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Spatial Pattern of Farmland Transfer in Liaoning Province, China

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Abstract: Farmland transfer (FT) is the key to achieving moderate agricultural scale management in China. Clarifying the spatial pattern of FT is important to improve FT strategies. In this study, the multinomial logit model was used to reveal the spatial pattern of FT in Liaoning Province, Northeast China. On this basis, the reasons for its formation were discussed, and suggestions were proposed. According to the statistical results, 39.7% of the sample peasant households participated in FT. Most of them live far from the regional core area. Regression analysis shows that the FT in Liaoning Province has a significant "core-periphery" spatial pattern. As the spatial distance between the residence and the regional core area (SDRRC) increases, the probability of FT rises for peasant households. Specifically, the odds ratios of farmland transfer out and farmland transfer in rise by 0.9% and 0.6% on average, respectively, for each 1 km increase in SDRRC. Widespread concurrent business and the increase in FT fees due to imperfect urbanization are the main reasons for the formation of the spatial pattern. We suggest that the promotion of FT requires high-quality urbanization in central cities, accelerating urbanization in medium and small cities and counties, implementing differentiated FT subsidy standards, and promoting new agricultural scale management models.

Keywords: farmland transfer; spatial pattern; multinomial logit model; urbanization; Liaoning province

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1. Introduction

Contemporary China has entered a new stage of integrated and coordinated development of agricultural modernization and urbanization [1,2]. Moderate agricultural scale management is an important aspect of achieving agricultural modernization. Only when the farmland area or agricultural industry size of agricultural production managers reaches a reasonable scale, can the efficiency and benefits of modern agriculture be achieved [3–5]. Some countries with developed agriculture have established moderate agricultural scale management models that meet local realities and have positive effects [6]. However, China still has a large rural population, low farmland per capita, and severe farmland fragmentation [7–9]. This means that China's agricultural modernization needs to accelerate the transfer of surplus rural labor, creating conditions for orderly farmland transfer (FT) and moderate agricultural scale management [10]. Regional urbanization has important effects on farmers' non-farming employment and FT. With the continuous development of urbanization, cities can provide more non-farming employment opportunities and higher incomes, thereby carrying more surplus rural labor, and the livelihoods of peasant households are also transformed [4,11–13]. FT demand increases and moderate agricultural scale management will be realized [14]. Additionally, agricultural modernization also releases surplus rural labor, which, in turn, promotes urbanization [15].

In the process of urbanization, there are many factors affecting rural population migration. However, it is mainly influenced by employment opportunities and migration distance. On the one hand, the rural population migrates more to economically developed regions in many countries, because there are more employment opportunities and

a stronger absorptive capacity for surplus rural labor [16–19]. On the other hand, the willingness to migrate and the number of migrating populations are negatively correlated with the migration distance [20,21]. According to the first law of geography proposed by Tobler [22], neighboring regions have fewer differences in natural environmental characteristics, lifestyles, cultural systems, and types of languages or dialects. Therefore, these are prone to population migration. The short migration distance for farmers can significantly reduce psychological and living costs caused by the above differences, facilitating integration into the urban social system [23]. It is also in line with the traditional Chinese value of being attached to one's native land. Therefore, the regional central city is usually the most important place for migrants in a region. As the distance from the regional central city rises, the probability of migration continues to decline. Since the migration of the rural population is closely related to FT, the spatial effects of urbanization are necessarily transmitted to FT. Exploring the spatial pattern of FT in a region can reveal the deep socio-economic reasons affecting FT, which has important practical implications.

It has been confirmed that there is a spatial differentiation of FT in a region from the core area to the periphery area. However, the findings of these studies are quite different. Previous studies have found that FT shows a downward trend with increasing spatial distance from central cities or commercial centers [24–26]. This is because farmers in these regions have more opportunities to engage in non-farming jobs. Beckers et al. [27] also found that the number of farmers in the rural-urban fringe will decline more significantly in the future. However, some scholars do not support this view. For instance, Wang et al. [28] found that Chinese peasant households living in suburban regions are less likely to participate in FT than those in rural regions far from cities. The reason is that such regions have obvious location advantages, with developed urban agriculture and a main focus on the plantation of high-value cash crops. Additionally, Yu et al. [29] studied several townships in Northeast China and found a low occurrence of FT in central villages. This means that the closer to the regional core area, the lower the probability of FT. Similar situations have been described in studies carried out in other countries. In Vietnam, a developing country with a similar system and culture to China, many peasant households living in the fringe of major cities have adjusted their livelihoods to obtain income from multiple sources rather than leaving farmland [30]. For developed countries like Germany, a study has also revealed that farmers in areas far from cities are more likely to exit farming, while farmers in areas with higher urbanity are more inclined to engage in agriculture [31]. Thus, it can be seen that the formation of FT spatial pattern is a complex process, with significant differences in different regions in the context of the interactive evolution of urbanization and agricultural modernization.

As an important old industrial base and a major grain-producing region in China, Liaoning Province has a high urbanization rate and great potential for developing modern agriculture. However, there is a large gap between Liaoning Province and developed regions in terms of FT and agricultural scale management, which has become an important factor restricting agricultural modernization and rural revitalization. The main purposes of this study are to analyze the spatial pattern of FT in Liaoning Province based on the logical relationship of "urbanization-rural population migration-FT", reveal the main reasons for the lack of development of FT in Liaoning Province, and propose countermeasures that are in line with the actual situation. The rest of this article is organized as follows. Section 2 presents the basic information about the study area. Section 3 describes the main research methods and data sources. Section 4 presents the research results. Section 5 presents the discussion and implications. Finally, the conclusion of this study is presented in Section 6. In particular, it should be noted that the FT mentioned in this study only refers to the transfer of farmland management rights.

