it examines the mechanisms through which local government fiscal deficits affect land expropriation and further reveals the impact of government fiscal deficits at different times as well as the influence of provincial-level and prefecture-level city fiscal deficits on land expropriation.

The remainder of this chapter is organized as follows. Section 2.2 provides background information on the pressure that cultivated land protection faces in China. Section 2.3 presents a theoretical framework for the analysis. Section 2.4 outlines the data set and

variable definitions, while Section 2.5 describes the econometric models used for estimation of the relationships. The results of the analysis and discussion are presented in Section 2.6, and Section 2.7 presents the conclusion and general discussion.

2.2. Background

The Land Administration Law, initially enacted in 1986, is the primary legal instrument governing land use in China. Through multiple revisions, this law has gradually enhanced its provisions addressing issues such as protecting cultivated land, regulating land expropriation, and monitoring illegal land use, to meet the demands of socio-economic development (Wu and Heerink, 2016). In addition, given the pivotal role of protecting cultivated land in ensuring national food security, the "Regulation on the Protection of Basic Cultivated Land", was enacted in 1998. This regulation emphasizes the preservation of both the quantity and quality of basic cultivated land and outlines the conditions under which conversions of such land are permissible (Ding, 2003; Liu *et al.*, 2023).

Changes in cultivated land area, 1989-2021

When urban expansion takes up cultivated land, the occupied land must be compensated elsewhere within the same province (or other provinces) through reclamation and opening up of wasteland (Fischer *et al.*, 2007), while ensuring the quality and quantity of cultivated land (Chen *et al.*, 2022; Gao *et al.*, 2014a). This approach is known as the "balance between the occupation and compensation of cultivated land" (1997), which is aimed at achieving a sustainable and stable level of cultivated land over time. The ultimate goal of this policy is to ensure that China has enough cultivated land to meet the needs of its growing population and food demands, while also safeguarding the environment and promoting sustainable land use practices. Moreover, in 2006, China has set the "Red Line" of 120 million hectares of cultivated land as a fundamental national policy to further protect the quantity of cultivated land (Huang and Yang, 2017; Zhou *et al.*, 2021). Despite this, China's cultivated land area is decreasing (see Table 2.1 for details). Moreover, as mentioned in the Introduction, the quality of the newly acquired land is in practice mostly lower than the land taken out of agricultural production.

China has conducted three national land surveys during the periods 1984-1997, 2007-2009, and 2017-2019. These surveys indicate that China's cultivated land area was 130.04 million hectares, 135.27 million hectares, and 127.44 million hectares in 1998, 2010, and 2020 respectively. Changes in measurement methods used for these surveys have caused unrealistically large changes in the total amount of cultivated land recorded in the years when the method changed, and make it problematic to compare their results (Qu *et al.*, 2011). The most recent data from 2021 indicates that the total area of cultivated land is 127.52 million hectares.

Table 2.1 presents statistics compiled by the Ministry of Natural Resources of the People's Republic of China (MNR, 2019-2022) (Formerly Ministry of Land and Resources of China, herein and hereafter referred to as MLR) (2005–2018) on the four main factors contributing to the changes in cultivated land area in China between 1989 and 2021. On average, 0.68 million hectares of cultivated land were taken out of cultivation annually, while 0.41 million hectares were brought into cultivation, resulting in a net decline of 0.26 million hectares per year. Land expansion for construction was a significant and relatively stable factor throughout the entire period, accounting for an average of 0.22 million hectares of land taken out of cultivation per year. There was a notable acceleration in land taken out of cultivation from 2000 to 2008, reaching 1.27 million hectares per year. As noted by, for example, Tan *et al.* (2007) and Qu *et al.* (2011), the increase during this period was primarily driven by ecological restoration programs (0.72 million hectares per year) and agricultural structural adjustment (0.30 million hectares per year). From 2010 to 2017, the average annual rate of land taken out of cultivation declined to 0.37 million hectares annually. Land used for construction purposes was responsible for the largest share of this decline, *i.e.*, 80%. During the same period, 0.30 million hectares of land was on average taken into cultivation each year, resulting in a net annual loss of 0.06 million hectares. From 2018 to 2021, the area of cultivated land occupied for construction purpose was 0.52 million hectares, and compensation was made through the "no reduction" policy. However, data on the reduction of cultivated land due to ecological restoration, destruction by natural disasters, and agricultural structural adjustment is missing. Therefore, the net decrease in cultivated land area for this period is reported as zero.

Table 2.1 Changes in cultivated land area, 1989-2021 (million hectares)

	1989- 1999	2000- 2008	2010- 2017	2018- 2021 ^a	Entire period
Land taken into cultivation	6.20	3.99	2.43	0.52	13.14
Land taken out of cultivation:	6.69	11.47	2.93	0.52	21.61
Construction	2.14	1.90	2.35	0.52	6.91
Ecological restoration	2.53	6.51	0.13	-	9.17
Destroyed by natural disasters	1.19	0.39	0.11	-	1.69
Agricultural structural adjustment	0.83	2.67	0.34	-	3.84
Net land taken out of cultivation	0.49	7.48	0.50	0.0	8.47

Source: Based on Qu *et al.* (2011) and MLR (2007-2018). For definitions of the type of land taken out of cultivation, see Table 2.A1.

^a: The data from 2018 to 2021 are sourced from the China Natural Resources Statistical Yearbook (MNR, 2019-2022). This yearbook exclusively accounts for the information on the occupation and compensation of cultivated land for construction purposes, and does not include statistics on other forms of cultivated land occupation. Consequently, there is a lack of data pertaining to ecological restoration, destruction by natural disasters, and agricultural structural adjustment.

Cultivated land expropriation since 2004

The average annual land expropriation from 2004 to 2021 in China was 0.36 million hectares, with cultivated land accounting for 48.1% of the expropriated land, averaging around 0.17 million hectares per year (MLR, 2005-2018; MNR, 2019-2022). As indicated in Figure 2, the total expropriated area increased after 2004 and reached its peak in 2011 and 2012, with a total expropriated area of 0.56 and 0.50 million hectares respectively. This peak was likely driven by China's economic growth demands after the global financial crisis of 2007-2009, which was considered by leading economists as the most severe financial crisis since the Great Depression (Yuan *et al.*, 2010). China was significantly affected by this crisis, prompting the government to implement an economic stimulus package called the "4-Trillion-Yuan Stimulus Plan". Its implementation greatly boosted urban economic development, leading to increased demand for urban housing, industry, infrastructure, and so on. After 2011-2012, the land expropriation area gradually decreased each year. By 2019, the newly acquired cultivated land area was about half of what it was in 2011. However, this trend rises slightly in 2020 and falls back in 2021. The trend in cultivated land expropriation during the period 2004-2021 mirrored that in the total expropriated area, as depicted in Figure 2.1. Its share fluctuated around 50% throughout the entire period.

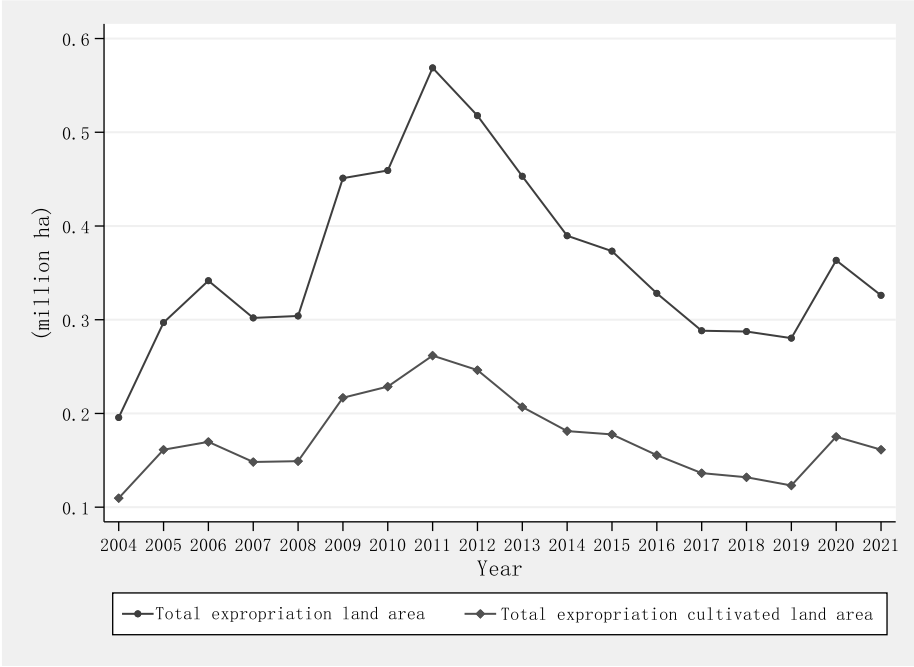


Figure 2.1 Expropriation of (cultivated) land, 2004-2021
Source: Calculated from MLR (2005-2018) and MNR (2019-2022)

2.3. Theory

Agglomeration implies lower production costs when firms cluster. There are three sources of agglomeration (McCann, 2013). First, knowledge spillover effects (*e.g.*, Peng *et al.*, 2022) emphasize that proximity maximizes the mutual accessibility of all individuals/firms within the cluster, thereby enhancing the availability of knowledge and information to all local participants. Second, presence of local non-traded inputs, such as specialized legal and software firms and banks whose role it is to provide specialist information or services, and local infrastructure, *e.g.*, roads or a wide-band fibre-optic cable system. The more firms join the cluster the lower the costs of the non-traded local inputs. Third, presence of a local skilled labor pool (*e.g.*, Carbonaro *et al.*, 2018; Tilley *et al.*, 2023). If firms require specialist labor, the existence of a specialized local labor pool is advantageous because it reduces labor acquisition costs, leading to lower wages and training costs.

This study focuses on industrial agglomeration and population agglomeration. The relationships between both types of agglomeration and the demand for cultivated land are

schematically illustrated in Figure 2.2. When industrial agglomeration occurs in a region, it tends to attract more population. Consequently, commercial activities flourish. Therefore, industrial agglomeration not only increases the demand for new industrial land but also has spillover effects on the land demand for commercial and residential purposes. This motivates local governments to acquire cultivated land and transfer it to private and public enterprises for different construction purposes.

Besides firms, people also tend to cluster in cities. There are two possible explanations for this. First, the creative class hypothesis. Places that are tolerant of cultural diversity and cultural differences are environments which are ideally suited for fostering unconventional approaches to the development of novel ideas, systems, products or services. The influx of creative people reinforces this. This hypothesis has been criticized but the effect of highly educated and creative people on economic growth is not (Besley *et al.*, 2011; Gyimah-Brempong *et al.*, 2006). Second, the consumer city hypothesis. High-skilled and high-income people will increasingly migrate towards cities offering high-quality amenities, such as opera houses, museums, etc. (Florida *et al.*, 2023). Besides these two explanations it is of course the employment opportunities and the availability of services (*e.g.*, health services, shops, schools and universities) in cities that attract people.

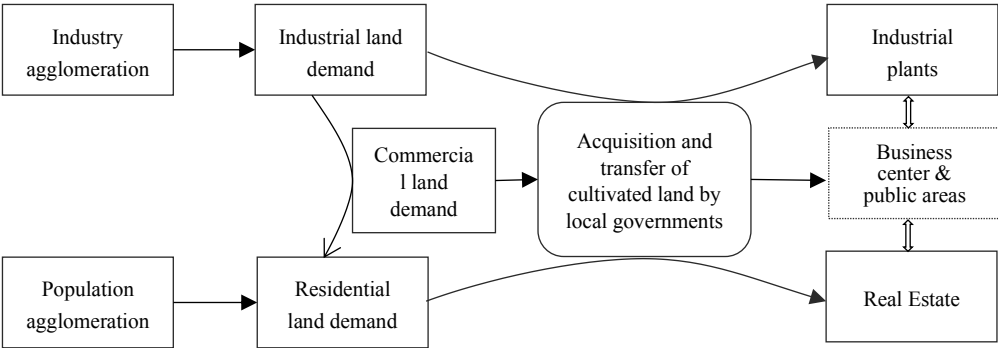


Figure 2.2 Relationship between agglomeration and demand for cultivated land

In China only the government can legally acquire cultivated land (*e.g.*, Tan *et al.*, 2009). Local governments have two main motives for acquiring land. First, the previously mentioned agglomeration requires cultivated land for industry location, housing and the other services for the population (recreational, health, etc.). Second, the financial pressures faced

by local governments while undertaking social responsibilities such as urban infrastructure construction and healthcare provision stimulates the use of ‘land finance’ as a complementary source of revenues (Cao *et al.*, 2008; Tan *et al.*, 2011). Local governments can alleviate the financial burden by selling expropriated cultivated land in the urban residential land market at higher price, while selling it in the industrial land market at lower prices. Additionally, they can generate tax income from these enterprises at a later stage (*e.g.*, Wu and Heerink, 2016). Given their monopoly position, governments are able to acquire land at artificially low prices set by them (Liu *et al.*, 2018; Tan *et al.*, 2011). This way, land finance has become one of the most effective approaches to address local government fiscal deficits, as it constitutes the largest and most easily controllable portion of fiscal income (Shu *et al.*, 2018). Other sources, such as central government contributions and land taxes, often experience delays (Fan *et al.*, 2020).

2.4. Data set and variable definitions

2.4.1 Data set

The data on the expropriation of cultivated land for the 2006–2021 period was obtained from the China Land and Resources Statistical Yearbook (MLR, 2007-2018) and the China Natural Resources Statistical Yearbook (MNR, 2019-2022). The data for the total urban construction land area originates from the China Urban Construction Statistical Yearbook (MHURD, 2007-2022). Data were available for 29 provinces. Shanghai, Hong Kong, Macao and Tibet were excluded because of missing data. The data used for the core independent variables and control variables originate from the China Statistical Yearbooks (NBS, 2007-2022), the Finance Yearbook of China (2007-2022), and other relevant yearbooks. The exact definitions and data sources of the variables are listed in Table 2.2. Descriptive statistics are provided in Table 2.3.

2.4.2 Variable definitions

Dependent variables

The core dependent variable in this study is the expropriation of cultivated land. To account

for variations in urban land shares across provinces, we utilize two ratios as dependent variables: (1) the ratio of expropriated cultivated land to the total area of urban construction land; and (2) the ratio of expropriated cultivated land for residential purposes to the total area of urban construction land.

Core explanatory variables

Industrial value-added. We selected the industrial value-added as the indicator of industrial agglomeration given its availability on provincial level. A higher industrial value-added not only indicates a greater level of industrial activity but it also shows the potential for increased industrial concentration given that a high level of industrial activity attracts further industrial settlement. Hence, the demand for land is expected to be larger in regions with a high industrial value-added.

Urban population density is used as a measure of population agglomeration (McCann, 2013). Urban population density is defined as the ratio of the total urban population to the total urban construction land area. Population density is a widely used measure of agglomeration economies in the available literature due to its apt representation of the proximity among individuals in a city (Yan and Huang, 2022). Henderson *et al.* (2021) provides evidence that a straightforward measure of population density is just as effective as more intricate measures of population agglomeration.

Fiscal deficit rate. We adopt the ratio of government fiscal deficits to the general public budget revenue as an indicator of local government fiscal pressure - referred to as the fiscal deficits rate hereafter. The general public budget revenue and general budget expenditure data used to calculate the fiscal deficit are the sum of the data for provincial governments and prefecture-level city governments.

Control variables

Four control variables are included in the regression analyses. Per capita GDP reflects the level of development of the market economy in a city or region (Tong *et al.*, 2023; Wu and

Heerink, 2016). A higher per capita GDP creates positive incentives for businesses and individuals to cluster around urban or regional centers, resulting in an increased demand for land. The GDP growth rate indicates the economic vitality of a city or region. This vitality may lead to an increased demand for land at given agglomeration levels. The GDP growth goal reflects the target of the local government to improve the level of economic activity of the city. To achieve this goal, the local government may acquire more cultivated land to attract more firms as a way to increase GDP. Land needed for green space puts an additional pressure on rural-urban land conversion independent of the land is required for industrial or residential purposes.

Table 2.2 Variable definitions and sources

Variables	Description	Source
Dependent variables		
Expropriated cultivated land ratio	Expropriated cultivated land area (hectares) / Total urban construction land area (hectares) ^a × 100%	CLRSY & CNRSY & CUCSY
Expropriated cultivated land for residential purpose ratio	Expropriated cultivated land area for residential purpose (hectares) / Total urban construction land area (hectares) × 100%	CLRSY & CUCSY
Core explanatory variables		
Industrial value added	Industrial value added (ten billion CNY ^b) (2006 CNY)	CSY
Location entropy	See details in section 6.2.	
Urban population density	Total urban population ^c / Total urban construction land area (persons/km ²)	CUCSY
Fiscal deficit rate	The sum of provincial and prefecture-level government fiscal deficits (100 million CNY) / The sum of provincial and prefecture-level government general public budget revenues ^d (100 million CNY) × 100%	FYC & CSY
Control variables		
GDP per capita	GDP per capita (ten thousand yuan, in 2006 prices)	CSY
GDP growth rate	Growth rate of the real gross domestic product (GDP)	CSY
GDP growth goal	GDP growth goal set by provincial governments at the beginning of the year (%)	PSYSB
Green space	Green coverage rate of built district (%)	CUCSY

Notes: **CUCSY** = China Urban Construction Statistical Yearbook (MHURD, 2007-2022); **CLRSY** = China Land and Resources Statistical Yearbook (MLR, 2007-2018); **CNRSY** = China Natural Resources Statistical Yearbook (MNR, 2019-2022); **CSY** = China Statistical Yearbook (NBS, 2007-2022); **PSYSB** = Provincial Statistical Yearbooks and Statistical Bulletins (PBS, 2006-2022); **FYC** = Finance yearbook of China (MFC, 2007-2022)

^a: The total area of urban construction land refers to the total, *i.e.* existing and newly added, land area occupied by residential land, land for administration and public services, land for commercial and business facilities, land for industrial manufacturing, land for logistics and warehousing, land for roads, streets and transportation, land for municipal utilities, and land for green spaces and squares.

^b: CNY stands for Chinese Yuan.

^c: Total urban population includes the population with urban *hukou* and the urban temporary resident population. Urban *hukou*, also known as urban household registration, refers to a system in China that categorizes individuals based on their legal residency in urban areas.

^d: The provincial government financial data here only shows the provincial level data, excluding the data of prefecture-level cities under provincial jurisdiction. The financial data of prefecture-level city governments are also limited to only the financial data of the prefecture-level cities themselves.

Table 2.3 Descriptive statistics

Variables	Mean	SD	Min	Max	N
Dependent variables					
Expropriated cultivated land ratio (%)	4.653	3.615	0.040	31.54	464
Expropriated cultivated land for residential purpose ratio (%)	1.662	1.159	0.000	5.928	348 ^a
Core explanatory variables					
Industrial value added	3472	3316	165.4	13245	464
Location entropy	0.954	0.263	0.372	1.834	464
Urban population density	2838	1216	598.0	6307	464
Fiscal deficit rate	146.9	91.69	12.22	544.0	464
Control variables					
GDP per capita	3.402	1.900	0.610	11.91	464
GDP growth rate	9.584	3.590	-5.000	19.20	464
GDP growth goal	9.071	2.095	4.500	15.00	464
Green space	38.05	4.647	22.99	49.29	464

Note: Data from 29 provinces for the years 2006-2021.

^a : Data on cultivated land expropriation for residential purposes is only compiled within the MLR from 2007 to 2018.

2.5. Model specification and estimation

The empirical model specification is as follows:

$$LA_{it} = \beta_0 + \beta_1 C_{it} + \beta_2 X_{it} + \delta_t + \mu_i + \varepsilon_{it} \quad (2.1)$$

Where LA_{it} denote the expropriated cultivated land ratios in province i in year t . C_{it} are the core explanatory variables for province i in year t . X_{it} are the control variables for province i in year t . β_0 is the constant term. β_1 are the coefficients of interest for the core explanatory variables. β_2 are the coefficients for the control variables. δ_t are the unknown coefficients representing time heterogeneity with individual province invariance. μ_i are the within-province error terms representing individual provincial heterogeneity, with time invariance; ε_{it} are the random disturbances, which vary across provinces and time; they are assumed to be independent, identically distributed, and uncorrelated with δ_t and μ_i .

The fixed effects estimator (using the *reghdfe* estimator in Stata) was used to estimate the model. The absorb option was used to control for δ_t and μ_i . To address the potential heteroscedasticity resulting from omitted factors or nonlinear relationships between the dependent and independent variables, we followed Benoit's (2011) approach by applying the natural logarithm transformation to industrial value-added, GDP per capita and urban population density (see also Henderson *et al.*, 2021). Moreover, we employed robust standard errors to estimate the model.

Endogeneity is potentially a problem in our estimations. One possible source of endogeneity is omitted variables that exhibit systematic variation over time and may be correlated with the dependent variable, such as financial crises (Wu and Heerink, 2016). In addition to the province fixed effects, we have included year fixed effects into the model which help control for any impact from such omitted time-dependent variables (Combes and Gobillon, 2015; Wu and Heerink, 2016). To deal with potential revers causality, we use lagged explanatory variables (Combes *et al.*, 2008; Combes and Gobillon, 2015). The selected explanatory variables generally do not influence land expropriation within the same year, given that it takes time to realize the land expropriations. The actual time lags between land expropriation and the explanatory variables are unknown. We therefore include one-year and two-year lagged variables, respectively, and use the results to test the robustness of the main findings.

To tests the robustness of the main findings we use three alternative model specifications. First, we replaced the industrial value added as measure for industrial agglomeration by an alternative measure, the location entropy index. Second, instead of taking expropriated land as dependent variable we took expropriation of cultivated land for residential purposes. Third, we identified differences in cultivated land expropriation policies before and after 2013. We therefore estimated the empirical model before and after this year. Finally, we tested the impact of fiscal deficits at the provincial and prefecture-level city on the expropriation of cultivated land.

2.6. Estimation results

2.6.1 Baseline results

Table 2.4 reports the regression results for models (2.1). Results of the Hausman test and the F-test, shown at the bottom of the table, indicate that the two-way fixed effects model is

appropriate. Estimation results for the one-year lag explanatory variables are presented in column (1), while the results for the two-year lagged explanatory variables are shown in column (2).

Industrial agglomeration, as measured by industrial value added, is found to have a statistically significant positive impact on the expropriated cultivated land area ratio. The estimated coefficients indicate that a 1% increase in industrial value added corresponds to a 0.068 percentage points increase in the expropriated cultivated land ratio. Urban population agglomeration, as measured by the urban population density, does not have a significant impact on the expropriated cultivated land ratio. Hence, population agglomeration does not contribute to cultivated land conversions when we control for industrial agglomeration. One possible explanation for this finding is that urban housing in China is characterized by high-rise buildings, which need little land as compared to land used for industrial expansion. To investigate this further we will examine the impact of population agglomeration on cultivated land expropriation for residential purposes later.

The government's fiscal deficit does not affect the ratio of expropriated cultivated land. This finding contradicts the conclusions of previous research. For instance, Liu *et al.* (2018), using data from Chongqing for the period 2003-2015, suggest that in response to fiscal deficit pressures, local governments are more likely to engage in the expropriation of cultivated land to generate additional revenue from land conversion activities. Similarly, Bai *et al.* (2023), analyzing micro-plot transaction data from www.landchina.com for the period 2007–2015, arrived at the same conclusion. The discrepancies in research outcomes can be attributed to two main factors. First, our dataset is updated to include the most recent year available, encompassing data from the "post-land finance era." During this era, influenced by national land use policies, the government gradually reduced its reliance on land finance and instead aimed to achieve stable and sustainable tax revenue through industrial restructuring, among other strategies. We examine this issue later. Second, previous studies only considered the provincial level of fiscal deficit (*e.g.*, Bai *et al.*, 2023), whereas we aggregate fiscal deficits at both the provincial and prefecture-city levels by weighting and summing them, to account for the primary role that prefecture-city governments play in the expropriation of cultivated land. We will examine later.

Table 2.4 Regressions results, fixed effects model

VARIABLES	Panel A: one-year lag of explanatory variables	Panel B: two-year lag of explanatory variables
	(1)	(2)
ln (Industrial value added)	6.771** (2.749)	6.030 (3.698)
ln (Urban population density)	0.764 (1.032)	0.352 (0.912)
Fiscal deficit rate	0.003 (0.006)	0.001 (0.007)
ln (GDP per capita)	-6.210*** (1.659)	-7.444*** (2.235)
GDP growth rate	0.062 (0.093)	-0.161 (0.115)
GDP growth goal	0.154 (0.155)	0.269* (0.157)
Green space	-0.062 (0.132)	0.016 (0.108)
Constant	10.144 (24.505)	29.979 (26.767)
Year-fixed effects	Yes	Yes
Province-fixed effects	Yes	Yes
Observations	435	406
Adjusted R-squared	0.636	0.652
Within R-squared	0.055	0.072
Hausman test	12.97**	12.55*
F test	5.90***	6.39***

Note: Robust standard errors clustered at provincial level in brackets.

*, **, *** denote significance levels of 10%, 5%, 1%, respectively.

The dependent variable is expropriated cultivated land ratio.

The F-test, based on the fixed effect model (using the *xtreg* estimator in Stata), controls for time fixed effects by including year dummy variables. This joint F-test assesses whether all years collectively have an effect equal to zero.

All explanatory variables were lagged by one or two years, except for the GDP growth goal which is set by the local government at the beginning of each year.

The ratio of expropriated cultivated land is not significantly affected by the control variables, except for GDP per capita and GDP growth goal. It is interesting to note that GDP per capita has a negative and statistically significant impact on the expropriated cultivated land ratio at a significance level of 1%. Specially, the estimated coefficients reveal that a 1% increase in GDP per capita corresponds to a 0.062-0.074 percentage points decrease in the expropriated cultivated land ratio. This finding is inconsistent with previous studies conducted by Deng *et al.* (2010) and Shu *et al.* (2018), which suggest that economic development positively influences the expansion of urban construction land area through the conversion of rural lands, including cultivated land. One possible explanation for this inconsistency is that we use ratios

instead of absolute amounts for measuring the dependent variables. This approach reduces differences between provinces in terms of scale, potentially affecting the observed relationship with GDP per capita. As regards the GDP growth goal, we find that it has a positive and significant effect on the expropriated cultivated land ratio. For a one unit increase in the GDP growth goal, the ratio of expropriated cultivated land is estimated to increase by 0.27 percentage points.

2.6.2 Robustness check: using new independent variable

Following the approach of Duranton and Puga (2004) and Liu *et al.* (2024), we used the location entropy as an alternative measure of industrial agglomeration to examine the robustness of the main findings. Location entropy includes the spatial distribution of value added and helps to mitigate the heterogeneity effect of urban size. Location entropy (LE) is defined as:

$$LE_{i,t} = (\frac{IG_{i,t}}{\sum_i IG_{i,t}}) / (\frac{G_{i,t}}{\sum_i G_{i,t}}) \quad (2.2)$$

where $IG_{i,t}$ and $G_{i,t}$ represent the total industrial value-added and the total value-added of the secondary and tertiary industry in province i in year t , respectively. Given the concentration of industry mainly in urban areas, this study incorporates both the secondary and tertiary sectors within urban regions for the calculation of the industrial locational entropy.

The results for the robustness check are presented in Table 2.5. The results align with the findings of Table 2.4. Hence the main conclusions regarding the effect of industrial agglomeration on expropriated cultivated land remain valid.

2.6.3 The effect of population agglomeration on cultivated land expropriated for residential purpose

Population agglomeration is also expected to be a major driving force for the expropriation of cultivated land. In China, when converting cultivated land to construction land, the purpose

of the conversion is determined, although it can still be changed later. Therefore, we replaced the dependent variable by land expropriation for residential purpose, to further examine the impact of population agglomeration on cultivated land expropriation for residential purpose. The data for this variable was sourced from the China Land and Resources Statistical Yearbook (2007-2018)³. Consistent with the previous analyses, this variable was calculated as a ratio to the total urban construction land area. Table 2.6 presents the estimation results for both the 1-year lagged and the 2-year lagged explanatory variables.

Table 2.5 Robustness check: using new independent variable (fixed effect model)

VARIABLES	Panel A: one-year lag of explanatory variables	Panel B: two-year lag of explanatory variables
	(1)	(2)
Location entropy	6.200** (2.312)	4.680* (2.523)
ln (Urban population density)	0.716 (1.030)	0.293 (0.917)
Fiscal deficit rate	0.001 (0.005)	-0.000 (0.005)
Control variables	Controlled	Controlled
Year-fixed effects	Yes	Yes
Province-fixed effects	Yes	Yes
Observations	435	406
Adjusted R-squared	0.641	0.653
Within R-squared	0.069	0.077
Hausman test	18.1***	14.37**
F test	7.15***	3.92***

Note: Robust standard errors clustered at provincial level in brackets.

*, **, *** denote significance levels of 10%, 5%, 1%, respectively.

The dependent variable is the expropriated cultivated land ratio.

All explanatory variables were lagged by one or two years, except for the GDP growth goal which is set by the local government at the beginning of each year.

³ No data regarding the expropriation of cultivated land for a specific purpose has been included in China's natural resources yearbooks. Therefore, the relevant data is restricted to the China Statistical Yearbook of Land and Resources 2007-2018.

Table 2.6 Regression results for cultivated land conversion for residential purpose, fixed effects model

	Panel A: one-year lag of explanatory variables	Panel B: two-year lag of explanatory variables
VARIABLES	(1)	(4)
ln (Industrial value added)	6.147*** (1.799)	6.196*** (1.414)
ln (Urban population density)	0.435* (0.246)	0.986*** (0.234)
Fiscal deficit rate	0.003 (0.002)	0.003 (0.004)
Control variables	Controlled	Controlled
Year-fixed effects	Yes	Yes
Province-fixed effects	Yes	Yes
Observations	319 ^a	290
Adjusted R-squared	0.581	0.607
Within R-squared	0.157	0.170
Hausman test	37.96***	34.89***
F test	2.49**	3.48***

Note: Robust standard errors clustered at provincial level in brackets.

*, **, *** denote significance levels of 10%, 5%, 1%, respectively.

The dependent variable is the ratio of expropriated cultivated land for residential purposes to the total area of urban construction land.

All explanatory variables were lagged by one or two years, except for the GDP growth goal which is set by the local government at the beginning of each year.

^a : Data on the expropriation of cultivated land for specific purposes is not included in China's natural resources yearbooks (2019-2022), but is available in the China Statistical Yearbook of Land and Resources 2007-2018.

The findings in Table 2.6 demonstrate that population agglomeration has a positive and significant effect on the increase of land designated for residential purposes when we control for the fiscal deficit on provincial level. When a 2-year lag of explanatory variables is incorporated, population agglomeration significantly and positively affects cultivated land conversion for residential land purpose at the 1% significance level. Urban population density serves as a representation of population agglomeration in the preceding one or two years. This suggests that local governments invest in the development of additional residential infrastructure to meet the needs of residents. Industrial agglomeration leads to increased land conversions for residential land purpose. This reveals the role of industrial agglomeration and

its facilitation of population mobility. Notably, the fiscal deficit has no effect on land conversion for residential purposes.

2.6.4 Cultivated land conversion changes in different periods

Land finance has been a significant driver of China's economic growth, contributing to the country's widely acknowledged "economic miracle" in recent decades (Gyourko *et al.*, 2022). This reliance on land finance has also alleviated fiscal pressures for local governments. Nevertheless, this growth strategy raises concerns regarding its sustainability due to the escalating economic and social costs and risks associated with local governments' strong reliance on land finance (Gyourko *et al.*, 2022). It is worth noting that the Chinese government has recognized these issues. Since 2005, China has repeatedly proposed in national policy documents to narrow the scope of land expropriation. This paper uses the "Decision of the Central Committee of the Communist Party of China on Several Major Issues Concerning Comprehensively Deepening Reform" in 2013 (hereinafter referred to as the *Decision*) as important point in time. This is because prior to this point in time, the premise of narrowing the scope of land expropriation was to improve the property rights system and land expropriation system. The 2013 *Decision* then proposed to establish a unified urban-rural construction land market, aiming to allow rural collective construction land to enter the market, in order to effectively narrow the scope of cultivated land expropriation. Consequently, the year 2013 marks the point in time when local governments initiated the reduction of their reliance on land finance. In the subsequent analysis, we conducted regressions separately for samples from these two distinct phases, utilizing variables and model definitions consistent with those reported in Table 2.4.

The regression results presented in Table 2.7 show the impact of industrial and population agglomeration, as well as the fiscal deficit, on the ratio of expropriated land. The results reveal that industrial and population agglomeration consistently align with the findings reported in Table 2.4 for both periods. Notably, the fiscal deficit rate exhibits a positive and significant effect on the expropriated cultivated land ratio from 2006 to 2013, but this effect is not present in the subsequent period from 2014 to 2021. This finding is consistent with prior research predating 2018, which indicated that the fiscal deficit contributes to increased

cultivated land expropriation (Bai *et al.*, 2023; Liu *et al.*, 2018). This suggests that in the post land finance era, local governments have curbed their dependence on land expropriation.

Table 2.7 Regressions results for different time periods, fixed effects model

VARIABLES	Panel A: one-year lag of explanatory variables	
	(1)	(2)
	Expropriated cultivated land ratio	
	Period of 2006-2013	Period of 2014-2021
ln (Industrial value added)	11.911*** (4.232)	4.230* (2.463)
ln (Urban population density)	0.980 (0.848)	-1.136 (1.041)
Fiscal deficit rate	0.044** (0.017)	-0.003 (0.003)
Control variables	Controlled	Controlled
Year-fixed effects	Yes	Yes
Province-fixed effects	Yes	Yes
Observations	203	232
Adjusted R-squared	0.657	0.615
Within R-squared	0.170	0.061
Hausman test	27.92***	7.55
F test	3.34***	3.28***

Note: Robust standard errors clustered at provincial level in brackets.

*, **, *** denote significance levels of 10%, 5%, 1%, respectively.

All explanatory variables were lagged by one year, except for the GDP growth goal which is set by the local government at the beginning of each year.

2.6.5 Considering the effect of provincial fiscal deficits and prefecture level fiscal deficits separately

In the previous section, we combined the deficits at the provincial and prefecture-level city levels into a unified variable, which aimed to capture the local government fiscal deficits. However, this approach may have led to an underestimation of the influence of prefecture-level city governments, considering their central role in land expropriation. In China, a significant portion of the land transfer fees (70%), is directly channeled into the revenue of these local governments. Therefore, for a more comprehensive analysis, we employed the

fiscal deficits of provincial and prefecture-level city governments as separate variables. The results are detailed in Table 2.8.

Table 2.8 reveals that the expropriated cultivated land ratio is significantly and positively influenced by the provincial fiscal deficit rate, with a one unit increase in the provincial fiscal deficits rate corresponding to a 0.013-0.017 percentage points increase in the expropriated cultivated land ratio. This finding is consistent with the research of Wu *et al.* (2015) and Liu *et al.* (2023), suggesting that local governments engage in cultivated land expropriation to generate revenue when facing provincial fiscal deficits. However, unexpectedly, the prefecture level fiscal deficit rate does not affect the expropriated cultivated land ratio.

