Article

Spatiotemporal Variations in Farmland Rents and Its Drivers in Rural China: Evidence from Plot-Level Transactions

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Abstract: Reasonable rent is the key to promoting land transfer and realizing agricultural operations on a moderate scale in rural China. The purpose of this study was to reveal the spatiotemporal variations in farmland rents and their drivers by employing a multilevel model based on 3547 plot-level transactions in Sichuan Province of China. The results show that the rents of paddy field, irrigated land, dry land and other types of farmland have all maintained an upward trend since 2014, rising by 61%, 53%, 44% and 224%, respectively. The average rent per ha for these properties reached CNY 13,920, 12,285, 10,230 and 7980 in 2020 (1 USD = CNY 6.90 in 2020), respectively. Farmland rents have shown a significant spatial agglomeration phenomenon, and the regions with higher rent were mainly distributed in Chengdu and its surrounding areas, while the regions with lower rent were distributed in the east and northeast of Sichuan Province. The differences in farmland rent were influenced by multilevel factors such as plot level and regional level, and the former explained 73.4% of the farmland rent variation. The plots with a larger area, longer transfer period, clear ownership, better location and good-quality land had higher rents; otherwise, the rents were lower.

Keywords: farmland rent; spatiotemporal variations; drivers; non-grain; rural China

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1. Introduction

In recent years, the continuous advancement of urbanization and industrialization has led to large-scale labor migration in rural China. The population in rural China decreased by about 260 million, and the proportion of households only engaged in agricultural operations decreased from 26.42% to 4.78% from 1988 to 2018 [1]. Meanwhile, farmland was in a state of extensive utilization in some rural areas, and food security was threatened in China [2]. The contradiction between land fragmentation caused by the household contract responsibility system (HCRS) and moderate-scale operation required by agricultural modernization is increasingly prominent [3,4]. In order to integrate land resources, the Chinese government has adopted a series of measures to promote moderate-scale operation of agriculture [5]. Thereafter, the land transfer market began developing, and the rate of transferred land has been rising [6]. The transferred land area expanded from 3.87 million hectares in 2004 to 35.33 million hectares in 2018 according to the data statistics from the Ministry of Agriculture and Rural Affairs. Meanwhile, the ratio of transferred land increased from 4.6% to 37% from 2006 to 2017, with an average annual growth rate of 2.7% [7].

The Chinese rural land market with distinctive Chinese characteristics, HCRS, is the current farmland system in rural China. Contrary to the private ownership of farmland in Western countries, the ownership of farmlands in rural China belongs to villages (collectives). Farmers only have a contractual management right to land. Under HCRS, members of collectives can obtain farmland management rights from villages by virtue of their membership rights. This arrangement of land right allocation leads villages to frequently reallocate farmland due to population changes [8]. Land may be reallocated through the market (“rentals”) or via administrative means (“re-allocation”, “village-mediated transfers” or “takings”); of these two approaches, the market is the most popular method [9].

It is worth noting that the system of “Three Rights Division” is the basis of farmland entering the trading market, and land rights confirmation guarantees the land’s rent or transfer. “Three Rights Division” is a system that separates the ownership right, contract right, and management right for farmland. When one household rents out land to another household or economic entity, it has management rights. The land is rented out for a period of time, and the land lessor will receive rent from the lessee; rental prices and lease duration are usually determined by mutual consultation, but the maximum lease duration cannot exceed the remaining contract duration of the leased land. Land right confirmation is the registration of the land title, and the government registers the details of the farmland, including location, area and the owner of management rights in the certifications given to the farmers. It clarifies the physical boundaries of the land and strengthens the enforcement of land rights [10].

However, with the development of the land transfer market, the farmland rents in some areas are on the rise, and the proportion of land rent or land cost in the total cost of grain production is increasing [11]. It has been reported that the land cost of the three main grain crops (wheat, rice and corn) in China increased from CNY 930.3 per ha (USD 1 = CNY 6.22 in 2015) to CNY 3373 (USD 1 = CNY 6.61 in 2018) from 2005 to 2018, an increase of nearly three-fold. With the rapid increase in land rent and agricultural operating cost, the income of agricultural operations has been severely compressed coupled with the unstable grain price, which undoubtedly brought great challenges to farmers operating on a moderate scale [12]. It is worth noting that the high land cost is mainly due to the high land transfer rent [13]; therefore, the spatiotemporal variations in farmland rents and their driving factors are systematically revealed that can help to form a reasonable pricing mechanism of farmland rent.