2. Study Area

Liaoning Province (118°53′~125°46′ E, 38°43′~43°26′ N) is located in the south of Northeast China (Figure 1). It belongs to the continental monsoon climate of medium lati-

tudes, with the same period of rain and heat, which is conducive to crop growth. Liaoning Province has an area of 148,600 km^2, of which 32.4% is plain. The soil is fertile, and the farmland is large and concentrated, which is convenient for large-scale utilization [32]. Table 1 shows the planting structure and output value of Liaoning Province in 2020 [33]. Grain, vegetables and oil-bearing crops are the main crops grown in Liaoning Province, accounting for 97.1% of the total sown area. The planting proportion of grain crops is the largest, with mostly maize and rice, and the highest output value obtained from vegetable production. In 2020, the urbanization rate of the permanent population in Liaoning Province reached 72.1%; the permanent population in rural areas was 11.87 million, of which 7.5 million were employed; the total grain output was 23.39 million tons; and the primary industry accounted for 9.1% of the GDP [33,34]. On the whole, Liaoning Province has a high level of urbanization and a large grain output. However, the transfer area of farmland management rights in Liaoning Province only accounts for 31.7% of the contractual management farmland area of peasant households, which is lower than China's average [35]. There is a gap between the FT level and the national requirement, which is a crucial problem to be solved in Liaoning Province.

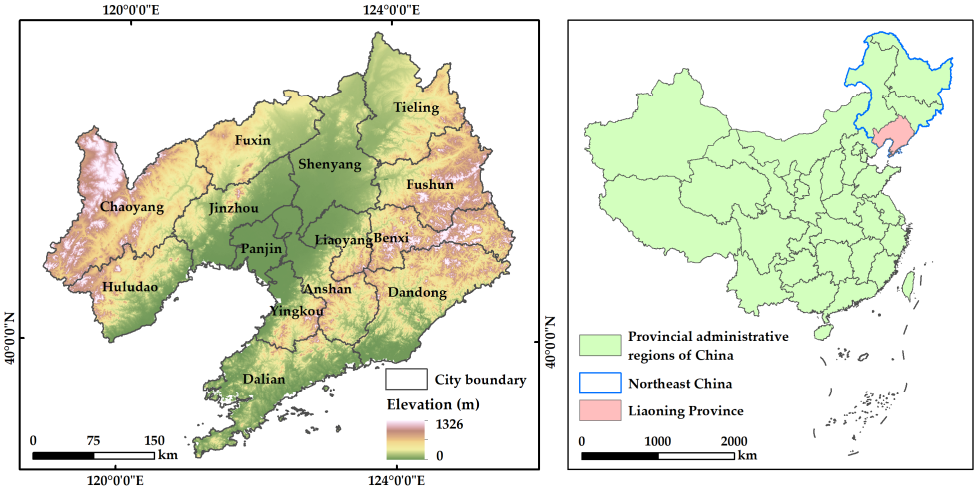

Figure 1. Overview of Liaoning Province and its location in China.

Table 1. Planting structure and output value of Liaoning Province in 2020.

Crop Type	Sown Area (10^3 ha)	Percentage of Sown Area	Output Value (10^8 Yuan)
Grain crops	3527.2	82.3%	568.2
Grain crops: Maize	2699.3	63.0%	425.9
Grain crops: Rice	520.4	12.1%	115.4
Grain crops: Soybeans	103.2	2.4%	6.1
Vegetables	325.6	7.6%	970.1
Oil-bearing crops	309.6	7.2%	51.5

3. Methods and Materials

3.1. Identification of Regional Core Area

The central place theory indicates that there are different grades of central places in a region [36,37]. Among them, the number of top grade central places is the lowest, but the radiation range is the widest and the centrality is the strongest; these have characteristics such as a large population, developed economy, advanced and convenient living conditions, remarkable service systems, and extensive functional positioning. Therefore, these are the center of the regional population and economic factors. In addition, according to the core–periphery theory, the top grade central place is the core area of regional development and occupies a dominant position in the region. Other parts of the region rely on the core area, and the core area also drives these parts to achieve sustained socio-economic progress

through its development [38]. Based on the above theories, the central place with the top grade in the region is regarded as the regional core area in this study, while the others are regarded as the regional periphery area.

Within China's provincial-level administrative regions, provincial capitals and a few developed cities are the top grade central places. From the actual situation of Liaoning Province, Shenyang and Dalian meet the standard. Shenyang is located in the north–central region of Liaoning Province. It is the provincial capital of Liaoning Province, as well as the political center, economic center, cultural center, and transportation hub of Liaoning Province and Northeast China. Dalian is the largest port city in Liaoning Province and Northeast China, located at the southern end of Liaoning Province. It has a high economic status, and the GDP has long ranked first in Liaoning Province. Furthermore, the municipal district is the political, economic, cultural, and trade center of Chinese cities, encompassing the main socio-economic resources of the city, the urbanization rate is significantly higher than that in other parts, and it has a higher status in urban development; additionally, the municipal district is characterized by concentrated and continuous distribution in space, forming the main part and core area of the city [39]. Hence, the municipal districts of Shenyang and Dalian are regarded as the regional core area of Liaoning Province in this study.

In combination with the above analysis, the average Euclidean distance between the county-level administrative region where the sample peasant households are located and the regional core area of Liaoning Province was calculated using ArcGIS in this study, which was used as an indicator to reflect the spatial distance between the residence and the regional core area (SDRRC). The smaller the SDRRC, the closer the residence is to the regional core area; the larger the SDRRC, the deeper the spatial location of the residence in the hinterland area of the region.

3.2. Variable Selection and Data Source

The purpose of this study is to explore and describe the spatial pattern of FT in Liaoning Province, and the key is to analyze the relationship between FT and SDRRC. Thus, the peasant household's FT behavior is taken as the dependent variable. For peasant households, driven by their needs and interests, they can choose to transfer out the farmland to other business entities, expand their management scale by transferring in the farmland of other peasant households, or choose to maintain the current status, that is, not participate in FT. Therefore, the FT behaviors adopted by peasant households can be divided into three types: farmland transfer out (FTO), farmland transfer in (FTI), and no farmland transfer (NFT).

The core independent variable is the SDRRC, which has been described in Section 3.1. In addition, the SDRRC is also divided into two categories, SDRRC > 100 km (denoted by "1") and SDRRC $\leq$ 100 km (denoted by "0"), which are introduced into the model as categorical variables reflecting the SDRRC. A total of 100 km is a suitable distance that the population can move between two places in one day, and it can express the spatial extent of the metropolitan area [40].

