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Involution Effect: Does China's Rural Land Transfer Market Still Have Efficiency?

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Abstract: Sustainable agricultural economic growth emphasizes the improvement of agricultural technical efficiency. This paper examines the impact of the rural land transfer market on agricultural technical efficiency by constructing a theoretical framework of the impact mechanism of the rural land transfer market on agricultural technical efficiency. The data of rural land transfer market in 30 provinces from 2005 to 2020 in China were used in this paper, and the stochastic frontier analysis (SFA) and Tobit model equation linkage was applied. The results showed: (1) In terms of time differences, the rural land transfer market had a significant stimulating and involution effect on agricultural technical efficiency. In 2006–2015, the rural land transfer market had a significant stimulating effect on agricultural technical efficiency, and, in 2016–2020, the rural land transfer market entered the stage of involution, and the rural land transfer market had a involution effect on agricultural technical efficiency. (2) In terms of regional differences, the stimulating effect of the rural land transfer market on agricultural technical efficiency was mainly concentrated in the main grain producing areas, and the involution effect was mainly concentrated in the non-main grain producing areas. (3) The involution effect of the rural land transfer market exceeded the stimulating effect, which made the rural land transfer market have a inhibition effect on agricultural technical efficiency from a comprehensive view of the overall trend.

Keywords: rural land transfer market; agricultural technical efficiency; stochastic frontier analysis (SFA); involution; rural land reform; China

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1. Introduction

The level of agricultural production affects the healthy development of the national economy [1]. Sustainable and stable agricultural development is the basis of healthy economic growth. Technical efficiency is a crucial index and a vital method to evaluate the quality and performance of agricultural economic growth [2,3]. Under certain technical conditions, if it is impossible to increase any output without reducing other outputs, or if it is impossible to reduce any input without increasing other inputs, the input and output are said to be technically effective [4]. From the perspective of development economics, Solow's economic growth model reveals two ways of economic growth when explaining the internal mechanism of sustained economic growth: one is to increase factor inputs, and the contribution to growth is affected by the marginal effect of factor inputs, but it is only a short-term effect; the second is to improve production efficiency, which is an increase in the marginal rate of total factor output and has a long-term effect [5]. At present, China is in a critical stage of rapid urbanization and industrial transformation, and agricultural production faces many uncertainties. Improving agricultural technical efficiency, which has a long-term effect on agricultural development, is the key to ensuring the sustainable and healthy development of agriculture amid uncertainties. To achieve stable growth of agricultural technical efficiency, it is necessary to optimize the allocation of agricultural input factors.

The development of the off-farm labor market [6] and the development of outsourced agricultural services [7] have led to the emergence of a rural land transfer market. The rural land transfer is gradually moving toward marketization. Market forces dominate the allocation of agricultural land resources, and farmers voluntarily conduct transactions through the rural land transfer market, highlighting the economic value of rural land resources. Many practices under the reform of farmland property rights show that the allocation of production factors is optimized through rural land transfer [8]. Under the demand of increasing agricultural technical efficiency, the transfer rate of rural land in China increased from 4.57% in 2005 to 36.16% in 2020, making an important contribution to the stable growth of the agricultural economy in China. Therefore, the rural land transfer market has been the most concerned area in China's rural land reform. Western traditional economics holds that government and market are antagonistic. Under liberal theory, the market can repair itself and achieve the optimal allocation of resources [9], and under market failure, it often takes a long time for the market to repair itself, and government intervention can effectively and quickly solve the problem of market failure and market development. In recent years, China's rural land reform has been accelerated, and market-based reforms initially improved the efficiency of agricultural land use [10], but the growth of agricultural output, grain output, and agricultural income have all gradually slowed down (Figure 1).