In this context, scholars have carried out significant research on the issue of land rent [6,7,14–16]. First of all, the spatial distribution of land rent has been widely reported [6,7,14–16], mostly focusing on the macro-scale such as prefecture-level cities, districts and counties, towns and villages, but micro-scale studies such as those operating at plot level are very rare. Secondly, farmland rent is influenced by many factors, such as nature, geographical location and social-economic development level. With the development of the land transfer market, the role of natural factors has been weakened, while the influence of regional economic factors and land resource endowment has been further strengthened [15] and the macro-social factors including land policy [17], grain price [18], labor migration [19], off-farm employment ratio [20], trust relationship between traders [21], bargaining power [22] and farmer relationship network [23]. In addition, most of the existing studies exploring the drivers of differences in farmland rent are conducted by questionnaire surveys. Although the influencing mechanism of differences in land rent can be explained by a micro-farmer, no reasonable explanation can be given for the rent differences between different plots belonging to the same farmer. Considering that most of the land transfer among farmers uses plots as the transaction object, the rent of the plot is influenced not only by macro-factors but also by the characteristics of plots themselves. Therefore, it is necessary to explore the driving factors of differences in farmland rent from a multilevel perspective, such as at the plot level.

Here, we investigate the extent of plot and regional hierarchy factors on the variations in land rent. The purpose of this study was to reveal the spatiotemporal variations in farmland rents and their drivers in rural China by employing spatial analysis techniques and a multilevel model based on 3547 plot transfer transactions released by the land transfer information platform of the Sichuan Province of China from 2014 to 2021. Our findings enhance the understanding of the spatiotemporal variations in farmland rents and their driving mechanism to inform future farmland resource management and provide an empirical reference that can be utilized to form a reasonable rent pricing mechanism.

2. Data and Methods

2.1. Study Area

This paper selected Sichuan as the research area, which is located in the southwest hinterland of the Chinese mainland and the upper reaches of the Yangtze River. Sichuan Province has abundant topography, crossing multiple geomorphic units, such as the Qinghai–Tibet Plateau, Hengduan Mountains, Yunnan–Guizhou Plateau, Qinba Mountain and Sichuan Basin. Meanwhile, it has an undulating land surface, with a high altitude in the east and low altitude in the west. Northwest Sichuan is a plateau with an elevation ranging from 4000 to 4500 m, while East Sichuan is a basin with an elevation of only 300 to 700 m, of which the Chengdu Plain covers an area of 80,000 ha, which makes it the largest plain in Southwest China. The central part of Sichuan is a transitional region from the western plateau to the Sichuan Basin, with undulating terrain and typical canyon landforms with high mountains and valleys. Thus, it can be seen that Sichuan Province has many coexisting topographies and landforms, such as the great plains, hills, basins and mountains, which represents the topographic and landform characteristics of Chinese Mainland.

In addition, Sichuan is a large agricultural province in China. In 2020, the grain output of Sichuan was 70.54 million kilograms, and the gross domestic product (GDP) of the primary industry was CNY 556 billion, accounting for 11.45% of Sichuan's GDP and ranking the second national wide. The government of Sichuan has continued to advance a new round of rural reform and fully improve the system of “Three Rights Division”, which is the system for separating the ownership right, contract right and management right for farmland. The government also accelerates the construction of modern agricultural parks and encourages moderate-scale operation by various forms. According to the statistics of the Sichuan Provincial Department of Agriculture and Rural Affairs in 2016, the number of family farms in Sichuan has reached 1.7×10^4 , with an operating area of 1.08×10^5 ha. Meanwhile, Sichuan has 4.5×10^5 households with large-scale planting and breeding and 1.3×10^4 households with more than 2 ha of farmland. The proportion of farmland in the transfer process in Sichuan Province reached 39.5% in 2019, which shows that the phenomenon of moderate-scale operation of agriculture is becoming prominent. Therefore, it can provide data support for studying the regional differences in farmland rent. However, the farmland transfer market in Sichuan Province is still in its infancy compared with economically developed areas and therefore has great development potential. Thus, it is of great importance and practical significance to study the spatiotemporal variations in farmland transfer rents and their driving factors in Sichuan Province. The location of Sichuan Province is shown in Figure 1.

Figure 1. Geographical location of the study area.