Some factors are chosen as control variables. The labor age structure is indicated by the average age of adults in a peasant household. The agricultural labor scale is reflected by the number of members in a peasant household who are engaged in agricultural production locally. Family members serving as cadres ("1" = Yes, "0" = No) reflect the social status of a peasant household. The health condition is indicated by the proportion of family members suffering from diseases affecting work and life. Several studies show that farmers decide how to use farmland according to their health, which affects the FT [41,42]. The peasant household's annual consumption level to maintain the minimum living standard, representing the cost of living. Additionally, this study also controls some characteristics of the county-level administrative region where the sample peasant households are located. The terrain condition is represented by the terrain niche index. The terrain niche index combines elevation and slope into an index, which can better reflect the terrain condition

of a region. Its calculation method can be derived from Emamian et al.'s work [43]. The other is whether it belongs to the municipal district ("1" = Yes, "0" = No). The purpose is to control the effect of the distance between the county-level administrative region where the sample peasant households are located and the urban center on the FT and prevent interference with the regression results. Basic information on independent variables is shown in Table 2.

Table 2. Basic information of independent variables.

Independent Variable	Symbol	Mean	Std. Dev.
SDRRC (continuous variable)	*SDRRCco*	103.965	80.628
SDRRC (categorical variable)	*SDRRCca*	0.427	0.495
Labor age structure	*LAS*	51.175	11.035
Agricultural labor scale	*ALS*	1.529	0.940
Social status	*SS*	0.059	0.235
Health condition	*HC*	0.072	0.200
Cost of living	*CL*	2.383	1.631
Terrain condition	*TC*	0.950	0.725
Whether it belongs to the municipal district	*MD*	0.141	0.348

Note: SDRRC is the spatial distance between the residence and the regional core area.

The data required for these variables include peasant household survey data at the micro scale and geographic data at the macro scale. The peasant household survey data are from the Chinese Household Income Project 2018 (CHIP 2018). It provides more information related to farmland management, thus facilitating relevant research. Research based on CHIP has made positive contributions to the understanding of the development of Chinese society [44–46]. SRTMDEM 90M elevation data from Geospatial Data Cloud site (http://www.gscloud.cn (accessed on 10 November 2022)) are used as geographic data, which are grid data with a spatial resolution of 90 m × 90 m. Additionally, the slope data are obtained based on the processing of elevation data in ArcGIS. Considering personal privacy, the individual information about peasant households and their members is not shown in this article. Additionally, with reference to the requirements of similar datasets, the names and geographic coordinates of the county-level administrative regions where the sample peasant households are located are not publicly displayed.

3.3. Multinomial Logit Model

Peasant household's FT behavior is a qualitative factor, and there is no grade difference among various types, which is a disordered multi-classification variable. According to previous studies, the multinomial logit model is generally adopted for the regression analysis where the dependent variable is a disordered multi-classification variable [47,48].

An important step of regression analysis using the multinomial logit model is to determine the base group in all categories of dependent variables; therefore, the regression coefficients of each independent variable are relative values with reference to the base group. The dependent variable belongs to the category of NFT as the base group for the purpose of this study. Based on the above analysis, the regression equation is determined as follows:

$$\ln\left[\frac{P(y_i = j)}{P(y_i = 0)}\right] = \alpha_j + \beta_{j0} CIV_i + \sum_{k=1}^{m} \beta_{jk} X_{ki} + \varepsilon_i \quad (1)$$

where i is the code of the peasant household; j refers to the FT behavior, $j = 0$ means NFT, i.e., the base group, $j = 1$ means FTO, and $j = 2$ means FTI; $P(y_i)$ is the probability that the peasant household i chooses a certain FT behavior; CIV represents the core independent variable, which is the SDRRC; X_k is control variable, and m is the number of control variables; β represents the regression coefficient of the independent variable, and α is the constant; and

ε is the random error. In detail, the regression models reflecting FTO and FTI are as in Equations (2) and (3), respectively.

$$\ln\left[\frac{P(y_i=1)}{P(y_i=0)}\right] = \alpha_1 + \beta_{10}CIV_i + \sum_{k=1}^{m}\beta_{1k}X_{ki} + \varepsilon_i \quad (2)$$

$$\ln\left[\frac{P(y_i=2)}{P(y_i=0)}\right] = \alpha_2 + \beta_{20}CIV_i + \sum_{k=1}^{m}\beta_{2k}X_{ki} + \varepsilon_i \quad (3)$$

An advantage of the multinomial logit model is that, based on the regression coefficient of the independent variable obtained from regression analysis, the odds ratio of the peasant household choosing certain FT behavior relative to the base group can be calculated, which has more practical significance. The calculation method of odds ratio is shown in Equation (4), as follows:

$$OR_{ji} = \frac{P(y_i=j)}{P(y_i=0)} = \exp\left(\alpha_j + \beta_{j0}CIV_i + \sum_{k=1}^{m}\beta_{jk}X_{ki} + \varepsilon_i\right) \quad (4)$$

With other factors held constant, only the effect of change in the core independent variable *CIV* on *OR* is considered. When a unit changes in *CIV* (i.e., $\Delta CIV = 1$), it can be represented as follows:

$$OR'_{ji} = \exp\left[\alpha_j + \beta_{j0}(CIV_i + 1) + \sum_{k=1}^{m}\beta_{jk}X_{ki} + \varepsilon_i\right] = OR_{ji}\cdot\exp(\beta_{j0}) \quad (5)$$

For $\exp(\beta_{j0})$, if $\beta_{j0} > 0$, then $\exp(\beta_{j0}) > 1$; if $\beta_{j0} < 0$, then $0 < \exp(\beta_{j0}) < 1$; if $\beta_{j0} = 0$, then $\exp(\beta_{j0}) = 1$. Further analysis shows the following:

$$\frac{OR'_{ji} - OR_{ji}}{OR_{ji}} = \exp(\beta_{j0}) - 1 = \{[\exp(\beta_{j0}) - 1] \times 100\}\% \quad (6)$$

Equation (6) means that other factors are constant; when $\Delta CIV = 1$, the odds ratio will increase $\{[\exp(\beta_{j0}) - 1] \times 100\}\%$ relative to the base group.

Then, we designed the flowchart of this study to visualize the analysis process about the spatial pattern of farmland transfer in Liaoning Province, as shown in Figure 2.