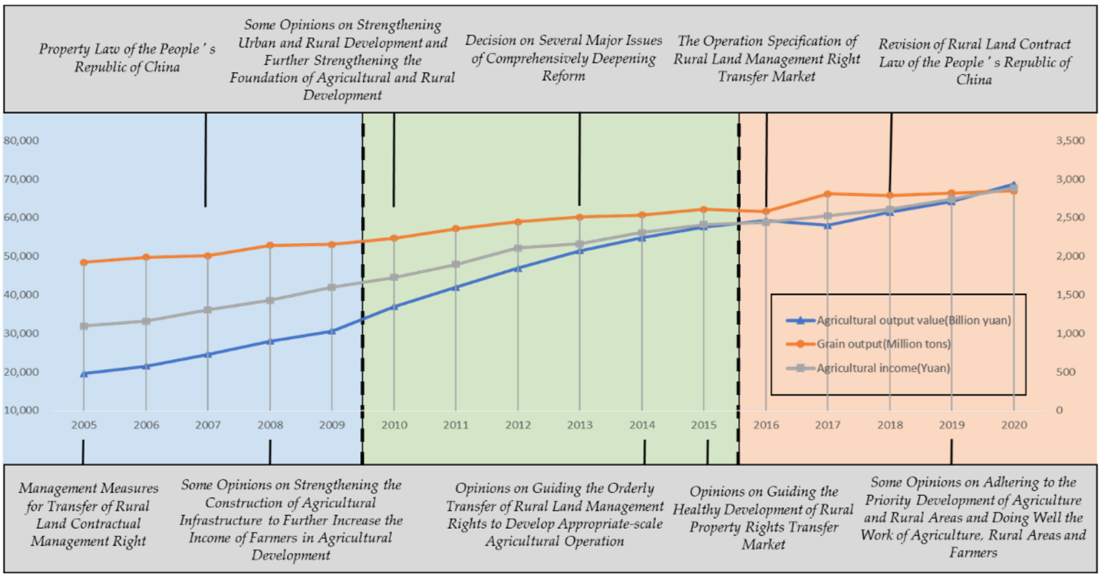


Figure 1. Change of the rural land reform system.

The remainder of this paper is organized as follows: Section 2 is Literature Review. Section 3 presents the theoretical framework of the study. Section 4 presents the data sources, variables, and methods. Section 5 includes the empirical results. Section 6 provides conclusions.

2. Literature Review

To cope with the problems of the insufficient agricultural high-quality labor force, severe land fragmentation, low production performance accompanying urbanization, and industrialization, the rural land transfer market has been actively promoted at the national and local levels. Scholars have also conducted much beneficial research and exploration from theoretical and empirical research fields. Established studies show that the reform of the land tenure confirmation system in China has improved the efficiency of the rural land transfer market [11], and promoted long-term investment in land by farmers [12]. With China's agricultural modernization reform, households' frequency of agricultural machinery use has increased and farmers are more inclined to transfer their land [13], and rural land leasing can increase agricultural labor inputs [14] and improve the labor efficiency of farmers [15]. An effective rural land transfer market can improve agricultural technical efficiency and increase farmers' income [16], produce marginal output leveling effects and transaction benefit effects [17], and improve agricultural technical efficiency [18–22]. The studies from different developing countries (Pakistan, India, Vietnam, Brazil, Mexico, etc.) show that the expansion of agricultural operation scale improves agricultural production efficiency [23–27].

Notably, some scholars have found that the rural land transfer market does not ultimately promote the improvement of agricultural technical efficiency. With the rise of land cost, the rural land transfer reduces the technical efficiency of agricultural production [8]. The process of land concentration leads to the decline of land-use efficiency [28]. The inverse relationship between agricultural operation size and agricultural production efficiency is a long-standing empirical rule in agricultural economic research [29–31]. The imperfect market of other factors, including labor, land, credit, and insurance, leads to the inverse relationship between agricultural operation scale and production efficiency [32–35]. Although rural land transfer has increased land productivity in developing countries, it does not lift households out of poverty [18,36]. Households that rent land do not benefit from land rents [37], and renting land, while increasing farm profits, increases production costs and reduces crop yields [26], which is due to market imperfections that result in total food production being much lower than its effective level [38]. Stimulating land transfer does not contribute well to structural transformation [39]; land leasing is not suitable for agricultural activities that require long-term investment [40]. In fact, because of policy promotion and the transfer effect, the rural land transfer market is involuted to some extent, and the rural land transfer market has a diminishing effect on agricultural technical efficiency [41]. The expansion of the farmland scale exacerbates the effect of capital on factor mismatch [42]. The rural land transfer market has a diminishing effect on agricultural technical efficiency. Only when the transfer promotes large-scale production and operation does the improvement of agricultural technical efficiency become apparent [43]. There is no conclusive evidence on the effect of the rural land transfer market on agricultural technical efficiency, but it can be observed that different mechanisms manifest this effect in different settings.