2.2. Data

2.2.1. Land Transfer Transaction Data at the Plot-Level

The land transfer data in this paper were mainly obtained from the Land Transfer Information Platform in the Sichuan Province of China (Tuliu.com. <https://www.tuliu.com/>, accessed on 10 August 2020). Tuliu.com is the largest Internet trading platform for rural land in China, accounting for 90% of the land transfer Internet market share. The data of land transfer transactions from the land transfer information platform have two significant advantages. First of all, the platform has a large number of data samples, a large amount of information and is strongly representative compared with the data obtained from an offline sampling survey of farmers. Secondly, the platform includes information on small-scale and large-scale land transfer transactions, which can fully reflect the spatial pattern of farmland rents at plot level with different scales [13], but the traditional survey focuses on the collection of small-scale land transfer information among farmers, lacking sufficient observation of the rent of large-scale land transfer. Therefore, this paper manually collated 3547 pieces of land transfer transaction data released by the land transfer information platform of the Sichuan Province of China from 2014 to 2020, including specific indicators such as plot types (paddy field, irrigated land, dry land and other types of cultivated land), plot size, rent, transfer type, number of transfer years, plot location, supporting facilities and surrounding environment, etc. It provides basic data for the study of the spatiotemporal variations in land transfer rents and their driving mechanism.

2.2.2. Statistical Data of Social and Economic Development

To comprehensively identify the driving factors of differences in farmland rent, this paper also collected the socio-economic data of the areas where the plots are located from the Sichuan Statistical Yearbook and National Compilation of Agricultural Products' cost-benefit data. The per capita GDP of each place comes from the Sichuan Statistical Yearbook, and the average cost and income, average output value per ha, labor cost, land cost, material and service cost of the three main grain crops and cash crops from 2014 to 2020 all come from the National Compilation of Agricultural Products' cost and income data.

2.3. Methods

2.3.1. Visualization of Spatial Differentiation of Farmland Rent

In order to explore the spatial pattern of farmland rent in Sichuan Province, the investigation of spatial statistics and analysis of land transfer rent were carried out according to 21 prefecture-level cities and 183 districts and counties by employing ArcGIS software. Firstly, the study period was divided into three years, i.e., 2014, 2017 and 2020. Then, farmland rent was divided into three grades with the help of grading colors in the ArcGIS symbol system. This study took the maximum land rent that grain crops and cash crops producers can bear as the cut-off value. Some scholars believe that 20% of the agricultural output value should be the maximum value for a reasonable level of land rent [12]. Different types of farmland have different output; therefore, the rent classification of different types of farmland is not identical (e.g., for paddy field and irrigated land, rent ranges were (<6000), (6000–12,000), (>12,000), of which, 6000 is the maximum land rent that grain crops producers can bear, and 12,000 is the maximum land rent that cash crops producers can bear). Finally, a map of the rent distribution of the four types of farmland was drawn.

2.3.2. Drivers of Differentiation in Farmland Rent

The differentiation in farmland rent is not only affected by the characteristics of the plots themselves but also by the socio-economic factors of the areas where the plots are located [7]. According to previous studies, this study selected the influencing factors from the two levels of land and region. Plot area, number of transfer years, land right confirmation, type of land transfer, type of land planting, plainness and land quality were taken as the driving factors at the plot level. Among them, different types of farmland reflect the quality of land, and the irrigation and drainage condition is an important index for the

classification of the farmland quality grade. When the farmland quality grade evaluation is not completed, the farmland type divided by the irrigation and drainage condition can represent the quality of the land to a certain extent. The irrigation and drainage condition of paddy field are good if the land quality of the paddy field is better than that of the irrigated land and dry land and the quality of the dry land is poor. Meanwhile, the ratio of mountains in the plot site and per capita GDP were taken as the influencing factors at the regional level. These data have the stratified characteristics of intra-group homogeneity and inter-group heterogeneity, which do not conform to the assumptions of the traditional econometric model on sample independence, normal distribution and homoscedasticity. Instead, the multilevel model can decompose the random error term in the traditional model into the level corresponding to the data hierarchical structure so the individual random error meets the assumptions, which is an effective method for processing multilevel data [24,25]. Therefore, it was necessary to construct a multilevel model to identify the drivers of differentiation in farmland rent accurately, in which farmland rent at the plot-level is regarded as the dependent variable, and it is assumed that the rent of plot is influenced by two levels of factors such as the plot level and the regional level.

The multilevel model includes the null model and full model. The null model does not incorporate any variables into the model simulation, which is designed to calculate the variance of the plot-level factors and regional-level factors. The intra-class correlation coefficient (ICC) is used to evaluate the interpretation degree of the overall variation of the dependent variables at different levels in most studies; therefore, we can calculate the strength of the explanation of the variation in the dependent variables. Additionally, before the empirical simulation, it was necessary to adopt the variance inflation factor (VIF) to test the collinearity between independent variables.