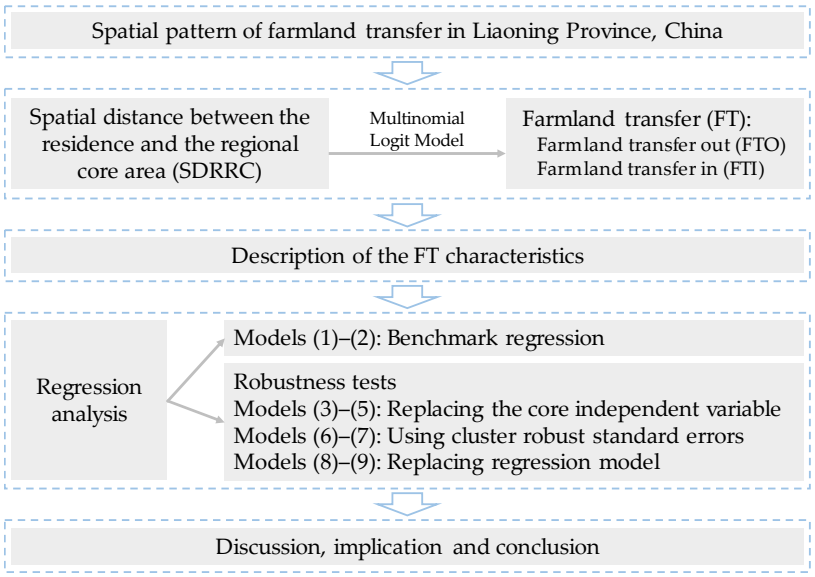

Figure 2. The analysis flowchart of this study.

4. Results

4.1. Differences in FT under Different SDRRC

As shown in Figure 3, overall, 39.7% of the sample peasant households in Liaoning Province participated in FT, including 19.7% in FTO and 20.0% in FTI. The proportion of participation in FTO and FTI is similar among peasant households.

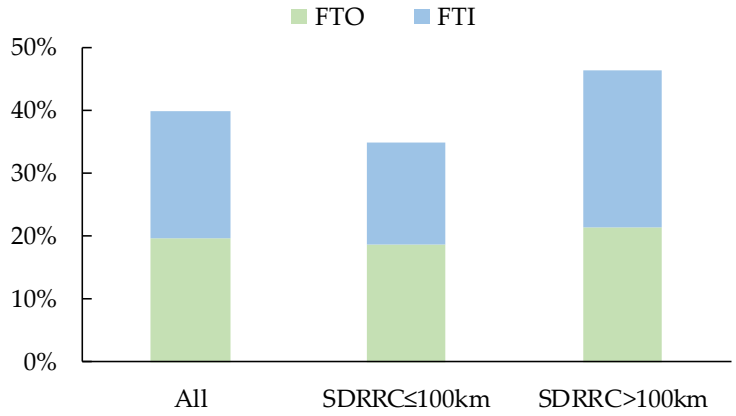

Figure 3. Proportion of peasant households that participated in FT.

Then, the differences in the proportion of peasant households that participated in FT were explored between the two categories with SDRRC $\leq$ 100 km and SDRRC > 100 km. The results show that the proportion of peasant households that participated in FT is 34.8% in regions with SDRRC $\leq$ 100 km, and 46.2% in regions with SDRRC > 100 km. This implies that a higher percentage of peasant households participated in FT in regions located far from the regional core area. In terms of the proportion of FTO and FTI, the regions with SDRRC > 100 km are similarly higher than those with SDRRC $\leq$ 100 km. The proportion of peasant households that participated in FTO is 18.6% in regions with SDRRC $\leq$ 100 km and 21.3% in regions with SDRRC > 100 km. The proportion of peasant households that participated in FTI is 16.3% in regions with SDRRC $\leq$ 100 km and 24.9% in regions with SDRRC > 100 km. Both FTO and FTI are more common in regions far from the regional core area.

4.2. Regression Analysis

Section 4.1 revealed that the proportion of participation in FT among the sample peasant households is higher in regions far from the regional core area. Nevertheless, the quantitative relationship between FT and SDRRC cannot be accurately understood and analyzed using basic statistical methods because the FT behavior of peasant households is also affected by other factors. In this section, regression analysis was used to control for the interference of other factors, which was implemented using Stata 16.0.

The results of the benchmark regression are shown in Table 3. In model (1), the SDRRC expressed by the continuous variable is used as the core independent variable. It can be seen that the SDRRC has a highly significant effect on peasant households' FT behavior under the premise of controlling other influencing factors. The regression coefficients are positive in both FTO and FTI groups and significant at the 1% level of significance. It means that there are significant differences in peasant households' FT behavior under different SDRRC. Specifically, compared with NFT, if the SDRRC is smaller, the possibility of FTO or FTI is lower; if the SDRRC is larger, the possibility of FTO or FTI is higher. On the basis of the regression coefficients, the effect on the odds ratio of FT is calculated according to Equation (6) when there is a unit change in SDRRC. The results show that for each 1 km increase in SDRRC, the odds ratios of FTO and FTI increase by an average of 0.9% and 0.6%, respectively. In model (2), the core independent variable is the SDRRC represented by the categorical variable. The results show that the regression coefficients of the core

independent variable are positive and significant at the 1% significance level. This indicates that the possibility of FTO or FTI is significantly higher in regions with SDRRC > 100 km than in regions with SDRRC $\leq$ 100 km, which is consistent with the findings in Section 4.1. Further calculations show that in regions with SDRRC > 100 km, the odds ratio of FTO is on average 290.3% higher than in regions with SDRRC $\leq$ 100 km, and the odds ratio of FTI is on average 154.3% higher than in regions with SDRRC $\leq$ 100 km. Both models (1) and (2) reveal that the FT in Liaoning Province has a significant "core-periphery" spatial pattern, which is manifested by the odds ratio of FT rising with the increase in SDRRC.

Table 3. Results of the benchmark regression.