Table 2.8 Considering the effect of provincial fiscal deficits and prefecture level fiscal deficits separately, fixed effects model

VARIABLES	Panel A: one-year lag of explanatory variables		Panel B: two-year lag of explanatory variables	
	(1)	(2)	(3)	(4)
ln (Industrial value added)	7.947** (2.918)	6.732** (2.653)	7.698* (4.009)	6.106* (3.510)
ln (Urban population density)	1.021 (1.073)	0.729 (1.033)	0.620 (0.940)	0.307 (0.901)
Fiscal deficit rate, provincial level	0.013** (0.006)		0.017* (0.009)	
Fiscal deficit rate, prefecture level		-0.005 (0.005)		-0.008 (0.005)
Control variables	Controlled	Controlled	Controlled	Controlled
Year-fixed effects	Yes	Yes	Yes	Yes
Province-fixed effects	Yes	Yes	Yes	Yes
Observations	435	435	406	406
Adjusted R-squared	0.647	0.638	0.668	0.657
Within R-squared	0.084	0.060	0.117	0.087
Hausman test	20.26***	11.35	22.50***	11.88*
F test	6.60***	5.82***	4.89***	6.96***

Note: Robust standard errors clustered at provincial level in brackets.

*, **, *** denote significance levels of 10%, 5%, 1%, respectively.

The dependent variable is the expropriated cultivated land ratio.

All explanatory variables were lagged by one or two years, except for the GDP growth goal which is set by the local government at the beginning of each year.

2.6.6 Further discussion

Comparison with Existing Research Findings

First, the process of industrial agglomeration involves the concentration of industries in certain areas, leading to increased economic efficiency, innovation, and productivity due to reduced transportation costs, easier access to markets, and enhanced opportunities for knowledge sharing among firms (Fujita and Thisse, 2002). Our research findings confirm that industries require substantial amounts of land for factories, warehouses, and other facilities, leading to the appropriation of cultivated land for these purposes, at the expense of agricultural land, which potentially affect food production and ecology (Zhang *et al.*, 2023). This highlights the need for balanced approaches that accommodate economic growth and industrial development while also preserving cultivated land ensuring food security.

Second, despite that our study does not find a direct link between population agglomeration and cultivated land expropriation, we expect an indirect link via industrial agglomeration, aligning with Skog and Steinnes' research from 2016 (Skog and Steinnes, 2016). As urban populations swell, demand for housing escalates, necessitating the conversion of agricultural land to accommodate the growing population. In developed nations and regions, government intervention by means of planning regulates the pressures of industrial clustering and demographic expansion. White and Allmendinger (2003) note that despite differing approaches—the UK's "plan-led" versus the US's "market-led" systems—both countries' planning have led to similar outcomes: rising prices, reduced supply, increased housing density, certainty provision, and risk mitigation. Shen *et al.* (2009) contend that only through planning policies high-density cities like Hong Kong can achieve sustainable land use, balancing environmental, social, and economic demands.

Third, our research findings suggest that government fiscal deficits have a significant and positive impact on the rate of cultivated land expropriation from 2006 to 2013. However, this effect was not present from 2014 to 2021. This suggests that local governments' reliance on land finance has weakened. Moreover, our findings indicate that provincial fiscal deficits increase cultivated land conversion. This is consistent with previous studies (*e.g.*, Liu *et al.*, 2023; Wu *et al.*, 2015). However, we do not find that prefecture-level city fiscal deficits have

a significant effect on the cultivated land conversion. This might be because prefecture-level city governments converting cultivated land into construction land are subject to controls by provincial or central governments (Gyourko *et al.*, 2022; Han *et al.*, 2020; Wu *et al.*, 2015).

Challenges and recommendations for the future

In 2022, China's rural population reached 491.04 million, with an urbanization rate of 65.22%⁴, which is still below the urbanization rate in western countries⁵. According to data from the Natural Resources Statistics Bulletin, in 2022, 0.46 million hectares of agricultural land were converted for construction purposes, with 0.16 million hectares being cultivated land⁶. These statistics indicate a continuing robust urbanization trend in China, presenting challenges to the protection of cultivated land. The effects of the post-pandemic crisis in China's real estate market have notably reduced revenue from land finance, emphasizing the need to decrease local governments' reliance on such funds. One approach to achieve less pressure on cultivated land is by improving land use efficiency and minimizing the expropriation of cultivated land. To address fiscal deficits and reduce local governments' dependence on generating revenue through land finance, it is vital to reform land expropriation, as suggested by Wu *et al.* (2015). Given that provincial fiscal deficits show a stronger dependence on 'land finance' than prefecture-level city governments it is important to reform the fiscal structure of provincial local governments. Moreover, it is important to improve the efficiency and transparency of the use of public funds, and reduce unnecessary expenditure and waste. The same applies also to prefecture-level city governments but less.

Implications for other countries

In the context of rapid urbanization and economic development, the competition for land use becomes more pronounced. This is a challenge not unique to China. With industrialization and population concentration, the increasing demand for land may conflict with

⁴ https://www.ndrc.gov.cn/fgsj/tjsj/jjsjgl1/202301/t20230131_1348084.html

⁵ <https://hbs.unctad.org/total-and-urban-population/>

⁶ <https://www.mnr.gov.cn/sj/tjgb/202304/P020230412557301980490.pdf>

environmental protection and sustainable development needs. China's experience offers valuable insights and lessons.

2.7. Conclusion

Cultivated land is a critical factor for sustainable agricultural development and national food security. In the process of industrialization and urbanization the expropriation and illegal conversion of cultivated land pose serious threats to the quality and quantity of China's cultivated land, thereby endangering national food security. This study adds to the available literature on the declining availability of cultivated land in China by examining the impact of (industrial and population) agglomeration and local government fiscal deficits on cultivated land expropriation and illegal land conversion. Provincial data on cultivated land expropriation between 2006-2021 were used for the empirical analysis. It was found that industrial agglomeration has a significant and positive impact on the expropriation of cultivated land. Although population agglomeration does not directly affect the rate of cultivated land expropriation, it significantly increases the ratio of cultivated land being converted into residential land. The local fiscal deficits (primarily at the provincial level) significantly increased the cultivated land expropriation rate before 2014, but this effect is no longer significant thereafter. Further examination reveals that, within the study period, provincial-level fiscal deficits significantly elevated the land expropriation rate, whereas fiscal deficits at the prefectural-city level had no impact on it.

However, our analysis, though based on the most recent data available, does not encompass recent events, such as the impact of China's recent real estate crisis on land expropriation. Therefore, future discussions should further explore the effects of similar crises on land acquisition in light of our findings.

Appendix 2

Table 2.A1 Types of Cultivated Land Increase and Decrease

Increase in Area of Cultivated Land	Land renovation	Adjusting and transforming the land use status to improve the utilization and output of land, and to improve the production, living conditions, and ecological environment. It includes the consolidation of agricultural land and construction land. The main contents include adjusting land use structure, merging scattered land parcels, leveling land, comprehensive management of roads, channels, etc., and the concentration, relocation, and internal renovation of village and rural enterprise land.
	Linking the Increase and Decrease of Urban and Rural Construction Land (Balanced Occupation and Compensation of Cultivated Land)	
	Reclamation of industrial and mining wasteland	Rehabilitating damaged land caused by excavation, subsidence, or occupation during the process of production and construction, by taking measures to restore the land to a usable state.
	Agricultural restructuring	Area of land that has been converted from other agricultural uses to cultivated land as a result of agricultural structural adjustment. For instance, the adjustment of the percentages of lands used by crop growing, forestry, livestock farming, aquatic products farming, and side-line occupation in agricultural production during the reporting period to meet the requirements for the economic development and eco-environmental protection.
	Other activities	Other activities that could increase cultivated land area
Decrease in Area of Cultivated Land	Construction	Reduction in cultivated land area due to various types of construction occupation. Before cultivated land is converted into construction land, it is necessary to go through the cultivated land expropriation procedure for approval.
	Destroyed by natural disasters	Cultivated land that cannot be cultivated due to natural disasters such as water erosion, sand pressure, landslides, mudflows, gully erosion, earthquakes, and other natural disasters.
	Ecological restoration	Cultivated land that is returned to forests, pastures, or lakes according to planning, plans, and actual needs for ecological environmental construction.
	Agricultural structural adjustment	Area of cultivated land that has been converted to other agricultural uses as a result of the adjustment of agricultural structure. For instance, the adjustment of the percentages of lands used by crop growing, forestry, livestock farming, aquatic products farming, and side-line occupation in agricultural production during the reporting period to meet the requirements for the economic development and eco-environmental protection.

Source: MLR (2007-2018) and MNR (2019-2022)

Chapter 3 Tenure security, social relations and contract choice: -Evidence from Jiangxi and Liaoning Provinces in China⁷

Abstract: In China rental transactions between partners with close social relations that use informal contracts are still widespread and this may reduce the potential of the land rental market to enhance productivity and equity. Based on household data collected in Jiangxi and Liaoning provinces in 2015, this paper examines the relationship between land tenure security, social relations and land rental contract choices, using a nested logit framework. The empirical results show that landlords are more likely to rent out land to tenants who live in the same village, rather than to relatives or strangers, and that insecure land tenure encourages landlords to select informal contracts. Our findings suggest that these decisions (of partner-type and contract-type) are made simultaneously, and that they are made on the basis of a landlord's perceived security of his land rights and the priority he gives to establishing a flexible rental relationship.

Key Words: land rental market; contract choice; tenure security, social relations

⁷ This chapter has been submitted to an international scientific journal.

3.1 Introduction

Agricultural economists have been discussing contract choice in agricultural land tenancy since the nineteenth century. This discussion, which has covered both developed and developing countries, has often focused around the choice between crop sharing and cash leases. Much theoretical work has identified that the optimal contract form is determined by the characteristics of the principal, agent and the task to be contracted on in the principal-agent model or transaction cost analysis framework. The empirical studies have focused on testing five major hypothesis to explain contract choice: optimal risk sharing and incentives, binding financial constraints, low transaction costs and screening/sorting (Akerberg and Botticini, 2002; Allen and Lueck, 1993, 2004; Bierlen *et al.*, 1999; Fukunaga and Huffman, 2009; Huffman and Just, 2004; Styán, 2020). In China crop sharing contracts do not exist and fixed rent contracts dominate. Moreover a significant part of most land rental transactions are conducted between neighbors or close circles of relatives so that social sanctions can be applied to ensure that the land is returned at the end of the rental period (Jin and Deininger, 2009; Prosterman *et al.*, 2009; Rozelle *et al.*, 2008; Wang *et al.*, 2015). This nature of contracting can be also found in other developing countries, such as Guatemala, Dominican Republic and Ethiopia (Ghebru and Holden, 2015; Macours *et al.*, 2010). Another significant characteristic of land rental contracts in China is that informal (verbal) contracts are widely used (Feng, 2008; Jin and Deininger, 2009; Wang *et al.*, 2015; Zhou *et al.*, 2019). These informal contracts are usually self-enforced and are based on the reputation or trust associated with social relations, and rarely involve third parties (such as courts or government authorities). However, Market-oriented trading in social networks of acquaintances is improving the situation (Qiu *et al.*, 2020b).

Although these two features of Chinese land rental contracts can reduce transaction costs when a high level of trust exists (Holden and Ghebru, 2005; Tione and Holden, 2019), they do contribute to market segmentation and unstable contracts and this generates two significant limitations. Firstly, these contracts normally only define a general contract relationship and lack some important aspects, such as the contract period, the rent to be paid and the way in which it is to be paid (frequency etc.) as well as measures for risk-prevention. The contracts are very vulnerable to change by both partners, which may inhibit the tenants from making long term investments in the land due to a perceived threat of opportunistic

expropriation or holdup (Jacoby and Mansuri, 2010). Secondly, it is often difficult to enforce these methods of informal governance, based on national land laws and formal regulations. In short these kind of contracts are considered to inhibit large scale land transfer and long-term land-related investment, which undermine potential productivity and the efficiency of the land rental market (Jacoby and Mansuri, 2010; Yu *et al.*, 2003; Zhou *et al.*, 2019).

Our research of the literature reveals little material on the factors that influence the choice of informal or formal contracts⁸ in either developed or developing countries, although the Chinese literature does contain a few studies concerning the choice between informal and formal contracts. These studies show that the land rental transactions between kinship members tend to be informal contracts as these contracts can be self-enforced, are less costly and based on trust and reputation, while those transactions between non-kinship members tend to be formal contracts as the enforcement costs become lower as social distance increases (Hong and Gong, 2015; Luo *et al.*, 2015; Qian *et al.*, 2015; Tang *et al.*, 2019)⁹. However, these studies do not take into account endogenous matching¹⁰ between landlords and tenants, which may bring out a potential estimation bias. They also do not take into account the greater flexibility of informal contracts: informal contracts are closely associated with relational governance (Qiu *et al.*, 2020b), which provides more flexibility in changing the contract's content, allowing both the landlord and the tenant to adapt them in response to unforeseeable events (Poppo and Zenger, 2002). Thus, these contracts may be preferred by partners who feel uncertain about the future.

There are two studies, from the Dominican Republic (Macours and Swinnen, 2002) and Guatemala (Macours *et al.*, 2010), that examine the determinants of the choice of contracting partners. They claim that landowners lacking a formal title to their land tend to only rent to

⁸ Formal contracts generally explicitly specify the rights and duties of both partners, *e.g.* the contract duration, the rent payable, how and when it is to be paid, penalties for non-compliance etc.; while informal contracts include written contracts that do not clearly specify these rights and duties and verbal contracts.

⁹ Contract choice is interrelated with the choice of partner, but the relationship is not fixed. Using data collected in six provinces between 2000 and 2008, Wang *et al.* (2015) found that even among non-kin members, 91.24% of those interviewed involved in renting-out and 75.1% of those involved in renting-in used oral contracts.

¹⁰ Akerberg and Botticini (2002) and Macours *et al.* (2014) state that contract choice between a principal and an agent is endogenous matching, *i.e.* there are incentives for certain types of agents to match (contract) with certain types of principals.

tenants from the same ethnic group due to higher levels of trust. However, different countries have different legal systems and in many developing countries, including China, the lack of an individual land titles does not necessarily imply that land tenure is insecure. In such instances household perceptions about land tenure security (*i.e.* the perceived tenure security) forms the basis upon which the landowner takes land-related decisions (Ma *et al.*, 2015a, 2020; Ren *et al.*, 2020; Van Gelder, 2009). Examining the effects of both actual (land certification) and perceived tenure security on contract choice can give a clearer picture of the role that land tenure plays in shaping contract types in developing countries.

This paper analyzes the relationship between land tenure security, social relations and land rental contracts in Chinese agricultural land tenancy, using household data collected in Jiangxi and Liaoning Provinces in 2015. We focus on both the choice between a formal and an informal contract and of the contracting partner. Different type of contracts involve different enforcement mechanisms, and imply different enforcement costs and different degrees of flexibility if one of the partners wants to change the terms of a contract. Social relations, an important informal institution, often play a key role in agricultural land tenancy contracting, especially when formal institutions' capacity to resolve property rights is (perceived to be) lacking. In this study we differentiate between relatives, people living in the same village who know each other, and strangers, as embodying different social distances. In order to reduce estimation bias resulting from endogenous matching between landlords and tenants, we follow Macours's (2014) methodology and use a nested logit framework for empirical analysis, and a mixed logit model to check for robustness.

The paper contributes to the literature on the relationship between formal and informal institutions and land rental contracts in three ways. First, by taking into account endogenous matching in the Chinese land rental market, it examines the effects of tenure security and social relations on two important features of land rental contracts, the choice between informal and formal contracts and the choice over contracting partners. Second it examines the effects of both the actual and the perceived tenure security on household decisions regarding choice of contract. Thirdly it identifies that household decisions regarding choice of contract are made by balancing tenure security and flexibility of contract relationship. Our research aims to provide new insights into the choices currently made about contract types

for agricultural land tenancy in China (and by extension other developing countries), where formal institutions do not function well and land rental markets are segmented.

The paper is structured as follows. Section 3.2 briefly introduces land tenure security in China, social relations in rural areas and recent developments in the land rental market. Section 3.3 presents a conceptual framework and the empirical specifications that we use to analyze how tenure security and social relations affect joint choices about informal/formal contracts and contracting partners. Section 3.4 summarizes the data collection methods and presents the definitions and descriptive statistics of the variables used in the analysis. Section 3.5 reports on, and discusses the estimation results. Our concluding remarks are presented in section 3.6.

3.2 Land tenure security, social relations and the land rental market in China

3.2.1 Land tenure policy and tenure security

Since 1978 China's agricultural production system has been de-collectivized by the Household Responsibility System (HRS) which assigns individual households' 15-year land use rights, with land ownership remaining with the collective (Tan *et al.*, 2011). The implementation of the HRS gave farmers greater incentives and led to a sharp growth in land productivity (Garnaut *et al.*, 2018; Lin, 1992; McMillan *et al.*, 1989). However, the HRS is generally believed to contribute to tenure insecurity (Qu *et al.*, 1995; Wang *et al.*, 2011). This is partly because village officials frequently reallocate land to address demographic changes within a village and partly because farm households' land use rights can be rescinded by the village if a household moves out of a village.

The market-oriented land tenure reforms have been gradually implemented since the early 1990s aim to stimulate land rental markets and enhance agricultural productivity (Ma *et al.*, 2015a; Zhu *et al.*, 2006). There have been six major reforms, listed below.

- Extending farmers' land rights to a period of 30 years (under the 1998 Land Administration Law (LAL) and the 2002 Rural Land Contract Law (RLCL)) and giving them permanent status under the 2007 Property Law (PL);

- Restricting land reallocations and prohibiting full-scale land reallocations and narrowing the scope of partial land reallocations under the 2002 RLCL;
- Mandatory issuing of land certificates to farmers under the 1998 LAL;
- Specifying compensation for farmers who lose land use rights under the 2002 RLCL;
- Specifying land transfer rights and allowing land transfers to occur outside the collectives under the 1998 LAL, and specifying the modes of land transfers under the 2002 RLCL, and;
- Recently establishing the ‘Three Rights Separation’ policy that divides land rights into land ownership (owned by the collective), contracting rights (owned by farmers) and management rights (owned by the person/entity operating the land).

The ‘Three Rights Separation’ policy was first put forward in the No.1 Document of the Party Central Committee in 2014, and has been strongly promoted since 2016. This policy specifies the scope of all three kinds of rights and provides more protection against third parties infringing these rights. The ‘Three Rights Separation’ policy, provides the core of the new rural land tenure reform and is expected to increase the security of land rights, to activate the land transfer market and thereby stimulate the rural economy.

In summary, the market-oriented land tenure reforms significantly increased legal land tenure security and transferability. In particular, stable land tenure plays an important role in facilitating the marketization of transactions and activating the land rental market (Qiu *et al.*, 2021). These land laws, however, were not always effectively enforced in many regions. Ma *et al.* (2015a) found that in some regions many farm households still experience substantial insecurity of actual and perceived land tenure, which caused by social security considerations, ambiguous formulations of laws, and village self-governance rules. In regard to actual tenure security, all rural households in China should possess official land certificates and land reallocations should be banned. However, in 2011 as many as 67 percent of the interviewed households in three counties in Jiangxi province (Yanshan County in Shangrao City, Yujiang and Guixi Counties in Yingtan City) stated that they did not have a land certificate and 70 per cent of the households had experienced at least one land reallocation since 1998 (Ma *et al.*, 2015a). Only 18 percent of these households expected that no land reallocations would take place within the coming five years. Fifty-eight per cent of the households possessing a land

certificate believe that land certificates are important for protecting land rights (ibid). In a broader survey of six provinces (Hebei, Hubei, Liaoning, Shaanxi, Sichuan and Zhejiang) in 2008 33.48% of interviewed households stated that they did not have a land certificate while 12.92 per cent of interviewed households had experienced minor reallocations in the last five years (Wang *et al.*, 2015).

3.2.2 Social relations in rural areas

The people's communes were gradually dismantled during the implementation of the HRS. They, together with the production brigades and production teams have been transformed into townships, administrative villages and villagers group (natural villages)¹¹, respectively. Many joint decisions about collective affairs, *e.g.* local investments and land reallocations, are taken through self-governed rules at administrative village, and are sometimes delegated to the natural village (Ma *et al.*, 2013b). According to *the Organic Law of Village Committees*, first promulgated in 1987, the Village Committees (VCs), which are at the level of an administrative village, are supposed to be mass organizations of self-government at the grassroots level in the rural areas. The final promulgation of *the Organic Law* in 1998 marked the beginning of the central government's push for more autonomous VCs as a solution to deteriorating rural governance in China (Huhe *et al.*, 2015).

Households living in the same natural village for a long period share the same cultural knowledge, social norms and self-governance rules and thus have close social relationships, which are often established on the basis of geographical proximity. The geographical relationship is stronger between households who live close to each other or cultivate adjacent plots.¹² Another established social relation in rural China is blood ties: the blood relation. These two traditional relations have come under pressure in more recent years by social

¹¹ A natural village is a natural environment in which a group of people have been living for a long period and sharing same culture and norms. In most area a natural village is a villagers' group, but a few big nature villages consist of two or more villagers' groups.

¹² An administrative village is usually identified and categorized based on geographical distance, which consists of several natural villages (village groups). In reality, some households also frequently interact with other households living in other natural villages, but within the same administrative village. However, most households living in different natural villages do not know each other. The households living in the same natural village are much closer geographically, and thus have a closer social relationship than those living in a different natural village in the same administrative village.

relations that are based on work ties or political proximity¹³, as an increasing number of farmers have migrated to urban areas for off-farm jobs and the village-level self-government institutions have improved in the past decades. However, traditional social relations, based on geographic and blood ties, still play a very important role in rural China. We can, on this basis, categorize rural social relations into three types: kinship relations, relations between villagers and relations between strangers. Kinship relations includes those with parents, children, siblings and relatives. Relations between villagers refers to households living in the same natural village, sharing the same village culture, social norms and self-governance rules, but without a blood tie. Relations between households who share both kinship relation and close geographical relation should be categorized as kinship relations because blood relations are much closer than geographical relations (Falco and Bulte, 2013). Relations between strangers refers to households who neither share blood nor geographical relations.

The trust associated with three different social relations significantly differs, with the trust inherent in kin relations higher than in others (Ma *et al.*, 2015a). Generally speaking, the high trust of kinship relations only extends to relatively few people, but a high level of general trust will make it easier for people from an entire society cooperate (Tu *et al.*, 2011). These rural social relations frame the relational governance of land rental activities. Since rural social relations are developed and maintained on geographical and blood ties, maintaining them does not involve a considerable cost. This is in contrast with the relational governance of firms where the development and maintenance of relational governance with a dense network of social ties may involve considerable cost in terms of time and resources (Larson, 1992).

3.2.3 The land rental market in China

The land rental market in rural China emerged in the late 1990s, and developed gradually (Brandt *et al.*, 2004; Deininger and Feder, 2009; Deininger and Jin, 2005; Wang *et al.*, 2015). Surveys show that the share of rural households who rented in cultivated land increased from 1-2 per cent in 1988 (Brandt *et al.*, 2004) to 9.4 per cent in 2000 (Deininger and Jin, 2005),

¹³ Political relationships in the villages are composed of ties between village leaders, including village committees' members and party members.

to 13.5 per cent in 2001-2004 (Deininger and Jin, 2009), and 27 per cent in 2008 (Wang *et al.*, 2011). The area of rented in (out) land per household increased from 0.61 mu (0.33mu) in 2000 to 2.1 mu (0.65mu) in 2008 (Wang *et al.*, 2015). A recent survey conducted in 29 provinces show that the share of households renting land in or out had increased from 11.4 per cent (13.1 per cent) in 2013 to 13.3 per cent (18.6 per cent) in 2015, and the area of cultivated land per household, on average, increased from 8.3 mu in 2013 to 12.9 mu in 2015 (He *et al.*, 2016)¹⁴. Despite a gradual growth in the rural land rental market, farmers in the most economically-underdeveloped regions, where a high share of rural households still rely on agricultural production as their main source of income or as social insurance against unstable off-farm employment, have not been able to attain the optimal land-labor ratio through land rental transactions (Deininger and Jin, 2009; Ma *et al.*, 2015a; Rozelle *et al.*, 2008). In contrast, Qiu *et al.* (2020a) found that the development of a land rental market had positive implications for alleviating agricultural labor shortages.

The high level of market segmentation and the informality of contracts are important features of China's rural land rental market. A recent survey conducted in 29 provinces show that more than 40 per cent of land transactions did not specify the rent price or the rental period, and that 88.1 per cent of transfers of land were to traditional farm households, rather than new agricultural management bodies¹⁵ in 2015 (He *et al.*, 2016). Another survey showed that 94 per cent of the rental contracts in Jiangxi were verbal contracts (2010) as were 58 per cent of rental contracts in Gansu (2009).

In summary, the rural land rental market has developed gradually since 2008, and the share of total cultivated land that is rented out has increased more rapidly since 2012 as a result of encouragement of central and local governments. However, in most agricultural regions, the land rental market has not developed to its full potential and is still segmented and dominated

¹⁴ According to a statistical report by the Agricultural Ministry, 30.4% of total household contracted cultivated land had been transferred by the end of 2014, with about 58.38% of the cultivated land transferred to households, and 21.91% and 9.62% to cooperatives and enterprises, respectively. See details: <http://www.tuliu.com/data/nationalContracted.html>.

¹⁵ A new agricultural management body is considered to have more professional technical advantages in agricultural management than traditional households. They mainly consist of professional farmers, family farms, farmers' cooperatives and agricultural enterprises.

by informal contracts. A reduction in market segmentation and an increase in the use of formal contracts could increase land rental activities.¹⁶

3.3 Conceptual framework and model specification

3.3.1 Conceptual framework

In the field of contract choice, a substantial amount of research follows the principal-agent framework to test the impacts of optimal risk sharing, optimal incentives, binding financial constraints, low transaction costs and screening/sorting on contract choice (Akerberg and Botticini, 2002; Allen and Lueck, 1993, 2004; Bierlen *et al.*, 1999; Fukunaga and Huffman, 2009; Huffman and Just, 2004; Styan, 2020). In terms of the endogenous matching of contract choice, which is the interest of this study, Akerberg and Botticini's (2002) model of the endogenous matching of contract choice, using a standard moral hazard model in which a principal and agent contract each over a task is generally applied. This model can be used to identify the observed and unobserved characteristics of the principal / task and agent and thereby explain the contract choice. During field observations in the Dominican Republic, Macours *et al.* (2010) established a principal-agent model in which the potential landlord makes an offer to the tenant, and the tenant accepts or rejects the offer. Since there is a possibility of the tenant squatting (*i.e.* illegal remaining on the land after the expiry date of the land contract) a potential landlord has to choose a tenant in whom he has confidence so as to minimize the chance of future disutility. Macours (2014) subsequently extended this model to analyze the determinants of both partner and contract choice in Guatemala. Once a potential landlord decides to rent out his land, he has to decide who he wants as a tenant and between a fixed rent contract and an interlinked land-labor contract. The probability of the same tenant squatting the landlord's land varies between two types of rental contracts, and under the same rental contract, the probability of different tenants squatting the land will also vary. Therefore, a landlord has to make a joint decision about the tenant and contract type. In

¹⁶ In a few economically-developed regions local governments have strongly promoted land transfer, in particular, by large scale (village-level) of land consolidation. Although this reduces market segmentation and the informality of contracts (Zhao and Wu, 2011), such interventions may infringe farmers' land rights and interests as farmers lose their freedom to choose between informal and formal contracts and their contracting partners (Gao *et al.*, 2014b).

this section we sketch the conceptual (principal-agent) framework that illustrates why partner and contract choices are jointly made and the factors that affect these choices in China.

Following Macours (2014) and Macours *et al* (2010), we model a landlord's joint decision for tenant type and formal/informal contract. However, our framework differs from Macours' (2014) framework in three aspects. First, Macours does not explicitly discuss the flexibility of rental relationships which is a major feature of relational governance that allow both landlords and tenants to adapt the content of rental contracts in response to unforeseeable events. This adaptation is based on a commitment to joint action and information-sharing which can benefit both parties (Jones *et al.*, 1997; Poppo and Zenger, 2002). In our framework, potential landlords choose a certain type of partner and contracts based on balancing the risk of losing the land and the flexibility of the rental relationship. Second, with an informal contract a tenant who seeks to squat the land will only be subject to moral sanctions, whereas under a formal contract he could also be subject to legal punishment. Third, apart from that of a tenant squatting, landlords can also lose their land without adequate compensation due to village-level reallocations or governmental expropriations in China (see Ma *et al.*, 2015, 2016). We will discuss these scenarios later.

As discussed in Section 3.2.3, land rental transactions in rural China mostly occur between households and land plays an important role as a substitute for the weak social security systems in rural areas (Ma *et al.*, 2015a). Given the context of insecurity of land tenure and unstable off-farm employment, landlords will not participate in the land rental market, especially, will not rent out land to non-family members and sign formal contracts unless they can get a satisfactory agreement.¹⁷ Therefore, landlords always have more bargaining power in land rental agreements and we assume that potential landlords first make an offer of land rental contract (formal or informal) to a tenant, who either accepts or rejects it. When choosing a partner, landlords have to balance different factors: on the one hand, since there

¹⁷ It is very common that off-farm employment takes the form of a part-time agricultural job. People often leave land with their relatives to produce on if they cannot successfully rent out land in most rural regions. However, in a few regions local governments (the township or village) strongly promote land transfers and some landlords are forced to follow agreements designed by local governments or large tenants (*e.g.* agricultural enterprise, large scale cooperatives). In this situation, landlords do not have the same bargaining power in rental agreements. Discussion about these types of contract choice is beyond the scope of this paper.

is the possibility of losing land due to insecure land rights, a landlord is more likely to rent out land to partners with whom he or she has close social relations (because the contract enforcement mechanisms under this form of matching are based on informal rules). On the other hand, if a landlord faces the possibility of ending or changing the rental relationship (for example as result of returning from migrant work in the city) he is more likely to choose a partner with whom he has close social relation as the rental relationship will be easier to change or terminate. As regards to contract choice, formal contracts have more complete contents (*i.e.* the contract duration, amount of rent, how and when the rent is to be paid, a clear definition of rights and duties) than informal contracts and the rules specified by formal contracts can be legally enforced. However, it is hard to estimate which type of contract provides better protection for the landlord's land tenure, and this usually depends on whether formal or informal enforcement mechanisms are dominant. Formal contracts are less flexible than informal contracts, and it is harder for either landlords or tenants to change the contents of the former.

In our framework, the landlord first makes his contract offer k ($k=1$ indicating formal contract, $k=0$ indicating informal contract) on plot i at $t=0$. The tenant j decides whether or not to squat plot i when the contract period is due at time $t=1$, with the decision variable S_{ijk} being either 0 (ending land rent contract and returning the plot to the landlord) or 1 (breaking the contract and squatting the plot). The tenant's decision is determined by the trade-off between the value of the future benefits of the plot if he successfully squats the land and the value of reputational loss or moral punishment (in the case of an informal contract), or both moral and legal punishment (in the case of a formal contract). The value of future benefits of the plot depends on the physical characteristics of the plot and the tenant's agricultural production skills. The value of reputation loss depends on whether the landlord and tenant have close social relations: the closer the social relation is, the larger the value of reputational loss will be.¹⁸ The legal punishment only applies under formal contracts and will depend on the extent to which formal enforcement mechanisms exist in the village. The better the legal enforcement mechanism is, the larger the legal punishment. All the benefits and costs occurred in the

¹⁸ Households with blood ties or within the same natural village usually involve a small group of familiar people, and all the households in the group know each other quite well. A household will be moral punished by the other households if he illegitimately deprives other households in the small group of benefits that are rightfully theirs.

future are discounted to the present value. The probability of successfully squatting depends on the (perceived) land rights security that the landlord has over the plot, since landlords who perceive that they have more secure land rights are more likely to expend more efforts in reclaiming their land.

The tenant will decide to squat if the expected utility $E(U)$ is positive:

$$E(U|S_{ijk} = 1) = \sigma_t(X_i^s) * V(X_i^q) - R(\Delta_{ij}) - (1 - \sigma_t(X_i^s)) * L(X_k) > 0 \quad (3.1)$$

where $\sigma_t(X_i^s)$ denotes the probability of success of squatting on plot i , which is a function of the plot characteristics (X_i^s) that determine the tenure security of that plot; the value of the plot, $V(X_i^q)$, is a function of physical characteristics of the plot (X_i^q); the cost of the reputational loss (moral punishment), $R(\Delta_{ij})$, is a function of the social relations between tenant j and the landlord of plot i (Δ_{ij}); and the legal punishment, $L(X_k)$, is a function of legal enforcement mechanism for contract k (X_k).

Let δ be the discount factor, and ε_{ijk} denote the tenant j 's unobserved aversion to squatting on plot i given contract k . The outcome of the tenant's decision process will be

$$S_{ijk}^* = S_{ijk}^*(X_i^s, X_i^q, \Delta_{ij}, X_k, \delta, \varepsilon_{ijk}) \quad (3.2)$$

The landlord chooses a certain tenant and contract based on the trade-off between the profits he gets from renting out the land versus all the anticipated costs involved in the land transfer. The profits mainly consist of land rent paid by the tenant. The expected costs include the potential loss of future profit of the land if the tenant successfully squats it, or expropriation by the village or the government if land reallocation and governmental expropriation (without adequate compensation) occurs in the village, the transaction costs involved in finding a tenant with desired characteristics and signing a contract, and the expected cost of ending or enforcing the rental contract or changing the content of the rental contract if for any reason he wants to reclaim the land for his own use. The landlord's utility from renting plot i to a tenant j under contract k is

$$U_{ijk} = (\pi_{ijk} - \bar{U}_{ijk} - S_{ijk} - C_{ijk} - A_{ijk}) - [Prob(S_{ijk}^* = 1) * \sigma_i(X_i^s) + \sigma_v(X_i^s)] * V(X_i^q) + V_{ijk} \quad (3.3)$$

Subject to:

$$\pi_{ijk} = V(X_i^q, X_j^p) \quad (3.4)$$

$$\bar{U}_{ijk} = V(X_i^p) \quad (3.5)$$

$$T_{ijk} = C(X_k^n) \quad (3.6)$$

$$C_{ijk} = C(X_k) \quad (3.7)$$

$$A_{ijk} = A(\Delta_{ij}, X_j^p, X_k) \quad (3.8)$$

where π_{ijk} is the profit from plot i with tenant j under contract k , which is affected by the characteristics of plot i (X_i^p) and the characteristics of the tenant j (X_j^p); The reservation utility of the tenant j willing to rent the plot i under contract k ($\bar{U}_{ijk}$) is determined by X_j^{p19} ; search costs (T_{ijk}) are determined by the number of tenants with the characteristics of j , who are interested in renting in land under contract k in the region of plot i (X_k^n); the costs of signing a contract (C_{ijk}) are a function of the contract-type (X_k) with formal contracts normally having a higher cost because they have more detailed contents. The costs of altering the contract relationship (A_{ijk}) is a function of the social relationship (Δ_{ij}), the characteristics of potential tenants (X_j^p) and the contract type (X_k). $[Prob(S_{ijk}^* = 1) * \sigma_i(X_i^s)]$ measures the risk of land loss due to the tenant squatting, and $\sigma_v(X_i^s)$ indicates the risk of land loss due to expropriation by the village or government. Both risks are related to the tenure security of plot *i.e.* V_{ijk} is the unobserved part of the landlord's utility.