The basic form of the null model and the definition of ICC and VIF are as follows:

Level 1 (plot level):

$$y_{ij} = \beta_{0j} + \gamma_{ij}; \text{Var}(\gamma_{ij}) = \delta^2 \quad (1)$$

Level 2 (regional level):

$$\beta_{0j} = \eta_{00} + \mu_{0j}; \text{Var}(\mu_{0j}) = \tau_{00}^2 \quad (2)$$

$$\text{ICC} = \frac{\tau_{00}^2}{\tau_{00}^2 + \delta^2} \quad (3)$$

$$\text{VIF} = \frac{1}{1 - R_i^2} \quad (4)$$

where β_{0j} and η_{00} are the intercepts on the first and second levels, respectively; γ_{ij} and μ_{0j} are the residuals of the random components of the first level and second level, respectively; δ^2 and τ_{00}^2 are the variances of the first- and second-level residuals, respectively, that is, intra-group variance and inter-group variance; and R_i is the negative correlation coefficient of the independent variable X_i for the remaining independent variables in the regression analysis.

The plot-level and regional factors were introduced to a full model based on the null model. The full model can not only explain the influence degree of the plot-level and regional-level variables on the dependent variables but also reflect the interaction between variables in two levels comprehensively. Its formula is as follows:

Level 1 (plot level):

$$y_{ij} = \beta_{0j} + \beta_{1j}X_{ij} + \gamma_{ij}, \quad (5)$$

Level 2 (regional level):

$$\beta_{0j} = \eta_{00} + \eta_{01}W_j + \mu_{0j}, \quad (6)$$

$$\beta_{1j} = \eta_{10} + \eta_{11}W_j + \mu_{ij} \quad (7)$$

where i and j are plots and regions, respectively; y_{ij} represents the transfer rent of plot i in area j ; X_{ij} represents the plot-level influencing factor of plot i transfer rent in area j ; β_{0j} and β_{1j} are the intercept term and slope of the plot transfer rent affected by the area j , respectively; W_j represents the influencing factors of the regional level; intercepts η_{00} and η_{10} are the influence of the factors representing the regional level on land rent; and slopes η_{01} and η_{11} represent the cross-level effect of regional-level factors on plot-level factors.

2.3.3. Calculation of Net Profit of Cultivated Land

The net profit of farmland refers to the total income of the farmland per unit area excluding direct costs such as labor, materials and services, land cost and indirect costs such as depreciation of fixed assets and insurance premiums. This value can be calculated by subtracting the total cost of each input from the total output value of agricultural products per ha. The total cost includes production cost and land cost, of which the production cost includes material and service costs and labor costs. The formulas are as follows:

$$r = p + I_{\text{Labor}} - I_{\text{matter}} - I_{\text{Land}} \quad (8)$$

$$I_{\text{matter}} = I_{\text{seed}} + I_{\text{pest}} + I_{\text{mach}} + I_{\text{irri}} + I_{\text{other}} \quad (9)$$

where r is the net profit of cultivated land per ha; p is the total output value per ha; and I_{Labor} , I_{matter} and I_{Land} represent the labor cost, material and service cost and land cost per ha, respectively. I_{seed} , I_{pest} , I_{mach} and I_{irri} are the material costs of seedlings, pesticides, fertilizers, machinery and irrigation, respectively; and I_{other} is other expenses.

3. Results

3.1. Spatiotemporal Variations in Farmland Rents

3.1.1. Time Variations in Farmland Rents

Figure 2 shows that an overall upward trend in farmland transfer rent, which excluded the influence of inflation and price factors from Q3 2014 to Q3 2020 (7 years and 25 quarters). We found that the farmland rents were increasing steadily during the study period, except for a slight fluctuation in 2018. Meanwhile, the change trends of different types of farmland rents were similar. It is worth nothing that the rents of paddy field, irrigated land, dry land and other types of cultivated land all exceeded CYN 7500 per ha in 2020.

Figure 2. Inter-annual variations in different farmland rents.

Firstly, in terms of different types of farmlands, the descending order of farmland rent is paddy field, irrigated land, dry land and other types of cultivated land. The paddy field rent increased rapidly, from CNY 8535 per ha in Q3 2014 to CNY 13,995 per ha in Q3 2020, with a growth rate of more than 60% during the study period. Secondly, there were few differences in rent between irrigated land and dry land, which increased by 57% and 49%, respectively, from 2014 to 2020, and the average rent per ha reached CNY 12,495 and CNY 10,275, respectively, in 2020. Finally, the rent of other types of cultivated land was the lowest, but it has rapidly grown since 2018. In 2020, the rent gap between other types of cultivated land and the other three types of cultivated land were already small.