Variable	Model (1)		Model (2)	
	Coef.	Std. Err.	Coef.	Std. Err.
FTO				
SDRRCco	0.009 ***	0.003		
SDRRCca			1.362 ***	0.405
LAS	0.016	0.015	0.012	0.015
ALS	−2.062 ***	0.252	−2.100 ***	0.268
SS	−0.527	0.636	−0.484	0.616
HC	−0.917	0.788	−0.950	0.756
CL	0.087	0.165	0.048	0.171
TC	−1.599 ***	0.401	−1.283 ***	0.300
MD	−0.349	0.502	−0.380	0.487
FTI				
SDRRCco	0.006 ***	0.002		
SDRRCca			0.933 ***	0.294
LAS	−0.046 ***	0.014	−0.047 ***	0.014
ALS	0.431 ***	0.152	0.419 ***	0.150
SS	0.500	0.578	0.535	0.592
HC	−2.081 *	1.102	−1.963 *	1.062
CL	−0.170 *	0.088	−0.187 **	0.091
TC	−0.897 ***	0.265	−0.691 ***	0.205
MD	0.449	0.426	0.346	0.420
McFadden's R^2	0.245		0.251	
Log likelihood	−329.497		−327.077	

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. FTO is farmland transfer out. FTI is farmland transfer in.

The significance of the control variables' regression coefficients is the same in models (1) and (2). It can be seen that there are differences in the effects of control variables on FT in the two types of FTO and FTI. Labor age structure, health condition, and cost of living have negative effects on FTI, but their effects on FTO are not significant. This means that when other conditions are constant, peasant households with a higher average age, poorer health conditions, and higher living costs are less inclined towards FTI. The effect of the agricultural labor scale is positive in FTI and negative in FTO, and the regression coefficients are all significant at the 1% level of significance. This indicates that the more members there are engaged in agricultural production in the peasant household, the more inclined they are towards FTI; conversely, the more they prefer FTO. Terrain conditions also significantly affect peasant households' FT behavior, with the regression coefficients of both FTO and FTI being negative and significant at the 1% level of significance. That is, the larger the terrain niche index, the lower the probability of FT. This means that in regions with poor terrain conditions such as high altitudes and large slopes, the FT is even more difficult. The regression coefficients of social status and whether it belongs to the municipal district are not significant in both groups, indicating that these factors have no statistically significant effect on peasant households' FT behavior.

4.3. Robustness Tests

The results in Section 4.2 show that the SDRRC has a significant effect on peasant households' FT behavior. The odds ratios of FTO and FTI rise with the increase in SDRRC. However, the robustness of the relationship needs further discussion. Thus, we used several methods to test the robustness in Stata 16.0. In models (3), (4) and (5), we replaced the core independent variables. Models (6) and (7) used cluster robust standard errors. The multinomial probit model was used for models (8) and (9). All models for robustness tests have the same control variables as models (1) and (2).

4.3.1. Replacing the Core Independent Variable

We used other variables that can represent the SDRRC as core independent variables. Similar to Section 4.2, both continuous and categorical variables are used for analysis. The core independent variables of models (3) and (4) are continuous variables, and the core independent variable of model (5) is categorical. The regression results are presented in Table 4.

Table 4. Regression results of the robustness test: replacing the core independent variable.

Variable	Model (3)		Model (4)		Model (5)	
	Coef.	**Std. Err.**	**Coef.**	**Std. Err.**	**Coef.**	**Std. Err.**
FTO						
DCU	0.009 ***	0.003				
TD			0.006 ***	0.002		
SL					−1.115 **	0.498
LAS	0.017	0.015	0.016	0.015	0.017	0.015
ALS	−2.053 ***	0.250	−2.073 ***	0.257	−1.991 ***	0.236
SS	−0.518	0.638	−0.485	0.634	−0.464	0.614
HC	−0.925	0.789	−0.964	0.771	−0.821	0.805
CL	0.085	0.163	0.070	0.166	0.078	0.150
TC	−1.563 ***	0.389	−1.374 ***	0.327	−1.322 ***	0.307
MD	−0.304	0.511	−0.138	0.522	−0.820 *	0.472
FTI						
DCU	0.006 ***	0.002				
TD			0.004 ***	0.001		
SL					−0.955 **	0.405
LAS	−0.045 ***	0.014	−0.046 ***	0.014	−0.043 ***	0.014
ALS	0.433 ***	0.152	0.426 ***	0.150	0.450 ***	0.146
SS	0.497	0.578	0.507	0.581	0.437	0.573
HC	−2.062 *	1.097	−1.971 *	1.070	−2.009 *	1.108
CL	−0.169 *	0.088	−0.176 **	0.089	−0.169 *	0.087
TC	−0.883 ***	0.261	−0.721 ***	0.216	−0.791 ***	0.223
MD	0.495	0.431	0.550	0.438	−0.005	0.399
McFadden's R^2	0.245		0.247		0.235	
Log likelihood	−329.733		−328.621		−333.777	

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

First, considering that the administrative boundaries of cities may not match the actual boundaries, this study used the parts of the municipal districts of Shenyang and Dalian that fall within the urban boundaries as the regional core area of Liaoning Province based on the global urban boundaries data developed by Li et al. [49]. The average Euclidean distance between the county-level administrative region where the sample peasant households are located and the regional core area (*DCU*) was calculated using ArcGIS, which was used as an alternative variable for the core independent variable. It can be seen from model (3) that the sign and significance of the regression coefficients of *DCU* are the same as those for the results of model (1).

Both Euclidean distance and traffic distance can reflect the spatial proximity of regions. The smaller the traffic distance, the lower the time and traffic costs for traveling between two places; thus, the closer the spatial connection is. Therefore, the traffic distance to the regional core area can also be used as the core independent variable. We obtained the shortest road distances between the government of the county-level administrative region where the sample peasant households are located and the governments of Liaoning Province, Shenyang, and Dalian through Baidu Map (https://map.baidu.com (accessed on 10 November 2022)) to indicate the traffic distance to the regional core area (*TD*). As shown in model (4), the regression results indicate that the probability of FTO and FTI rises significantly with the increase in traffic distance. Further calculation shows that for each 1 km increase in traffic distance, the odds ratios of FTO and FTI increase by an average of 0.6% and 0.4%, respectively. It is noteworthy that the regression coefficients of the core independent variable in model (4) and the calculated odds ratios are relatively small compared with model (1). The reason is that the traffic distance between two places is generally larger than the Euclidean distance; therefore, it has a relatively lower marginal effect on the dependent variable.