The landlord will choose tenant j under contract k in order to maximize his expected utility:

$$EU_{ijk} = \max_{jk} U_{ijk} \quad (3.9)$$

Based on Equation (3.9) the landlord's decision process in our conceptual framework is similar to that proposed by Macours (2014), but some aspects are unique to our case. Contract

¹⁹ The reservation utility can be considered to be the tenant's opportunity costs in renting in the plot, namely, the benefits from renting (an) other plot(s) or engaging in off-farm employment.

choice (informal or formal) and partner choice (transactions with partners with whom the landlord has different social relations) involve different enforcement mechanisms, and thus imply different degrees of punishment and flexibility. Tenure insecurity has three sources which are the tenant squatting, village-level land reallocations and governmental expropriations without appropriate compensation. We can draw three propositions from this conceptual framework.²⁰

a. A landlord's choice of partner and contract are made simultaneously, if we estimated the determinants of partner choice and informal/formal contract choice separately this would give a biased estimation.

b. The choice of contract type and partner involve making a trade-off between the flexibility of the rental relationship and the security of land rights (in the case of high tenure insecurity and unstable off-farm employment). Greater flexibility will reduce the cost of altering the contract relationship in the future, which needs to be traded off against the perceived risk of losing land benefits in the future.

c. Both the nature of the social relationship and the land tenure security affect joint decisions about the partner and the type of contract through reducing the risk of losing the land and increasing the flexibility of the rental relationship.

3.3.2 Specification of the empirical model

Akerberg and Botticini (2002) propose using regional instruments for endogenous partner choice in order to reduce estimation bias brought about by joint decisions of partner and contract choices. Macours (2014), however, suggests using a nested logit approach to model the key features of the joint decisions that landlords make. There are two main advantages of using the nested logit approach, compared to the instrumental variable (IV) approach used by Akerberg and Botticini (2002). First, in the nested logit framework, the characteristics of

²⁰ In theory the first-order condition, the utility maximization problem (Equation (3.9)), can be drawn by combining Equations (3.2)-(3.8). However, the formula of the first-order condition is very complicated, and we were not able to resolve all the first-order conditions. This does not prevent us from drawing these three propositions.

several potential tenants (*e.g.* the number of potential tenants, the average age of the household head and the education level of potential tenants) can be modelled as alternative-specific variables that affect the joint partner and contract choice, while the IV approach only accounts for overall differences in all landlords and tenants in the sample by using a regional dummy as a proxy. In practice, it is very difficult to find appropriate instruments to evaluate each of several potential tenants. Second, the nested logit approach allows the analysis to derive conclusions on the differences in the importance of partner choice for different type of contracts. In light of these advantages, we use a nested logit approach to model the joint decisions of partner and contract choices.²¹

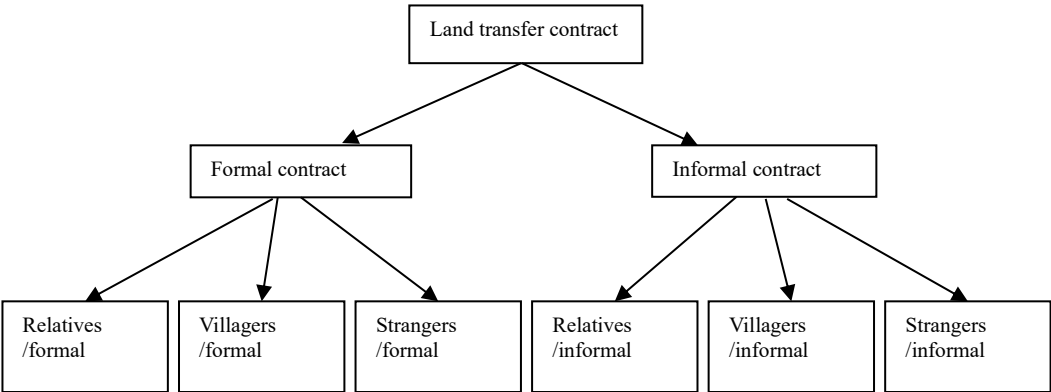


Figure 3.1 Schematic structure of nested logit model

Because informal and formal contracts have different degrees of flexibility and enforcement mechanisms, we hypothesize that partner choice will be less important for formal contracts, since these are mostly enforced by legal, rather than informal, rules. To test this hypothesis, a nested logit is estimated by allowing partner choice to have a different effect on the two types of contracts. The nested logit model covers two levels: the first level equation models the determinants of a landlord's contract choice, while the second level equation models the

²¹ The nested logit model relaxes the assumption of independently distributed errors and the independence of irrelevant alternatives (IIA) that are inherent in multinomial logit models by clustering similar alternatives into nests. This allows us to disregard the need to estimate multinomial logit models in this study.

determinants of partner choice, given the choice of a certain contract type.²² The decision tree for the nested logit model is presented in Figure 3.1.

Let the landlord's utility from renting plot i under contract k to tenant-type j be

$$U_{ijk} = W_{ik}\beta_k + Y_{ijk}\gamma + e_{ijk} \text{ for } j \text{ in } B_{ik} \quad (3.10)$$

where B_{ik} is the set of possible types of tenant with whom the landlord with plot i can match, given contract k . k indicates the contract type, either an informal contract (a) or a formal contract (b), W_{ik} affects the choice of contract k , and does not correlated to the tenant-type j ; Y_{ijk} correlates to both contract k and tenant-type j ; e_{ijk} is assumed to follow a generalized extreme value (GEV) distribution, which allows the e_{ijk} within each subset to be correlated, but not correlated between subsets. $\tau_k = \sqrt{1 - \text{Corr}(\varepsilon_{kj}, \varepsilon_{kl})}$ is the coefficient of dissimilarity. β_k and γ are estimated parameters. The probability of choosing tenant-type j in subset B_{ik} can be written as

$$P_{ij} = P_{B_{ik}} \cdot P_{ij|B_{ik}} = \frac{\exp(W_{ik}\beta_k + \tau_k I_{ik})}{\sum_{k \in (a,b)} \exp(W_{ik}\beta_k + \tau_k I_{ik})} \cdot \frac{\exp(Y_{ijk}\gamma/\tau_k)}{\sum_{j \in B_{ik}} \exp(Y_{ijk}\gamma/\tau_k)} \quad (3.11)$$

where $I_{ik} = \ln \sum_{j \in B_{ik}} \exp(Y_{ijk}\gamma/\tau_k)$

In Equation (3.11), W_{ik} is determined by the landlord or plot specific characteristics affecting the contract choice; and Y_{ijk} is determined by a vector of characteristics of the partnership created by matching the landlord of plot i with tenant-type j and contract k .

²² In reality, we can only observe six types of mixed choices (between villagers using a formal contract, between villagers using an informal contract, between relatives using a formal contract, between relatives using an informal contract, between strangers using a formal contract and, between strangers using an informal contract). This makes it difficult to determine whether the landlord first makes the choice about the contract or about the partner. Because informal and formal contracts differ in terms of their flexibility and enforcement mechanisms, we categorized the six types of choices into two groups (formal and informal contracts) in the first-stage. This structure allowed us to test if partner choice is less important for formal contracts, a question of interest to us.

3.4 Data Set

3.4.1 Data collection

This study uses data from two household surveys, one from Jiangxi Province, located in the Poyang Lake plain in central-south China, and Liaoning Province in the Songnen Plain, north east China (see Figure 3.2). Both provinces are important bases for commercial grain production in China. Table 3.1 shows some social-economic indicators for these two provinces and the average values for rural China as a whole. It shows that these two provinces had similar household incomes and households earn a similar proportion of their income through agriculture (in 2014), but that land endowments per capita in Liaoning were more than double than in Jiangxi. Rice and maize are the two most widely cultivated crops in Liaoning province; while rice is the most widely cultivated crop in Jiangxi province. Household income per capita in the two provinces is slightly higher than the average for rural China, and agricultural income plays a more important role in households' overall income as these provinces are important commercial grain production bases.

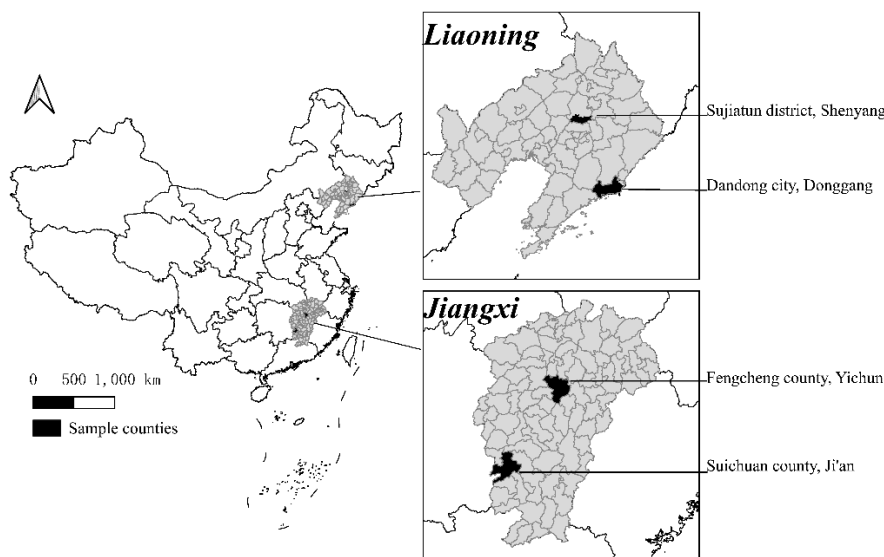


Figure 3.2 Geography location of sample sites

Table 3.1 Socio-economic indicators for the two case study areas and rural China

Indicator	Liaoning	Jiangxi	Rural China
Household net income per capita in 2014 (RMB)	11191.5	11242.56	10488.9
Share of agricultural income in total income in 2014 (%)	46.93%	45.53%	40.40%
Household land area per capita in 2012 (mu)	3.78	1.57	2.34
Main crops	Rice and maize	Rice	-

^a Source: Calculated from NBS (2013, 2015a, 2015b, 2015c)

A multistage sampling procedure was used to select households. First, four counties (two in each province) were selected through consulting with local researchers and policy makers. They were Fengcheng County, Yichun City and Suichuan County, Jian City, in Jiangxi Province, and Sujiatun District (County), Shenyang City and Donggang County, Dandong City, in Liaoning Province. These counties are good representatives of each region in terms of topography, distance from the provinces' capital cities and economic development. Fengcheng County and Sujiatun District are mainly on the plains, close to the capital city and have a higher level of economic development. The other two counties are in more hilly areas, further away from the capital city with a lower level of economic development. We then selected seven towns in each county of Jiangxi province, and four towns in each county of Liaoning province.²³ These towns were chosen as being representative of the diverse rural conditions found in each county (*e.g.* topographic features, distance to county center, agricultural development and rural labor force). We then randomly selected a number of villages in each town. The number of villages chosen in each town was based on the number of villages and their size (in terms of land and population). The primary rule is that more villages were selected from towns with more villages and / or more land and population. In most towns between 2 and 4 villages were surveyed, with a maximum of 6 and a minimum of 1. Next a number of households was selected randomly from each village, with the number of households interviewed varying according the size of each village (in terms of both population and the land area).²⁴ Households were grouped into three categories: renting in

²³ As *Sujiatun* is located close to *Shenyang* (the capital city of Liaoning Province) and the towns are more heterogeneous we selected five towns, with guidance from local informants.

²⁴ On average, 19 households per village were interviewed in Jiangxi and 35 households in Liaoning. In Jiangxi there are many small villages scattered in hilly areas, which is why we sampled more villages there –and less households per village.

households, those self-sufficient in land and renting out households. Rural household surveys with a random selection process often under-enumerate renting out households because they are more likely to migrate elsewhere (permanently or temporarily) and cannot be found at home at the survey time. In order to reduce this bias, we first interviewed village leaders to get a general idea of the share of each group of households in the village, and then used this estimate to adjust the number of households from each group that were interviewed. Through the sampling strategy we tried to make the share of the three groups of households (renting-out, self-sufficient and renting-in) was consistent with the population in the villages. The farm household survey in Jiangxi province was held in January 2015. It covered 817 households, living in 44 villages. The survey in Liaoning province was held in May 2015, and covered 811 households, living in 23 villages.²⁵ We excluded seven sample households that did not belong to the sample villages in Jiangxi province, and therefore use a sample of 1621 households for this study (810 households in 38 villages in Jiangxi province and 811 households in 23 villages in Liaoning province).

3.4.2 Descriptive statistics

Table 3.2 summarizes the characteristics of the development of the land rental market in the two case study areas, which can best be described as partially developed. The probability of renting out land and renting in land are comparable in two regions, with approximately 30 per cent of households renting in land and 30 per cent of households renting out. However, the land area leased per household is larger in Liaoning (5.43 mu²⁶ for renting out and 31.85 mu for renting in) than in Jiangxi (3.74 mu for renting out and 15.01 mu for renting in) (see Table 3.2). Other surveys conducted in three other counties in Jiangxi province (Yanshan County, Yujiang County, Guixi County) in 2011 (2010 data) found 37 per cent of households were renting in land, with an average rented-in land area of 10.0 mu. Thus the probability of participating in the land rental market has not changed significantly, but the area that is rented has increased significantly from 2010 to 2014.

²⁵ In addition to the household survey, surveys of village leaders and agricultural cooperatives and enterprises were conducted in the two research areas at the same time.

²⁶ Fifteen mu equals one hectare.

Table 3.2 Land rental market development in the two case study areas ^a

Regions	Share of renting-out households (%)	Share of renting-in households (%)	Area that is rented out per household (mu) ^b	Area that is rented in per household (mu) ^b
Jiangxi	32	29	3.74	15.01
Liaoning	31	27	5.43	31.85

Source: Calculated from household surveys.

15mu=1ha,

^a In our sample 28households in Jiangxi case and 31 households in Liaoning case rented out land to cooperatives or agricultural enterprises although these cases are not included as household-level renting in activities.

^b Calculated from the sub-sample of households renting-out and renting-in households.

Table 3.3 shows the characteristics of landlords in our sample who selected formal and informal contracts: 15.75 per cent of the rental contracts in the two regions were formal contracts. Informal contracts were much more common in Jiangxi with 91.54 per cent of the rental contracts being verbal or informal written ones, compared to 76.47 per cent of rental contracts in Liaoning. Overall, only 3 per cent of landlords who used formal contracts rented land to relatives, 36 per cent of them rented land to villagers, and the remainder (61%) were with strangers. With informal contracts an almost opposite pattern appeared only 10 per cent of these contracts were with strangers, and 90 per cent of them were with relatives or villagers. In general, landlords preferred informal contracts when renting out land to partners with whom they have closer social relations. We also found that landlords who used formal contracts had a higher possession of land certificates, and a slightly higher perception of the risk of losing land in the future. This finding suggests that possession of a land certificate does not necessarily strengthen perceptions about land tenure security (Ma *et al.*, 2015a). We found that the age and education of the household head, the contracted land area, available family labor and assets did not significantly influence the choice between formal or informal contracts. However, political status and geography did play a role: landlords whose head of household is a village leader or party member preferred informal contracts and landlords located closer to the center of town were more likely to use formal contracts. Lastly, we found that the land area rented through formal contracts was generally less than through informal contracts. The finding is not consistent with our expectation that the transformation of land rental contracts from informal to formal ones will induce the transfer of larger areas of land. One possible reason is that landlords are more likely use formal contracts when they rent out land to strangers and also chose to rent them less land.

Table 3.3 Characteristics potentially affecting landlords' preference for formal or informal contracts

Landlords' characteristics	Formal contract	Informal contract	Significance of difference
Observations ^a	71	383	***
Social relation			
Ratio of renting to relatives (%)	3	24	***
Ratio of renting to other villagers (%)	36	66	***
Ratio of renting to strangers (%)	61	10	***
Land certificate	0.847	0.714	
Perceived tenure security	0.375	0.436	
Age of household head (years)	59.15	57.69	
Education of household head ^b	2.50	2.64	
Village leader or party member	0.042	0.070	*
Household wealth (ten thousand yuan)	11.51	14.83	
Distance to town (km)	3.455	4.415	*
Contracted land area (mu)	7.68	6.85	
Rented land area (mu)	3.90	4.79	**
Family labor	2.81	2.84	

Source: Calculated from household.

15mu=1ha

^a In our sample 59 households (11%) rented out their land to cooperatives or agricultural enterprises. In these cases landlords are usually forced to follow agreements designed by local governments and large tenants (*e.g.* agricultural enterprises and large scale cooperatives) and do not have any bargaining power in rental agreements. These landlords therefore are not included in our analysis.

^b A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

Table 3.4 presents the characteristics of potential tenants that are used in the matching analysis. Based on our field survey, landlords chose their partners from within the boundaries of township and potential landlords usually search for partners from the village where they live. If they fail to find matching partners in their own village they will then look for partners from the surrounding villages, but they seldom look for partners from outside of the township.²⁷ These potential tenants include households who already rent in land or are willing to rent in land from the certain range of landlord types and contract options. Since we

²⁷ We found a few agricultural enterprises (strangers) from outside the township or county to invest in agricultural production, but these cases samples were excluded in this study (as explained in Section 3.4.1).

only randomly interviewed a portion of households from each village, we could not identify potential tenants with specific characteristics (renting land from different landlords and selecting different contracts). We therefore calculated the ratio of potential tenants to all households that were interviewed in each town. As Table 3.4 shows, the highest percentage (20.09 per cent) of potential tenants would prefer to rent in land from other villagers and to use informal contracts, and about 12 per cent of potential tenants would prefer to rent in land from other villagers and to use formal contracts, or to rent in land from relatives using an informal contract. Only 2 per cent of potential tenants would prefer to rent in land from strangers, whatever the contract type.

Table 3.4 Characteristics of potential tenants

Social relation	Potential tenants (willing) to rent from relatives	Potential tenants (willing) to rent from villagers	Potential tenants (willing) to rent from strangers	Significance of difference
Tenants' characteristics				
Ratio of formal contracts (%) ^a	5.64	11.72	2.01	***
Ratio of informal contracts (%) ^a	11.69	22.09	1.88	***
Average household head age of potential tenants (years)	54.29	54.24	52.31	
Average household head education of potential tenants ^b	2.72	2.73	2.77	
Average family labor of potential tenants	3.18	3.21	3.26	
Average agricultural assets of potential tenants (ten thousand yuan)	0.77	1.15	0.65	**

Source: Calculated from household.
15mu=1ha

^a: The ratio of potential tenants who match or are willing to match the landlord-type (renting to relatives, villagers or strangers) and contract-type (formal or informal contract) to all households surveyed in each town.

^b: A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

We also calculated the average value of household characteristics (*e.g.* age and education of household head, available family labor, agricultural assets) for potential tenants who would be willing to rent from different types of landlord. We did not find any significant differences in the age, the education of household head or and available family labor between different group of potential tenants, although we did find that tenants who would potentially rent land from other villagers had more agricultural assets (11500 yuan) than those would rent land from relatives and strangers (around 7000 yuan). This suggests that those who would rent land from other villagers operate larger scale agricultural production than those who would

rent land from relatives and strangers. On the one hand, this finding is consistent with our expectation that rental activity between kinship members generally does not involve transferring land to households with a higher production capacity. On the other hand, it shows that tenants who would potentially rent from strangers are not large agricultural production entities and that large scale farming households are more likely to rent land from villagers rather than strangers.

3.4.3 Variable definitions and expected effect

(1) Contract choice and partner choice

Contract choice is measured by a dummy variable which is equal to 1 if a landlord selects a formal contract, and 0 otherwise. Two dummy variables are used to measure partner matching between landlords and tenants. Renting to villagers equals 1 when a landlord rents land to villagers living in the same village and 0 otherwise; Renting to strangers takes the value of 1 when a landlord rents land to strangers and 0 otherwise. These two dummy variables also measure social relations between landlord and tenant, which interact with the land tenure security variables, to test the hypothesis that renting to closer social relations is less likely when land tenure is secure. In our nested logit model, at the first decision level, we test the landlord's choice between a formal or informal contract; while at the bottom level the decision between tenant type under specific contract is decided.

(2) Land tenure security

As we discussed in the conceptual framework, apart from that of a tenant squatting, landlords can also lose their land due to village-level reallocations or governmental expropriations, and possession of a land certificate probably can protect against tenant's illegally squatting the land, but it hardly provides enough protection against village-level reallocations or governmental expropriations (Ma *et al.*, 2015a, 2016). Following Van Gelder (2009) and Ma *et al.* (2015), we differentiate between actual land tenure security and perceived security.

Actual tenure security is represented by possession of a land certificate ²⁸, which takes the value 1 when a household possessed an official land certificate at the time of the survey, and 0 otherwise. Perceived tenure security is measured by household perceptions on the risk of losing contracted land, which takes the value 1 when a household does not expect that he/she will lose contracted land in the future, and 0 if the household either expects land loss in the future or is unsure. In our sample 73.58 per cent of the interviewed landlords possessed official land certificates, and 42.58 per cent of the interviewed landlords did not expect land loss in the future.

The actual tenure security variable is predetermined, because possession of a land certificate is determined before a household makes land rental decisions.²⁹ However, some unobserved characteristics and past actions of households and villages may influence whether an individual household holds a land certificate and may also affect land rental decisions made by the household at the time of the survey. The possession of a land certificate may therefore be endogenous. In order to test this its potential endogeneity, a bivariate probit model is estimated to specify the determinants of possession of a land certificate and land contract choice, respectively. The results showed that the correlation coefficients of ρ between the two error terms are significantly different from zero at a 1 percent level of confidence, suggesting a correlation between possession of a land certificate and land contract choice, although the mechanisms involved were undetermined. Following Macours (2014) and Ma *et al.* (2017),³⁰ we used the two-step instrumental variables approach to address potential endogeneity. In the first step, we regressed the individual possession of a land certificate against individual characteristics, land endowments as well as instruments (the average value of individual status of possession of a land certificate in the village, based on other sampled households who live in the same village as the surveyed household). In the second stage, the resulting predicted values of the individual status of possession of a land certificate was

²⁸ We focus our analysis on land use rights certificates (land certificates) instead of land use rights contracts. Although two documents are correlated, they are not same. Land certificates can give better protection of land rights than land use rights contracts (Ma *et al.* 2017).

²⁹ According to our field survey, land certificates were issued to households in our research areas at the beginning of second round of the Land Contracting Program, between 1998 and 2000.

³⁰ Macours (2014) uses the average past and current title status of up to 5 neighbouring plots, excluding plots from the same owner, to obtain a prediction of the title status of the rented plot. Ma *et al.* (2017) use the village-average tenure security perceptions as instruments to predict individual tenure security perceptions.

introduced into the main equations seeking to explain the determinants of joint and contract choice. Given that the rules of issuing land certificates are largely determined by village governance procedures and informal norms, the individual possession of a land certificate is closely correlated with other households in the same village possessing a land certificate. However, it seems reasonable to assume that other households' possession of a land certificate does not affect the landlord's matching along social relations and contract choice other than through the correlation with the landlord's possession of a land certificate.

There is also a potential endogeneity problem with perceived tenure security, which arises from the potential causal relationship between the perception of tenure security and participation in the land rental market, as well as other, omitted and unobservable, characteristics that may affect both contract choice and tenure perception (Brasselle *et al.*, 2002; Ma *et al.*, 2016, 2017; Mullan *et al.*, 2011). We used a similar method to address this potential problem as we did for the possession of a land certificate. We used the average value of perceived tenure security in the village based on the other sampled households that live in the same village as the surveyed household as an instrument to obtain the predicted values of individual perception on tenure security, which were then introduced into the main equations. Given that the unobservable factors that affect perceived tenure security are mainly the village-level rules (informal and formal) associated with enforcement of land tenure reform and the dissemination of information (Ma *et al.*, 2015a), individual tenure security perception is closely correlated with the tenure security perceptions of other households in the same village. However, other households' tenure security perceptions do not affect matching along social relations and contract choice other than through correlation with the tenure security perceptions.³¹

(3) The characteristics of landlords and the land

Landlord's characteristics include the age and education level of the household head, whether

³¹ One could argue that the tenure security perceptions of other households in the same village are related to contract matching because other households are potential tenants that could be matched with the landlord. However, the tenure security perception is defined as the risk of contracted land loss, which is not correlated to the land rental contract. Given this definition, the possibility of such matching effects seems limited.

or not he is a village leader or party member and the household's wealth. The education level of the household head is measured by a categorical variable, which is defined as: 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or specialized secondary school), 5=undergraduate (or above). Being a village leader or party member is a dummy which takes the value of 1 when a household head is a party member or village leader, and 0 otherwise. Household wealth is the value of all agricultural devices, livestock, electronic instruments, furniture and vehicles and is used as an indicator of the economic and social power of a household within the village. These characteristics are expected to have an impact on contract choice for two reasons. Firstly, they affect a household's risk aversion, and thus have an influence on the choice between informal or formal contracts in land rentals, since the two types of contracts are associated with different levels of risk. Second, these characteristics, to a large extent, affect the opportunities for, and stability of, individual off-farm employment and thus the extent to which an individual landlord may need to rely on land production to support himself and his family in the future. When off-farm employment is less stable, the landlord is more likely to have to rely on his land, and so will look for a safer and more flexible contract. Therefore, the effect of landlords' characteristics on contract choice is underdetermined prior. We discuss this in Section 3.5.

Land characteristics are measured by the contracted land area allocated by village committee in the second round Land Contracting Program. The effect of contracted land area on contract choice is ambiguous. The more contracted land a landlord has, the more land he may rent out. The type of contract he will select will depend on which contract is safer and more flexible. The area and quality of the land that is leased by a landlord are also important attributes in determining its value. However, we excluded them from our models. Land area that is leased is expected to be endogenous with contract choice because the two decisions are determined simultaneously.³² Our survey did not cover information about land quality and we did not include them in the model. 'Distance to town' measures the distance between the household's

³² The area of land leased by a potential landlord may be correlated with the contract type he selects. He may lease more (less) land when he gets a desired (undesired) contract. As a test, we also included the area of land that is leased in the model, and found this had a negative effect on the probability of selecting a formal contract. The conclusions drawn from the variables of our interest (*i.e.* social relations and land tenure security) are consistent with those obtained from the models without including land area variable that will be presented in section 3.5. These estimation results for the test are available from the authors if required.

residence and the closest town. The landlords living in more remote villages are more likely to select informal contracts because social relations may play a more important role in remoter areas.

(4) The characteristics of potential tenants

Potential tenant's characteristics include the ratio of potential tenants, their average age and the education level of the household head, the average available family labor and their agricultural assets. The ratio of potential tenants is defined as the proportion of potential tenants selecting each type of contract and partner out of all the households interviewed in a town (see detail discussion in Section 3.4.1). This variable measures the relative scarcity of the different types of potential tenants in each town. We expect that this variable will have a positive effect on partner choice as the tenant-type with more potential tenants is easier to match. The characteristics of the household head and family of potential tenants are also included in order to test whether landlords use characteristics other than social relations (*i.e.* age, education, family labor and agricultural assets) to match tenants.

(5) Regional characteristics

Since we introduced village and town dummies to address the endogenous problem of tenure security variables and calculated the characteristics of potential tenants in each town, we also included county dummy variables in the models. Three dummy variables, that equal one for households living in *Suichuan*, *Sujiatun* and *Donggang* counties, respectively, are included to control for major unobserved differences between the four counties in factors which may affect contract choice.

3.5 Estimation results

The nested logit models were estimated using full-information maximum-likelihood estimations. The hypotheses that the coefficients of the inclusive values are both equal to one were rejected for all specifications, supporting our choice for a nested logit as opposed to a more restrictive model. We were surprised to find that the dissimilarity parameters, which

measure the degree of correlation of random shocks within each of the two types of contracts, were significantly greater than one. This is inconsistent with the random utility maximization (RUM) principal. One possible reason is that we did not specify suitable variables at the bottom-level that vary between the three types of tenant types, but not between households. We will later estimate a mixed logit model to test whether the findings obtained from the nested logit model are robust. Table 3.5 reports the regression results for the effect of holding a land certificate and social relations on joint decisions about partner and contract choice, while Table 3.6 shows the effect of perceived tenure security and social relations on these joint decisions and we report on these two models. Possession of a land certificate is assumed to be exogenous, and its original value is included in model 1; while in model 2 possession of a land certificate is considered to be an endogenous variable and its predicted value is used (see our detail discussion about instrument identification in Section 3.4.3). Due to the insignificance of the interaction between land tenure variables and social relation dummies in most models, Tables 3.7 and 3.8 report the regression results for possession of a land certificate and perceived tenure security, respectively, excluding the interaction terms.

With regards to the determinants of partner choice, we found that the two interaction terms of land tenure security variables and social relation dummies are not significant (Tables 3.5 and 3.6), particularly when controlling for the endogeneity of land tenure variables. This finding does not support evidence that landlords with lower tenure security are more likely to choose tenants with whom they have closer social relations, which is not consistent with Macours's (2014) finding in Guatemala.³³ The possible reason is that security of land tenure is not the main criterion for landlords to match tenants: the flexibility of the rental relationships may play a more important role in partner matching (as we argued in the conceptual framework).³⁴ The results reported in Tables 3.7 and 3.8 show that, keeping other variables constant, landlords in our research areas are more likely to rent out land to people from the same village as them. It further indicates that landlords may match tenants according

³³ Macours's (2014) found that landowners without a title are more likely to choose tenants of the same ethnicity.

³⁴ If land tenure security is only criterion for matching tenants with closer social relations, landlords who perceive insecure land tenure will be less likely to rent out land to strangers and more likely to rent out land to relatives. However, the interaction terms are not significant. The possible reason is that security of land tenure can reduce the risk of losing land, but cannot increase the flexibility of the rental relationship for the landlord.

to their social relations not only to protect their security of land rights, but also for flexibility in the rental relationship. A flexible rental relationship play a more important role, as landlords may face lower costs for ending or changing rental relationships if they rent land to other villagers as opposed to relatives or strangers.³⁵ The literature about company contracts shows that formal contracts serve only as reference points to a trading relationship; while flexibility provisions provide an informal framework that enables mutual adaptations to unfolding contingencies, without the associated hazards of underinvestment or maladaptation (Banerjee and Duflo, 2000; Schwartz and Watson, 2001; Susarla, 2011). The ratio of potential tenants is significant in all models, suggesting that search costs are important and that landlords are more likely to match with a more common tenant-type with more household members. We also found that landlords are more likely to match potential tenants who are older and have less family laborers. These potential tenants have less power to enforce land rental contracts and are also less likely to be mount a larger scale agricultural production. Landlords may have less risk of losing their land if they match with tenants with these characteristics and land rental relationships with these tenants are easier to end or change.

As for the determinants of contract choice, we found that possession of a land certificate significantly increases the probability of selecting a formal contract, but this positive effect becomes not significant when controlled for by the potential endogeneity of possessing a land certificate. We also found that perceived tenure security has a positive effect on the probability of formal contracts. This, again, confirms that perceived tenure security plays a more important role than an actual land certificate in China (Ma *et al.*, 2015a, 2017). The positive effect suggests that informal contracts associated with relational governance may substitute formal contracts in regions with lower land tenure security. We also found that landlords with a higher education level are inclined to select informal contracts, which runs against our expectations.³⁶ One possible reason is that better educated landlords are more likely to take off-farm employment, and informal contracts allow them to change or end

³⁵ According to the field survey, landlords may be burdened by more guilt (moral sanction) in case of ending or changing rental relationship with relatives than with villagers; while landlords may be subject to more legal punishment in case of ending or changing rental relationship with strangers than with villagers.

³⁶ Educated households can be expected to have a better knowledge of laws and agreements and thus are expected to prefer formal contracts for land rentals.

contract relationships if they need to return to their village. The landlords with more contracted land from the second round contracting period are more likely to select formal contracts for land rentals since these landlords, on average, rent out more land and prefer formal contracts as a means of preventing tenants making changes to the contract relationship. As expected, landlords in more remote areas are more likely to select informal contracts as informal rules play a more important role in these areas.

As a robustness check, we estimated a group of mixed logit models (an alternative-specific conditional logit model) which allows for two types of independent variables: alternative-specific variables, which vary across both cases and alternatives, and case-specific variables, which only vary across cases. The variables which vary across alternatives but not across cases are not necessarily specified in the mixed logit model. Tables 3.A1-3.A4, in the Appendix 3, report the results of these mixed logit models.³⁷ We again found that the ratio of potential tenants was significant in all models, and suggest that search costs are important determinants of contract type and partner matching. We also found that land tenure security, measured by a low level of perceived risk of land loss, encourages landlords to select formal contracts and to match with people from the same village. This again confirms that the effect of search costs leads landlords to match with partners whom they have certain social relations (medium-level social relations in our case) by signing formal contracts. This kind of matching may provide a good balance between tenure security and a flexible contract. These findings are consistent with the data presented in Tables 3.5-3.8.

³⁷ Leader or party member and county dummy variables were excluded from the mixed logit models because the estimation process cannot be concave if they are included.

Table 3.5 Nested logit estimations of joint partner and contract choice (with land certificate as the variable indicator for tenure security and with interaction terms)

	Model 1	Model 2
Determinants of contract choice (probability of formal contract)		
Land certificate ^a	1.446*** (0.454)	-0.403 (0.978)
Age of household head	-0.015 (0.014)	-0.018 (0.014)
Education of household head ^b	-0.607*** (0.204)	-0.572*** (0.207)
Village leader party member	0.286 (0.690)	0.415 (0.686)
ln(Household wealth)	0.097 (0.204)	0.020 (0.192)
Distance to town	-0.107** (0.051)	-0.097* (0.051)
Contracted land area	0.028 (0.034)	0.070* (0.039)
Determinants of partner choice		
Renting to villagers	2.614 (2.100)	4.029 (3.035)
Renting to strangers	0.849 (1.924)	1.737 (3.250)
Renting to villagers * Land certificate ^a	1.443 (1.563)	-0.686 (2.916)
Renting to strangers * Land certificate ^a	0.861 (2.025)	-0.566 (4.005)
Ratio of potential tenants	0.247*** (0.046)	0.212*** (0.047)
Average household head age of potential tenants	0.893* (0.469)	0.963* (0.516)
Average household head education of potential tenants ^b	-2.029 (10.075)	-3.828 (10.677)
Average family labor of potential tenants	-6.358** (3.185)	-6.270* (3.224)
Average agricultural asset of potential tenants	-3.375 (2.843)	-2.249 (2.892)
No. of possible matches between landlords and tenant-types	2,700	2,700
No. of landlords	450	450
LR chi2 (P_value)	47.12 (0.000)	40.93 (0.002)
LR test $\tau_f = \tau_i = 1$: χ^2 -statistic (p-value)	22.91 (0.000)	18.01 (0.000)
τ_f	7.234*** (2.283)	7.693*** (2.419)
τ_i	5.143*** (1.540)	4.861*** (1.626)

Notes:

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Results for regional characteristics (county dummy) are not reported.

^a The original value of the land certificate is used in model 1; model 2 introduces the predicted value of the land certificate using the average value of land certificates in the village based on the other sampled households who live in the same village as the surveyed household.