3.1.2. Spatiotemporal Variations in Different Types of Farmland Rents

Sichuan Province is a major agricultural province in China and has various landform types; therefore, choosing Sichuan Province as the research area is highly representative. First of all, the rents of different types of farmlands all maintained an upward trend at the municipal level. At the beginning of the study, the average rent per ha of paddy field, irrigated land, dry land and other types of cultivated land was CNY 8535, 7845, 6885 and 2775, respectively, and their corresponding rent ranges were (6000, 12,000), (6000, 12,000), (4500, 9000) and (0, 3000), respectively. The regions with lower rent were mainly distributed in the east and northeast of Sichuan Province, such as Neijiang, Zigong and Guangyuan, while the regions with higher rent were mainly distributed in Chengdu city and its surrounding areas. At the end of the study, the average rent per ha of the four types of farmlands was found to be CNY 13,995, 12,330, 10,275 and 8025, respectively, which increased by 64%, 57%, 49% and 239% from 2014 to 2020, respectively. Rent increased in the direction of west to east, and the scope is constantly expanding. Taking paddy field as an example, the average rent per ha was less than CNY 12,000 in almost all prefecture-level cities in 2014, while the average rent per ha was more than CNY 12,000 in almost all prefecture-level cities in 2020. On the whole, the rents of four types of farmlands in all prefecture-level cities in the study area showed a significant upward trend, and regions with higher rent were concentrated in Chengdu city and its surrounding areas. Figure 3 shows spatiotemporal variations in farmland rents at prefecture-level city.

Figure 3. Spatiotemporal variations in farmland rents at prefecture-level city.

Secondly, the rents for different types of farmlands at the county level also showed a significant increase. The regions with higher rent were mainly distributed in Chengdu city and its surrounding districts and counties, showing a strip distribution in the northeast and southwest, while the regions with lower rent were mainly distributed in the east and west of Sichuan Province. At the beginning of the study, the average rent per ha ranges of paddy field, irrigated land, dry land and other types of cultivated land were mainly (6000, 12,000), (6000, 12,000), (4500, 9000) and (0, 3000), respectively. The regions with higher rent were mainly concentrated in the Chengdu Plain, while the regions with lower rent were mainly distributed in northeast and northwest Sichuan Province, showing obvious characteristics of spatial autocorrelation. Farmland rents exceeded CNY 12,000 per ha in many districts and counties for paddy fields and irrigated land in 2020, but only a few districts and counties had rents less than CNY 9000 per ha. On the whole, the farmland rents in all districts and counties of Sichuan Province were rising continuously. The spatial pattern of high-rent regions shows an obvious strip-shaped structure in the northeast and southwest. Simultaneously, the regions with low rent were mainly distributed in the northeast and northwest districts and counties of Sichuan Province. Figure 4 shows spatiotemporal variations in farmland rents at district and county level.

Figure 4. Spatiotemporal variations in farmland rents at district and county level.

3.2. Driving Factors of Differences in Farmland Rent

Table 1 presents the variable definitions and statistical descriptions. On the whole, the farmland rent per ha was CNY 10,500. In terms of plot-level characteristics, the average area of the transferred plot was 4.99 ha, the average transfer period was nearly 21 years, and the ratio of transferred plots which had completed the land confirmation and certification documentation was 63%. From the regional level factors, the per capita GDP of prefecture-level cities was CNY 56,255, and the proportion of mountain counties was 67%, and the number of samples for each type of farmland was uniform; thus, it is very representative.

The multilevel model was used to identify the key driving factors of differences in farmland rent. Before the empirical simulation, this study first adopted VIF to test the collinearity between independent variables. The results show that the VIF of a single variable was less than 3.1, and the comprehensive VIF of all variables was less than 3, which is far less than the critical point of 10, indicating that there was no serious collinearity problem between the variables. Additionally, Rho was 0.113, which indicates that the

multilevel model was the best option. Table 2 presents the empirical results of different models. Model 1 is a null model without any variables, which was mainly used to judge the goodness-of-fit of the model. Model 2 is based on model 1, adding the plot-level factors and regional factors. Model 3 and model 4 are the fixed-effect model and random-effect model, which were used for the robustness test of model results.

Table 1. Definitions and statistical descriptions of variables.