Finally, major regional development strategies with the regional core area as the main focus were used as a categorical variable to reflect the core independent variable. Shenyang Modern Metropolitan Area with Shenyang as the core and Liaoning Coastal Economic Belt with Dalian as the core are major regional development strategies promoted and implemented by Liaoning Province in recent years; thus, the regions associated with them are generally more adjacent to the regional core area of Liaoning Province. Therefore, whether the county-level administrative region where the sample peasant households are located is included in Shenyang Modern Metropolitan Area or Liaoning Coastal Economic Belt (*SL*) is used to indicate the core independent variable ("1" = Yes, "0" = No). Model (5) shows that the regression coefficients of *SL* are negative and significant at the 5% level of significance. It indicates that the odds ratios of FTO and FTI are significantly low in regions located in Shenyang Modern Metropolitan Area or Liaoning Coastal Economic Belt. The results are essentially the same as those of other regression models.

4.3.2. Using Cluster Robust Standard Errors

The spatial scale of each variable in the regression model constructed in this study is inconsistent. For example, the dependent variable is from the perspective to the peasant households, while the core independent variable is from the perspective of the county-level administrative region. The behavior of individuals belonging to the same region is often correlated due to various reasons such as history, geography, and social development. Hence, cluster robust standard errors at the county-level administrative region level are used in the regression results in models (6) and (7). This means that models (6) and (7) assume that the sample peasant households within the same county-level administrative region are interrelated, while the sample peasant households in different county-level administrative regions are not. From Table 5, it can be found that using cluster robust standard errors at the county-level administrative region level does not affect the significance level of the core independent variables.

4.3.3. Replacing Regression Model

Since the multinomial probit model is also a common model suitable for regression analysis where the dependent variable is the disordered multi-classification variable, it is used instead of the multinomial logit model for the exploration. As shown in Table 5, the core independent variables are still significant at the 1% significance level in models (8) and (9), and the sign of the coefficients has not changed. This indicates that replacing the regression model does not have a significant impact on the regression results.

In summary, the application of several methods for robustness tests does not change the main results of this study. Hence, the results of this study can be considered robust. It is further confirmed that the "core-periphery" spatial pattern of FT exists in Liaoning

Province, and the odds ratio of FT gradually increases from the regional core area to the periphery area.

Table 5. Regression results of the robustness tests: using cluster robust standard errors and replacing the regression model.

Variable	Model (6)		Model (7)		Model (8)		Model (9)	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
FTO								
SDRRCco	0.009 ***	0.002			0.007 ***	0.002		
SDRRCca			1.362 ***	0.192			0.966 ***	0.281
LAS	0.016	0.016	0.012	0.016	0.012	0.011	0.009	0.011
ALS	−2.062 ***	0.359	−2.100 ***	0.376	−1.493 ***	0.167	−1.499 ***	0.173
SS	−0.527	0.616	−0.484	0.600	−0.417	0.471	−0.365	0.466
HC	−0.917	0.593	−0.950	0.634	−0.733	0.564	−0.718	0.551
CL	0.087	0.143	0.048	0.152	0.064	0.100	0.037	0.103
TC	−1.599 ***	0.261	−1.283 ***	0.198	−1.171 ***	0.277	−0.933 ***	0.210
MD	−0.349	0.446	−0.380	0.518	−0.163	0.381	−0.184	0.368
FTI								
SDRRCco	0.006 ***	0.001			0.005 ***	0.002		
SDRRCca			0.933 ***	0.250			0.793 ***	0.228
LAS	−0.046 ***	0.010	−0.047 ***	0.011	−0.034 ***	0.011	−0.036 ***	0.011
ALS	0.431 ***	0.148	0.419 ***	0.146	0.298 **	0.117	0.294 **	0.115
SS	0.500	0.434	0.535	0.423	0.421	0.446	0.466	0.452
HC	−2.081 **	0.940	−1.963 **	0.842	−1.327 *	0.758	−1.299 *	0.727
CL	−0.170	0.107	−0.187 *	0.113	−0.139 **	0.068	−0.150 **	0.070
TC	−0.897 ***	0.154	−0.691 ***	0.130	−0.738 ***	0.194	−0.587 ***	0.159
MD	0.449	0.611	0.346	0.634	0.349	0.329	0.293	0.324
McFadden's R^2	0.245		0.251		—		—	
Log likelihood	−329.497		−327.077		−330.038		−327.664	

Note: ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. Cluster robust standard errors at the county-level administrative region level are used in models (6) and (7).

5. Discussion and Implication

According to the results in Section 4, it can be seen that regions near the regional core area participate less in FT despite having more convenient socio-economic resources and more access to products and services provided by the regional core area. We analyzed and discussed the following aspects, and determined their implications.

5.1. Reasons for Forming the "Core-Periphery" Spatial Pattern of FT in Liaoning Province

The spatial pattern of FT in a region is essentially influenced by the development of urbanization. For developing countries, urbanization is imperfect in many regions [50,51]. Based on relevant research and China's reality, this paper summarizes some characteristics of imperfect urbanization [51–53]. First, the proportion of urban population has increased, but the support capacity is insufficient. Second, cities of different sizes have an uneven development. Third, the ability of cities to drive rural development is weak. At present, the proportion of the population with urban household registration in Liaoning Province is far lower than the urbanization rate; thus, many people cannot have access to urban public services. Growth is prominent in central cities, while other regions are shrinking. The rural population is rapidly declining, and the income gap between urban and rural residents is large. Therefore, the urbanization development of Liaoning Province is imperfect, which is closely related to the economic characteristics of the old industrial base. For one thing, the dual urban–rural economic structure has not been effectively addressed. Farmers need to obtain more income through non-farming employment. Moreover, farmers' non-farming employment is mainly concentrated in central cities because the gap between cities is relatively pronounced and the socio-economic development of small cities and counties

is sluggish. For another, Liaoning Province is in the transition from secondary to tertiary industry [54]. The employment structure has changed in this process, causing part of the urban labor to be facing unemployment [55]. Liaoning Province had the highest urban unemployment rate in China during 2020 [34]. At this stage, it is necessary to give priority to the re-employment of such groups in order to alleviate social pressure. Furthermore, the tertiary industry in Liaoning Province is underdeveloped [56]. Although industrial restructuring increases employment in the tertiary industry, the stability is poor and the security mechanism is imperfect [57]. Thus, the capacity of cities to absorb rural labor is limited. Reasons for the formation of the "core-periphery" spatial pattern of FT in Liaoning Province were analyzed based on this perspective.