^b A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

Table 3.6 Nested logit estimations of joint partner and contract choice (with perceived tenure security variable as the tenure security indicator and with interaction terms)

	Model 1	Model 2
Determinants of contract choice (probability of formal contract)		
Perceived tenure security ^a	0.106(0.355)	5.748**(2.315)
Age of household head	-0.015(0.014)	-0.018(0.014)
Education of household head ^b	-0.555*** (0.203)	-0.750*** (0.219)
Leader or party member	0.461(0.689)	-0.310(0.790)
Ln (Household wealth)	0.048(0.192)	0.078(0.197)
Distance to town	-0.095*(0.051)	-0.109**(0.051)
Contracted land area	0.061*(0.032)	0.056*(0.032)
Determinants of partner choice		
Renting to villagers	2.662(1.954)	1.536(3.589)
Renting to strangers	1.240(1.373)	4.916(4.681)
Renting to villagers * Perceived tenure security ^a	2.745*(1.542)	7.033(8.165)
Renting to strangers * Perceived tenure security ^a	-0.223(1.807)	-8.496(10.756)
Ratio of potential tenants	0.222*** (0.045)	0.243*** (0.046)
Average household head age of potential tenants	0.842*(0.450)	0.896*(0.492)
Average household head education of potential tenants ^b	-2.144(9.504)	-3.807(10.678)
Average family labor of potential tenants	-5.637*(3.096)	-5.113(3.460)
Average agricultural assets of potential tenants	-3.212(2.763)	-4.071(3.204)
Nr. of possible matches between landlords and tenant-types	2,700	2,700
Nr. of landlords	450	450
LR chi2(P_value)	39.34(0.004)	43.66(0.001)
LR test $\tau_f = \tau_i = 1$: χ^2 -statistic (p-value)	17.42(0.000)	22.66(0.000)
τ_f	7.389*** (2.490)	7.311*** (2.432)
τ_i	4.993*** (1.651)	5.751*** (1.873)

Note:

*, ** and *** indicate statistical significance at the levels of 10%, 5%, and 1% respectively. Results for regional characteristics (county dummy) are not reported.

^a The original value of perceived tenure security is used in model 1; model 2 introduces the predicted value of perceived tenure security using the average value of perceived tenure security in the village based on the other sampled households who live in the same village as the surveyed household.

^b A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

Table 3.7 Nested logit estimations of joint partner and contract choice (with land certificate as the variable indicator for tenure security and without interaction terms)

	Model 1	Model 2
Determinants of contract choice (probability of formal contract)		
Land certificate ^a	1.293*** (0.401)	-0.334 (0.868)
Age of household head	-0.015 (0.014)	-0.018 (0.014)
Education of household head ^b	-0.612*** (0.204)	-0.571*** (0.207)
Leader or party member	0.288 (0.690)	0.414 (0.686)
Ln(Household wealth)	0.093 (0.204)	0.021 (0.192)
Distance to town	-0.107** (0.051)	-0.096* (0.051)
Contracted land area	0.029 (0.034)	0.070* (0.039)
Determinants of partner choice		
Renting to villagers	3.662* (2.106)	3.542* (2.066)
Renting to strangers	1.619 (1.294)	1.251 (1.202)
Ratio of potential tenants	0.248*** (0.046)	0.212*** (0.047)
Average household head age of potential tenants	0.985** (0.473)	0.933** (0.454)
Average household head education of potential tenants ^b	-3.513 (10.057)	-2.997 (9.351)
Average family labor of potential tenants	-6.634** (3.294)	-6.119** (3.105)
Average agricultural assets of potential tenants	-2.833 (2.840)	-2.508 (2.658)
Nr. of possible matches between landlords and tenant-types	2,700	2,700
Nr. of landlords	450	450
LR chi2(P_value)	47.56 (0.000)	40.96 (0.000)
LR test $\tau_f = \tau_i = 1$: χ^2 -statistic (p-value)	23.47 (0.000)	18.26 (0.000)
τ_f	7.532*** (2.336)	7.600*** (2.359)
τ_i	5.277*** (1.591)	4.825*** (1.591)

Notes:

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Results for regional characteristics (county dummy) are not reported.

^a The original value of land certificate is used in model 1; model 2 introduces the predicted value of land certificate using average value of land certificate in the village based of the other sampled households that live in the same village as the surveyed household as instruments.

^b A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

Table 3.8 Nested logit estimations of joint partner and contract choice (with perceived tenure security variable as the tenure security indicator and without interaction terms)

	Model 1	Model 2
Determinants of contract choice (probability of formal contract)		
Perceived tenure security ^a	-0.392(0.288)	3.903*(2.061)
Age of household head	-0.018(0.014)	-0.019(0.014)
Education of household head ^b	-0.604*** (0.201)	-0.749*** (0.219)
Leader or party member	0.509(0.690)	-0.329(0.785)
Ln(Household wealth)	0.023(0.192)	0.067(0.196)
Distance to town	-0.099*(0.051)	-0.109**(0.051)
Contracted land area	0.062*(0.032)	0.058*(0.032)
Determinants of partner choice		
Renting to villagers	3.662*(2.131)	3.852*(2.191)
Renting to strangers	1.307(1.248)	1.548(1.289)
Ratio of potential tenants	0.223*** (0.045)	0.243*** (0.046)
Average household head age of potential tenants	0.979** (0.470)	0.960** (0.471)
Average household head education of potential tenants ^b	-3.126(9.773)	-3.555(10.039)
Average family labor of potential tenants	-6.401** (3.213)	-6.531** (3.290)
Average agricultural assets of potential tenants	-2.586(2.769)	-2.993(2.867)
Nr. of possible matches between landlords and tenant-types	2,700	2,700
Nr. of landlords	450	450
LR chi2(P_value)	39.34(0.004)	43.70(0.001)
LR test $\tau_f = \tau_i = 1$: χ^2 -statistic (p-value)	17.42(0.000)	22.73(0.000)
τ_f	7.389*** (2.490)	7.470*** (2.361)
τ_i	4.993*** (1.651)	5.294*** (1.642)

Note:

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively. Results for regional characteristics (county dummy) are not reported.

^a The original value of perceived tenure security is used in model 1; model 2 includes the predicted value of perceived tenure security using the average value of perceived tenure security in the village based of the other sampled households who live in the same village as the surveyed household.

^b A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

3.6 Conclusions

The development of land rental markets can play an important role in enhancing productivity and equity among rural households, particularly when there are major imperfections in rural credit and labor markets. However, in many regions of China the land rental market is characterized by serious market segmentation and dominated by informal rental contracts, which reduces the potential of the land rental market to enhance productivity and equity. Using data collected from two household surveys in Fengcheng County and Suichuan County (Jiangxi Province) and in Sujiatun County and Donggang County (Liaoning Province) we found that landlords are more likely to rent out land to tenants who live in the same village, rather than relatives or strangers. This kind of partner matching may be based on consideration of both the risk of land loss and the flexibility of rental relationships. In the first place since landlords who rent out land to tenants with whom they have closer social relations will have less risk of losing land, while the latter suggests that landlords select tenants with whom they have certain social relations so that the rental relationships will be less costly to end or change if they lose off-farm employment in urban area, return to village and need to reclaim their land. Search costs are an important factor that drives landlords to match with a more common tenant-type as the search for such tenants generally involves fewer search costs.

With respect to contract choice, we found that insecure land tenure encourages landlords to select informal contracts, because these contracts may function as substitutes for formal contracts in regions with lower land tenure security. Besides tenure security, landlords also make contract decisions based on the flexibility that the contract will afford them. Better educated landlords are more likely to opt for a flexible (informal) contract, because they are more likely to take off-farm employment. We also found that landlords living in relatively remote areas are more likely to select informal contracts, due to the social norms that prevail in such regions.

The focus of our research has been on two economically less-developed areas with low degrees of urbanization where mandatory land rentals promoted by governments are not widespread. It would be interesting to explore the extent to which our paper's main findings

hold true in other settings in rural China, particularly in more economically developed regions (*i.e.* Yangtze River Delta and Pearl River Delta regions) where land transactions between households and village committees or between households and agricultural enterprises are more common. Although we discussed two important functions of land rental contracts in rural China, (*i.e.* security of land rights and flexibility of rental relationship) the observed effect of land contracts is the combined effect of these two functions. Future empirical research could separate out these two functions and compare them, using appropriate variables to indicate the different characteristics of contracts.

Taking these limitations into account, the results of our study raise a number of potentially important implications for policy making. One such implication is that land rental market segmentation and the informality of contracts in terms of endogenous matching of social relations limit productivity and equity in rural China. Recent policy reforms have focused on improving land tenure security and reducing peasant's reliance on it as a social security mechanism. The recent land tenure policy reforms (particularly the New Round of Rural Land Ownership Registration Certification Work initiated by the central government in 2013), are expected to help strongly develop land rental markets, but could be further strengthened by additional measures to convince rural households that formal rules (*i.e.* land certificates, land laws) are a more robust way of protect existing land rights than informal village rules. More specifically the rural legislative system could be adapted to reduce the potential costs to farm households incurred in protecting their land rights through legal means, including official meditation, arbitration and in the last resort, going to court. A second implication is related to the central role that land plays as a social security mechanism for those who return from cities as a result of losing their jobs or becoming older. This leads landlords to match with tenants with whom they have certain (close) social relations and to sign informal contracts. The " Three Rights Separation " policy initiated in 2014 can be used to reduce farmers' reliance on land which, by separating contracting rights and management rights, would reduce social matching between partners with close relations. If effectively implemented on the ground, this policy could significantly reduce market segmentation. Other helpful governmental measures, apart from land tenure policy reforms, could include initiating and /or improving access to pensions for rural inhabitants and unemployment insurance for returning rural-urban migrants as well as providing more stable rural off-farm employment, all of which could play an important role in improving the rural land rental market.

Appendix 3

Table 3.A1 Mixed logit estimations of joint partner and contract choice (with the original value of land certificate variable as the indicator of tenure security)

Equations	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Contract-tenant	Formal-villagers	Formal-relatives	Formal-strangers	Informal-villagers	Informal-strangers
Land certificate		1.878** (0.808)	14.302 (1256)	0.712 (0.484)	0.144 (0.300)	-0.288 (0.446)
Age of household head		-0.038 (0.024)	-0.011 (0.074)	0.015 (0.019)	-0.002 (0.012)	-0.008 (0.020)
Education of household head ^a		-0.137 (0.337)	-0.503 (1.067)	-0.290 (0.266)	0.195 (0.170)	-0.218 (0.270)
Ln(Household wealth)		-0.810*** (0.267)	0.118 (0.621)	-0.064 (0.190)	-0.201 (0.130)	-0.122 (0.196)
Distance to town		-0.162* (0.096)	-0.522 (0.471)	-0.028 (0.063)	-0.005 (0.037)	0.052 (0.056)
Contracted land area		-0.011 (0.055)	-0.083 (0.217)	0.017 (0.044)	-0.017 (0.031)	-0.012 (0.050)
Ratio of potential tenants	0.036*** (0.013)					
Average household head age of potential tenants	0.142 (0.088)					
Average household head education of potential tenants ^a	-0.837 (2.211)					
Average family labor of potential tenants	-0.017 (0.802)					
Average agricultural assets of potential tenants	-0.467 (0.537)					
Constant		1.700 (2.015)	-13.833 (1250)	-0.872 (1.668)	0.686 (1.061)	0.869 (1.649)
Nr. of observations	2700					
Nr. of landlords	450					
Log likelihood	-530.47					

Notes:

*, ** and *** indicate statistical significance at the levels of 10%, 5%, and 1% respectively.

^a A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

Table 3.A2 Mixed logit estimations of joint partner and contract choice (with the predicted value of land certificate variable as the indicator of tenure security)

Equations	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Contract-tenant	Formal-villagers	Formal-relatives	Formal-strangers	Informal-villagers	Informal-strangers
Land certificate ^a		-1.602 (1.058)	-3.438 (2.886)	-0.059 (1.004)	-0.094 (0.622)	-0.466 (1.002)
Age of household head		-0.046* (0.024)	-0.008 (0.080)	0.013 (0.019)	-0.001 (0.012)	-0.007 (0.020)
Education of household head ^b		-0.012 (0.334)	0.157 (1.019)	-0.263 (0.269)	0.223 (0.175)	-0.172 (0.277)
Ln (Household wealth)		-0.658** (0.268)	0.437 (0.593)	-0.058 (0.190)	-0.208 (0.131)	-0.147 (0.201)
Distance to town (km)		-0.146 (0.093)	-0.384 (0.424)	-0.024 (0.063)	-0.006 (0.037)	0.047 (0.057)
Contracted land area		0.055 (0.056)	-0.027 (0.242)	0.027 (0.047)	-0.017 (0.033)	-0.009 (0.053)
Ratio of potential tenants	0.038*** (0.014)					
Average household head age of potential tenants	0.138 (0.103)					
Average household head education of potential tenants ^b	-1.356 (2.466)					
Average family labor of potential tenants	-0.090 (0.809)					
Average agricultural assets of potential tenants	-0.309 (0.571)					
Constant		3.706* (1.922)	-0.935 (6.223)	-0.294 (1.667)	0.701 (1.078)	0.920 (1.671)
Nr. of observations	2700					
Nr. of landlords	450					
Log likelihood	-534.95					

Notes:

*, ** and *** indicate statistical significance at the levels of 10%, 5%, and 1% respectively.

^a The original value of land certificate is replaced by the predicted value of land certificate using average value of land certificate in the village based of the other sampled households who live in the same village as the surveyed household.^b A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

Table 3.A3 Mixed logit estimations of joint partner and contract choice (with the original value of perceived tenure security variable as the indicator of tenure security)

Equations	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Contract-tenant	Formal-villagers	Formal-relatives	Formal-strangers	Informal-villagers	Informal-strangers
Perceived tenure security		1.045** (0.480)	-12.652 (495.629)	-0.508 (0.426)	0.473 (0.276)	0.215 (0.411)
Age of household head		-0.046** (0.024)	-0.019 (0.076)	0.013 (0.020)	-0.002 (0.013)	-0.008 (0.020)
Education of household head ^a		-0.115 (0.324)	-0.155 (0.934)	-0.266 (0.267)	0.187 (0.171)	-0.218 (0.271)
Ln(Household wealth)		-0.708*** (0.263)	0.288 (0.599)	-0.031 (0.188)	-0.182 (0.132)	-0.158 (0.199)
Distance to town		-0.139 (0.095)	-0.494 (0.466)	-0.029 (0.063)	-0.002 (0.037)	0.051 (0.057)
Contracted land area		0.014 (0.052)	-0.057 (0.213)	0.027 (0.044)	-0.020 (0.032)	-0.018 (0.049)
Ratio of potential tenants	0.038*** (0.013)					
Average household head age of potential tenants	0.118 (0.085)					
Average household head education of potential tenants ^a	-0.982 (2.123)					
Average family labor of potential tenants	-0.101 (0.808)					
Average agricultural asset of potential tenants	-0.509 (0.530)					
Constant		2.791 (1.872)	-0.448 (5.874)	-0.288 (1.664)	0.610 (1.060)	0.702 (1.637)
Nr. of observations	2700					
Nr. of landlords	450					
Log likelihood	-529.5					

Notes:

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.

^a A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

Table 3.A4 Mixed logit estimations of joint partner and contract choice (with the predicated value of perceived tenure security variable as tenure security indicator)

Equations	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Contract-tenant	Formal-villagers	Formal-relatives	Formal-strangers	Informal-villagers	Informal-strangers
Perceived tenure security ^a		6.225** (2.806)	16.574* (9.731)	-1.219 (2.328)	0.711 (1.545)	-1.768 (2.422)
Age of household head		-0.044* (0.024)	-0.015 (0.086)	0.012 (0.019)	-0.002 (0.012)	-0.007 (0.019)
Education of household head ^b		-0.412 (0.368)	-1.685 (1.460)	-0.230 (0.285)	0.167 (0.190)	-0.140 (0.294)
Ln(Household wealth)		-0.671** (0.264)	0.305 (0.553)	-0.040 (0.189)	-0.196 (0.131)	-0.161 (0.200)
Distance to town		-0.161* (0.095)	-0.609 (0.501)	-0.016 (0.063)	-0.007 (0.037)	0.057 (0.057)
Contracted land area		0.003 (0.053)	-0.205 (0.269)	0.026 (0.044)	-0.018 (0.032)	-0.016 (0.050)
Ratio of potential tenants	0.032** (0.014)					
Average household head age of potential tenants	0.131 (0.084)					
Average household head education of potential tenants ^b	-1.022 (2.134)					
Average family labor of potential tenants	0.131 (0.813)					
Average agricultural asset of potential tenants	-0.502 (0.531)					
Constant		1.211 (2.092)	-4.003 (6.861)	-0.029 (1.759)	0.625 (1.107)	1.189 (1.760)
Nr. of observations	2700					
Nr. of landlords	450					
Log likelihood	-531.50					

Notes:

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels respectively.

^a The original value of perceived tenure security is replaced by the perceived tenure security using average value of perceived tenure security in the village based of the other sampled households that live in the same village as the surveyed household as instruments.

^b A categorical variable is used for indicating educational level, 1=illiteracy, 2=primary school, 3=junior school, 4=senior school (or secondary specialized school), 5=undergraduate (or above).

Chapter 4 Social relations, public interventions and land rent deviation -Evidence from Jiangsu Province in China³⁸

Abstract: Price mechanism plays an important role in allocating resources and enhancing economic efficiency and equity of land market. In this paper, we examine the impacts of social relations between rental partners and public interventions imposed by local governments or village collectives on land rent deviation, and discuss efficiency and equity impacts as well. Household-level data collected in 2014 covering 907 households in 30 villages in Jiangsu Province, China, are used for empirical analysis. We find that social relations based on blood tie and geographical location increase the levels of land rent deviation, and lead to the loss of efficiency and equity of segmented land rental market. However, public interventions, *i.e.*, land use limitation, collective permission and collective organization, may contribute to reducing land rent deviation and improving efficiency and equity of the market. Further evidence suggests that public interventions induce land rental transactions among partners other than relatives or familiar villagers.

Keywords: Land rental market; Rent deviation; Social relations; Public interventions

³⁸ This chapter is based on the paper published as Tang, L., Ma, X., Zhou, Y., Shi, X., Ma, J., 2019. Social relations, public interventions and land rent deviation: Evidence from Jiangsu Province in China. *Land Use Policy* 86, 406–420. <https://doi.org/10.1016/j.landusepol.2019.05.025>

4.1 Introduction

In the process of the rural structural transformation that China and many other developing countries are experiencing, land rental markets can play an important role in enhancing productivity as well as equity in rural societies (Deininger, 2003a; Jin and Deininger, 2009). However, pervasive market failure caused by high transaction costs and imperfect information inhibits the process of efficiency and equity-enhancing land reallocation (Ravallion and Van De Walle, 2006; Wang *et al.*, 2015)

Since its emergence in the late 1990s, the land rental market in rural China has been developing gradually (He *et al.*, 2016; Wang *et al.*, 2015). According to the statistical report of the Ministry of Agriculture and Rural Affairs, approximately 35.1%³⁹ of total contracted cultivated land was transferred by the end of 2016. Market should have played an important role in allocating resources such as land and labour force. However, a high transfer⁴⁰ rate does not necessarily increase economic efficiency and equity. In fact, neoclassical economics proposes that prices determine the efficiency of factor distribution, and the function of markets is realized via price mechanism (Kreps, 2013; Luenberger, 1995).

A high level of market segmentation is an important feature of the land rental market in rural China, which may result in a malfunctioning price mechanism. On the one hand, most land rental transactions are limited to a close circle of relatives, which allows the application of social sanctions to ensure that land is returned at the end of the rental period (Jin and Deininger, 2009; Prosterman *et al.*, 2009; Rozelle *et al.*, 2008; Wang *et al.*, 2015); on the other hand, informal (oral) contracts are widely used between partners in the segmented land rental market (Feng, 2008; Jin and Deininger, 2009; Wang *et al.*, 2015). To reduce market segmentation and promote the formalisation of the land rental market, both land tenure reforms and public interventions from local governments and village committees have been implemented in China.

³⁹ See details: <http://www.tuliu.com/data/nationalContracted.html>.

⁴⁰ Land transfer transactions include subcontracting, renting, exchanging, and so on, among which land renting is the most popular form in China and thus is the focus of this study.

Centred on the land rental market, two issues have attracted wide attention in the extant literature. First, a large body of studies have examined the determinants of segmentation and informality of the rental market and suggested that land tenure security, social security and reputation are major factors (Holden and Otsuka, 2014; Macours, 2014; Wang *et al.*, 2015). Second, the existing studies have also attempted to examine the impact of the (segmented and informal) land rental market on agricultural investment, production efficiency and farmer welfare (Ghebru and Holden, 2015; Holden and Otsuka, 2014; Jin and Deininger, 2009; Ma *et al.*, 2017).

However, little attention has been paid to the effect of informal/formal institutions on land rent levels, with the exceptions of the studies of Kirwan (2009) and Bryan *et al.* (2015). Kirwan (2009) suggests that landlord-tenant relationships engender trust, which, in turn, influences rental rates. However, Bryan *et al.* (2015) do not find strong evidence that family relations between landlord and tenant affect the magnitude of cash rental rates in southern Ontario, Canada. These studies provide some important evidence for understanding the determinants of land rental. In contrast, land rent deviation, which is measured by to what extent the transacted rent is deviated from the real value of land, is a more precise indicator to measure whether the price mechanism functions in the land rental market. Moreover, effective public interventions are also considered to be an important measure to improve market function by reducing information asymmetry and transaction costs (Mankiw *et al.*, 2002). Unfortunately, there are few studies on the determinants of land rent deviation and particularly on the impacts of social relations and public interventions on rental deviation, and economic efficiency and equity as well.

Therefore, the main objective of this paper is to examine the impacts of social relations and public interventions on land rent deviation in rural China, and discuss economic efficiency and equity impacts of the segmented and integrated markets as well. We focus our analysis on both the supply and demand sides of the land rental market. In the theoretical analysis, we explain how social relations and public interventions may affect rent deviation and economic efficiency and equity of land rental market. In the empirical analysis, we first apply a production function to calculate the land shadow rent and deviation level of land rent and then use the Tobit model to examine the determinants of land rent deviation. A cross-sectional dataset containing 907 households in Jiangsu Province in 2013 is used to estimate these

models. This study is therefore limited to one province in China. Nevertheless, it intends to provide some novel insights into how social relations and public interventions impact the land rent deviation in rural China and other countries where land rental market segmentation is prevailing.

The paper is organized as follows. Section 4.2 presents a brief literature review and a conceptual framework on the role of social relations and public interventions in transition of land rental markets, and draws hypotheses that will be tested empirically. Section 4.3 presents empirical specifications for estimating land rent deviation and its determinants. Section 4.4 summarizes the data collection process and descriptive statistics of the variables used in the analysis. Section 4.5 reports and discusses the estimation results. Concluding remarks are presented in Section 4.6.

4.2 The transition of land rental markets: the role of social relations and public interventions

In this section we first discuss the transaction costs (TCs) and real land rent in the development of the three stages of land rental market, and explore how social relations and public interventions may contribute to the transition of land rental market. Secondly, we develop a conceptual framework to further demonstrate the main properties of these three stages in China. This is followed by a brief summary about efficiency and equity issue of land rental market and hypotheses.

4.2.1 The transition of land rental markets and land rent deviation in China

(1) Stage 1: locked market

In China, before 1984, rural land was not allowed to be transferred. In this period, the rural land rental market was locked. Rural households either cultivated their contracted land by themselves or laid it idle when they migrated to urban area and engaged in off-farm employment.

(2) Stage 2: segmented market

The Chinese rural households were then given land transfer rights as early as 1984 by the state document No. 4, which indicated that households could rent in/out their land. However, for reasons including insecurity of land rights, among other things, in most areas, land transactions were limited to social relations with close ties (Wang *et al.*, 2015). In fact, the segmented land rental market in which land transactions were limited to social relations with close ties is responsive to high TCs involved land rental transactions outside close social relations.

From an institutional cost perspective, TCs include 1) information costs, such as searching for information about products, prices, inputs, buyers and sellers, and their reputation, 2) bargaining and negotiation costs that are connected with reaching an acceptable agreement and writing a contract to support it, and 3) ex-post monitoring costs that are necessary to oversee the behaviour of a trading partner and the quality of what they deliver (Pejovich, 1990). Many studies have discussed the role of TCs in rental contract choice and argued that certain contracts are chosen to mitigate TCs involving these three types of costs (Allen and Lueck, 1993; Fukunaga and Huffman, 2009; Kassie *et al.*, 2015).

On the one hand, trust and reputation inherent in blood ties or geographical relations (close social relations) can reduce the three types of TCs as follows. First, households that have close social relations know each other quite well and share the same culture and social norms. The information on potential renting-in households' characteristics (*e.g.*, reputation) and land characteristics (*e.g.*, plot quality) is shared among these people, which consequently decreases searching costs. Second, households with close social relations commonly use informal (oral) and simple contracts that specify only the general contract relationship and lack important items, such as contract period, quantity of rent, rent payment method, and measures for risk prevention (Hong and Gong, 2015; Wang *et al.*, 2015). These contracts are signed based on long-term trust and reputation, and they may entail less negotiation costs than formal and more complex contracts (Poppo and Zenger, 2002). Third, the monitoring costs of contracts are lower among a small group of familiar households, and renting-out households have lower risk of losing rented land after the rental contract has expired (Holden

and Bezabih, 2006; Macours, 2014), and renting-in households also have lower risk of losing rented land before the rental contract has expired (Ma *et al.*, 2018).

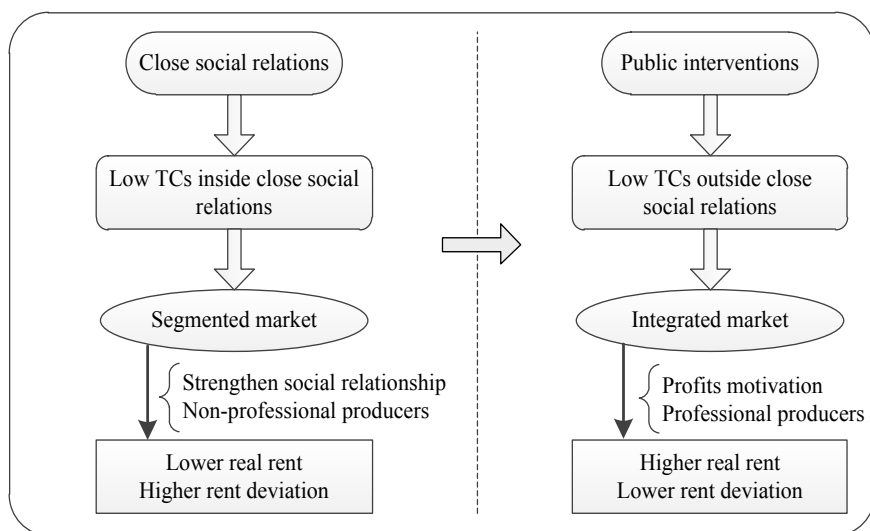


Figure 4.1 The framework of the effects of social relations and public interventions on rent deviation

The segmented land rental market however leads to a lower rent that may significantly deviate from the value of marginal product (VMP) of land in agricultural production. On the one hand, potential renting-out households who rent land to relatives or other familiar people usually ask for less land rent, which is an important mean to strengthen the social relationships with renting-in households. For example, to keep social capital valid, renting-out households usually use low rent (or discounted prices) or zero rent when leasing land to neighbours and relatives (Kostov, 2010). Therefore, the loss of land rent for renting-out households can be compensated by the increased social capital, *e.g.*, looking after elderly and children, providing assistance in agricultural production and sharing information with migrants. On the other hand, potential renting-in households are limited to few familiar people, and they are less likely to be professional producers with high agricultural productivity, *i.e.* professional family farm, cooperatives, and agricultural enterprises (Holden and Ghebru, 2005). These renting-in households are more likely to help to avoid land idle, and thus incline to pay lower rent.

As a result, renting-out households are willing to sacrifice part of land rent to reduce TCs and strengthen social relations, and renting-in households are willing to take care of other households' land. It allows the two parties to reach an agreement at a lower land rent which may result in a larger rent deviation from the market prices.

(3) Stage 3: integrated market

As the land rental market further develops and the desire to further improve efficiency and equity of land rental markets, land rental transactions inevitably fall outside of kinship members and familiar villagers, and experience inevitable formalization in many regions (He *et al.*, 2016; Wang *et al.*, 2015). In the case a new alternative governance mechanism is needed to substitute social relations in order to reduce TCs. Since 2010, local governments have carried out public interventions in land rental activities to promote the transformation from segmented to integrated rental markets.⁴¹ Three main types of public interventions are prevailing in our study area.

(i) Monitoring land use pattern (Land use limitation): To guarantee grain safety as well as the sustainable production ability of grain-growing land, local governments and village committees initiate land use control on rental land. In some regions, rental land may not be used for non-agricultural purpose or cultivating cash crops, such as lotus root, that may damage land production capacity.

(ii) Standardizing land rental process (Collective permission): To increase formality of the rental process and reduce the *ex-post* risk of contract enforcement, local governments and village committees request that land rental transactions obtain approval and be registered in the land rental centre or village committee.

(iii) Organizing land rental transaction by collectives (Collective organization): To increase the scale of the land rental market, some local governments and village committees take the initiative to act as an intermediary in the organization of land rental transactions. According

⁴¹ In addition to public interventions discussed in the paper, land titling programme and the policy on separation of "three rights" are important instruments to promote the formalization of land rental markets (see discussion by Cheng *et al.* (2019)).

to the rural administrative system in China, local governments usually trust village committees to carry out detailed tasks of organizing land rental transactions.

Public interventions, as a substitute for social relations, may facilitate the reduction of all three types of TCs when land rental transactions fall outside of familiar people.⁴² First, local governments and villages disseminate land rental information among villagers through formal meetings and even established land rental platforms (information exchange). The reliability of information on land demand and supply issued by governments and villages is carefully investigated. Public interventions can therefore substitute social relations to reduce information costs. Second, as a third party, local governments and villages participate in the negotiation of land rental contracts and provide necessary help to the contract parties, *e.g.*, concerning juridical knowledge, standard contract format, and effective supervision of contract signing. With this assistance, households will face lower bargaining and negotiation costs even if they rent land from/to strangers. Third, local governments and villages play an important role in enforcing land rental contracts in terms of monitoring the implementation of contracts and mediating land rental conflicts, particularly in response to unforeseeable events.

In the presence of the public assistance, even when land rental transactions occur among strangers, renting-out households run lower risk of not getting back rented land, and renting-in households also run lower risk of losing rented land before the rental contract has expired. Therefore, public interventions, as a formal enforcement mechanism, will substitute for informal enforcement mechanisms (social relations) in terms of reducing the TCs of land rental markets. This substitution helps to dismantle the lock-in effect of social relations on previous land rental relationships.

⁴² One may argue that public interventions discussed in the paper, *per se* also increase TCs, because household decisions on land rentals in the situation may involve additional process posed by local governments or village committees, and land rental activities may not be such free or voluntarily. However, in our research area, land rental activities were voluntary, and did not go against farmers' wills. The increased TCs associated with additional process are tiny compared to the total decline of TCs in the whole process of rental activities relating to searching/negotiating/monitoring costs, we therefore do not take into account the increased TCs in the analysis.

The integrated rental market allows price mechanism to play a more important role in land allocations where land can transfer easier from less productive to more productive households (Deininger and Jin, 2009; Wang *et al.*, 2015). Both renting-in and -out households in the integrated rental markets have stronger profit motivations and weaker motivations of social capital than in the segmented rental markets. On the one hand, renting-out households are willing to ask for higher rent regardless of social relations, and renting-in households with higher agricultural productivity can pay higher rent, and they are also willing to pay higher rent in order to hold securer land rights over rented land. It allows the two parties to reach an agreement at a higher land rent which may result in a smaller rent deviation from the market prices (Figure 4.1).

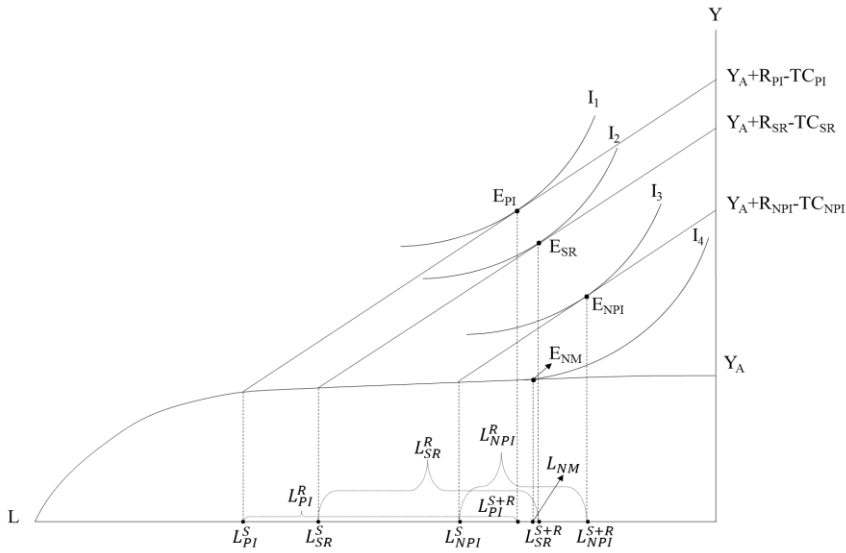
4.2.2 A conceptual framework

Following the study about farm household production on labour allocation and productivity of farm labour by Schmitt (1989, 1990), we develop a conceptual framework that demonstrates the three stages of land rental markets in China (see Figure 4.2). In Figure 4.2, Y_A represents the income possibility curve obtained from cultivating his/her own land, which is subject to the law of diminishing returns. The aggregated income possibility curve $Y_A + R_{SR} - TC_{SR}$ reflects the total income for renting land to close social relations, where the net rental income is the difference between rent (R_{SR}) and TCs (TC_{SR}). Similarly, we also have aggregated income possibility curve $Y_A + R_{PI} - TC_{PI}$ and $Y_A + R_{NPI} - TC_{NPI}$, for land rental transactions outside close social relations with and without public interventions, respectively. I_1 - I_4 reflect the household's indifference curve, and the higher indifference curve, the more utility.⁴³

In the absence of land rental market, the optimal land allocation for a household is at point E_{NM} . The household cultivates L_{NM} units of land and leaves the rest of land idle. Due to the locked land rental market, the household cannot get any land rental income, leading to lower

⁴³ Farm households can engage in different levels of off-farm employment among three stages of land rental markets, and obtain different off-farm income. In general, households can obtain more off-farm income in integrated land rental market than segmented rental market or in the absence of rental market. For simplicity, the off-farm income does not include aggregated income possibility curve in figure 4.2, but it does not influence the theoretical analysis.

total income. In the segmented land rental market, the optimal land allocation for that household moves forward to point E_{SR} where the aggregated income possibility curve ($Y_A + R_{SR} - TC_{SR}$) is tangent to the household's indifference curve (I_2). The household cultivates L_{SR}^S units of land, and rents out L_{SR}^S units of land. Compared to the locked market, the household can rent out land and achieve higher income obtained from land.