Variables	Definitions	Mean	S.D.	N
Farmland rent	Farmland rent per ha (CNY)	10,500	10,849.8	3547
Plot-level characteristics				
Plot area	Plot area, ha	4.99	4.65	3547
Years of land transfer	Years of land transfer, years	20.78	14.28	3547
Land right confirmation	Whether the land ownership and other rights are confirmed; yes = 1, no = 0	0.63	0.34	3547
Type of land transfer	The method of land transfer: renting out = 1, other ways (exchange, subcontract, etc.) = 0	0.46	0.5	3547
Type of land planting	Type of land planting: cash crop = 1, food crop = 0	0.16	0.36	3547
Plain	Is it plain: yes = 1, no = 0	0.33	0.47	3547
Paddy field	Is the land type a paddy field: yes = 1, no = 0	0.25	0.43	3547
Irrigable land	Is the land type an irrigable land: yes = 1, no = 0	0.25	0.43	3547
Dry land	Is the land type a dry land: yes = 1, no = 0	0.25	0.43	3547
Regional level characteristics				
per capita GDP	Gross domestic product per capita	56,255	18,864	183
Ratio of mountains	Ratio of mountainous area in the counties	0.36	0.33	183

Table 2. Driving factors of rent difference of cultivated land transfer.

Variables	Model 1 Zero Model	Model 2 Non-Null Model	Model 3 Fixed-Effect Model	Model 4 Random-Effect Model
Plot-level characteristics				
Plot area		0.322 *** (3.13)	0.541 *** (5.53)	0.421 *** (3.89)
Plot area ²		0.007 (−0.73)	0.024 *** (−2.73)	0.023 (−1.43)
Year of land transfer		0.051 *** (8.34)	0.067 *** (9.23)	0.055 *** (5.93)
Years of land transfer ²		−0.001 *** (−5.24)	−0.001 *** (−6.94)	−0.001 *** (−3.54)
Land right confirmation		0.243 *** (3.29)	0.311 *** (3.31)	0.282 *** (3.89)
Types of land transfer		0.543 *** (10.43)	0.645 *** (11.23)	0.554 *** (9.23)
Types of land planting		0.164 ** (2.32)	0.178 ** (2.34)	0.163 *** (2.32)
Plain		0.385 *** (9.43)		0.923 *** (4.88)
Paddy field		0.463 *** (3.13)		0.792 *** (4.13)
Irrigated land		0.265 *** (3.43)		0.462 *** (3.83)
Dry land		0.102 ** (2.12)		0.284 ** (2.32)
Regional characteristics				
Log (per capita GDP)		0.323 *** (4.23)	0.321 *** (4.53)	0.722 *** (4.12)
Ratio of mountains		−0.242 (−1.11)	−0.241 (−1.21)	−0.244 (−1.21)
Regional dummies		Yes	Yes	Yes
Year dummies		Yes	Yes	Yes
Constant	5.973 *** (80.52)	7.354 *** (29.67)	5.311 *** (7.43)	8.221 *** (34.33)
$\text{Var}(\gamma_{ij})$	0.431	0.973		
$\text{Var}(\mu_{0j})$	1.189	0.984	0.984	
Rho	0.113	0.495		
R ² within		0.311	0.243	
Number of samples	3547	3547	3547	3547

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

Model 1, also known as a null model, was mainly used to test whether it is reasonable to adopt the multilevel model. The results show that Rho was 0.113; as this was far

greater than 0.059, it was not suitable to adopt traditional regression analysis model, so the multilevel model was used for analysis. Meanwhile, according to the cross-level correlation coefficients δ^2 and τ_{00}^2 , we were able to calculate ICC to estimate the influence degree of different levels of factors on the variation in dependent variables, and the results show that the plot-level factors can explain 73.4% of the variations in farmland rents, while the regional level factors can explain 26.6%.

Model 2 includes the plot-level and regional-level factors based on model 1. In terms of plot-level, the plot area was significantly positive at the significance level of 1%, with the coefficient of 0.322, indicating that as the plot area increased, the farmland rent increased without changing any other conditions. Meanwhile, factors such as years of land transfer, land right confirmation, types of land transfer, types of land planting and types of farmland, especially paddy field and irrigated land, were all significantly positive at the significance level of 1%, that is, the plots with a long transfer period, clear ownership, superior location and good quality had higher transfer rents, and the planting type was significant at the level of 5%, with a coefficient of 0.164, indicating that the planting type also has a certain impact on farmland rent. In terms of regional level, the per capita GDP was significantly positive at a significant level of 1%, with a coefficient of 0.323, which indicates that the higher the per capita GDP of the area where plots were located was, the higher the farmland rent would be.

Model 3 and model 4 are fixed-effect models and random-effect models. The results show that the simulation results of these two models were very close to those of model 2. Plot area, years of land transfer, land certification, types of land transfer, types of land planting, per capita GDP and types of farmland had significant positive effects on farmland rent.

In brief, plot area, years of land transfer, land certification, types of land transfer, plain and types of farmland were the key drivers at the plot level that affected the variation in land rent, and these factors explain nearly 3/4 (73.4%) of the variations in farmland rents. That is, plots with a large area, long transfer periods, clear ownership, better location and good-quality land had higher rent in the process of transfer, whereas the rent was lower in plots without these characteristics.