The main innovations of this study are as follows: (1) The existing literature on the rural land transfer market involution effect is mostly at the level of theoretical analysis and less at the level of empirical analysis, and in fact there are regional differences in the rural land transfer market involution effect. In terms of research methods, most current research focuses on Data Envelope Analysis (DEA) without considering random errors, and relatively few researchers use SFA to measure technical efficiency. SFA is more practical. To gain a more comprehensive understanding of the rural land transfer market's impact on agricultural technical efficiency, this study analyzes the impact of the degree of the rural land transfer market on agricultural technical efficiency using Chinese agricultural provincial panel data from 2005 to 2020, based on a combination of the SFA model in the form of a translog production function and Tobit model. (2) This study considers the temporal and regional differences in rural land market effects on agricultural technical efficiency. Unlike previous studies that divided China into eastern, central, and western parts, this study divides the region into main grain producing and non-main grain producing areas, and found that there is an involution effect in China's rural land transfer market based on a long time span analysis. It can provide experiences for the rural land transfer markets in developing countries and help the country to provide precise policies when dealing with the phenomenon of rural land transfer market involution.

3. Theoretical Analysis and Research Hypothesis

3.1. The Stimulating Effect

The rural land transfer market aims to optimize the allocation of agricultural production factors and large-scale operation. With the development of urbanization, many farmers have moved to the cities to work, and the phenomenon of abandoned or inefficient use of land has emerged in rural areas. The optimization of factor allocation structure reduces the probability of abandonment and inefficient use of land, reduces the degree of farmland mismatch [44,45], and promotes the transfer of rural land from low-skilled farmers to high-skilled farmers, which improves the technical efficiency of agricultural production [46]. The establishment of the rural land transfer market is helpful to promote the rational transfer of agricultural land resources among agricultural operators and realize the leveling effect of marginal output and the transaction benefit effect of improving agricultural technical efficiency. Since different households have different resource endowment structures, some farmers have higher production efficiency due to their higher planting techniques, and rural land will be concentrated to these farmers who have advantages in agricultural production techniques. The opening of the rural land transfer market raises the expectation of farmers for long-term investment in farmland. Long-term investment in agricultural land includes land improvement, irrigation and drainage facilities, etc. Although these investments are usually high in one-time investment, they can generate long-term benefits, help farmers improve their ability to resist risks, and effectively increase agricultural output, thus realizing the improvement of agricultural technical efficiency.

Due to the small scale of agricultural land operations caused by the current resource endowment conditions of China's large population and small land area, the allocation of agricultural land under the family joint production responsibility system according to quality and location has led to severe fragmentation of agricultural land, which not only hinders the use of agricultural machinery and other factors of modern production but also increases the area of field ridges and ditches, resulting in the waste of agricultural land resources [24]. The rural land transfer market enables agricultural producers to adjust the scale of agricultural production, effectively integrate land, and reduce land fragmentation, thus improving agricultural technical efficiency. Although the rural land transfer market does not directly bring technological innovation, it promotes the application of new technology. According to the induced innovation theory, the rapid development of new technology will promote the relatively scarce factors in resource endowment to be replaced by relatively cheap factors [47]. The machinery technology that promotes the substitution of agricultural machinery for labor force is "labor-saving", which replaces labor with capital factors [48]. The application of new agricultural technology generally has high investment cost and strong asset specificity and has specific requirements on the scale of production and operation [49]. Due to China's unique national conditions and land system, farmers tend to operate small. Agricultural machinery is even less profitable than traditional human and animal power production based on cost considerations. With the increase in the market, farmers expand their production and operation scale, which can significantly reduce the application cost of new technology per unit of land to realize scale economy and improve agricultural technical efficiency based on guaranteeing output.