Symbolic Notations:

Y_A	Farm income possibility curve in a locked market
R_{SR}	Rent income obtained from segmented market
R_{PI}	Rent income obtained from integrated market (with public interventions)
R_{NPI}	Rent income obtained from integrated market (without public interventions)
TC_{SR}	Transactions costs from segmented market
TC_{PI}	Transactions costs from segmented market (with public interventions)
TC_{NPI}	Transactions costs from segmented market (without public interventions)
I	Indifference curve
L_{NM}	Land cultivated by a household in a locked market (autarky)
L_{SR}^S	Land cultivated by a household in a segmented market
L_{PI}^S	Land cultivated by a household in an integrated market (with public interventions)
L_{NPI}^S	Land cultivated by a household in an integrated market (without public interventions)
L_{SR}^{S+R}	Total land area cultivated and rented out by a household in a segmented market
L_{PI}^{S+R}	Total land area cultivated and rented out by a household in an integrated market (with public interventions)
L_{NPI}^{S+R}	Total land area cultivated and rented out by a household in an integrated market (without public interventions)

Figure 4.2 Allocation of farmland and the potential yields

In the integrated market, in the situation where effective public interventions are absent, higher TCs involved in the rental transactions outside close social relations would reduce the total income obtained from participating land rental market, and thus pull down the aggregated income possibility curve to $Y_A + R_{NPI} - TC_{NPI}$. The optimal land allocation for that household is at point E_{NPI} where the lower income possibility curve is tangent to the lower indifference curve (I_3). The household rents out L_{NPI}^R units of land that is less than L_{SR}^R . The income obtained from land in this situation is also less than the segmented market. Therefore, land rental transactions will be remained in the segmented market where close social relations are dominant. It is unlikely to transform from the segmented market to integrated market spontaneously.

However, if effective public interventions are adopted to reduce TCs involved in the rental transactions outside close social relations ($TC_{PI} < TC_{NPI}$), the aggregated income possibility curve will move up to $Y_A + R_{PI} - TC_{PI}$, and it is tangent to the household's indifference curve (I_1). The optimal land allocation for the household is at point E_{PI} , indicating that the household will rent out more land (L_{PI}^R), and obtain higher income from land in the integrated market.

4.2.3 Land rental market: an efficiency and equity issue

Well-functioning rural land rental markets can play an important role in enhancing economic efficiency by allowing households with higher agricultural ability to gain access to additional land and households with lower agricultural ability to participate in the nonfarm economy (Chamberlin and Ricker-Gilbert, 2016; Jin and Deininger, 2009). In addition, evidence shows that well-functioning rural land rental markets can improve equity by transferring land to the landless or land-poor households as is found in the Dominican Republic and India (Deininger *et al.*, 2008; Macours *et al.*, 2010), or by transferring land to the poor and less-educated households when better-educated individuals join the non-agricultural employment as is demonstrated in China (Jin and Deininger, 2009).

Normally, the change from an existing institutional arrangement to an alternative is a costly process. It will only occur when the net gains to individuals from changing to the new

arrangement outweigh the costs of the change (Lin, 1989). In China, the rapid growth of the land rental market to a large extent has been proven to improve efficiency as well as equity (Jin and Deininger, 2009; Wang *et al.*, 2015). The mechanism why the gains of the transition of land rental market through the abovementioned three stages may outweigh the costs with the aid of public interventions can be elaborated as follows. As illustrated in Figure 4.2, the transition of land rental market from locked market to segmented market significantly increase income obtained from land, and avoid land idle. However, the improvement in efficiency and equity is not as expected in the segmented land market. First, as discussed in the presence of high TCs in Section 4.2.2, land rental transactions are limited to a close circle of relatives or other familiar people. Price mechanism thus plays a weak role in land allocation, which prohibits the transfer of land from low-productive households to high-productive ones (Wang *et al.*, 2015). Second, fewer households are willing to rent land to partners that they are not familiar with, which prohibits the expansion of land operation scale ($L_{SR}^R < L_{PI}^R$). In particular, this limits the transfer of land from smallholders to larger-scale operators (*e.g.* cooperatives or agricultural enterprises) (Deininger, 2003a, 2003b). Third, informal land transactions usually use either short-term or indefinite contracts based on close social relations (Wang, 2011). These short-term or indefinite contracts offer farmers less incentive to make investments on rented-in plots (Gao *et al.*, 2012; Jacoby and Mansuri, 2010; Yoder *et al.*, 2008), which imposes negative impacts on economic efficiency (Zhou *et al.*, 2019).

Public interventions are thought to be important measures to dismantle the lock-in effect of social relations on land rental relationships and induce the transition from segmented land rental market to integrated market. In the integrated market, the limitations of segmented market is resolved by: (1) transferring land from low-productive households to high-productive ones, rather than (probably still low productive) partners with close social relations; (2) expanding land rental scale and operation scale; (3) improving land rental contracts and thus inducing farmers' incentives to make long-term investment and adopt technology innovations (Wang, 2011; Zhou *et al.*, 2019).

4.2.4 Hypotheses

We specify the following hypotheses that will be tested empirically in our study:

H1: The close social relations between rental partners are positively related to the levels of land rent deviation.

H2: Public interventions from local governments and villages dismantle the lock-in effect of social relations on land rent relationships and reduce the levels of land rent deviation.

H3: Effective public interventions facilitate the transition of land rental market from segmented market to integrated market, and increase efficiency and equity.

4.3 Model specification and estimation strategy

4.3.1 Model specification

(1) Land shadow rent

Land shadow rent measures the VMP obtained by cultivating land. In this study, we first use a production function approach to examine the value of land marginal output.⁴⁴ Different functional forms can be chosen for the production function. Numerous early studies preferred to employ a Cobb-Douglas specification largely due to the empirical difficulties surrounding the estimation of more flexible functional forms. Recent studies have preferred to use a translog functional form because the translog function is more flexible and can be interpreted as a second-order approximation to any true functional form (Abdulai and Tietje, 2007; Chen *et al.*, 2009; Tan *et al.*, 2010). The translog function can be specified as Equation (4.1):

$$\ln Y_i = \beta_0 + \sum_{j=1}^n \beta_j \ln X_{ij} + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \beta_{jk} \ln X_{ij} \ln X_{ik} + u_i, \text{ with } \beta_{jk} = \beta_{kj} \text{ for } j \neq k \quad (4.1)$$

where the dependent variable Y_i is the total output of each grain crop (rice, wheat, maize)

⁴⁴ Uncertainty and irreversibility have significant impacts on households' inputs, and thus they need to be considered in household models (see *e.g.* Dangerfield *et al.*, 2018; Degnet *et al.*, 2017; Ma *et al.*, 2013). In the case we use the production function to measure actual relationship between the inputs and outputs given that a given technology level, which has considered the uncertainties and irreversibilities faced by famers under specific conditions.

grown by household i in our research region. X_{ij} is the j^{th} production input used for each crop grown by household i .

The elasticity of output with respect to land input (E_j) is calculated by taking the partial derivative of output value with respect to land. The elasticity is as follows:

$$E_j = \frac{d(\ln Q)}{d(\ln X_j)} = \beta_j + \beta_{jj} \ln X_j + \frac{1}{2} \sum_{k=1, k \neq j}^n \beta_{kj} \ln X_k \quad (4.2)$$

The land shadow rent is calculated by Equation (4.3):

$$R_c = E_c \cdot (P_c \cdot Y_c - N_c) / S_c \quad (4.3)$$

where R_c indicates the shadow rent of land for each grain crop (c=rice, wheat, maize), E_c is the elasticity of output with respect to land input for each crop, calculated by Equation (4.2), P_c and Y_c are the market price and output of each crop, N_c is the net profit for each crop, and S_c indicates the cultivated area for each crop. Because more than one crop may be cultivated on a plot in a year, the land shadow rent is averaged by using Equation (4.4):

$$WR = \sum_{c=1}^3 R_c \times \frac{S_c}{S_t} \times M_{index} \quad (4.4)$$

where WR is the average shadow rent of land on which more than one crop is cultivated. S_c indicates the area cultivated for each crop. S_t is the total area cultivated for all crops. M_{index} is the crop multiplication index.

We use different data to calculate the land shadow rent for renting-in and renting-out households. For renting-in households, we use input and output data covering the survey year when land rental activities occurred, while for renting-out households, we use input and output data covering the year before land rental activities to calculate the land shadow rent.

(2) Land rent deviation

In the absence of TCs, the equilibrium rent in a perfect rental market is determined by the value of the marginal product (VMP) of land, *i.e.* the shadow land rent. However, in the presence of TCs associated with market participation, the costs cause a gap between rented-in and rented-out prices, creating a ‘price band’ (Huy *et al.*, 2016). Since the observed land rental market in reality is not a perfect rental market, we cannot calculate the optimal equilibrium rent. However, from the economic perspective, a potential renting-in household is willing to rent in land only when the VMP obtaining from cultivating the rented land (observed renting-in household’s shadow rent) is larger than or equal to its real land rent. In a similar way, a potential renting-out household is willing to rent out land if the real land rent is larger than or equal to the VMP obtained from cultivating that piece of land by himself/herself (observed renting-out household’ shadow rent).

For renting-in households, the difference between shadow rent and real rent indeed measures the magnitude of TCs associated with renting in activity. Whereas for renting-out households, this difference not only measures the magnitude of TCs associated with renting out activity, but also measures the potential productivity gap between renting-in and renting-out households, as land is usually transferred from lower productive households to higher productive households.

In our study, the deviation of the land rent level for household i is defined as the ratio of real rent (TR_i) to the weighted average shadow rent calculated based on input and output data (WR_i) and is specified as Equation (4.5).

$$D_i = \frac{TR_i}{WR_i} \quad (4.5)$$

In a well-functioning rental market, D_i is expected to equate to one for renting-in households, but is larger than one for renting-out households. However, in reality, D_i is usually less than one because social relations cause the real rent to be less than the land shadow rent. A larger D_i indicates that the real transacted rent is closer to the shadow rent of land and consequently that the rent deviation is smaller. It is also possible that D_i is greater than one for some renting-

in households, especially when serious natural disasters hit agricultural production, incorrect production decisions are made, or real rent that is higher than shadow rent is to be paid. We will describe the distribution of land rent deviation in Section 4.5.

(3) Determinants of land rent deviation

The basic model that we will use for estimating the factors affecting land rent deviation is specified as follows:

$$D_i = \alpha_0 + \alpha_1 SR_i + \sum \alpha_{2j} X_{ji} + u_i \quad (4.6)$$

$$D_i = \beta_0 + \beta_2 PI_i + \sum \beta_{3j} X_{ji} + \varepsilon_i \quad (4.7)$$

where SR_i and PI_i indicate social relations and public interventions for household i , respectively. X_{ji} is a set of control variables for household i , including village, household, land and regional characteristics. u_i and ε_i are the residuals with standard properties. Since social relations between rental parties are affected by public interventions, as the second hypothesis states, variables indicating social relations and public interventions cannot be included simultaneously in the model. The effect of public interventions on social relations can be estimated by model (4.8):

$$SR_i = \gamma_0 + \gamma_1 PI_i + \sum \gamma_{2j} X_{ji} + \vartheta_i \quad (4.8)$$

4.3.2 Estimation strategy

When we estimate the determinants of land rent deviation (Equations (4.6) and (4.7)), four issues must receive more attention. First, since we observe land rent and its deviation only for households that participated in the land rental market, there may be a selection bias because unobserved characteristics that influence the probability of participating in the land rental market could also influence the decision on land rent deviation. Neglecting this selectivity effect is likely to give biased estimates when the effect is significant. We therefore use the Heckman selection model to test for possible selection bias. If the null hypothesis that there is no selection bias is rejected, we apply the Heckman selection approach. If the null

hypothesis cannot be rejected, we estimate a Tobit model. The Heckman selection model requires a suitable identification strategy employing a variable that strongly influences the probability of participating in the land rental market but that is uncorrelated with land rent deviation. We identify an instrument that measures whether a household understands the land rental policy. We expect that households with better understanding of the land rental policy are more likely to participate in the land rental market, but we do not have a priori expectation concerning the effect on land rent deviation. One may argue that familiarity with the land rental policy may reduce (illegal) public interventions in land rentals from local governments and village committees; however, no current public interventions in the land rental market violate national rental policy in our research area.

Second, social relations between rental households is an endogenous matching process, which suggests that there are incentives for certain types of renting-out households to match with certain types of renting-in households (Akerberg and Botticini, 2002; Macours, 2014). For example, risk-averse households are more likely to rent in (out) land from (to) their relatives or other familiar villagers to reduce the risk of losing land.

Some unobserved factors that influence rental relations could also influence the decision on land rent. We identify three instruments, *i.e.*, household rental information, village rental information and government subsidy for land rentals⁴⁵ (see detailed definitions in Table 4.6), which are included in the models explaining the determinants of social relations but are excluded in the models explaining the determinants of rent deviation. Land rental information offered by villagers may increase the probability of land rentals between villagers, while information from governments or village committees may increase the probability of land rentals between non-villagers. In villages where village committees initiatively provide households with land rental information or local government provides financial subsidies for large-scale land rental activities, households are more likely to rent land from/to non-villagers. It is unlikely, however, that these instruments will directly affect land rent deviations other than through social relations between rental households. We select only the strong

⁴⁵ In our research area, to promote land rental market development, the local government gives a certain amount of subsidy (around 1500 yuan per hectare in many villages) to households that rent in land at large scale and use written and long-term rental contracts. The subsidy is paid once and to some extent compensates the cost of initiating the large-scale management of land.

instrumental variables, namely, household rental information and government subsidy for land rentals, in the regressions for renting-in households, while we consider household rental information and village rental information in the regressions for renting-out households. To ensure that our selection of instrumental variables is appropriate, we first confirm that the instrumental variables are correlated with social relations but not with the land rent deviation variables. Then, we use the over-identification test to examine the appropriateness of the instrumental variables.

Third, there may be significant interdependence among the three types of public interventions. For example, the collective organization of land rental activities usually means that rental activities require the permission of village collectives and that land use patterns are limited by village collectives. This interdependence results in potential multicollinearity between different types of public interventions. To address this issue, we estimate several models that include each type of public intervention and two or three types of public intervention variables. The joint effects of the two or three types of public interventions are examined by testing the significance of the sum of coefficients of the two or three public intervention variables.

Fourth, as will be explained in Section 4.4.1, the data used for estimating the models are collected among 907 households in 30 villages. We apply cluster-adjusted standard errors, adjusted for the 30 villages to account for correlated errors within villages.⁴⁶

Finally, to examine the impact of social relations on the extent of rent deviation, an IVTobit model may be used. It assumes that the endogenous regressor is continuous. In our case, however, the social relation variables are discrete. Following the study of Ma *et al.* (2013a), instead of IVTobit, we employ the instrumental variables least squares (IVLS) model, with a probit model in the first-stage and then introduce the predicted values into the second-stage equations for land rent deviation in equation (4.6). In this method the standard errors obtained by using conventional methods may be biased, therefore we used a bootstrap estimate of the

⁴⁶ In one village, all households rented out land, and no households rented in land; therefore, in all regressions for renting-in households, the cluster-adjusted standard errors are adjusted for the 29 villages.

standard error to solve this problem (Cameron and Trivedi, 2010). More specifically, we randomly draw 400 sub-samples to estimate the first- and second- stages of equations.

4.4 Data and descriptive statistics

4.4.1 Data collection

This study uses household survey data collected in January 2014 in Jiangsu Province, which is located in the Jianghuai Plain in eastern China and is a major grain production area. A multistage sampling procedure was used for data collection. First, two counties, Guanyun County and Jinhu County, were selected by consulting local researchers and policy makers. These two counties are located in the northern part of Jiangsu Province and are important bases for marketable grain production. Table 4.1 shows some social-economic indicators at the county, provincial and national levels. These two counties had similar household income per capita and share of agricultural income to total income in 2013. The proportion of agricultural employees in Guanyun County is higher than that in Jinhu County, but the land area per capita in Jinhu County is larger than that in Guanyun County. Compared to the average values at the provincial and national levels, household incomes per capita in the two counties are both higher than the average in rural China but less than the average in Jiangsu Province. Agricultural income plays a more important role in household livelihood in the two counties than in Jiangsu Province and rural China. The proportion of agricultural employees in the two counties is much larger than the average proportion in Jiangsu Province but smaller than the average proportion in rural China.

Second, seven towns and five towns are selected in the two counties, with guidance from local informants. These towns are considered representative of the diversity of the rural conditions that can be found in each county (*e.g.*, topographic features, distance to county centre, agricultural development, rural labour force).

Third, a number of villages were selected randomly in each town. The number of villages selected in each town was estimated according to the number of villages, the size of the land area and the population in each town. The primary rule is that more villages were selected

from towns with a larger number of villages and/or a larger size of land endowment and population. Two to four villages were selected in each town.

Table 4.1 Socio-economic indicators for the research area, Jiangsu Province and rural China in 2013

Indicator	Guanyun County	Jinhu County	Jiangsu Province ^a	Rural China ^a
Household net income per capita (RMB)	10016	11931	13598	9429.6
Share of agricultural income to total income (%)	50.70	47.84 ^b	27.36	41.73
Share of labour engaged in agriculture to total rural labour (%)	46.51	38.57	29.69	62.4
Land area per capita (mu)	2.04	2.88	1.58	1.48

Source: Calculated from household and village leader surveys.

^a Source: Calculated from NBS (2014a, 2014b, 2014c)

^b The share of agricultural income to total income was not counted for Jinhu County, and it was replaced by the value for Huaian City. Jinhu County is one of nine counties (districts).

Fourth, because households that migrated elsewhere and rented out their land to other households are not found at home at the survey time, the number of renting-out households is usually under-enumerated in rural household surveys. This indicates that a smaller share of renting-out households will be interviewed than would be interviewed according to the random selection process. To reduce this bias, a corrected random sampling strategy was used to choose households. All households can be categorized into three groups in the villages: rent-in households, self-sufficient households and rent-out households. We first obtained a general idea of the share of each group of households out of all households in the villages based on interviews with village leaders and then used the estimated share of each group of households to adjust the number of households from each group that were finally interviewed. Households were selected randomly in each group in each village, and the number of households selected differed across villages depending on the size of the population and land area in the village. On average, 30 households were interviewed in each village.

Finally, we obtain a dataset that covers 907 households in 30 villages. The household survey questionnaire is related to land rental market participation, farm production, off-farm employment, land tenure and other land policy.

4.4.2 Definitions and descriptive statistics

(1) Input and output

The output for three major grain crops (rice, maize and wheat) is measured separately by their output quantity. Input factors include land, seed, family own labour, hired labour, inorganic fertilizer, organic fertilizer, machinery and pesticide.⁴⁷ Land is measured by the land area that is cultivated by a household in a year (in *mu*⁴⁸). Its mean value equals 94.19 *mu* for renting-in households (*i.e.*, 6.28 hectare) and 4.13 *mu* (*i.e.*, 0.27 hectare) for renting-out households.⁴⁹ Seed is measured by its costs (in *yuan*)⁵⁰. For farmers who use both retained seed and purchased seed, the retained seed is valued at market prices.

The amount of labour used for agricultural production is measured in man-days. We asked farmers to estimate both their own labour and hired labour used in the process of crop growing, such as in land preparation, seeding, weeding, fertilization, pesticide application, and harvesting. On average, a household used 11.72 man-days of labour in 2013. Hired labour constituted only 18.32% of the total labour use. Because farmers apply different types of inorganic fertilizer, the total amount used cannot easily be aggregated. Thus, inorganic fertilizer is also measured by the costs paid in the market. Organic fertilizer is measured by the amount of organic fertilizer used by farmers (in kg). Machinery is measured by its hiring costs plus farmers' own machinery cost (*e.g.*, the cost of gasoline if the household uses its own machines). Farmers also apply different types of pesticides that cannot easily be aggregated; therefore, pesticide is measured by the cost of purchasing from the market.

(2) Social relation

In our research area, 22.38% households rented in land, and 51.27% households rented out land. Households rented out land to different types of partners, including relatives, familiar

⁴⁷ Labour in agriculture is often divided into the owner-operator, his family members, and hired permanent or seasonal workers. Labour organization may affect the adoption of innovations (Beckmann and Wesseler, 2003). In this study we therefore distinguish family own labour from hired labour in agricultural production.

⁴⁸ 15 *mu* is equal to 1 hectare.

⁴⁹ The average contracted land area per household in the two counties is 7.75 *mu*, which is similar to the average contracted land area in China (approximately nine *mu*).

⁵⁰ 1 USD=6.19 *yuan* in 2013.

villagers, strangers outside of their own villages, cooperatives, enterprises and village collectives. Households usually rented in land from relatives, familiar villagers, strangers outside of their own villages and village collectives. Table 4.2 shows the overview of land rental partners in our sample. More than 80% of renting-out households rented out land to village collectives, strangers or enterprises, and cooperatives; while 17% to relatives or other familiar villagers.

Table 4.2 Social relations in land rental transactions in the research area

Indicator	Renting-in households	Indicator	Renting-out households
From whom land is rented in		To whom land is rented out	
Relatives or familiar villagers	160 (78.82%)	Relatives or familiar villagers	79 (17%)
Own village collective	16 (7.88%)	Strangers or enterprises	103 (22.15%)
Strangers	13 (6.40%)	Cooperatives	26 (5.6%)
Other village collectives	14 (6.90%)	Village collectives	257 (55.25%)
Total number	203 (22.38%)		465 (51.27%)

We also find that around 79% of renting-in households rented in land from relatives or other familiar villagers and 21% from village collectives or strangers. The mismatch between renting-out and renting-in households is caused by the fact that the respondents to our survey exclude cooperatives, enterprises and village committees. According to geographical relations and blood ties, we divide social relations between rental partners into two categories: relations between relatives or familiar villagers and relations between strangers, cooperatives, village collectives and enterprises. We use a dummy (1=relatives or familiar villagers, 0=otherwise) to measure the closeness of the social relations between rental parties.

Table 4.3 reports the amount of rent and rent deviation between different social relations. We find that the average rental prices for both renting-out and renting-in households were much lower between relatives or familiar villagers than that between other partners. Consequently, the extent of rent deviation is significantly larger when land rental transactions occurred among relatives or familiar villagers compared to other partners. According to the discussion in Section 4.2, we expect that close social relations increase the deviation of land rent, which will be tested in Section 4.5.

Table 4.3 Rent amount and deviation between different social relations

	Rent for renting-in households	Rent for renting-out households
Relatives or familiar villagers	370.274 (0.452)	576.854 (0.918)
Others	568.481 (0.960)	828.449 (1.177)

Note: the unit of rent is yuan/mu; Values of rent deviation are presented in parentheses.

(3) Public interventions

To measure three types of public interventions, we use three dummy variables, *i.e.*, land use limitation, collective permission and collective organization. As discussed in Section 4.2, land use limitation refers to whether the rented land has restrictions on land use from village collectives (1=has use limitation, 0=otherwise). Collective permission refers to whether rental requires the permission and approval of village collectives (1=needs collective permission, 0=otherwise). Collective organization refers to whether land rentals are organized by local governments or village collectives (1=organized by local governments or village collectives, 0=otherwise). Table 4.4 shows the overview of public interventions in the land rentals in our sample for renting-out and renting-in households.

These three types of public interventions differ in terms of the degree of intervention. Land use limitation refers to the minimal degree of intervention because most farmers may not overexploit land even though land use has not been restricted by village collectives. Collective permission is a greater degree of intervention that requires the permission of the village collective in the process of land rental activities. Thus, village collectives may monitor land rental relationships during the process of rental contract enforcement. Collective organization represents the greatest degree of intervention, as it allows village collectives to supervise both the ex-ante contracting process and the ex-post enforcement of land rental activities. As Hypothesis 2 presents, we expect that the higher the degree of intervention is, the greater the effect on the deviation of land rent. Table 4.5 presents the amount of rent and rent deviation between public intervention and non-intervention groups. We can find that the average rent for public intervention group is larger than that for non-intervention group. Correspondingly, the rent deviation is smaller for public intervention group than that for non-intervention group (except for the intervention in land use limitation for renting-out households).

Table 4.4 Public interventions in land rental transactions in the research area

Indicator	Number of households	
	Renting-in households	Renting-out households
Land use limitation		
Yes	50 (24.63%)	259 (55.70%)
No	153 (75.37%)	206 (44.3%)
Collective permission		
Yes	53 (26.11%)	394 (84.73%)
No	150 (73.89%)	71 (15.27%)
Collective organization		
Local government or village committee	48 (23.64%)	400 (86.02%)
Voluntary	155 (76.36%)	65 (13.98%)
Total households	203	465

Table 4.5 Rent amount and deviation between public intervention group and non-intervention group

	Rent for renting-in households		Rent for renting-out households	
	Intervention	Non-intervention	Intervention	Non-intervention
Land use limitation	492.000	376.417	803.973	768.524
	(0.834)	(0.449)	(1.099)	(1.186)
Collective permission	645.189	335.344	821.254	589.179
	(1.060)	(0.388)	(1.151)	(1.048)
Collective organization	626.400	354.190	821.898	566.644
	(1.031)	(0.427)	(1.161)	(0.975)

Note: the unit of rent is yuan/mu; Values of rent deviation are presented in parentheses.

(4) Other explanatory variables

The other independent variables used in the present study include village, household, land and regional characteristics. The village characteristics include village migration prevalence and village infrastructure. Village migration prevalence serves as an indicator of the development of the labour market. Migration decisions may be endogenous in explaining household land rental decisions (Feng and Heerink, 2008). We therefore define village migration prevalence as the average number of the migrating members in the village based on the other sampled households that live in the same village as the surveyed household. Its expected impact on rent deviation is ambiguous, depending on whether migration stimulates

land rental transactions among familiar villagers or with non-villagers. Village infrastructure plays an important role in shaping land quality, and land price increases as land quality improves (Perry and Robison, 2001). Therefore, we employ household evaluation of village irrigation and road facilities to measure village infrastructure by using a Likert scale from 1 (=very satisfied) to 5 (=very dissatisfied). Because these two variables are reported only for renting-in households, we apply them only in the models estimating the determinants of rent deviation for rented-in land. Better irrigation and road facilities can increase both actual land rent and shadow rent, leading to an ambiguous effect on rent deviation.

Household characteristics include household head's age, education, village leadership, agricultural skill training, number of dependents, income source, and land tenure security. The expected effects of household head's age, education and village leadership on land rent deviation are ambiguous because there are no a priori reasons that these household head characteristics may increase or decrease actual rent. However, these variables could affect the household head's attitude towards rental market participation and willingness to accept rental prices (Holden and Bezu, 2016). The number of dependents is expected to have a positive effect. The land may be more important for meeting subsistence needs for households with more dependents (Holden and Bezu, 2016). Therefore, the actual rent paid or received may be increased, along with the degree of rental deviation. The dummy of agricultural skill training is reported only for renting-in households. The households that received agricultural skills training are more likely to operate large-scale farms with professional management modes. Therefore, they may pay a more reasonable rent and experience less rent deviation. Family income source is measured by two dummies (agricultural income dummy and non-agricultural income dummy⁵¹). We expect that households with higher agricultural income have more incentives to rent in land and engage in professional management, which reduces rent deviation. However, the non-agricultural income dummy is expected to have an opposite effect.

⁵¹ We employ the household evaluation of income source, and households report three categories of main income source: agricultural income, non-agricultural income or both (agricultural income is equivalent to non-agricultural income).

Land tenure security may affect the contracting partners to whom the land is offered and the expected land value. Secure land tenure induces renting-out households to rent land to partners other than relatives or familiar villagers to increase land value and reduce rent deviation. For renting-out households, we used two dummy variables to measure actual and perceived tenure security: possession of land certificates (1=if a household has a land certificate, 0=otherwise) and perceived risk of losing land (1=if a household perceives that there is no possibility of losing land in the future; 0=otherwise) (see a detailed discussion about components of land tenure security in Ma *et al.* (2015b)). The potential endogeneity problem arises when we use household-level perceived tenure security (Ma *et al.*, 2016, 2017). To address this problem, the village-level perceived risk of land loss is used, which is defined as the average value of the surveyed renting-out households living within the same village. For renting-in households, the land tenure security attached to own contracted plots would not affect the rental of their renting-in plots. However, the rental of the renting-in plots is indeed affected by the land tenure security of renting-out households because the rentals are matched between the partners. Therefore, village-level possession of land certificates and village perceived risk of land loss for renting-out households are also included in the models explaining the determinants of rent deviation of rented-in land.

Land characteristics capture site-specific differences that could alter actual and shadow land rents. The contracted land area (*i.e.*, the size of the land allocated to the household by the village leader) per labourer is used to measure land endowment. On the one hand, households with a relatively large land endowment may manage land in a more professional way, which is expected to reduce rent deviation; on the other hand, they may manage land in a less precise way because they lack labourers. The impact on rent deviation is therefore ambiguous. A multiple crop index is expected to impact shadow rent (output value). A higher multiple crop index may increase land rent deviation if land transaction rent is not fully realized by higher production intensity. However, this is not the case if land transaction rent is adapted according to production intensity. Two additional dummy variables are used to measure the location of the rented plots, which plays an important role in land scale management. One dummy variable is whether the number of plots managed by a household is reduced after renting land; the other is whether the rented-in plot is adjacent to the household's own contracted land. The

expected effects of these two variables on the actual-shadow rent ratio are positive, as land scale management is more likely to be professional and cause less rent deviation.

Because our research area is located in a small area on the plain (two counties), land quality is not very heterogeneous in terms of soil type and organic content, and thus, information about soil type and organic components was not covered by the survey. The heterogeneity in agricultural facilities is captured by the village irrigation and road situation (see the discussion for village characteristics). One may argue that contract type (written or oral contract) and contract duration (long-term or short-term contract) may affect the shadow land rent and thus the rent deviation. However, these choices concerning contract relation (measured by social relations in the study), contract type and contract duration are closely related to each other and are made simultaneously. A household is more likely to offer the land to a relative or neighbour and select an oral contract with a short duration or an open-ended duration than to a person without blood ties or geographical relations. Therefore, we did not include contract type and contract duration in the models, as shown in Equation (4.6).

Finally, regional characteristics, as measured by township dummies, are included to control for major unobserved differences between different towns that may affect land rent deviation and the social relations between rental parties. Moreover, following the literature by Holden and Ghebru (2005) and Ma *et al.* (2015b), in Equation (4.8) that explains the determinants of social relations, we also include trust variables. Respondents were asked to indicate their trust of different groups (*i.e.*, relatives, villagers, strangers outside of the village, local officials), using a scale from 1 (totally distrust) to 10 (fully trust). We use the average scores for trust in these different groups. Table 4.6 defines the variables, their expected signs included in the regressions and their descriptive statistics.

Table 4.6 Descriptive statistics of variables used in the models

Variable	Definition	Mean (Std. dev.)	Obs	Expected signs
Land rent deviation variable^a				
Rent deviation for renting-in households	Ratio of actual land rent to shadow rent (calculated by inputs and outputs) for renting-in households	0.530 (0.634)	175 ^a	/
Rent deviation for renting-out households	Ratio of actual land rent to shadow rent (calculated by inputs and outputs) for renting-out households	1.137 (0.767)	394 ^a	/
Social relation variable				
Relatives or familiar villagers	1=Households rented land from/to relatives or other familiar villagers, 0=otherwise	0.358 (0.480)	668 ^b	-
Public intervention variables				
Land use limitation	1=Land use on the rented land is limited by the village collective, 0=otherwise	0.463 (0.499)	668 ^b	+
Collective permission	1=Rental transactions require permission of the village collective, 0=otherwise	0.669 (0.471)	668 ^b	+
Government organization	1=Rental transactions are organized by local governments or village collectives, 0=otherwise	0.671 (0.470)	668 ^b	+
Village characteristics				
Village migration prevalence	Average number of the migrating members in the village based on the other sampled households that live in the same village as the surveyed household	1.207 (0.232)	907	+/-
Village irrigation conditions	Respondent's subjective evaluation of village irrigation infrastructure, ranging from 1 (=satisfied) to 5 (=dissatisfied)	3.291 (1.278)	203	+/-
Village road conditions	Respondent's subjective evaluation of village road infrastructure, ranging from 1 (=satisfied) to 5 (=dissatisfied)	3.030 (1.185)	203	+/-
Household characteristics				
Age of household head	Age of household head (years)	56.598(10.433)	907	+/-
Education of household head	Years of formal education of the household head (years)	2.654 (0.914)	907	+/-
Village leader	1=Household head is a village leader, 0=otherwise	0.103 (0.304)	907	+/-
Agricultural skill training	1=Household heads experienced agricultural skills training, 0=otherwise	0.103 (0.304)	907	+
Number of dependents	Number of dependents in the family	1.310 (1.102)	907	+
Agricultural income dummy	1=Main income source is agricultural income, 0=otherwise	0.556 (0.497)	907	+
Non-agricultural income dummy	1=Main income source is non-agricultural income, 0=otherwise	0.173 (0.379)	907	-
Individual possession of land certificates	1=Household possesses an official land certification, 0=otherwise	0.721 (0.449)	907	+
Village possession of land certificates for renting-out households	Average value of possession of land certificates for renting-out households in the village	0.722 (0.293)	907	+
Village perceived risk of land loss for renting-out households	Average value on the probability of land loss in five years perceived by renting-out households in the village	0.553 (0.183)	907	+
Land characteristics				
Contracted land-labour ratio	Ratio of contracted (=allocated) land area to labourers in the household (mu)	0.557 (0.415)	907	+
Multiple crop index	Ratio of total sown area to land area during the survey year	1.834 (0.348)	907	+/-
Change in number of plots	1=Number of plots reduced after renting in land, 0=otherwise	0.665 (0.473)	203	+
Land adjacent relationship	1=Rented land is adjacent to contracted land, 0=otherwise	0.291 (0.455)	203	+
Trust variables (used only in regressions about relationship between public intervention and social relation)				
Trust towards known people	Average scores for trust towards parents, relatives and villagers, calculated by comprehensive questions about trust	7.890 (1.321)	907	/
Trust towards strangers	Trust towards strangers living outside the village, calculated by comprehensive questions about trust	4.187 (2.345)	907	/
Trust towards government	Trust towards government officer and village cadres, calculated by comprehensive questions about trust	4.355 (3.035)	907	/
Instruments for social relations				
Household rental information	1=Households reported that they obtained rental information from villagers, 0=otherwise (from village committee or local government)	0.355 (0.479)	668 ^b	/
Village rental information	1=If village committees provide rental information for villagers, 0=otherwise	0.576 (0.495)	907	/
Village subsidy for land rentals	1=If village committees provide subsidies for land rental activities, 0=otherwise	0.350(0.477)	907	/

Note: Regional dummies (towns) are not reported in the table. There are 907 households in the whole sample, including 203 households that rented in land, 465 households that rented out land, and 239 households that have self-sufficient land.

^a We excluded households that received production profit less than zero because the shadow rent for this excluded sample is negative. Finally, we use a sample that includes 175 renting-in households and 394 renting-out households for empirical analysis.

^b The sub-sample includes 203 rented-in households and 465 rented-out households.

4.5 Econometric results

4.5.1 Social relation and land rent deviation

The regression results of the relationship between social relation and rent deviation obtained from the estimation of Tobit models for renting-in households and renting-out households are reported in Tables 4.A1 and 4.A2 in the Appendix 4, respectively⁵². The first part of Table 4.7 shows the average marginal effects of social relations on rent deviation for both renting-in and renting-out households. A key finding is that social relations between rental households have a negative effect on rent deviation, indicating that land rent deviation that occurred between relatives or familiar villagers is greater than that between other partners. This result is robust to alternative specifications of the models in which social relation is considered to be endogenous and is addressed by using instruments.⁵³

Table 4.7 Average marginal effects for social relations and public interventions

Model: Variable	Renting-in households (Tobit) ^a		Renting-out households (Tobit) ^a	
	Coef.	Std. Err.	Coef.	Std. Err.
Social relationships^b				
Relatives or familiar villagers	-0.123*	0.065	-0.170***	0.052
Public interventions				
Land use limitation	0.132*	0.075	0.063	0.119
Collective permission	0.339***	0.102	0.241*	0.146
Collective organization	0.295**	0.117	0.269**	0.121

Notes:

Standard errors are adjusted for clusters (villages).