3.3. Cost–benefit of Farmland at Different Utilization Modes

Figure 5 shows the changes in the cost–benefit of the three main grain crops and cash crops from 2014 to 2020. The land cost per ha was less than CNY 4500 in 2014, and it increased to CNY 9000 in 2020, representing a 200% increase, which indicates that the land cost has maintained a rapid growth in recent years. However, the average grain output value per ha did not increase significantly. Correspondingly, the net profit of farmland decreased year by year. The net profit of the grain crops was less than CNY 1500 per ha in 2014, since then, it has continued to decrease and the main grain crops were in a loss stage in 2016, which means that the current land cost in agricultural operations has exceeded the reasonable level that grain producers can bear.

Generally, the returns of cash crops were relatively high, and the output value of cash crops per ha was five times that of grain crops. Therefore, when the returns of planting the main grain crops decline or farmers lose money, rational farmers will turn to planting highly profitable cash crops instead of planting the grain crops, which leads to the “non-grain” use of the farmland to some extent. In recent years, with the continuous increase in labor costs and material costs such as fertilizers, the net profit of cash crops has also been declining. Some farmers are not willing to plant cash crops and engage in non-agricultural industries, which leads to the “non-agricultural” use of the farmland and undoubtedly brings great challenges to food security in China.

Figure 5. Cost–benefit comparison of cultivated land per ha under different utilization modes: (a) cost–benefit of the main grain crops; and (b) cost–benefit of the cash crops.

4. Discussion

4.1. Fact of Overcapitalization of Farmland

In recent years, the Chinese government has actively promoted the moderate-scale operation of agriculture. Land transfer is one of the most important ways to realize this goal [14]. However, with the development of the land transfer market, the phenomenon of high land cost is more prominent [11]. The proportion of the land cost in the total cost of agricultural operations has risen as well, and in some areas, higher farmland rent has even exceeded the reasonable level that grain producers can bear, leading to overcapitalization of farmland. In fact, this phenomenon is not only unique to Sichuan Province, the target area of this paper, but also occurs in the plain areas of China according to the data. The farmland rent in the plain areas of China doubled from 2014 to 2020, and land rent cost accounted for 31% of total production costs in 2020. Accordingly, the net profit of farmland has been declining. The net profit of grain crops per ha in the plain area dropped from CNY 8445 in 2010 to CNY 1755 in 2018, with a drop of 80%. There are many reasons for the overcapitalization of farmland. First, the farmland transfer market in rural China is at the development stage; some systems are not perfect, and the transaction costs are very high. Second, the price of agricultural product is affected by many factors, especially the COVID-19 epidemic, and some countries have introduced policies to restrict grain exports, aggravating the imbalance of global grain supply, and thus the price of agricultural production is unstable [26,27]. Although grain price in international markets has significantly increased due to the changes of monetary policy in developed countries, weather disasters in major grain producers and other factors, the domestic grain supply is sufficient, and the overall impact of the rising grain prices in international market on the domestic market is limited, therefore, domestic grain price is mainly affected by the domestic supply and demand relationship and production costs. Finally, in the context of rapid urbanization, labor wages have risen, which has increased the cost of agricultural labor. Meanwhile, prices for agricultural materials such as fertilizers continue to increase, and the trend of declining profit has become even more obvious, especially in recent years. This will definitely impair the profits of farmers, and rational farmers will plant cash crops instead of grain crops to achieve greater profits, which leads to the “non-grain” use of the farmland [28]. However, the Chinese government has implemented measures for the special protection and use control of farmland, especially high-quality farmland, to develop grain production, but the fruit industry and digging ponds to raise fish are prohibited. Therefore, farmland users do not have complete freedom in choosing the direction of cultivation. If the rising trend of land cost is not controlled, labor costs and materials costs will remain high, and cash crops will not be profitable. Therefore, it can be expected that farmers will give up cultivating the land, which leads to farmland abandonment and the

waste of land recourses; this is obviously contrary to the strict farmland protection system implemented by Chinese government. In short, the high rent of farmland threatens food security in China and urgently needs to be addressed by all sectors.

4.2. Local Practices of Reducing the Operating Cost of the Land System

On the one hand, existing studies have already found the root cause of the over-capitalization of farmland, which lies in the high transaction cost of the process of land transfer [29], so reducing the transaction cost of land transfer is an urgent problem that need to be solved at present. On the other hand, the current policy on land transfer lays too much emphasis on protecting the property income of farmland contractors, which cannot resolve the problem. In addition, many restrictions have been introduced, such as the minimum transfer price, without considering their influence on large-scale operators. Therefore, it is necessary to determine the rational range of farmland rent and to actively explore the reasonable pricing mechanism of farmland rent to make land transfer more profitable for both land-givers and land-receivers.