5.1.1. Imperfect Urbanization Leading to Widespread Concurrent Business

Peasant households' concurrent business is an inevitable phenomenon in the process of urbanization, but it is also a transitional state [58]. Despite its limited scale, the contracted farmland has a series of functions that provide subsistence for farmers [59,60]. Due to imperfect urbanization, although farmers can achieve non-farming employment, it is less stable; moreover, the relevant social resources and basic welfare guarantees are insufficient, resulting in a lack of motivation to attract farmers to completely leave their farmland, thereby reducing the willingness of FT [61,62]. It has led to the bulk of China's agricultural production and management still being dominated by small farmers [35]. On the other hand, agriculture is a less profitable industry that requires subsidies and policy support [63]. In general, most peasant households cannot rely on agricultural income alone to meet the needs of family life under the small farmers' management model, and they need to supplement it with other sources of income [64]. In addition, the seasonality of farming and increased agricultural production efficiency have also created conditions for concurrent business [58]. The combined effect of these factors makes concurrent business a reasonable choice for most of the farmers based on their interests, so the phenomenon of concurrent business among farmers is becoming increasingly common. This phenomenon is also prevalent in other developing countries [30,65].

Central cities have become the major inflow of rural labor because of their various advantages. In this case, farmers living in regions with small SDRRC can save time costs due to the shorter spatial distance. They can combine agricultural production and non-farming employment without having to give up their farmland [66]. In addition, due to the high costs of expanding agricultural production scale, they also have no intention of transferring in farmland. In regions with large SDRRC, farmers are more likely to abandon agricultural production if they engage in non-farming employment in central cities; and few opportunities for concurrent business require farmers to appropriately expand their management scale to increase their income and thus promote FT. As shown in Figure 4, among the sample peasant households that did not participate in FT, the concurrent business proportion of household members is higher in regions with SDRRC $\leq$ 100 km, which proves the rationality of the above view.

With the continuous development and improvement of urbanization, the rural population will gradually move to cities and settle down, and farmland will be transferred to new agricultural management entities; thus, the concurrent business will be decreased [4,58]. For example, the FT rate exceeds 90% in Shanghai, which has the highest level and quality of urbanization in China [35]. Peasant households near cities do not need to use farmland as a necessary livelihood because of high non-farming incomes and low risks [67]. Hence, it is conducive to promoting the non-farming transfer of surplus rural labor and accelerating FT by optimizing the quality of urbanization.

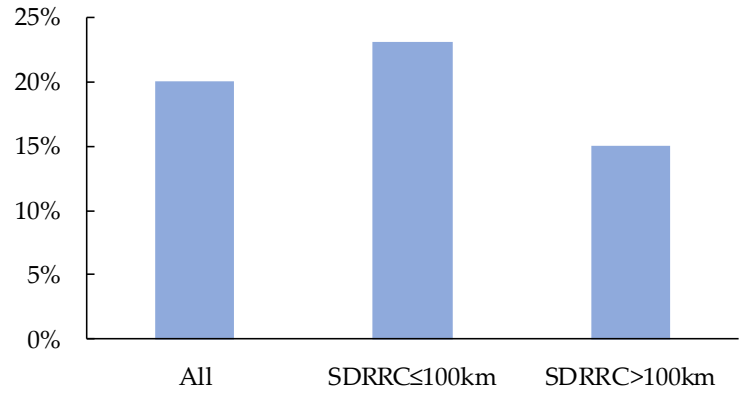

Figure 4. Proportion of concurrent business members of peasant households that did not participate in FT.

5.1.2. Imperfect Urbanization Increasing FT Fees

In the context of imperfect urbanization, farmers' participation in urban life is difficult and their expected utility is reduced [68]. Farmers who plan FTO will inevitably hope the FT fees are above the economic value of farmland to cope with the risks posed by imperfect urbanization [60]. It hinders the process of transferring farmland to peasant households in need because this group has to pay more money than expected. Spatial location affects differential rent [69]. In a region, the central place that ranked the highest grade is the largest market, and the location conditions near it are relatively superior. Therefore, farmland in the vicinity of the central place tends to have a relatively higher economic value [28,70–72]. The average FT fees under different SDRRC were calculated by selecting the sample peasant households that participated in FT. As shown in Figure 5, the average fees of both FTO and FTI decrease with the increase in SDRRC. Most of the farmland in Liaoning Province is used to grow grain; yet, the net profit from grain has been consistently low in recent years [73]. Thus, for peasant households in regions near central cities, the double squeeze of high costs and low returns weakens their willingness to expand the management scale through FTI, resulting in a lower overall FT level. Additionally, in regions far away, the FT fees are relatively low [74]. The barriers to FT are reduced and the likelihood of peasant households' participation in FT is higher.

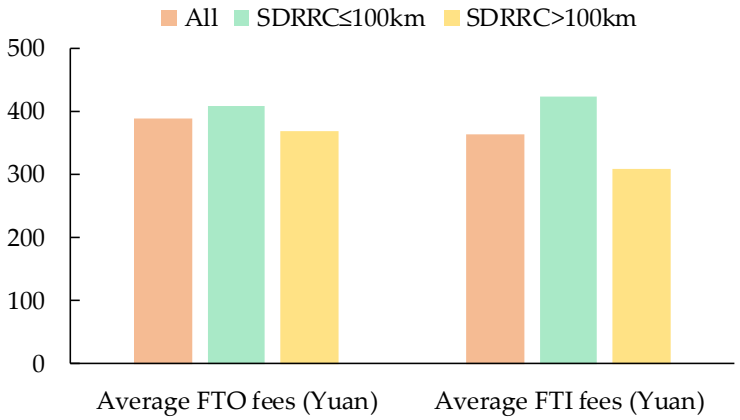

Figure 5. Average FTO and FTI fees.

It is also important to understand that although FT is more common in regions with a large SDRRC, there are some problems because of imperfect urbanization. For peasant households, their higher probability of participating in FTO is due to the distance from the central cities and not having the conditions for concurrent business. It is an indication that this behavior is more influenced by objective conditions rather than based on subjectivity.

For peasant households that participated in FTI, despite expanding their management scale, urbanization has a limited driving effect on agricultural development, and productivity and income growth are slow. The long-term stability of FT will be impacted.