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a In the Tobit model, the marginal effects on the unconditional expected value of the (censored and uncensored) observed dependent variable are reported for each variable.

^b The estimated results obtained from the Tobit (IVLS) models are used to calculate average marginal effects for social relations. Standard errors have been corrected by randomly drawing 400 sub-samples to estimate the first- and second- stages of equations.

⁵² We investigated the potential sample selection bias using a Heckman selection model. In the two-step procedure, the coefficient of the inverse Mills ratio and standard error are -0.209 and 0.189 for renting-in households and -0.077 and 0.288 for renting-out households. Therefore, we cannot reject the null hypothesis that there is no selection bias, and we report the results obtained by Tobit models.

⁵³ Bryan *et al.* (2015) argued that social relationship (*e.g.*, whether the tenant is part of the family of the landlord) was exogenous, but as discussed in Section 4.4.2, social relation between tenants and landlords is an endogenous matching process.

This finding provides support for Hypothesis 1, that the closer the social relations are, the larger the land rent deviations are. It is also consistent with some existing studies arguing that a close relationship between sellers and buyers enables the buyer to obtain a significant price discount (Kostov, 2010; Perry and Robison, 2001). However, our finding does not support Bryan *et al.*'s (2015) finding of no strong evidence that the landlord-tenant family relation significantly affects the rental rate. The non-significant effect can be explained by the fact that family relationship should not affect the rental rate without any benefits to both parties from a discount (or premium) (Bryan *et al.*, 2015). In our research area, however, as argued in Section 4.2, the transaction cost reduction effect and the social capital investment effect are two important factors contributing to land rent deviation.

Regarding the estimation results for the control variables for renting-in households (Table 4.A1 in the Appendix 4), we find that village migration prevalence negatively affects rent deviation, indicating that land rent deviation is greater in villages with more migration. Agricultural skills training experience and two household characteristics (non-agricultural income dummy and village possession of land certificates) are significant in the Tobit model. However, they become insignificant when the social relation variable is instrumented in the IVLS regressions.

As for land characteristics, the contracted land-labour ratio has an insignificant effect on rent deviation. Changes in both plot number and multiple crop index have negative effects on rent deviation. Although households with reduced land fragmentation and higher multiple crop index are more likely to rent in more land and act as professional farmers, they have a higher marginal output value (shadow rent) due to the improvement of land quality and intensive use of land. This causes greater divergence between actual rent and shadow rent.

Table 4.A2 in the Appendix 4 reports the estimation results for the control variables for renting-out households. We find that households with higher education levels and larger contracted land-labour ratios have a greater rent deviation. A possible reason is that households with these two characteristics have higher agricultural productivity and thus larger shadow rent before they rented out land. Similar to renting-in households, we also find that the multiple crop index has a negative effect on rent deviation, as the larger the multiple crop index is, the higher the shadow rent.

4.5.2 Public interventions and land rent deviation

The estimation results for the relationship between public interventions and rent deviation are reported in Table 4.A3 for renting-in households and in Table 4.A4 for renting-out households in the Appendix 4. The latter part of Table 4.7 shows the average marginal effects of public interventions on rent deviation for both renting-in and renting-out households. For renting-in households, all three types of public interventions are found to reduce rent deviation in separate models (see models 1-3 in Table 4.A3). The sum of the estimated coefficients for two or three types of public interventions is significantly different from zero in all four models at the 5% significance level (see models 4-7, Table 4.A3), which shows that at least one type of public intervention variable is significant.

For renting-out households, we find that both collective permission and collective organization reduce rent deviation, but land use limitation does not significantly affect rent deviation (see Table 4.A4). As discussed in Section 4.4.2, land use limitation is a weaker public intervention compared to collective permission and collective organization. These findings provide support for Hypothesis 2, that public interventions from local governments and villages reduce the levels of land rent deviation.

For the control variables in the models, the signs and significance levels of the estimated coefficients are very similar to those reported in Tables 4.A1 and 4.A2, except for village perceived risk of land loss for renting-out households. Perceived risk of land loss has a significant and negative effect on rent deviation in Table 4.A3, which is inconsistent with our expectations. One possible reason is that households are more likely to rent out land to cooperatives, village collectives or enterprises than to relatives or other familiar villagers when they perceive higher risk of land loss.

4.5.3 Transmission mechanism: public interventions and social relations

In Section 4.2, we argue that public interventions may impact rent deviation by inducing land rental transactions beyond relatives or familiar villagers. To justify the transmission mechanism, we estimated the effects of three types of public interventions on social relations

and reported the estimated results in Table 4.8 for renting-in households and in Table 4.9 for renting-out households. The results reported in models 1-3 in both Tables 4.8 and 4.9 show that collective permission and collective organization, two strong intervention variables, have negative impacts on social relations. This indicates that these two types of interventions induce land rental transactions beyond relatives or familiar villagers. The models including two or three types of public interventions (models 4-6 in both Tables 4.8 and 4.9) present that the sum of the estimated coefficients for two or three types of public interventions is significantly different from zero at the 10% significance level. Land use limitation, however, does not significantly contribute to dismantling social relations. This finding is consistent with the fact that land use limitation has a smaller or insignificant impact on land rent deviation, as reported in Table 4.7. In other words, the transmission mechanism specified in first part of Hypothesis 3 is supported by this empirical evidence.

As for the control variables for renting-in households presented in Table 4.8, we find that households that are satisfied with the irrigation situation are more likely to rent in land from partners other than relatives or familiar villagers because these renting-in households tend to be professional farmers and to select land with good irrigation status. Furthermore, we also find that land rented from relatives or other familiar villagers is more likely to be adjacent to the contracted land. Three trust variables are found to be significantly correlated with social relations. Households with higher trust towards acquaintances are more likely to rent land from relatives or other familiar villagers, while those with higher trust towards strangers tend to rent land from partners other than relatives or familiar villagers, as expected. The trust towards government officers induces households to select relatives or familiar villagers as contracting partners, as households evaluate their trust towards government officers based on village leaders.

Table 4.8 Regression results of public intervention and social relation for renting-in households

VARIABLES	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Public intervention variables						
Land use limitation	-0.646(0.408)	-2.026*** (0.248)	-2.884*** (0.337)	-0.161(0.510)	-0.326(0.333)	0.149(0.585)
Collective permission				-1.984*** (0.262)	-2.669*** (0.439)	-2.936*** (0.383)
Collective organization						
Village characteristics						
Village migration prevalence	0.993** (0.450)	0.212(0.572)	0.236(0.744)	0.208(0.565)	0.173(0.740)	0.228(0.753)
Village irrigation situation	0.232* (0.125)	0.407*** (0.112)	0.578*** (0.155)	0.414*** (0.112)	0.590*** (0.153)	0.574*** (0.153)
Village road situation	0.062(0.135)	-0.066(0.150)	0.032(0.141)	-0.065(0.150)	0.016(0.149)	0.034(0.141)
Household characteristics variables						
Age of household head	0.035*** (0.012)	0.034* (0.018)	0.030(0.020)	0.034* (0.017)	0.032(0.021)	0.030(0.019)
Education of household head	0.011(0.137)	-0.055(0.157)	-0.137(0.183)	-0.030(0.141)	-0.133(0.186)	-0.163(0.152)
Leader member	-0.096(0.325)	0.201(0.356)	0.318(0.351)	0.169(0.356)	0.345(0.365)	0.358(0.360)
Agricultural skills training	0.171(0.427)	0.592(0.419)	0.693(0.519)	0.587(0.416)	0.743(0.524)	0.702(0.498)
Village possession of land certificates for renting-out households	0.512(0.595)	-0.155(0.505)	0.237(0.514)	-0.154(0.505)	0.170(0.514)	0.258(0.539)
Village perceived risk of land loss for renting-out households	1.662*** (0.513)	0.125(0.657)	-0.481(0.767)	0.121(0.656)	-0.590(0.780)	-0.489(0.770)
Contracted land-labour ratio	0.176(0.265)	0.087(0.261)	0.204(0.287)	0.100(0.250)	0.185(0.281)	0.193(0.275)
Land characteristics						
Land adjacent relationship	0.727*** (0.279)	0.652*** (0.300)	0.636(0.394)	0.657*** (0.301)	0.634(0.397)	0.636(0.394)
Trust variables						
Trust towards known people	0.280** (0.112)	0.498*** (0.130)	0.432*** (0.151)	0.498*** (0.130)	0.458*** (0.157)	0.425*** (0.154)
Trust towards strangers	-0.139** (0.068)	-0.268*** (0.081)	-0.252*** (0.091)	-0.271*** (0.080)	-0.270*** (0.098)	-0.247*** (0.089)
Trust towards government	0.074(0.050)	0.092(0.061)	0.108(0.066)	0.095(0.058)	0.109* (0.065)	0.105* (0.062)
Regional characteristics						
Township dummies	yes	yes	yes	yes	yes	yes
Observations	203	203	203	203	203	203
Pseudo R ²	0.263	0.428	0.545	0.429	0.546	0.545
Mean VIF	2.39	2.43	2.41	2.41	2.57	2.40
Log pseudolikelihood	-77.237	-59.977	-47.706	-59.875	-47.573	-47.647
% correct prediction	85.22	86.21	90.64	86.21	90.64	90.64
χ^2 -statistic for joint sig. of public interventions (<i>p</i> -value)			18.56*** (0.000)		88.06*** (0.000)	28.11*** (0.000)

Note: Standard errors are adjusted for 29 clusters (villages) for the full sample because no household rented in land in one village.

***, ***, * indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a Mean VIF tests the degree of multicollinearity among the independent variables.

Table 4.9 Regression results of public intervention and social relation for renting-out households

VARIABLES	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Public intervention variables						
Land use limitation	-0.258(0.166)			0.216(0.160)		0.264*(0.153)
Collective permission		-2.169*** (0.395)		-2.244*** (0.375)	-1.089*** (0.374)	
Collective organization			-2.432*** (0.447)		-1.780*** (0.475)	-2.526*** (0.472)
Village characteristics variables						
Village migration prevalence	1.401*(0.804)	2.174*** (0.601)	2.179*** (0.620)	2.108*** (0.596)	2.406*** (0.613)	2.075*** (0.597)
Household characteristic variables						
Age of household head	0.009(0.010)	0.003(0.012)	0.006(0.012)	0.003(0.012)	0.004(0.012)	0.005(0.012)
Education of household head	0.064(0.074)	-0.064(0.092)	0.008(0.081)	-0.062(0.093)	-0.038(0.088)	0.013(0.081)
Leader member	-0.937** (0.461)	-0.990* (0.571)	-0.545(0.420)	-1.062* (0.580)	-0.591(0.435)	-0.592(0.421)
Individual possession of land certificates	0.070(0.260)	0.034(0.279)	0.224(0.406)	0.026(0.280)	0.157(0.392)	0.229(0.413)
Village perceived risk of land loss for renting-out households	3.562** (1.418)	4.233*** (1.542)	2.407(1.549)	4.069*** (1.564)	2.827** (1.428)	2.146(1.524)
Land characteristics						
Contracted land-labour ratio	0.032(0.203)	0.165(0.211)	0.035(0.274)	0.161(0.212)	0.077(0.266)	0.029(0.272)
Trust variables						
Trust towards known people	0.003(0.053)	-0.042(0.060)	0.006(0.062)	-0.043(0.061)	-0.018(0.057)	0.012(0.061)
Trust towards strangers	-0.019(0.041)	-0.033(0.047)	-0.068(0.046)	-0.034(0.048)	-0.065(0.051)	-0.072(0.046)
Trust towards government	-0.014(0.021)	-0.020(0.017)	-0.002(0.020)	-0.019(0.018)	-0.008(0.019)	-0.001(0.021)
Regional characteristics						
Township dummies	yes	yes	yes	yes	yes	yes
Observations	465	465	465	465	465	465
Pseudo R ²	0.192	0.385	0.426	0.387	0.449	0.430
Mean VIF	2.20	2.19	2.19	2.19	2.28	2.19
Log pseudolikelihood	-171.184	-130.380	-121.623	-129.860	-116.860	-120.875
% correct prediction	85.59	88.82	90.97	89.03	91.61	90.97
χ^2 -statistic for joint sig. of public interventions (<i>p</i> -value)				21.84*** (0.000)	31.83*** (0.000)	28.98*** (0.000)

Note. Standard errors are adjusted for 30 clusters (villages) for the full sample. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a Mean VIF tests the degree of multicollinearity among the independent variables.

Regarding renting-out households presented in Table 4.9, we find that in villages where migration is more prevalent, households prefer to rent land to relatives or other familiar villagers. This finding is consistent with the field survey that migration itself does not necessarily reduce land rental market segmentation in rural areas. Migrants largely rely on land to provide social security, and renting land to relatives or other familiar villagers is an important way to keep tenure security of land (Ma *et al.*, 2016; Tao and Xu, 2007). As expected, households whose heads are village leaders have more connections with cooperatives or village collectives and are more likely to rent land to these partners.

Surprisingly, higher land tenure security, measured by household perceived risk of land loss in the future, is found to be positively correlated with social relations, indicating that households are more likely to rent land to cooperatives, village collectives or enterprises than to relatives or familiar villagers when they perceive higher risk of land loss. The possible reason is that formal contracts are usually used for renting land to cooperatives, village collectives or enterprises, which provides greater security than the informal or oral contracts widely used between relatives or familiar villagers.

Three trust variables are not found to affect social relations for renting-out households. This is not consistent with the findings of Kassie and Holden (2007) and Macours (2014) and our expectation. However, this finding is consistent with the explanation that households do not necessarily face a higher risk of losing land when they rent land to cooperatives, village collectives or enterprises than when they rent to relatives or other familiar villagers in our research area.

4.5.4 Robustness check

As we discussed in Section 4.3.1, the value of rent deviation does not necessarily range from 0 to 1. Table 4.A5 in the Appendix 4 shows the distribution pattern of households with different intervals of rent deviation in our sample. For renting-in households, the share of rent deviation ranging between 0 and 1 accounts for 86.86%, and the share between 1 and 2 accounts for 9.71%. For renting-out households, the share between 0 and 1 is 51.78% and

that between 1 and 2 is 39.34%. One may argue that land rent is not distorted downward when actual rent is higher than shadow rent. In particular, for approximately 13% of renting-in households, land rent may be distorted upward because they pay rent that is higher than their benefit from land production in the survey year. To test the robustness of the estimated results obtained from different sub-samples of households, we regress several groups of censored Tobit models specifying different lower and upper limits for censoring. The average marginal effects in different intervals are reported in Table 4.A6 in the Appendix 4 for renting-in households and in Table 4.A7 in the Appendix 4 for renting-out households. We find that the estimated results are closely consistent with those reported in Table 4.7.

4.5.5 Discussion: efficiency and equity impacts

(1) Social relations and efficiency/equity loss

In our research area, 22.38% households rented in land, and 51.27% households rented out land. The average output value per mu of land for the renting-out households was 927 yuan before land rentals, it increased to 1170 yuan for the renting-in households, which means in general the land has been transferred to more productive households. However, social relations still restrict 17% of households renting out land to relatives or other familiar villagers, and 79% of households renting in land from relatives or other familiar villagers (see Table 4.2). These informal land rental transactions result in significant deviation of real land rent from shadow rent (see Table 4.3), which demonstrates that price mechanism plays a weak role in land allocation.

Table 4.10 presents the share of households between different social relations who reported income change before and after land rentals.⁵⁴ We can find that smaller share of rental transactions within relatives or familiar villagers reported significant increase in farm income, although almost same share of households reported farm income increase (significant and slight increase). We do not find significant difference in wage income for renting-out

⁵⁴ Since farm income and wage income are major income sources for renting-in households and renting-out households, respectively, we reported farm income obtained from land cultivation for renting-in households, and wage income obtained from off-farm employment for renting-out households.

households between different social relations, but households gain less rent income when rental transactions occur within relatives or familiar villagers (576.854 yuan/mu vs. 828.449 yuan/mu). All these provide some evidence that social relations lead to the loss of economic efficiency and equity in our research area. Moreover, we also find that 48% of households that have rented in land would like to rent more land, but could not find potential renting-out households; and around 50.7% of renting-out households stated that they inclined to select partners from the same social class. Therefore, social relations restrict land transactions within the same class, reproducing social inequalities (Macours *et al.*, 2010).

Table 4.10 The share of households for changing income before and after land rentals: different social relations (%)

	Significant increase	Slight increase	Unchanged	Slight decrease	Significant decrease
<i>Farm income – for renting-in households</i>					
Relatives or familiar villagers	34.90	48.60	15.80	0.00	0.70
Others	44.00	36.00	16.00	4.00	0.00
<i>Wage income – for renting-out households</i>					
Relatives or familiar villagers	9.70	21.00	69.40	0.00	0.00
Others	9.30	22.60	67.20	0.60	0.30

(2) Public interventions and efficiency/equity gains

As transmission mechanism analysis suggests that public interventions from local governments and villages dismantle the lock-in effect of social relations on land rent relationships and reduce the levels of land rent deviation. This finding is also supported by Table 4.5 that public intervention groups have larger average rents and smaller rent deviation than non-intervention groups. In our research area, among the 203 renting-in households, 24.63%, 26.11% and 23.64% of them have land use limitation, collective permission and collective organization, respectively. Among the 465 renting-out households, 55.70%, 84.73% and 86.02% of them have land use limitation, collective permission and collective organization, respectively (see Table 4.4).

Table 4.11 presents the share of households between different public interventions who reported income change before and after land rentals. We can find that a larger share of rental

transactions with public interventions reported significant or slight increase in farm income for renting-in households and in wage income for renting-out households. This provides evidence that public interventions lead to the gains of economic efficiency and equity in our research area. Renting-in households have larger improvement space for efficiency and equity because smaller share of renting-in households take public interventions. As such, Hypothesis 3 has been proved: in our research area, under the assistance of public interventions, the land rental market has been transited from the segmented market to integrated market, which could benefit both renting-in and renting-out households during this transition.

Table 4.11 The share of households for changing income before and after land rentals: different public interventions (%)

		Significant increase	Slight increase	Unchanged	Slight decrease	Significant decrease
<i>Farm income for renting-in households</i>						
Land use limitation	Yes	45.90	40.50	10.80	2.70	0.00
	No	33.60	48.50	17.20	0.00	0.70
Collective permission	Yes	47.20	36.10	13.90	2.80	0.00
	No	33.30	49.60	16.30	0.00	0.70
Collective organization	Yes	44.80	34.50	17.20	3.40	0.00
	No	45.90	40.50	10.80	2.70	0.00
<i>Wage income – for renting-out households</i>						
Land use limitation	Yes	9.70	26.50	62.80	0.40	0.40
	No	9.00	16.80	73.70	0.60	0.00
Collective permission	Yes	8.60	23.90	66.70	0.60	0.30
	No	14.80	13.00	72.20	0.00	0.00
Collective organization	Yes	9.00	23.90	66.20	0.60	0.30
	No	12.00	12.00	76.00	0.00	0.00

4.6 Conclusions and policy implications

Segmentation prevails in the land rental markets in many developing countries and is thought to contribute to the failure of price mechanisms and thus lead to the loss of economic efficiency and equity in the land rental market. Using a household survey data collected in Jiangsu Province in 2014, our empirical results show that the efficiency and equity costs arise from the fact that land rental transactions are restricted to a close social relations and price

mechanism cannot lead to efficient factor allocation. As a consequence, land could not be transferred to more productive producers under guidance of land rent, and land transactions are restricted within the same class, reproducing social inequalities. Public interventions on land rental process and organization modes imposed by local governments or village collectives dismantle the lock-in effect of social relations on land rental relationships, and contribute to the reduction of land rent deviation. Public interventions could be an important measure to substitute social relations and thus improve economic efficiency and equity of rural land rental market in China.

Although our study is limited to a relatively small region in rural China, the insights gained are likely to be relevant not only for other parts of rural China but also for a wider range of developing countries. The results of our study point to a number of potentially important implications for policy making. One such implication is that public intervention is an important complement of formal land institutions in the development of land rental markets. If effective public interventions are applied, they will further dismantle the lock-in effect of social relations on land rent relationships and reduce the segmentation and informality of the land rental market. Possible types of public intervention include restriction on the intensity of the use (over-exploitation) of transacted land, official approval (permission) of land rental relationships, and collective organization of the land rental process.

However, two important issues must be given more attention when public interventions are used to correct land price mechanism. First, public interventions may push up excessive land rent and cause upward rent deviation, which may in turn reduce the incentives for renting-in land. A reference rent calculated by average input and output could provide helpful information for forming land rent, whether by negotiation between partners or by collectives. Second, public intervention, especially the collective organization of land rental processes, could constrain farmers' land rights and interests because farmers may lose the freedom to transfer land and be forced to rent land to certain types of partners. Public interventions therefore need to avoid depriving farmers of basic rights (*i.e.*, rights of the freedom to rent land, guaranteed rights to yields of land) in the process of land rental. Any type of enforced land transfer must be prohibited.

Last but not least, it should be noted that we did not employ econometric analysis to examine the impact of land rental market structure change resulted from social relations and public

interventions on efficiency and equity. In reality efficiency and equity gains observed may not be an indicator of “gains” but an indicator of other factors that have not been covered in the analysis (unobserved factors), in particular, we could not identify whether the observed differences in efficiency and equity stem from the land rental market transition or technical change. In future research it is suggested using panel data to further explore the influence of land rental market structure change on efficiency and equity issues.

Appendix 4

Table 4.A1 Regression results of social relations and rent deviation for renting-in households

Variables	Tobit model	Tobit (IVLS) model ^b
Social relation variable		
Relatives or familiar villagers	-0.261**(0.126)	-0.153*(0.080)
Village characteristics		
Village migration prevalence	-0.385*(0.211)	-0.392*(0.222)
Village irrigation situation	0.036(0.035)	0.019(0.033)
Village road situation	-0.042(0.028)	-0.033(0.037)
Household characteristics		
Age of household head	-0.005(0.005)	0.000(0.005)
Education of household head	0.049(0.044)	0.050(0.076)
Leader member	-0.091(0.082)	-0.060(0.133)
Agricultural skill training	0.373**(0.187)	0.384(0.239)
Number of dependents	0.037(0.036)	0.055(0.040)
Agricultural income dummy	-0.027(0.118)	-0.050(0.125)
Non-agricultural income dummy	-0.160**(0.073)	-0.125(0.093)
Village possession of land certificates for renting-out households	-0.371*(0.218)	-0.238(0.268)
Village perceived risk of land loss for renting-out households	-0.428(0.262)	-0.306(0.417)
Land characteristics		
Contracted land-labour ratio	0.134(0.089)	0.154(0.227)
Plot change	-0.249*(0.136)	-0.224*** (0.086)
Multiple crop index	-0.768*** (0.146)	-0.766*** (0.155)
Land-adjacent relationship	0.002(0.071)	0.074(0.089)
Regional characteristics		
Township dummies	yes	yes
Observations	175	175
Pseudo R ²	0.343	0.349
Mean VIF ^a	2.74	2.87
Log pseudolikelihood	-110.4	-109.3
<i>F</i> -statistic for instruments in first-stage estimations (<i>p</i> -value)	44.64 (0.00) for relatives or familiar villagers	
<i>F</i> -statistic for over-identification (<i>p</i> -value)	0.465 (0.495)	

Notes:

Eleven town dummies are included in the model to control town fixed effects but are not reported in the table. Standard errors are adjusted for 29 clusters (villages) for the full sample because no household rented in land in one village.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a The mean VIF tests the degree of multicollinearity among the independent variables.

^b Standard errors have been corrected by randomly drawing 400 sub-samples to estimate the first- and second- stages of equations.

Table 4.A2 Regression results of social relations and rent deviation for renting-out households

Variables	Tobit model	Tobit (IVLS) model ^b
Social relation variable		
Relatives or familiar villagers	-0.210*(0.121)	-0.182*** (0.057)
Village characteristics		
Village migration prevalence	-0.357(0.345)	-0.058(0.327)
Household characteristics variables		
Age of household head	-0.004(0.003)	-0.003(0.004)
Education of household head	-0.077**(0.032)	-0.076*(0.041)
Leader member	0.184(0.152)	0.052(0.142)
Number of dependents	-0.028(0.031)	-0.030(0.051)
Agricultural income dummy	0.098(0.093)	0.116(0.106)
Non-agricultural income dummy	0.077(0.108)	0.086(0.135)
Individual possession of land certificates	0.002(0.093)	-0.008(0.127)
Village perceived risk of land loss for renting-out households	-1.276**(0.634)	-0.639(0.925)
Land characteristics		
Contracted land-labour ratio	-0.231**(0.094)	-0.221(0.143)
Multiple crop index	-0.320**(0.155)	-0.339**(0.142)
Regional characteristics		
Township dummies	yes	yes
Constant	4.020*** (0.625)	2.966*** (0.798)
Observations	394	394
Pseudo R ²	0.101	0.109
Mean VIF ^a	2.18	2.39
Log pseudolikelihood	-412.4	-408.7
F-statistic for instruments in first-stage estimations (<i>p</i> -value)	37.60 (0.00) for relatives or familiar villagers	
F-statistic for over-identification (<i>p</i> -value)	2.05 (0.152)	

Notes:

Eleven town dummies are included in the model to control town fixed effects but are not reported in the table.

Standard errors are adjusted for 30 clusters (villages) for the full sample.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a The mean VIF tests the degree of multicollinearity among the independent variables.

^b Standard errors have been corrected by randomly drawing 400 sub-samples to estimate the first- and second- stages of equations.

Table 4.A3 Regression results of public interventions and rent deviation for renting-in households

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Public intervention variables							
Land use limitation	0.165*(0.097)			0.074(0.069)		0.094(0.071)	0.074(0.064)
Collective permission		0.447*** (0.133)		0.428*** (0.126)	0.431*** (0.134)		0.422*** (0.133)
Collective organization			0.368** (0.153)		0.023(0.164)	0.342** (0.143)	0.009(0.154)
Village characteristics							
Village migration prevalence	-0.448*(0.231)	-0.279(0.216)	-0.336(0.232)	-0.279(0.217)	-0.277(0.217)	-0.336(0.232)	-0.279(0.217)
Village irrigation situations	0.026(0.039)	0.032(0.040)	0.028(0.040)	0.033(0.040)	0.032(0.040)	0.029(0.040)	0.033(0.040)
Village road situations	-0.040(0.028)	-0.032(0.032)	-0.046(0.030)	-0.033(0.031)	-0.033(0.032)	-0.047(0.030)	-0.033(0.032)
Household characteristic variables							
Age of household head	-0.006(0.005)	-0.004(0.005)	-0.004(0.005)	-0.005(0.005)	-0.004(0.006)	-0.004(0.005)	-0.005(0.005)
Education of household head	0.047(0.045)	0.036(0.042)	0.052(0.044)	0.028(0.043)	0.036(0.042)	0.042(0.045)	0.028(0.043)
Leader member	-0.079(0.083)	-0.117(0.092)	-0.125(0.090)	-0.108(0.090)	-0.118(0.094)	-0.113(0.088)	-0.109(0.093)
Agricultural skill training	0.354*(0.191)	0.329*(0.181)	0.367** (0.185)	0.328* (0.181)	0.331* (0.185)	0.363* (0.185)	0.328* (0.185)
Number of dependents	0.047(0.033)	0.023(0.035)	0.049(0.034)	0.026(0.033)	0.024(0.031)	0.052(0.033)	0.026(0.030)
Agricultural income dummy	-0.057(0.116)	-0.035(0.111)	-0.044(0.113)	-0.038(0.109)	-0.035(0.111)	-0.048(0.111)	-0.038(0.109)
Non-agricultural income dummy	-0.127(0.081)	-0.091(0.075)	-0.104(0.079)	-0.086(0.076)	-0.090(0.076)	-0.098(0.082)	-0.085(0.077)
Village possession of land certificates for renting-out households	-0.409*(0.228)	-0.283(0.199)	-0.348(0.220)	-0.285(0.198)	-0.284(0.197)	-0.348(0.218)	-0.285(0.197)
Village perceived risk of land loss for renting-out households	-0.527*(0.278)	-0.249(0.248)	-0.297(0.273)	-0.254(0.247)	-0.244(0.253)	-0.305(0.270)	-0.252(0.251)
Land characteristics							
Contracted land-labour ratio	0.133(0.084)	0.152** (0.070)	0.139*(0.082)	0.140** (0.067)	0.151** (0.068)	0.125(0.079)	0.140** (0.066)
Multiple crop index							
Plot change	-0.236*(0.131)	-0.224*(0.124)	-0.248*(0.130)	-0.221*(0.124)	-0.225*(0.125)	-0.244*(0.128)	-0.221*(0.124)
Land-adjacent relationship	-0.024(0.075)	0.017(0.062)	-0.000(0.067)	0.013(0.064)	0.017(0.062)	-0.005(0.070)	0.013(0.064)
Regional characteristics							
Township dummies	yes	yes	yes	yes	yes	yes	yes
Observations	175	175	175	175	175	175	175
Pseudo R ²	0.336	0.382	0.359	0.384	0.382	0.362	0.384
Mean VIF	2.72	2.78	2.76	2.74	2.92	2.72	2.88
Log pseudolikelihood	-111.560	-103.868	-107.697	-103.568	-103.858	-107.237	-103.567
χ^2 -statistic for joint sig. of public interventions (<i>p</i> -value)				9.06*** (0.003)	8.01*** (0.005)	5.69*** (0.018)	7.13*** (0.008)

Notes: Standard errors are adjusted for 29 clusters (villages) for the full sample because no household rented in land in one village.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a The mean VIF tests the degree of multicollinearity among the independent variables.

Table 4.A4 Regression results of public interventions and rent deviation for renting-out households

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Public intervention variables							
Land use limitation	0.068(0.130)			0.029(0.112)		0.030(0.131)	0.022(0.116)
Collective permission		0.259*(0.153)		0.248*(0.133)	0.123(0.245)		0.117(0.217)
Collective organization			0.289***(0.132)		0.207(0.201)	0.280***(0.133)	0.204(0.211)
Village characteristics							
Village migration prevalence	-0.436(0.373)	-0.422(0.348)	-0.415(0.345)	-0.429(0.360)	-0.418(0.344)	-0.423(0.358)	-0.423(0.356)
Household characteristic variables							
Age of household head	-0.005(0.003)	-0.004(0.003)	-0.004(0.003)	-0.004(0.003)	-0.004(0.003)	-0.004(0.003)	-0.004(0.003)
Education of household head	-0.081***(0.033)	-0.069***(0.033)	-0.075***(0.032)	-0.069***(0.032)	-0.071***(0.032)	-0.075***(0.032)	-0.071***(0.032)
Leader member	0.199(0.151)	0.198(0.150)	0.182(0.150)	0.195(0.148)	0.185(0.149)	0.180(0.148)	0.183(0.146)
Number of dependents	-0.026(0.030)	-0.028(0.031)	-0.034(0.029)	-0.028(0.031)	-0.033(0.029)	-0.034(0.029)	-0.033(0.029)
Agricultural income dummy	0.118(0.096)	0.122(0.103)	0.124(0.105)	0.119(0.100)	0.123(0.105)	0.121(0.101)	0.121(0.101)
Non-agricultural income dummy	0.097(0.117)	0.095(0.118)	0.105(0.118)	0.091(0.115)	0.100(0.117)	0.100(0.114)	0.097(0.114)
Individual possession of land certificates	0.005(0.093)	0.002(0.095)	-0.018(0.096)	0.001(0.095)	-0.014(0.096)	-0.019(0.097)	-0.014(0.096)
Village perceived risk of land loss for renting-out households	-1.404***(0.631)	-1.333***(0.610)	-1.250***(0.624)	-1.340***(0.615)	-1.262***(0.621)	-1.259***(0.632)	-1.268***(0.630)
Land characteristics							
Contracted land-labour ratio	-0.239***(0.101)	-	-0.237***(0.095)	-	-	-0.236***(0.097)	-
Multiple crop index	-0.296*(0.154)	-0.338***(0.152)	-0.332***(0.162)	-0.339***(0.150)	-0.343***(0.155)	-0.333***(0.158)	-0.343***(0.153)
Regional characteristics							
Township dummies	yes	yes	yes	yes	yes	yes	yes
Observations	394	394	394	394	394	394	394
Pseudo R ²	0.098	0.102	0.103	0.102	0.104	0.103	0.104
Mean VIF	2.19	2.18	2.18	2.18	2.24	2.18	2.24
Log pseudolikelihood	-414.0	-411.9	-411.4	-411.9	-411.1	-411.3	-411.0
				1.55 (0.213)	4.08**	3.37* (0.067)	2.68* (0.102)

χ^2 -statistic for joint sig. of public interventions (p -value)

Notes: Standard errors are adjusted for 30 clusters (villages) for the full sample.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a The mean VIF tests the degree of multicollinearity among the independent variables.

Table 4.A5 Sub-sample sizes of different intervals of rent deviation

	Sub-sample for different intervals				Full sample
	0-1	1-2	0-2	>2	
Renting-in households	152 (86.86%)	17 (9.71%)	169 (96.57%)	6 (3.42%)	175
Renting-out households	204 (51.78%)	155 (39.34%)	359 (91.12%)	35 (8.88%)	394

Table 4.A6 Average marginal effects in different censor intervals for renting-in households

Model: Variable	Tobit ^a (0, 1)		Tobit ^a (0, 2)		Tobit ^a (1, 2) ^b	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Social relations^c						
Relatives or familiar villagers	-0.059**	0.027	-0.071*	0.043	-	-
Public interventions						
Land use limitation	0.039	0.039	0.091*	0.055	-	-
Collective permission	0.220***	0.047	0.288***	0.070	-	-
Collective organization	0.165***	0.058	0.204***	0.081	-	-

Notes:

Standard errors are adjusted for clusters (villages).

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a In the Tobit model, the marginal effects on the unconditional expected value of the (censored and uncensored) observed dependent variable are reported for each variable.^b Only 17 households were included in the sub-sample, with rent deviation ranging between 1 and 2; therefore, the Tobit model cannot be estimated for the sub-sample.^c The estimated results obtained from the Tobit (IVLS) models are used to calculate the average marginal effects for social relations. Standard errors have been corrected by randomly drawing 400 sub-samples to estimate the first- and second- stages of equations.**Table 4.A7 Average marginal effects in different censor intervals for renting-out households**

Model: Variable	Tobit ^a (0, 1)		Tobit ^a (0, 2)		Tobit ^a (1, 2)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
Social relations^b						
Relatives or familiar villagers	-0.078***	0.018	-0.158***	0.042	-0.066***	0.025
Public interventions						
Land use limitation	0.002	0.023	-0.010	0.056	-0.036	0.031
Collective permission	0.159***	0.039	0.251***	0.088	0.087*	0.045
Government organization	0.154***	0.034	0.266***	0.087	0.094*	0.050

Notes:

Standard errors are adjusted for clusters (villages).

*, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a In the Tobit model, the marginal effects on the unconditional expected value of the (censored and uncensored) observed dependent variable are reported for each variable.^b The estimated results obtained from the Tobit (IVLS) models are used to calculate the average marginal effects for social relations. Standard errors have been corrected by randomly drawing 400 sub-samples to estimate the first- and second- stages of equations.

Chapter 5 Estimated size and determinants of fertilizer use by rice farmers in China: Results from Jiangsu, Jiangxi and Liaoning Provinces⁵⁵

Abstract: China is facing major environmental problems arising from the high levels of fertilizer application. Fertilizer is often assumed to be overused not only from an environmental, but also from an economic point of view. However, this paper hypothesizes that revealed fertilizer use follows from optimizing behavior of farmers, and examines the roles of risk aversion and land rentals play in this revealed fertilizer use. Using a rural household balanced panel data set with 542 farms collected in Jiangsu, Jiangxi and Liaoning Province for 2014 and 2018, rice production function estimates are used to obtain farm-specific values for revealed fertilizer use. The regression model results indicate that risk-averse farmers are more likely to overuse fertilizer in our research area. However, with an increase in the farm size, the risk-averse farmers tend to reduce fertilizer overuse. Additionally, it was found that positive rainfall deviations have a negative effect on fertilizer overuse.

Keywords: fertilizer overuse; fertilizer underuse; risk-aversion; land rentals; China

⁵⁵ This chapter has been submitted to an international scientific journal.

5.1. Introduction

The Green Revolution has increased agricultural production in Asia and Latin America through the use of high-yielding varieties, fertilizers, and reliable irrigation (Holden, 2018; Kassie *et al.*, 2015; Matson *et al.*, 1998). In China, it has contributed to hunger elimination and poverty reduction (Hazell, 2009; Huang *et al.*, 2015). China's grain production has increased from approximately 300 million tons in 1978 to 617 million tons in 2020, an annual increase of approximately 1.73% (NBS, 2020). This increase was accompanied by a 2-fold increase in N fertilizer, a 2.5-fold increase in P fertilizer, a 16-fold increase in K fertilizer, and an 82-fold increase in compound fertilizer, whereas the size of irrigated cropland has only increased by 50% (NBS, 2020). However, the use of fertilizers has become more than optimal from an agronomic point of view and, therefore, causes a waste of resources (Mueller *et al.*, 2014; Vitousek *et al.*, 2009). Moreover, longstanding fertilizer overuse has resulted in severe adverse environmental impacts such as soil acidification, eutrophication, and increased greenhouse gas emissions (Guo *et al.*, 2010; Huang *et al.*, 2015; Sutton *et al.*, 2011). Therefore, the Chinese government aims to transform the present high-input and high-output production system into a more sustainable one (Jiao *et al.*, 2018).

Two factors that may obstruct a transformation towards more sustainable use of fertilizers are the increase in land rentals and farmers' risk aversion in rural China. Many rural residents have left the agricultural sector and have become engaged in off-farm employment in recent decades. According to the National Bureau of Statistics (NBS, 2021), approximately 59.38% of rural laborers were engaged in off-farm employment in 2020. Consequently, the number of transactions in the land rental market increased. According to the Chinese government, approximately 40% of the total cultivated land was transferred by the end of 2021⁵⁶. Well-functioning land rental markets allow relatively efficient households access to additional land (Chamberlin and Ricker-Gilbert, 2016; Jin and Deininger, 2009). However, when rental contracts have a short duration, renting-in farmers have few incentives to use sustainable practices that will mainly benefit farmers using the land after the contract ends. Moreover, the uncertainty of land use rights under informal contracts exposes farmers to the risk of

⁵⁶ <https://www.tuliu.com/data/nationalProgress.html> (in Chinese, data available for registered users only)

losing land. Therefore, the land rental market may reduce long-term agricultural productivity and sustainability (Kabubo-Mariara *et al.*, 2010; Kassie *et al.*, 2013, 2015).

Risk behavior can influence fertilizer use. For example, Lamb (2003) found that a risk-averse Indian farmer using off-farm labor to smooth consumption increases fertilizer use. A study of cotton farmers in northern China by Qiao and Huang (2021) found that risk-averse farmers applied more fertilizer than risk-taking farmers.

To alleviate the environmental problems caused by high levels of fertilizer (and pesticide) application while ensuring that food production is not affected, the Chinese government introduced in 2015 an action plan proposing four pathways to achieve fertilizer reductions. The first is precision fertilization through, for example via soil testing. The second is to optimize the ratio of nitrogen, phosphorus, and potassium in the compound fertilizers. The third is improved fertilizer application through deep mechanical plowing and optimization of water application. The last pathway encourages producers to substitute inorganic fertilizers with organic ones. However, the NACB (2021) concluded that fertilizer use in cereal production did not decrease between 2013-2020 (see Figure 5.A1 in Appendix 5.A). Thus, the policy did not obtain expected results, leading to a demand for further research.

This study will address three research gaps. First, existing studies often suggest that the present fertilizer use is inefficient (*e.g.*, Bai *et al.*, 2019), ignoring that farmers make rational choices when they decide on fertilizer use. Second, studies that estimated the impact of risk aversion on fertilizer use did not distinguish between the types of risks faced by farmers (*e.g.* Qiao and Huang, 2021; Wu *et al.*, 2021a). Third, previous studies have not yet considered the heterogeneity of farm households with respect to land renting and its influence on fertilizer use (*e.g.*, Wu *et al.*, 2021a).

This study aims to estimate fertilizer use and determine the roles that risk aversion and land rentals play in fertilizer overuse/underuse. To achieve this objective, we first derive a measure of fertilizer overuse/underuse, both theoretically and empirically. Overuse is defined here as use above the level one would expect on the basis of profit maximization. Next, we examine the role of land renting and risk on fertilizer use using a regression analysis. For the empirical analysis, we use a panel dataset containing data for 542 households in Jiangsu, Jiangxi and

Liaoning provinces covering 2014 and 2018. This dataset contains data on grain (rice, wheat and maize) production, fertilizer use, risk preferences, and land rental market participation.

Section 5.2 reviews the literature on the factors affecting fertilizer use, and theoretically derives a measure of overuse/underuse. Section 5.3 presents the study data. Section 5.4 discusses the estimation strategy and empirical results. The last section presents conclusions and a general discussion.

5.2. Theory and literature review

In this section, we derive a measure of fertilizer overuse/underuse. We then investigate the roles of risk preferences and land rental in this fertilizer use.

5.2.1 Measure of fertilizer overuse/underuse

Previous studies have typically employed a production function that incorporated additional factors unrelated to inputs, such as household age and educational level, to determine the optimal levels of fertilizer usage. Alternatively, they utilized agronomic response functions to derive the optimal fertilizer application (De Janvry, 1972; Qiu *et al.*, 2014; Yadav *et al.*, 1997). In our research, we employ a regular production function, and using first-order conditions of profit maximization, we define overuse/underuse as the difference between the fertilizer use resulting from profit maximization and the actual fertilizer use. Thus, we derive the additional net marginal cost/benefit associated with fertilizer application.

Suppose that the relationship between output y , a vector of variable inputs x , a vector of fixed inputs z and fertilizer m can be represented by the production function $f(\cdot)$:

$$y = f(x, z, m) \tag{5.1}$$

We assume that farmers maximize profit by choosing the optimal levels of variable inputs and fertilizer and that the market price of fertilizer does not entirely reflect its marginal value or shadow price for the farm. For example, fertilizer may have an additional marginal value because it can reduce production risk. The first-order condition of profit maximization is as follows:

$$\frac{\partial f}{\partial m} \cdot p = w_s = w_f + t_f \tag{5.2}$$

where p is the price of the output, w_s is the shadow price of fertilizer, w_f is the market price of fertilizer, t_f is the additional net marginal cost/benefit of the fertilizer.

If we have an estimate of the production function and we know the output price, we can derive the shadow price w_s . If we also have information about the market price of fertilizers, we can then obtain $t_f = w_s - w_f$. It should be noted that w_s can take negative values. We defined fertilizer overuse as the amount of fertilizer that corresponds to t_f . If t_f is negative, there are extra marginal benefits attached to the use of fertilizer, such as its production risk-reducing effect. This means that there is overuse. If t_f equals zero, this indicates there is neither overuse nor underuse. Otherwise, a positive t_f implies underuse. Figure 5.1 illustrates the overuse of fertilizers. x_s is the actual use of fertilizer, and the use in the case of market price w_f (x_f) is calculated using $\frac{\partial f}{\partial m} \cdot p = w_f$.

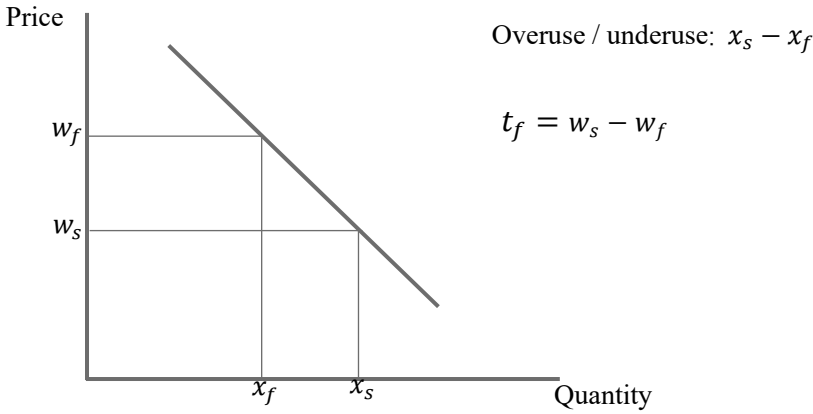


Figure 5.1 The use of fertilizer.

5.2.2 Determinates of fertilizer use

Risk preference

Ex-ante risk-management strategies, such as precautionary savings and crop insurance, can help reduce income losses due to risks (Daidone *et al.*, 2019; Tang and Luo, 2021). However, for many risk-averse farmers, these strategies are not available, for example, due to the small farm size. Alternatively, risk-averse farmers may adjust their production behavior to cope

with uncertainty, for example, by growing multiple crops or using more fertilizer to avoid potential output losses (Qiu *et al.*, 2014; Wu *et al.*, 2021a). Bora (2022) found that both extreme rainfall and drought reduce farmers' fertilizer use, as it makes it less profitable to apply fertilizers when the harvest is likely to fail. Overall, the effect of risk preference on fertilizer use is indeterminate.

Land renting

Achieving economies of scale in agriculture is considered an important means of increasing agricultural productivity and profitability in China (Cai, 2020). Therefore, the government has long encouraged land transfer. It is through land rentals that more professional, and therefore, more productive and profitable farmers are able to access land. They are also more likely to attend agricultural technology training and therefore improve fertilization. Considering that fertilizer costs are higher on large-scale farms, they are more susceptible to changes in fertilizer prices (Ju *et al.*, 2016), which, in turn, may reduce the amount of fertilizer used (Wu *et al.*, 2021a; Yan *et al.*, 2019). However, Wu *et al.* (2018) found that larger farms reduce input intensity, but not necessarily fertilizer intensity. One reason could be that land renting-in farmers have little incentive to adopt sustainable intensification practices when rental contracts are informal and have a short duration (Zhou *et al.*, 2019). Unclear land titles, for example, due to lack of registration or risk of land reallocation by village leaders, may have similar effects. Overall, in theory, the effect of land rentals on fertilizer use is indeterminate. Therefore, the effect of land rentals and its interaction with farm size on fertilizer use needs further analysis.

Other explanations for fertilizer use

In the literature, a wide variety of other explanations for fertilizer use have been provided. Examples include general education and agricultural skill training of farmers (Smith and Siciliano, 2015), farm size (Wu *et al.*, 2021a, 2021b; Yan *et al.*, 2019), and time and labor constraints (Lamb, 2003; van Wesenbeeck *et al.*, 2021). The effects of farm size are primarily linked to land rental. However, larger farms are also often more able to buy fertilizer because they have better access to credit. In addition, they are also more likely to be labor constrained making them to substitute the labor-intensive application of organic fertilizers, such as animal manure or compost, with the application of chemical fertilizers. Off-farm employment

deprives the agricultural sector from labor but boosts rural household incomes, smooths consumption, and increases fertilizer use (Lamb, 2003; Zhang *et al.*, 2021). The latter is true because off-farm labor increases farmers' incomes and therefore allows them to purchase fertilizer. High incomes also improve access to credit. Time and labor constraints are less likely with a large family size in combination with fewer dependents, that is, children below 18 years and elderly people above 65 years old. Farmer age is another explanatory variable for fertilizer use. Younger farmers are better able to optimize fertilizer use as they received more education and training and are more likely to hold commercial farms (Ren *et al.*, 2023). However, they have less experience. The amount of family assets may also influence fertilizer use, as wealthier farmers may have a higher degree of mechanization, more land, and have received more education and training (Alene *et al.*, 2008; Huffman, 1974; Ren *et al.*, 2021). Organic fertilizers, such as manure, can substitute for chemical fertilizers, and therefore, are expected to have a negative impact on chemical fertilizer use.

5.3. Data

The data in this study were collected from a household survey conducted in Jiangsu, Jiangxi and Liaoning provinces in 2014/2015 for the year 2014 and January 2019 for 2018. These three provinces are important bases for marketable rice production in China and are located in Eastern, Southeast and Northeast of China, respectively (see Appendix 5.A Figure 5.A2).

We used a multistage sampling procedure to select sample households for the first survey in 2014/2015. China has four levels of administrative regions: provincial, county, township, and village. First, four counties (two per province) were selected through consultation with local researchers and policymakers. These counties are representative of the entire region in terms of topography, distance from provincial capitals, and economic development. Second, four to seven townships in each county were selected based on the scale of the county. The selected townships represent the diversity of rural conditions in each county (*e.g.*, topographical features, distance from the county seat, agricultural development, and rural labor). Third, we randomly selected a certain number of villages from each township. The number of villages in each township is based on the total number of villages, land area, and population. These gave a total number of 95 villages in the sample. Fourth, according to the size of the village population and land area, to 20-40 households were randomly selected from each village, giving a total sample size of 2538 households. In the second survey in January 2019 obtaining

2018 data, we randomly selected 12 households from each village's 2014/2015 household sample list. After cleaning the data, a balanced panel dataset with 443 households was obtained, including 140 households in Jiangsu Province, 128 households in Jiangxi Province and 175 households in Liaoning Province. There were 293 households in 2014 and 249 households in 2018 across 41 villages cultivating rice. Thus, the total sample consisted of 542 observations. Table 5.1 provides an overview of these data.

Both surveys included questions on fertilizer application by farmers. In 2014/2015 we only captured the amount of compound fertilizers used by farmers and their prices. However, in 2019, the questionnaire deepened. More detailed information on fertilizer application was obtained, and fertilizer use was subdivided into compound fertilizer, Urea, DAP, AMS, SSP, Potassium chloride, and K_2SO_4 . In 2018, 95.34% of farmers applied compound fertilizers. We only included farmers who used compound fertilizers in both periods in our sample to ensure data consistency.

Rainfall data were extracted from the Famine Early Warning Systems Network Land Data Assimilation System (Amy McNally NASA/GSFC/HSL, 2018). We retrieved the rainfall data for different villages for 2014 and 2018 using the latitude and longitude coordinates of the villages.

Table 5.1 Variables definitions and descriptive statistics.

Variable	Definition	Obs	Mean	Std.dev.	Min	Max
Production function variables						
Ln Total output	Total output of rice (jin) ^a	542	8.848	1.365	5.704	14.022
Ln Area sown to rice	Total area planted with rice (mu) ^a	542	2.072	1.121	0.223	6.957
Ln Total seed cost	Total seed costs for rice (yuan, 2014 price)	542	5.904	1.561	0	13.12
Ln Hired labor	Total number of hired laborers for rice (person = labor/day) ^b	542	0.314	0.99	-1.609	6.254
Ln Total fertilizer application	Total amount of fertilizer applied to rice (jin)	542	6.689	1.333	3.401	11.873
Ln Total pesticide cost	Total pesticides costs for rice (yuan, 2014 price)	542	3.793	1.393	-1.162	6.57
Ln Total machinery cost	Total machinery costs for rice (yuan, 2014 price)	542	6.183	2.506	0	11.942
Family size	The number of family members (person)	542	4.552	2.296	1	16
Prices						
Price of fertilizers	Price of fertilizer purchased by farmers (yuan/jin, 2014 price) ^c	542	1.099	0.408	0	2.667
Price of rice	Price of rice sold by farmers (yuan/jin, 2014 price)	542	1.153	0.426	0	2.621
Key explanatory variables						
Risk aversion dummy	I rarely invest in new crop varieties because it is risky to do so. (1=Very agree, 0=Disagree)	542	0.317	0.466	0	1
Risk aversion category	I rarely invest in new crop varieties because it is risky to do so. (1=Very disagree, 0=Very agree)	542	3.279	1.541	1	5
Share of rented land	Share of rented land in total arable land	542	0.203	0.31	0 ^d	1
Rainfall	Average monthly planting season rainfall in the village (mm)	542	148.062	36.251	75.6	226.79
Rainfall deviation	1=The rainfall deviation is positive, 0=otherwise	542	0.568	0.496	0	1
Control variables						
Age of household head	Age of household head (years)	542	58.954	8.575	34	93
Household head migration	1=Household head works outside of the farm in last 12 months, 0=Otherwise	542	0.266	0.442	0	1
Agricultural skill training	1=Household head experienced agricultural skills training, 0=Otherwise	542	58.954	8.575	34	93
Family labor size	Number of effective household labor force that is older than 18 and younger than 65 years	542	3.348	1.422	0.5 ^e	8
Dependency burden	Number of dependents under the age of 18 and over the age of 65 in the household	542	1.518	1.447	0	13
Ln Family fixed assets	Family fixed assets (yuan)	542	11.454	1.881	0	15.886
Land titling	1=The land has been registered, 0=Otherwise	542	0.679	0.467	0	1
Ln Organic fertilizer application	The amount of organic fertilizer used per mu (jin/mu)	542	0.454	1.604	0 ^f	9.210

Note:

^a: Here, jin is the unit of weight and mu is the unit of area, where one jin is half a kilogram and one mu equals 1/15 ha. Yuan is the currency unit of China. In 2014, one Yuan equaled 0.12243 EUR, and in 2018, it equaled 0.12817 EUR.

^b: Here, labor/day indicates that one laborer works for 8 hours a day.

^c: The price of fertilizer purchased by farmers in Jiangsu province in 2014 was missing in our questionnaire, but we captured the cost of fertilizer per mu. Therefore, the price was replaced by the average compound fertilizer selling price at the county level.

^d: Data for 196 households that rented-in land. The models were constructed using zero values for farmers who did not rented-in land.

^e: Some households in rural China still rely primarily on elderly people over 65 years of age for labor. Accordingly, we discount the over-65s as 0.5 laborers based on their current situation and their ability to work.

^f: Data for 44 households that applied organic fertilizer. Models were constructed using zero values for farmers who did not use organic fertilizers.

5.4. Empirical model

5.4.1 Estimation strategy

In this section, we first specify the Cobb-Douglas production function used to estimate fertilizer overuse and the regression model used to determine the factors affecting fertilizer overuse. We present and discuss the estimation results at the end of this section.

1) Production functions and fertilizer overuse/underuse

Equation (5.3) specifies the Cobb-Douglas production function used for calculating fertilizer overuse/underuse (see also Foster *et al.*, 2008; Mairesse and Jaumandreu, 2005):

$$\ln(Y_{jt}) = \beta_0 + \sum_{i=1}^N \beta_{it} \ln(X_{ijt}) + \varepsilon_{jt} \quad (5.3)$$

where the dependent variable Y_{jt} is the total rice output grown by household j in year t . The independent variable X_{ijt} represents input i in the production of household j in year t ; the N inputs included in the model are land area, cost of seed, amount of fertilizer, cost of pesticide, number of family and hired laborers, and cost of machinery. Cost is used as a measure of quantity to allow for the aggregation of inputs. Here, we use family size to indicate the family labor used in agricultural production. The inaccurate measurement of farm households' working hours in the questionnaire did not make it possible to use this variable. Moreover, child labor was not recorded, despite the fact that it was relevant. ε_{jt} is a year specific disturbance term. To be able to take the logarithm, zero values of the continuous variables are replaced by ones (*i.e.*, making the logarithm zero). The methods proposed by Battese (1997) and Battese *et al.* (1996), which involve adding a dummy variable, were used to deal with households having zero values for fertilizers, hired labor, machinery, pesticides, and seed inputs (Qian, 2021).

The Cobb-Douglas model has restrictive properties (*e.g.*, the same substitution elasticity between all combinations of inputs). Therefore, we also estimated the translog production function, a flexible functional form. The results for the translog production function show severe multicollinearity, which made us decide not to use the outcomes of the estimation in

the rest of this study (see Appendix 5.B in the supplementary files for further details). Fertilizer overuse/underuse was calculated from the estimation results by applying Equation (5.2) and using data on household-specific output and fertilizer prices.

2) Determinants of fertilizer overuse/underuse

The basic model for estimating the factors affecting fertilizer use is specified as:

$$t_{f,jt} = \alpha_0 + \alpha_1 RA_{jt} + \alpha_2 RI_{jt} + \alpha_3 RF_{jt} + \alpha_4 (RA_{jt} \times A_{jt}) + \alpha_5 (RI_{jt} \times A_{jt}) + \alpha_6 (RF_{jt} \times RF_{jt}) + \sum_i^M \alpha_{7i} Z_{ijt} + \delta_j + \sigma_t + \mu_{jt} \quad (5.4)$$

where RA_{jt} , RI_{jt} and RF_{jt} are the key explanatory variables; they are dummies/categorical variables representing the level of farmers' j risk aversion in year t , the share of rented land, and the rainfall shocks, respectively. A_{jt} is the area owned by rice in year t . Z_{ijt} is a vector of control variables for household, land, and village characteristics. α_0 is a constant term; $\alpha_1, \alpha_2, \dots, \alpha_6, \alpha_{7i}$ are the parameters of interest. δ_j are the unknown coefficients representing time heterogeneity with individual household invariance. σ_t are the within-village error terms representing individual village heterogeneity, with time invariance; and μ_j is the error term. We applied cluster-adjusted standard errors, adjusted for the 41 villages that plant rice, to account for correlated errors within villages.

Two variables were used to indicate the rainfall shocks. First, the rainfall deviation (1 for a positive deviation, 0 for a negative deviation) was defined in terms of the standardized deviation of the total rainfall from its past five-year average based on Yu and Babcock (2010) and Bora (2022). It is calculated by subtracting the village means from each village and then dividing by village-level standard deviations. Second, the rainfall in the season was defined as the average monthly rainfall in the village during the grain growing season. For example, the rice-growing season in Liaoning Province lasts from April to July. Whether the land has been registered is used to indicate the risk of land tenure insecurity. When land has been registered, land use rights are legally protected and landowners are less exposed to the risk of losing their land, which may incentivize them to adopt long-term sustainable management strategies and reduce chemical fertilizer use. We included the squared term of the average rainfall to account for a possible nonlinear relationship. We also included cross terms for

average rainfall with area and the share of land rented-in with area to account for the fact that for large and small farms, both variables have a different effect on fertilizer overuse.

The fixed effects estimator (using the *reghdfe* estimator in Stata) was used to estimate the model. In our panel dataset, the sample of households planting rice is unbalanced. According to Correia (2015), controlling for individual fixed effects in the unbalanced regression will underestimate the standard errors and overstate the statistical significance. Therefore, we choose to control for the village fixed effect.

5.5 Results

This section presents the estimation results of the Cobb-Douglas production function, the values of the fertilizer overuse/underuse that were calculated from this estimate, and the regression results for the factors explaining fertilizer use.

5.5.1 Cobb-Douglas production function and values of t_f

Cobb-Douglas production function

Table 5.2 presents the regression results for the Cobb-Douglas production function. The adjusted R-squared value indicates that the model explains 95.9% of the total variation in output.

The results show that a 1% increase in chemical fertilizer use significantly increased rice output by 0.207%. This finding is consistent with those of studies conducted in other Chinese provinces. For instance, Sun *et al.* (2019) found that a 1% increase in chemical fertilizers increased rice output by 0.022%, and Wu *et al.* (2021a) found an increase in wheat output of large-scale farmers by 0.102% and by 0.128% for small-scale farmers. Moreover, a 1% increase in land area significantly increased the rice output by 0.855%. Rice output was also significantly influenced by seed, pesticide and machinery use, with a production elasticity of 0.047%, 0.022% and 0.051%, respectively.

Table 5.2 OLS regression results of the Cobb-Douglas production function.

VARIABLES	(1) Ln (Total Output)
ln (Area sown to rice)	0.855*** (0.054)
ln (Total seed cost)	0.047** (0.022)
ln (No. of hired laborers)	-0.085*** (0.024)
ln (Total fertilizer application)	0.207*** (0.037)
ln (Total pesticide cost)	0.022* (0.012)
ln (Total machinery cost)	0.051** (0.024)
ln (Family size)	-0.008 (0.030)
Constant	5.343*** (0.222)
Dummy variables ^a	Controlled
Observations	542
Adjusted R-squared	0.959
Likelihood-ratio test	170.37***

Notes: Robust standard errors in parentheses are adjusted for villages. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

^a: According to Battese (1997) and Battese *et al.* (1996), dummy variables are used to account for households reporting zero expenditure on inputs such as hired labor, machinery, pesticides, and seeds. A value of 1 is assigned to indicate expenditure on these inputs, whereas a value of 0 indicates no expenditure.

Table 5.3 Production elasticities derived from production function estimation results.

Inputs	Elasticity	t-ratio
Land	0.855***	15.78
Fertilizers	0.207***	5.58
Seed	0.047**	2.09
Hired labor	-0.085***	-3.58
Pesticides	0.022*	1.78
Machinery	-0.051**	2.11
Family size	-0.008	-0.26
Scale elasticity	1.089***	27.92

Neither hired nor family labor (*i.e.*, family size) have the expected signs. A 1% increase in hired labor leads to a 0.085% decline in rice output, for family labor this is 0.008%. However, the latter is non-significant. We hypothesize that the negative sign of hired labor is the result of a farmer's wish to guarantee that the harvest is finished in a relatively short time. The sum of the estimated coefficients (1.089), the scale parameter, shows that there are small but significant increasing returns to scale (see Table 5.3).

Values of t_f (fertilizer overuse or underuse)

Table 5.4 reveals that while 464 farmers use less fertilizer than expected from profit-maximizing farmers, 78 farmers tend to overuse chemical fertilizers. This shows that only a small proportion of farmers overuse. This is somewhat unexpected as since the Green Revolution, the use of chemical fertilizers in China has remained at a high level, making the country the largest consumer of agricultural chemicals worldwide (Wu *et al.*, 2018).

Table 5.4 Values of t_f for different farm sizes.

	Area sown to rice (mu)	Mean	SD	Min	Max	N
$t_f < 0$ Overuse	(0-5)	-0.933	0.513	-2.167	-0.013	73
	(5-10)	-0.833	0.168	-0.952	-0.714	2
	(10-50)	-0.654	1.023	-1.834	-0.031	3
	(50-2100)	-	-	-	-	-
	Total	-0.920	0.526	-2.167	-0.013	78
$t_f \geq 0$ Underuse	(0-5)	1.915	1.973	0.056	16.342	188
	(5-10)	1.579	1.026	0.028	8.162	135
	(10-50)	1.499	0.801	0.031	4.485	107
	(50-2100)	1.426	0.61	0.235	2.814	34
	Total	1.685	1.445	0.028	16.342	464
Overall	(0-5)	1.118	2.214	-2.167	16.342	261
	(5-10)	1.544	1.059	-0.952	8.162	137
	(10-50)	1.440	0.876	-1.834	4.485	110
	(50-2100)	1.426	0.610	0.235	2.814	34
	Total	1.312	1.632	-2.167	16.342	542

The underuse of fertilizer may occur due to reasons such as a lack of credit for purchasing fertilizer or farming being a secondary activity, and the constraints of environmental protection policies. Notably, the positive mean value of t_f for each farm size group suggests that fertilizer use is not influenced by farm size. However, it is observed that as farm size increases, the mean value of negative t_f also increases, approaching zero. Consequently, the overuse of fertilizer diminishes with larger farm sizes. In addition, the mean value of positive t_f decreases as farm size increases, indicating that larger farms are more likely to apply fertilizer optimally rather than underutilizing it.

5.5.2 The determinants of fertilizer use

This section presents the estimation results of the models explaining the values of t_f derived using the Cobb-Douglas production function estimates.

Table 5.5, column (1) presents the results when risk preference is measured on a 1–5 scale, while column (2) shows the results using a dummy variable indicating whether farmers were absolutely risk averse or not. Column (3) presents the results when the cross products of risk & farm size and rented land share & farm size are added to the model with the risk aversion dummy. In addition to the results presented in column (3), column (4) presents the results when rainfall deviation and the rainfall during the growing season interact. In order to make the results easier to interpret we reversed the signs of t_f . So, a positive sign of an estimated coefficient indicates that the variable is positively correlated with revealed fertilizer overuse, while a negative sign indicates that the variable is negatively associated with revealed fertilizer overuse.

The estimates in Columns (1) and (2) show that both the categorical and dummy variables for farmers' levels of risk aversion have a positive and significant effect on the value of t_f at the 10% and 1% level, respectively. Our findings are consistent with those by Qiu *et al.* (2014) and Lamb (2003) that show that risk averse farmers use more fertilizer, indicating overuse. There are two plausible explanations for this phenomenon in China. Firstly, small-scale farmers in Chinese agricultural production have traditionally relied heavily on chemical fertilizers. Driven by habit and past experiences, these farmers persist in using chemical

fertilizers, despite evidence indicating a gradual decline in nutrient effectiveness over time (Liao *et al.*, 2023). This persistence results in the marginal benefit of fertilizers becoming less than the marginal cost (van Wesenbeeck *et al.*, 2021). Secondly, farmers in China exhibit a natural inclination towards risk aversion. Past research has shown that instead of focusing on maximizing profits, farmers tend to prioritize maximizing yield (Ogieriakhi and Woodward, 2022).

When controlling for risk preferences and natural rainfall shocks, the estimates in Columns (3) and (4) show that the interaction term between the risk aversion dummy and the area sown to rice shows a significant negative impact on the value of t_f at a 1% significance level. This suggests that farmers with higher levels of risk aversion tend to decrease their application of chemical fertilizers as their scale of operation expands. The statistical result of the value of t_f also supports this observation, revealing that with larger scales, the value of t_f tends to decrease, indicating a shift towards a more optimal level of fertilizer application. Consequently, it can be inferred that large-scale farms are more inclined to apply lower amounts of chemical fertilizer compared to small farms, aligning with previous research conducted by Wu *et al.* (2018) which demonstrated a negative association between farm size and agrochemical use intensity in China. Moreover, supporting this trend, Ren *et al.* (2023) also noted that smaller farm sizes correspond to higher chemical fertilizer usage.

Although, we did not find an effect of the share of rented land and the sown area to rice on the value of t_f it is worth noting that short-term contracts, specifically those with a duration of one year, more often have a negative value of t_f than contracts of other durations (see Table 5.A1). So, they are more inclined to underuse fertilizer. This can be due to the fact that land renting in China is dominated by short-term and fixed-rent agreements (Zhou *et al.*, 2019), resulting in households having little incentive to engage in long-term land soil improvement activities (Ma *et al.*, 2020; Macours, 2014). This result is consistent with the findings of Kousar and Abdulai (2016), who found that fixed-rent tenants typically apply more chemicals to their fields than other farmers do.

Table 5.5 OLS regression results of influencing factors on t_f (we switched the sign of t_f , a positive sign of t_f implies more overuse, a minus sign less overuse).

Variables	(1) t_f	(2) t_f	(3) t_f	(4) t_f
Risk aversion category	0.083* (0.042)			
Risk aversion dummy		0.354*** (0.105)	0.991*** (0.259)	1.003*** (0.264)
Share of rented land	0.395 (0.449)	0.417 (0.450)	-0.358 (0.806)	-0.274 (0.801)
ln (Area sown to rice)	-0.116 (0.155)	-0.108 (0.154)	-0.171 (0.181)	-0.135 (0.182)
Risk aversion dummy $\times$ ln (Area sown to rice)			-0.316*** (0.093)	-0.308*** (0.093)
Share of rented land $\times$ ln (Area sown to rice)			0.316 (0.226)	0.267 (0.227)
ln (Rainfall)	22.663 (26.916)	21.683 (27.055)	19.703 (27.888)	51.551* (27.411)
Square: ln (Rainfall)	-2.244 (2.601)	-2.150 (2.615)	-1.968 (2.691)	-5.441* (2.774)
Rainfall deviation	-0.963* (0.516)	-0.954* (0.519)	-0.966* (0.519)	-26.725* (15.818)
Rainfall deviation $\times$ ln (Rainfall)				4.920 (3.138)
Age of household head	0.003 (0.008)	0.003 (0.008)	0.001 (0.008)	0.002 (0.008)
Household head migration	-0.145 (0.212)	-0.170 (0.213)	-0.179 (0.216)	-0.171 (0.213)
Agricultural skill training	0.003 (0.008)	0.003 (0.008)	0.001 (0.008)	0.002 (0.008)
Family labor size	0.065 (0.051)	0.058 (0.050)	0.067 (0.050)	0.059 (0.050)
Dependent burden	-0.043 (0.048)	-0.041 (0.048)	-0.029 (0.048)	-0.030 (0.049)
ln (Family fixed assets)	0.081 (0.056)	0.076 (0.057)	0.074 (0.058)	0.078 (0.059)
Land titling	-0.013 (0.176)	-0.021 (0.175)	0.010 (0.174)	-0.055 (0.177)
ln (Organic fertilizer application)	-0.060* (0.033)	-0.058* (0.033)	-0.052 (0.031)	-0.060* (0.031)
Constant	-59.024 (69.542)	-56.317 (69.892)	-50.802 (72.129)	-123.104* (68.222)
Time fixed effects	Yes	Yes	Yes	Yes
Village fixed effects	Yes	Yes	Yes	Yes
Observations	542	542	542	542
Adjusted R-squared	0.098	0.102	0.112	0.121
Within R-squared	0.082	0.086	0.101	0.112

Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

In addition, in each regression, a negative and statistically significant effect of natural rainfall shocks, as measured by rainfall deviation, was observed. This effect on the value of t_f reveals that when there is more rainfall than the average of the past five years, less chemical fertilizer is applied. This finding is in line with the conclusions drawn in the study conducted by Bora (2022). This phenomenon occurs because the excess rainfall contributes to the loss of nutrients like nitrogen (N), phosphorus (P), and potassium (K) along surface waters runoff (Kleinman *et al.*, 2006). Consequently, farmers are evidently conscious of this correlation and adjust their fertilizer application accordingly. Organic fertilizer application also had a negative effect on the t_f value, suggesting that organic fertilizer is a substitute for chemical fertilizers. Other explanatory variables such as the household head's age, migration, and agricultural skill training do not have a statistically significant effect on fertilizer use.