Secondly, agricultural subsidies give extra income to farmers and further increase farmland rent [30]. The existing method of granting agricultural subsidies disturbed the healthy development of the land transfer market to a certain extent [31] and changed some agricultural subsidies into invisible rents [32]. Therefore, the government should implement targeted subsidy measures for agriculture to support the large-scale grain producers, in turn avoiding the issue of subsidies flowing to contractors rather than to real farmland operators.

Thirdly, moderate-scale operation of agriculture is inevitable in agricultural modernization and needed to improve agricultural labor productivity. Currently, many regions have been exploring the modes of consolidating farmland to realize the moderate-scale operation, which is regionally suitable for them, such as “one family has a piece of land mode” (Bengbu city in Anhui Province, Zhangye city in Gansu Province, Zaozhuang city in Shandong Province, etc.), “joint farming and joint planting mode” (Sheyang city in Jiangsu Province) and “small plots combined with large plots mode” (Chongzuo city in Guangxi Province). These modes have important reference value because they not only effectively solve the problem of rural land fragmentation but also bring huge social and economic benefits [33].

Finally, scaling up the service can be used instead of scaling up the land in some areas where moderate-scale operation of farmland cannot be realized. In 2017, The Guiding Opinions on Accelerating the Development of Agricultural Productive Service Industry emphasized that developing the agricultural productive service industry is urgently need to promote multiple forms of moderate-scale operation. Some scholars believe that the role of land transfer is not significant for encouraging grain production. Instead of expanding the scale of land transfer, it is better to improve the level of socialized services, especially agricultural mechanization services [34]. The government should create a more promising environment for agricultural producers, especially small farmers, to improve agricultural production efficiency.

4.3. Research Limitations

First of all, this paper focuses on the Sichuan province for representative research, as it is a major agricultural province in China and has various landform types. However, considering the vast territory of China, heterogeneity of natural conditions and socio-economic development in different regions, it is impossible to systematically and comprehensively ascertain the characteristics of farmland transfer rent in China with only 3547 plots of land data in one region, and this method does not provide enough references for formulating land transfer policies at the national level. Second, soil quality is an influencing factor in farmland rent; but as this is limited in the collected data, we selected different types of farmlands to represent land quality instead of soil quality. In the future, it is worth collecting the soil data of plots as a key variable in the analysis model. Finally, although

this study adopted a multilevel model to identify the driving factors of the differences in land rent, which can effectively analyze nested data and decompose the explanation of plot rent variation into different levels, there still exists an obvious spatial autocorrelation phenomenon in farmland rents. It is necessary to use spatial econometric model at the county or municipal level for further research if we want to reveal the spatial correlation and agglomeration of farmland rent.

5. Conclusions and Implications

This study collected the data of 3547 land transfer transactions in Sichuan Province from 2014 to 2020 and systematically revealed the spatiotemporal variations in farmland rents and their driving factors by employing spatial analysis techniques and the multilevel model. The findings are as follows:

On the whole, the rents of paddy field, irrigated land, dry land and other types of cultivated land all showed an upward trend from 2014 to 2020, but there were obvious differences in the growth rates. The regions with higher rent were mainly distributed in the central part of Sichuan Province, especially in Chengdu city and its surrounding areas, while the regions with lower rent were mainly distributed in the eastern and northeastern parts of Sichuan Province.

The differences in farmland rent were mainly influenced by multilevel factors such as the plot level and regional level, including plot-level factors such as plot area, years of land transfer, land certification, types of land transfer, types of land planting and types of land, which can explain nearly 73.4% of the variations in farmland rents, while regional factors can explain about 26.6%. Plots with a large area, long transfer period, clear ownership, better location and good-quality land have higher rents, and vice versa.

With the continuous increase in land cost in agricultural operations, the cost of land has exceeded the reasonable level that grain producers can bear, which has reduced the enthusiasm of farmers and seriously threatened food security in China. Therefore, the government should formulate relevant policies to stabilize farmland rent. For example, they should formulate a reasonable pricing mechanism for land transfer, strengthen the normalized supervision of farmland rent and prevent farmland utilization for “non-grain” and “non-agricultural” use of the farmland caused by excessive farmland rent. Meanwhile, the government should actively improve the land transfer system, build a land transfer platform and reduce the transaction cost in the process of land transfer to realize the win-win situation of increasing farmers’ income and the moderate-scale operation of agriculture.

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