In developed countries with high-quality urbanization, these problems have been better addressed. For example, in peri-urban areas of Sweden, despite the high value of land, the government leases it at lower rents and provides security of rights, thus achieving an efficient use of farmland and avoiding the decline of peri-urban agriculture [75,76]. In France, with the continuous progress of urbanization, a large number of surplus rural labor has been absorbed, material and technology have been provided for agricultural production, and various measures have been introduced so as to achieve the success of moderate agricultural scale management [77,78]. These examples can provide a reference for Liaoning Province and even China to optimize FT in the future.

5.2. Implications for Promoting FT in Liaoning Province

In recent years, the total population of Liaoning Province has shown a downward trend, the urbanization rate of the population has increased significantly, and the aging process has accelerated, resulting in a rapid decline of rural labor. Developing FT is in line with the realities of regional agricultural development. As a major grain-producing region, accelerating and optimizing FT in Liaoning Province can promote the scale and mechanization of agricultural production, innovate management models, improve the income and competitiveness of agricultural products, stabilize grain supply and ensure national food security, and realize the coordinated development of agriculture and other industries, thus developing agricultural modernization.

In fact, despite the variation in FT across different regions of Liaoning Province, the overall level is still relatively low. There is a contradiction between the important development orientation and the less advanced agricultural management methods, which is undoubtedly detrimental to the improvement of regional agriculture. In response to the reality and in light of the findings of this study, proposals are made to promote FT in Liaoning Province. First, efforts will be made to promote the urbanization of central cities in the direction of high-quality development. The status of Shenyang and Dalian as the regional core area of Liaoning Province should be enhanced and optimized, and the construction process of Shenyang Modern Metropolitan Area and Liaoning Coastal Economic Belt accelerated. Industrial restructuring and upgrading should be promoted, resource allocation and population distribution optimized, more stable non-farming employment opportunities created, and a sound social security system established, and gradually, the region should transition from population urbanization to socio-economic urbanization. Second, the urbanization of medium and small cities and counties should be accelerated. For medium and small cities and counties that are underdeveloped, it is necessary to explore urbanization models that meet regional realities in combination with their conditions and development positioning. Farmers should be encouraged to migrate to these regions. This will not only add vitality to medium and small cities and counties but also reduce the burden caused by the massive migration of farmers to central cities, which is conducive to the balanced and coordinated development of the whole region. Additionally, it can drive the development and construction of more rural areas and accelerate the realization of urban–rural integration. Third, differentiated FT subsidy standards based on location conditions should be implemented. In response to the actual situation of high FT rents and low FT rates in regions with small SDRRC, it is suggested that the government adjust the FT subsidy standards upward in such regions so as to both meet the expectations of peasant households participating in FTO and reduce the costs of peasant households participating in FTI, thereby promoting FT. Considering the importance of Liaoning Province as a major grain-producing region, additional subsidies are available for farmland that is being used for grain cultivation. Finally, new agricultural scale management models should be encouraged. According to the actual agricultural production behavior characteristics of peasant households that concurrent business and the development trend of the aging

rural population, new agricultural scale management models represented by "land trust" and "joint farming and joint planting" can be popularized. These realize agricultural scale management without changing the original contractual management relationship, give full play to the advantages of small farmers' management and socialized services, and reduce the time costs of concurrent business and the burden of the elderly.

In the process of promoting FT and moderate agricultural scale management, the mistakes made by some developed countries cannot be ignored. For example, some countries have failed to effectively drive concurrent business peasant households to exit their farmlands and the policies implemented lack coordination, resulting in a slow progress in moderate agricultural scale management and unresolved farmland fragmentation [79]. In some regions, despite governmental promotion of land lease, insufficient infrastructure investment cannot meet farmers' needs [75]. Productivity is impacted as a result. These situations should be avoided in future practice.

5.3. Prospects and Limitations

The spatial pattern of FT in a region is constantly evolving. For Liaoning Province, the "center-periphery" spatial pattern of FT is closely related to its current urbanization characteristics and socio-economic development. With the continuous optimization of urbanization in central cities, the phenomenon of peasant households' concurrent business in nearby regions will decrease; the rapid urbanization of medium and small cities and counties means that peasant households' concurrent business will gradually become popular in these regions. In the future, urbanization will be further improved, and peasant households will transition from concurrent business to professional business or non-farming employment. It can be expected that new spatial patterns of FT will be continuously evolving according to this development trend. Therefore, the issues discussed in this study will also be of value in the future.

There are some limitations to the study. With one province as a case study and limitations in data availability, we only discussed the aspect of urbanization. In fact, the spatial pattern of FT is also influenced by other factors. At the scale of farmland, differences in crop type, soil quality, water resources' availability, etc., can affect peasant households' decisions of FT. From the perspective of regional and even national scales, differences in economy, society, system, law and other factors also form diverse spatial patterns of FT. In addition, the FT in this study is the transfer of farmland management rights. There are diverse spatial patterns for other FT modes. Therefore, further research from the above aspects is worthwhile in the future. Nevertheless, our findings can provide insights into the formation of FT spatial patterns, and also have significance for facilitating agricultural modernization.

6. Conclusions

This study analyzed the spatial pattern of FT in Liaoning Province of China. We calculated the SDRRC and explored its relationship with FT. Our finding is that the FT in Liaoning Province has a significant "core-periphery" spatial pattern. FT is more prevalent in regions far from the regional core area, and the probability of peasant households' FT rises with the increase in SDRRC. We used multiple robustness tests to demonstrate the reliability of this result.

This is an interesting finding, and we further explored the reasons for forming the spatial pattern from the perspective of urbanization development. We considered that the current urbanization of Liaoning Province is imperfect. Under this background, the concurrent business of peasant households is more common, and high FT rents hinder the transaction, resulting in a low probability of FT in regions with small SDRRC. Conversely, in regions with large SDRRC, farmers are more likely to participate in FT because of fewer concurrent business opportunities and relatively low FT rents.

Achieving moderate agricultural scale management is the key to China's agricultural modernization development. Therefore, we proposed some suggestions. First, it is nec-

essary to guide the urbanization of central cities into high-quality development. Second, it is necessary to accelerate the urbanization of medium and small cities and counties, and encourage farmers to migrate to these regions. Third, differentiated standards for subsidizing FT should be implemented based on location conditions. Finally, it is necessary to advocate for new agricultural scale management models, and fully utilize the advantages of small farmers' management and socialized services.

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