5.6 Conclusion and discussion

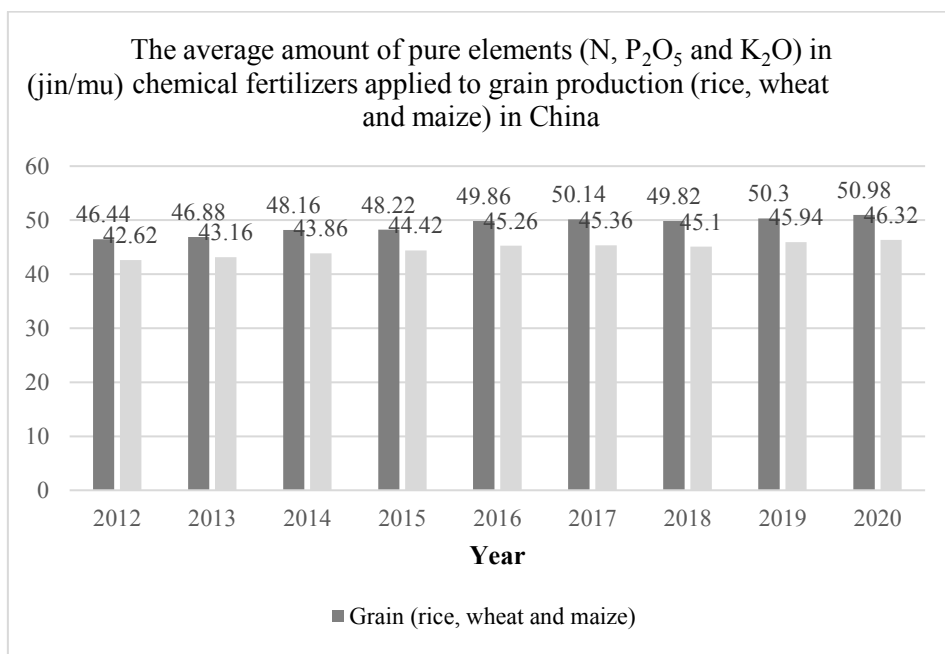
This study uses panel data of farm households in Jiangsu, Jiangxi and Liaoning provinces in China covering 2014 and 2018 to determine and analyze the causes of fertilizer overuse. The results of the study show that there is fertilizer overuse in 78 out of 542 farms, including both small and large farms. This is less than expected, and most farms face fertilizer underuse. This may come from the constraints of environmental protection policies. The results indicate that risk-averse farmers tend to overuse chemical fertilizers. Moreover, farmers with higher levels of risk aversion tend to decrease their application of chemical fertilizers as their scale of operation expands. In addition, an increase in rainfall (positive rainfall deviation) reduces the overuse of fertilizers by farmers. This is likely due to the fact that in situations where nutrient loss occurs through surface water runoff and crops fail, applying fertilizer becomes unprofitable. Given the varying attitudes among farmers towards different risks, it is crucial to adopt an experimental approach in future research to determine farmers' risk preferences regarding fertilizer overuse (Tu, 2005). This could aid in the formulation of appropriate policies aimed at minimizing fertilizer overuse.

Although the present study contributes to the literature by applying profit maximization to derive a "revealed" measure of fertilizer use, it still has two main limitations. First, this paper focuses only on rice farmers in three provinces. Expanding the research area to include more

provinces across the entire country and examining other crops may provide further insights for policymakers. Second, while this paper estimates the determinants of fertilizer use, it overlooks the environmental effects of fertilizer overuse or underuse. Despite these caveats, we think this paper contributes to understanding, and therefore, formulating better policies to address high fertilizer use in China.

Appendix 5

Appendix 5.A Fertilizer use and sample area



Data source: From the 2013-2021 National Agricultural Cost Benefit Data Compilation

Notes: China's National Bureau of Statistics requires fertilizers to be included in its yearbook as discounted amounts of pure elements. Nitrogen, phosphorus, and potash fertilizers are considered discounted pure elements based on nitrogen (N), phosphorus pentoxide (P₂O₅), and potassium oxide (K₂O), containing 100 percent of the composition of the converted amount. Specifically, the formula is: discounted pure element amount = actual amount of fertilizer × refractive rate (N, P₂O₅ and K₂O as a percentage of active ingredient content). One jin equals 0.5 kg.

Figure 5.A1: The average amount of pure elements (N, P₂O₅ and K₂O) in chemical fertilizers applied to grain production (rice, wheat and maize) in China (unit: jin/mu)

Table 5.A1 Values of t_f for land transfer contracts of different durations

Duration of contract (years)		Mean	SD	Min	Max	N
Overall	1	-1.305	1.339	-9.325	2.07	139
	2	-1.837	0.539	-2.218	-1.455	2
	3	-1.298	0.701	-2.814	-0.235	16
	4	-1.191	0.477	-1.722	-0.583	4
	5	-1.499	1.26	-4.485	0.278	11
	6	-1.018	0.88	-2.233	-0.152	4
	8	-0.678	0.085	-0.738	-0.618	2
	10	-1.01	0.706	-2.359	0.097	9
	12	.	.	.	.	0
	13	-1.274	0.002	-1.275	-1.273	2
	15	-0.231	1.899	-1.574	1.111	2
	20	-7.318	4.844	-10.743	-3.893	2
	30	0.034	1.451	-1.369	1.528	3
	Total	-1.322	1.418	-10.743	2.07	196
$t_f < 0$	1	-1.17	0.547	-2.07	-0.031	14
	5	-0.278	.	-0.278	-0.278	1
	10	-0.097	.	-0.097	-0.097	1
	15	-1.111	.	-1.111	-1.111	1
	30	-1.528	.	-1.528	-1.528	1
	Total	-1.077	0.585	-2.07	-0.031	18

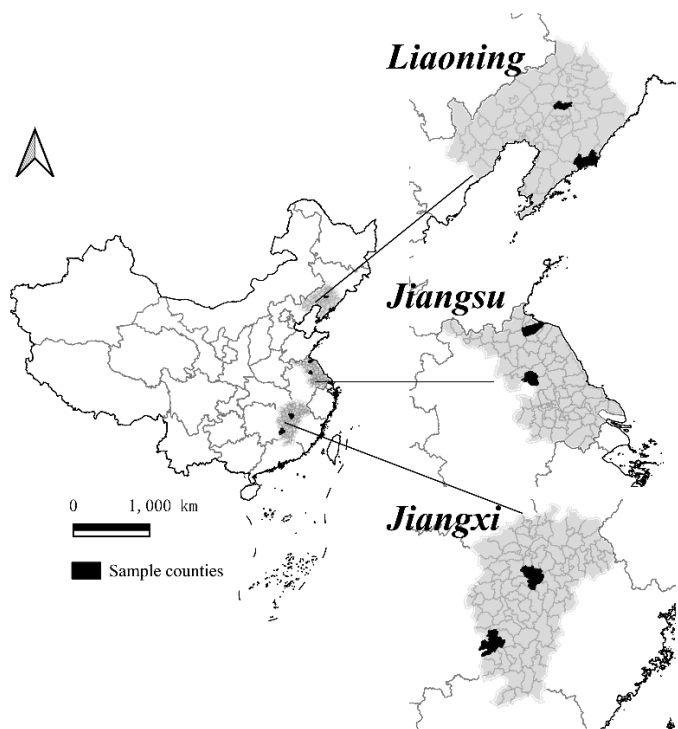


Figure 5.A2 Geographic location of sample sites.

Appendix 5.B. The translog production function and its OLS regression results

Translog production function:

$$\ln(Y_{jt}) = \beta_0 + \sum_{i=1}^N \beta_i \ln(X_{ijt}) + 0.5 \sum_{i=1}^N \sum_{k=1}^N \gamma_{ik} \ln(X_{ijt}) \ln(X_{kjt}) + \varepsilon_{jt} \quad (5.B1)$$

Where the dependent variable Y_{jt} is the total grain output grown by household j in year t . The number of independent variables is N . The independent variable X_{ijt} represents input I in the production of household j in year t ; inputs included in the model are land area, the cost of seed, the amount of fertilizer, the cost of pesticide, family size and hired laborers and the cost of machinery. ε_{jt} is a year specific disturbance term. In order to be able to take the logarithm, zero values of the continuous variables are replaced by ones (*i.e.* making the logarithm zero).

Estimation results of the translog production function

The estimation result of the translog production function is presented in Table 5.B1.

The high degree of multicollinearity makes that the individual estimated coefficients have to be interpreted carefully as different variables are statistically seen similar as they are highly correlated (Pavelescu, 2011). This makes the estimation results are not useful for the purpose of our research. So, we stopped the further analysis.

Table 5.B1 OLS regression results of the Cobb-Douglas and translog production function.

VARIABLES	(1) Translog ln (Total Output)
ln (Area sown to food crops)	0.970 (1.321)
ln (Total seed cost)	-0.422* (0.237)
ln (No. of hired laborers)	-0.574 (0.592)
ln (Total fertilizer application)	0.051 (0.869)
ln (Total pesticide cost)	-0.540 (0.566)

ln (Total machinery cost)	0.324 (0.417)
ln (Family size)	-0.244 (0.327)
Square: ln (Area sown to food crops)	-0.014 (0.088)
ln (Area sown to food crops) # ln (Total seed cost)	-0.115* (0.059)
ln (Area sown to food crops) # ln (No. of hired laborers)	0.046 (0.117)
ln (Area sown to food crops) # ln (Total fertilizer application)	-0.061 (0.118)
ln (Area sown to food crops) # ln (Total pesticide cost)	-0.028 (0.053)
ln (Area sown to food crops) # ln (Total machinery cost)	0.099 (0.075)
ln (Area sown to food crops) # ln (Family size)	-0.146* (0.083)
Square: ln (Total seed cost)	0.013 (0.016)
ln (Total seed cost) # ln (No. of hired laborers)	0.130* (0.069)
ln (Total seed cost) # ln (Total fertilizer application)	0.075 (0.048)
ln (Total seed cost) # ln (Total pesticide cost)	0.014 (0.023)
ln (Total seed cost) # ln (Total machinery cost)	-0.011 (0.028)
ln (Total seed cost) # ln (Family size)	0.009 (0.035)
Square: ln (No. of hired laborers)	0.024 (0.038)
ln (No. of hired laborers) # ln (Total fertilizer application)	-0.058 (0.099)
ln (No. of hired laborers) # ln (Total pesticide cost)	-0.025 (0.032)
ln (No. of hired laborers) # ln (Total machinery cost)	-0.109** (0.050)
ln (No. of hired laborers) # ln (Family size)	-0.010 (0.065)
Square: ln (Total fertilizer application)	0.054 (0.054)
ln (Total fertilizer application) # ln (Total pesticide cost)	0.008 (0.043)
ln (Total fertilizer application) # ln (Total machinery cost)	-0.124** (0.051)
ln (Total fertilizer application) # ln (Family size)	0.040 (0.064)
Square: ln (Total pesticide cost)	0.029** (0.014)
ln (Total pesticide cost) # ln (Total machinery cost)	0.022 (0.028)
ln (Total pesticide cost) # ln (Family size)	0.004 (0.032)
Square: ln (Total machinery cost)	0.028 (0.019)

ln (Total machinery cost) # ln (Family size)	0.059 (0.038)
Square: ln (Family size)	-0.030 (0.040)
Constant	5.428* (3.095)
Dummy variables	Controlled
Observations	542
Adjusted R-squared	0.967
Likelihood-ratio test	170.37***

Notes: Robust standard errors in parentheses are adjusted for clusters (villages), *, ** and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Dummy variables account for households with zero expenditure on inputs such as hired labor, machinery, pesticides, and seeds, where 1 indicates no zero values for these inputs and 0 indicates at least one zero value. Results for dummy variables and their cross-terms are not reported in the table. The regression analysis includes time effects.

Appendix 5.C. Quantifying fertilizer overuse*Quantifying fertilizer overuse*

As outlined in the theory section in equation 5.2, we use the value of t_f to reveal the overuse of fertilizer. Here we first repeat equation 5.2.

$$\frac{\partial f}{\partial m} \cdot p = w_s = w_f + t_f \quad (5.2)$$

Where: f is the production function, m is the quantity of fertilizer, p is the price of the output, w_s is the shadow price of fertilizer, w_f is the market price of fertilizer, t_f is additional net marginal cost/benefit of fertilizer.

Suppose now $t_f = 0$, then we get:

$$\frac{\partial f}{\partial x_{fer}} \cdot p = w_s \quad (5.C1)$$

Where: x_{fer} is the fertilizer use in case there is now overuse.

Applying equation 5.C1 to the Cobb-Douglas production function we obtain:

$$x_{fer} = \frac{\alpha \cdot p \cdot \hat{y}}{w_s} \quad (5.C2)$$

Where: α is the estimated production elasticity of fertilizer, $\hat{y}$ is the estimated output level.

Then, the total amount of the fertilizer overuse equals:

$$x_{over,t} = x_{act,t} - x_{fer,t} \quad (5.C3)$$

Where: x_{over} fertilizer overuse in year t , x_{act} actual fertilizer use in year t .

Table 5.C1 Calculated quantity of overuse of chemical fertilizers on the surveyed farms.

	Cobb-Douglas production function				
	Mean	SD	Min	Max	N
Actual amount of fertilizer applied (jin/mu)	137.41	55.53	33.33	390	542
With overuse:					
Amount of overused fertilizer (jin/mu)	125.60	76.16	0.01	380	78
The proportion of overused chemical fertilizer (%)	84.18 ^a	35.54	0.01	153.645	78
With underuse:					
Amount of underused fertilizer (jin/mu)	217.93	225.65	0.00	1314.15	464

Notes:

^a: This figure is determined by calculating the percentage overused chemical fertilizer for each observation and then averaging.

Chapter 6: Synthesis

This chapter concludes the thesis. It aims to provide an answer to the research questions (Section 6.1) and to present some general conclusions (Section 6.2). Next, Section 6.3 tries to summarize the main contributions to the scientific debate. Conclusions are just as strong as the weakest point in the analysis. Therefore, Section 6.4 discusses some of the limitations of this thesis. Finally, based on these limitations, Section 6.5 recommends some future research.

6.1 Answers to research questions

The general objective of the thesis is to support the development of strategies for managing scarce arable land resources and promoting sustainable agriculture by analysing the rural-urban land conversion in China, understanding the dynamics of the land rental market, and obtaining deeper insights into the functioning, driving forces and environmental effects of the land rental market in rural China. To reach this objective four research questions were answered.

(1) How are industrial and population agglomeration affecting the expropriation of cultivated land in China, and what role do government fiscal deficits play during the land expropriation process?

Chapter 2, the empirical results from a two-way fixed effects regression model indicate that industrial agglomeration has a significant and positive impact on the expropriation of cultivated land. Although population agglomeration does not directly affect the rate of cultivated land expropriation, it significantly increases the ratio of cultivated land being converted into residential land. The local fiscal deficits (at the provincial and prefectural-city level) significantly increased the cultivated land expropriation rate before 2014, but this effect is no longer significant thereafter. Further examination reveals that, within the study period, provincial-level fiscal deficits significantly elevated the land expropriation rate, whereas fiscal deficits at the prefectural-city level had no impact on it.

(2) What is the relationship between land tenure security, social relations and contract choice in rural land rentals?

Chapter 3 presents the principal-agent framework that illustrates why partner and contract choices are jointly made, and indicates the factors that affect these choices in China. I utilized household data collected from Jiangxi and Liaoning provinces in 2015, employing nested logit models that were estimated using a full-information maximum-likelihood estimator. Findings indicate that China's land rental market is severely segmented and predominantly operates through informal rental contracts. This undermines the market's potential to elevate productivity and to deliver an equitable distribution. I found that landlords are more likely to rent out land to tenants who live in the same village, rather than to relatives or strangers. This suggests that this form of partner matching considers both the risk of land loss and the flexibility of rental relationships. Furthermore, insecure land tenure encourages landlords to select informal contracts. This indicates that informal contracts serve as substitutes for formal contracts in regions with lower land tenure security. In addition to tenure security, landlords' choices regarding contracts are also influenced by the flexibility of the contracts. Better educated landlords are more likely to choose flexible (informal) contracts, as they are more likely to engage in off-farm employment. Moreover, the analysis revealed that landlords residing in remote areas are more likely to select informal contracts, possibly due to the prevalent social norms in such regions.

(3) What is the impact of social relations and public interventions on the land rent deviation in China's rural land rental market?

Chapter 4, following the study of the role of farm household production in labour allocation and productivity of farm labour by Schmitt (1989, 1990), develops a conceptual framework that demonstrates the three stages of land rental markets in China, namely the locked market, segmented market, and integrated market, based on new institutional economics—transaction cost theory. This involves explaining the reasons behind land rent deviations and examining the role of social relations and public interventions during land transfers. Using household survey data collected in Jiangsu Province in 2014 and a Tobit model, the empirical findings demonstrate that land rental transactions that are limited to close social relations prevent the price mechanism from leading to an efficient factor allocation. Consequently, land cannot be

transferred to more productive producers as dictated by the land rent, and land transactions remain confined within the same social class, perpetuating social inequalities. Local governments and village collectives impose public interventions on the land rental process and organizational modes to eliminate the lock-in effect of social relations on land rental relationships. By doing so, they contribute to reducing land rent deviations. Therefore, public interventions can serve as a measure to substitute for social relations and improve the economic efficiency and equity of the rural land rental market in China.

(4) To what extent and how does land renting-in and individual risk preferences impact fertilizer use?

Chapter 5 derives a measure of artificial fertilizer overuse and underuse based on agricultural production economics. Next it investigates the roles of risk preferences and land rental in this overuse and underuse. The results reveal fertilizer overuse across all farm sizes in the research area. The results indicate that risk-averse farmers tend to overuse artificial fertilizers. Moreover, an increase in rainfall (positive rainfall deviation) reduces the overuse of fertilizers by farmers. However, I did not find any effect of renting-in land on farmers' fertilizer overuse. The interaction term between the risk aversion dummy and the area sown to rice shows a significant negative impact on farmers' fertilizer overuse. This suggests that farmers with higher levels of risk aversion tend to decrease their application of artificial fertilizers as their scale of operation expands.

6.2 General conclusions

From the research I can draw four general conclusions. **Firstly, industrial agglomeration has led to urban expansion, which promotes the conversion of rural to urban land.** This conversion often encroaches on high-quality cultivated land (see also Hu *et al.*, 2020; Huang *et al.*, 2019; Liu *et al.*, 2019), thereby reducing its availability and overall quality. Chapter 2 showed that industrial agglomeration is the main driver of urban expansion, while provincial government fiscal deficits accelerate this process. Therefore, they have a positive and significant effect on the conversion of cultivated land. Recent Chinese policies like the "Standards for Land Expropriation in Continuous Development (Trial)" highlight the importance of protecting cultivated land by promoting efficient land development and

minimizing its occupation. Cultivated land is scarce and crucial for national food security (see also Ye, 2015), and therefore, must be used and protected optimally.

Secondly, a well-functioning land rental market increases the availability of formal contracts and reduces deviations in land rent. This leads to improved market-oriented land transfers, promotes large-scale cultivation, and enhances resource efficiency (see also Chavas *et al.*, 2022; Jin and Deininger, 2009; Jin and Jayne, 2013; Tang *et al.*, 2019). The 2014 reform of "Three Rights Separation (TRS)" separates the ownership, contracting right and operation right of rural land. By clarifying these property rights, the reform promoted land transfer. However, the existing social relations in China have to some extent constrained this process. This is because the characteristics of rented-in and rented-out farmers in the land transfer process exhibit endogenous matching (see also Ackerberg and Botticini, 2002; Gebrehiwot and Holden, 2020), leading to a prevalence of zero-rent and oral agreements, as well as uncertain contract durations (see Chapter 3). However, Chapter 4 showed that public intervention has played a role in breaking down social relations based on kinship and geography, thereby promoting the market-oriented transfer of cultivated land.

Thirdly, in agricultural practices, regardless of the scale, there is a prevalent issue of artificial fertilizer overuse that is affected by the operators' risk preferences. Well-functioning land rental markets allow relatively efficient households access to additional land (Chamberlin and Ricker-Gilbert, 2016; Jin and Deininger, 2009), reducing the intensity of land use and enabling more sustainable agricultural practices. Chapter 5 indicated that the inefficient operation of the land rental market can have negative environmental consequences, as evidenced by the sometimes excessive use of fertilizers. However, risk-averse farmers operating large farms reduce the overuse of chemical fertilizers. Therefore, a well-functioning land rental market is necessary for ensuring a sustainable food security.

Fourthly, land use has many external effects and involves the provision of public goods. This requires government intervention. For example, public policy can be an important tool for alleviating the negative effects of the scarcity of cultivated land. Industrial agglomeration and land finance have exerted pressure on the availability of regional cultivated land. On the basis of the existing quantity of cultivated land, further enhancing land tenure security, breaking social relations through public intervention, reducing land rent deviations,

improving agricultural production efficiency, can promote agricultural production, and protect national food security. However, public policies can also be potentially conflicting. For example, subsidies for grain production, improving food security, have led to increased fertilizer use, and therefore, pollution.

6.3 Contribution to scientific debates

This thesis contributes to the scientific literature by jointly analyzing cultivated land expropriation, land transfer contract choice, land rent deviation and fertilizer use. More specifically, I mention three contributions to available literature.

(1) How local governments fiscal deficits affect cultivated land expropriation?

Previous studies have explored various perspectives regarding issues associated with cultivated land expropriation, such as conflicts and investment (Jacoby *et al.*, 2002; Lin *et al.*, 2018; Wu and Heerink, 2016), violence (Sargeson, 2013), livelihoods and welfare of displaced farmers and national food security (Liu *et al.*, 2023; McCarthy *et al.*, 2012; Tagliarino *et al.*, 2018; Wang *et al.*, 2020), and negative environmental impacts (Kusiluka *et al.*, 2011). Despite the breadth of topics addressed, there has been a notable gap in understanding the drivers behind such expropriation practices, especially concerning fiscal incentives at both the provincial and prefectural-city levels.

Chapter 2 uncovered the influence of government fiscal deficits on the rate of cultivated land expropriation during the period from 2006 to 2013, identifying a significant and positive correlation. This effect, however, does not extend into the period from 2014 to 2021, indicating a shift in local governments' dependency on land finance. Furthermore, the investigation reveals that fiscal deficits at the prefecture-level city do not significantly impact the conversion of cultivated land to construction land, likely due to regulatory oversight by higher levels of government. These findings spotlight the nuanced differences in land finance reliance among local government tiers in China, guiding the direction for future research endeavors in this field.

(2) How does security of land rights and flexibility of rental relationship affect contract selection?

Chapter 3 of this research makes a significant contribution by examining how insecure land tenure influences landlords' preferences for informal contracts in rural China. The study finds that in areas with lower tenure security, landlords opt for informal contracts as they offer a viable alternative to formal ones. This preference is also affected by the flexibility these contracts provide, with more educated landlords who engage more in off-farm employment favoring informal, more flexible contracts. Notably, the research context is restricted to two economically underdeveloped areas with low levels of urbanization, where government-promoted mandatory land rentals are not common. This raises intriguing questions about the applicability of these findings in more economically developed regions, such as the Yangtze River Delta and Pearl River Delta, known for their more dynamic land transactions.

The chapter underscores two crucial aspects of land rental contracts in these rural settings: the role they play in ensuring land rights security and their flexibility in the rental relationship. However, it is the interaction between these two factors that predominantly shapes the observed impact of land rental contracts. Future research could further delineate these roles, employing distinct variables to reflect the unique characteristics of the contracts and comparing their effects in varied rural contexts across China. This direction would help in understanding the broader implications of land rental practices and their impact on rural economies.

(3) Land rent deviation and fertilizer use?

Centered on the land rental market, the existing studies have attempted to examine the impact of the (segmented and informal) land rental market on agricultural investment, production efficiency and farmer welfare (Ghebru and Holden, 2015; Holden and Otsuka, 2014; Jin and Deininger, 2009; Ma *et al.*, 2017). However, little attention has been paid to the effects of informal and formal institutions on land rent levels, as well as the role that land rentals play in fertilizer use.

Chapter 4 dealing with land rent deviations finds that social relations based on blood ties and geographical location increase the levels of land rent deviation and lead to a loss of efficiency and equity of the segmented land rental market. However, public interventions, *i.e.*, land use limitations, collective permission and collective organization, may contribute to reducing land rent deviation and improving the efficiency and equity of the market. Further evidence suggests that public interventions induce land rental transactions among partners other than relatives or familiar villagers. In addition, Chapter 5 provides more insight in fertilizer use by quantifying and explaining both the overuse and underuse of fertilizers from an economic standpoint. The study reveals that larger-scale, risk-averse farmers are likely to decrease the overapplication of fertilizers. Furthermore, large-scale farmers show a greater tendency towards the optimal application of fertilizers.

6.4 Limitations of the research

This study addressed the research questions using various types of data and empirical methods, yielding information for policy makers at both the macro and micro level related to arable land scarcity. However, there are certain caveats that need to be discussed.

First, the data used have their limitations. These include issues of aggregation, missing data, representation, and time. For example, with respect to aggregation in Chapter 2, the agglomeration was indicated by provincial-level indicators only. With respect to missing data, there is for example a lack of data on changes in cultivated land quality in Chapter 2, which has led to an underestimation of the effect of cultivated land expropriation on land quality. The conclusion drawn from existing literature is that newly supplemented cultivated land compensating for urban land expansion is generally of lower quality, by 2-3 grades out of 15, compared to occupied cultivated land (see also Tang *et al.*, 2020; Xiao and Ning, 2013). With respect to representativity, Chapters 3-5 utilized field surveys from three provinces in China across different years. This may impede the ability to draw conclusions about the function of the land rental market and its environmental effects across the entire country. Finally, Chapters 3 and 4 used data for only 2014, and Chapter 5 used data for only 2014 and 2018 making it difficult to draw conclusions on factors affecting the land rental development over time.

Secondly, there are limitations to the methodology employed in this study. Each core chapter utilizes the most appropriate econometric model to address the research question. However, issues with respect to as endogeneity, choice of estimator, and imperfect model specifications remain. For example, in Chapter 2, there was a potential endogeneity problem because of omitted variables and reverse causality. I addressed the endogeneity problem by incorporating lagged explanatory variables and time and provincial fixed effects. However, I was unable to employ Generalized Method of Moments (GMM) methods due to the unavailability of a suitable set of instrumental variables. Similarly, in Chapter 3, to depict the farmers' contract choice on transferring land to whom, I utilized the nested logit model, which has the drawback of not addressing the endogeneity problem of farmers' contract choices. Furthermore, in Chapter 4, I employed village-level variables and the average value of households' variables in the village as instrumental variables to address the potential endogeneity of the explanatory variable. However, these may not be completely exogenous with respect to the household land renting behaviors.

The third limitation pertains to the policy implications of the study. More specifically, Chapters 3-5 exclusively utilize data from three provinces, namely Jiangsu, Jiangxi, and Liaoning. While the study's focus is limited to these specific provinces in rural China, the insights gained are likely to have relevance not only for other parts of rural China but also for a broader range of developing countries. However, the policy implications derived from this study may not be applicable to provinces that do not align with the specific cases examined in the research. Therefore, the research may not yield meaningful policy implications for provinces that differ significantly from Jiangsu, Jiangxi, and Liaoning in terms of their socio-economic, political, or cultural characteristics. Finally, it has to be noted that the land rental market is already a highly regulated market with a wide range of fast changing policies on the national and provincial level. This makes that the institutional setting is changing continuously and makes that the effect of individual policies is difficult to determine. Moreover, government policies are only one factor affecting the land rental market, also actors in the production chain and market developments play an important role.

6.5 Recommendations for future research

Given the previous section, the recommendations can be grouped into three aspects. Firstly, the data collection process should be enhanced. For example, efforts should be made by the government to collect long-term datasets and to expand the coverage of cultivated land expropriation data to include prefecture-level cities and counties. This expanded data collection would not only facilitate government monitoring of cultivated land use change, but also serve as a valuable resource for academic institutions conducting research. Consequently, this expanded data coverage could lead to a more effective land and natural resource management. As an illustration, the EU utilizes the Farm Accountancy Data Network (FADN) to monitor farm income and business activities. This dataset is similar to the long-term data (the fixed point observation survey data) from the Ministry of Agriculture, which has already been established but is not yet available to most researchers. Additionally, more case studies and experiments such as the Science and Technology Backyard organized by China Agricultural University could be conducted to deepen knowledge and insights. In the data collection also, more attention could be paid to the research methods used to analyze the data. For example, data should be collected not only to focus on the research questions but also to focus on instrumental variables that are general and exogenous, to coping with potential endogeneity problems.

Furthermore, instead of relying solely on econometric methods, alternative methods such as Agent-based Modeling (*e.g.*, Magliocca *et al.*, 2011) and experiments (*e.g.*, Buchholz *et al.*, 2022), could be employed to analyze the land rental market. Agent-based Modeling, for instance, simulates the interactions of individuals in a market to comprehend complex dynamics, making it valuable for scenario testing and understanding the impact of different variables on the land rental market. Similarly, experiments can establish a clear causal relationship between factors such as the characteristics of a household's head and policy shocks on the land rental market, demonstrating high internal validity when well-designed.

Finally, to improve government policies it is important to conduct more ex-ante (before implementation) and ex-post (after implementation) impact analyses. Examples of ex-ante analyses are cost benefit analysis (Fischhoff, 2015) and pilot studies (Malmqvist *et al.*, 2019)

both assessing the potential benefits and costs of a policy or project before its implementation. Additionally, undertaking ex-post analyses can evaluate the actual impact of a policy, allowing for a comparison with the predicted impacts from the ex-ante analysis and facilitating more robust and adaptive policymaking. Examples are econometric analyses such as differences-in-differences and the econometric analysis performed in this thesis.

Despite the caveats and the resulting recommendations, I feel this thesis contributes to a better understanding of arable land scarcity and the land rental market in China. This will hopefully contribute to improving its functioning so that it can better serve China and its inhabitants' interests.

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Summary

Arable land is scarce, not only in China but also in almost all countries. Smallholder farming predominantly drives agricultural production in most developing countries, playing a significant role in global agricultural systems. However, land transfer within traditional social relations, which are based on blood and geographic ties, may hinder the access of relatively efficient households to additional land. Additionally, small farms may adopt intensive agricultural practices due to limited land resources, which can cause environmental pollution. The aim of the thesis is to support the development of strategies for managing scarce arable land resources and promoting sustainable agriculture by analysing the rural-urban land conversion in China, understanding the dynamics of the land rental market, and obtaining deeper insights into the functioning, driving forces and environmental effects of the land rental market in rural China.

This thesis consists of six chapters. Chapter 1 reports on the research background, research questions, study area, and estimation methods used in this thesis. Chapter 2 examines the impact of industrial and population agglomeration and local government fiscal deficits on cultivated land expropriation in China. The provincial and prefectural-level data set analyzed in this chapter includes 29 provinces (autonomous regions, municipalities) of P.R. China from 2007 to 2021, excluding Shanghai, Tibet, Hong Kong, and Macao due to missing data. The findings reveal that industrial agglomeration has a significant and positive impact on the expropriation of cultivated land. Population agglomeration does not directly affect the rate of cultivated land expropriation, but it significantly increases the ratio of cultivated land being converted into residential land. Provincial-level fiscal deficits significantly elevate the land expropriation rate, whereas fiscal deficits at the prefectural-city level have no impact on it.

Chapter 3 examines the relationship between land tenure security, social relations and land rental contract choices. This is done using household data collected from Jiangxi and Liaoning provinces in 2015, by employing nested logit models and using full-information maximum-likelihood estimations. Findings indicate that China's land rental market is severely segmented and predominantly operated through informal rental contracts. This undermines the market's potential to elevate productivity and provide an equitable income

distribution. We found that landlords are more likely to rent out land to tenants who live in the same village, rather than to relatives or strangers, suggesting that this form of partner matching considers both the risk of land loss and the flexibility of rental relationships. Furthermore, insecure land tenure encourages landlords to select informal contracts, as they may serve as substitutes for formal contracts in regions with low land tenure security. In addition to tenure security, landlords' choices regarding contracts are also influenced by the flexibility that the contracts' offer.

Chapter 4 examines the impacts of social relations between rental partners and public interventions imposed by local governments or village collectives on land rent deviation (the ratio of real rent to the weighted average shadow rent) and discusses efficiency and equity impacts as well. Household-level data collected in 2014 covering 907 households in 30 villages in Jiangsu Province, China, are used for an empirical analysis. The empirical findings demonstrate that land rental transactions being limited to close social relations prevent the price mechanism from leading to efficient factor allocation. Consequently, land cannot be transferred to more productive producers as shaped by the land rent, and land transactions remain confined within the same social class, perpetuating social inequalities. Local governments and village collectives impose public interventions on the land rental process and organizational modes to eliminate the lock-in effect of social relations on land rental relationships. By doing so, they contribute to reducing land rent deviations. Therefore, public interventions can serve as a measure to substitute for social relations and improve the economic efficiency and equity of the rural land rental market in China.

Chapter 5 estimates the size and determinants of fertilizer overuse/underuse in China. Using a rural household balanced panel data set collected for 542 farms in Jiangsu, Jiangxi and Liaoning Province for the years 2014 and 2018, grain rice production function estimates are used to obtain farm-specific values for revealed fertilizer overuse and underuse. The results indicate that risk-averse farmers tend to overuse chemical fertilizers; an increase in rainfall (positive rainfall deviation) reduces the overuse of fertilizers by farmers. However, we did not find any effect of renting-in land on farmers' fertilizer overuse. The interaction term between the risk aversion dummy and the area sown to rice shows a significant negative impact on farmers' fertilizer overuse. This suggests that farmers with higher levels of risk aversion tend to decrease their application of chemical fertilizers as their scale of operation expands.

Chapter 6 presents a synthesis. It presents answers to the research questions raised in the first chapter and draws a general conclusion. It also summarizes the limitations of this study and makes suggestions for future research.

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Liang Tang
June 2024, Nanjing, P.R. China

Liang Tang
Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan



Name of the learning activity	Department/Institute	Year	ECTS*
A) Project related competences			
A1 Managing a research project			
WASS Introduction Course	WASS	2021	1
<i>'Land rent and fertilizer use in rural China'</i>	9th EAAE PhD WORKSHOP 2022, Parma, Italy.	2022	1
<i>'Estimated size and determinants of fertilizer overuse in China: Results from Jiangxi and Liaoning Provinces'</i>	2023 the 15th CAER-IFPRI Annual International Conference: Transforming Agri-food Systems in the Digital Age: Challenges and Opportunities. Nanjing, China.	2023	1
The Essentials of Scientific Writing & Presenting	Wageningen In'to Languages	2022	1.2
Research Proposal	Wageningen University & Research	2021	6
A2 Integrating research in the corresponding discipline			
Advanced Econometrics, YSS-34306	Wageningen University & Research	2021	6
Advanced Microeconomics, UEC-51806	Wageningen University & Research	2021	6
Risk Analysis and Risk Management in Agriculture: Updates on Modelling and Applications	WASS	2022	3
B) General research related competences			
B1 Placing research in a broader scientific context			
Economics and Policy of Agricultural Development, DEC-53306	Wageningen University & Research	2020	6
B2 Placing research in a societal context			
Making Impact: Increasing the relevance of research through science-society interaction	Wageningen Graduate Schools (WGS)	2022	1
C) Career related competences/personal development			
C1 Employing transferable skills in different domains/careers			
Mobilising your - scientific - network	Wageningen Graduate Schools (WGS)	2022	1
Total			33.2

*One credit according to ECTS is on average equivalent to 28 hours of study load

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