3.2. The Involution Effect

Although the optimization of factor allocation structure brought by the rural land transfer market has a specific positive effect on agricultural technical efficiency, when the rural land transfer market reaches a certain height, the phenomenon of diminishing returns to scale will arise; that is, the effect of involution on agricultural technical efficiency will occur. The internalization of the transfer of rural land is mainly reflected in the increasing frequency and scale of market and transaction, but the decentralized pattern of agricultural operation is solidified, and agricultural technical efficiency remains unchanged or decreases [41]. There are two reasons for the involution effect: One is the market failure in rural land transfer, which leads to the misallocation of rural land in the process of transfer. Rural land transfer market activity increases gradually, but an excessively high rate of rural land transfer will cause disorder in the market and impair efficiency of agricultural land allocation. Due to the difference in the endowment effect of farmers for different transfer agents and the distortion of the price mechanism, land is more likely to be transferred to small farmers. The rural land does not transfer to farmers with higher production performance because there is an inefficient or ineffective transfer resulting in a large number of "smallholder replication" scenarios, the application of new agricultural technology is inhibited, the difficulties in the transformation of agricultural production mode affect the transfer efficiency, the smallholder economy is solidified, and the large-scale production is inefficient. The other is the ineffective substitution of capital for labor. Only when the market has matured will farmers adopt the principle of efficiency in the transfer of rural land [50]. Although agricultural operations have formed a specific scale under the increased development of the market, the process of land integration requires a large number of capital deposits. Rural land transfer does help to upgrade the agricultural structure. Many farmers choose to grow cash crops after rural land transfer, but cash crops are actually far more labor-intensive than food crops and are not highly mechanized. Farmers are unable to achieve an effective substitution of capital for labor or continue to increase labor, and capital input costs are too high, generating technical inhibition. Unable to generate more profits from agricultural production, farmers lack the enthusiasm to invest, small farmers cannot transform the land, the allocation efficiency of production factors is reduced, and agricultural technical efficiency cannot be improved. The imperfection of the factor market means that farmers who conduct rural land transfer are faced with different factor prices and make different decisions on the allocation of resource factors. The blind development of the rural land transfer market is beyond the ability of agricultural operators, which will lead to the decline of technical efficiency.

Hypothesis 1. *As the development of the rural land transfer market deepens, the stimulating effect on agricultural technical efficiency may have a decreasing trend, and the rural land transfer market may have the involution effect.*

3.3. Regional Differences

The rural land transfer market on agricultural technical efficiency requires good regional conditions. The ultimate purpose of rural land transfer is to rely on scale operation to increase production profit, and this increase in profit mainly occurs in areas with larger farm areas, that are more market-oriented with greater ability to purchase agricultural machinery and invest in agricultural infrastructure, and most importantly, due to the relatively flat terrain, with greater technical abilities. The main grain producing areas meet this characteristic, and the higher use of agricultural machinery in grain producing than in nongrain producing areas means that more technical inputs can be available, leading to more efficient farming techniques. There is also a large surplus labor force in the main grain producing regions, and the rural land transfer market has made farmers shift to nonfarm industries, reducing labor-intensive agriculture and shifting to capital-based agriculture, further improving agricultural technical efficiency. Non-main grain producing areas are mainly located in some developed provinces in the east and some economically backward provinces in the west, where agriculture is mainly based on cash crop or livestock development, farms are much smaller, farmers focus on subsistence products or horticultural products, and agricultural machinery is not used efficiently, especially in some areas with altitude or slope restrictions. The degree of rural land transfer market development has not allowed farm concentration beyond the limits of self-sufficiency, often accompanied by off-farm employment and abandonment of land, which occurs mainly in the smallest and marginal areas. Since the rural land transfer market is still not well developed, the market for rural land transfer is a "humane" market, which causes some farmland transferees to be forced to transfer their land, which results in two phenomena: first, the transfer of farmland does not occur in a concentrated and contiguous manner, and the pattern of decentralized agricultural operations is solidified, so that scale efficiency is not achieved; second, the farmers' interest in the transferred farmland is not as high as it should be. The subjective use of transferred farmland by farmers will reduce the average capital input per unit of land and make it difficult to achieve higher utilization of agricultural machinery in the production of cash crops, which means that cash crops require more labor than grain crops and becomes a labor-intensive form of agriculture. The increase in technical efficiency in agriculture is brought about more by the input of the capital factor than the labor factor. Agricultural policies in non-main grain producing regions do not primarily target grain production, which leaves more deficiencies in policy support and market support, which likewise generates more market imperfections and failures and further reduces agricultural technical efficiency (Figure 2).

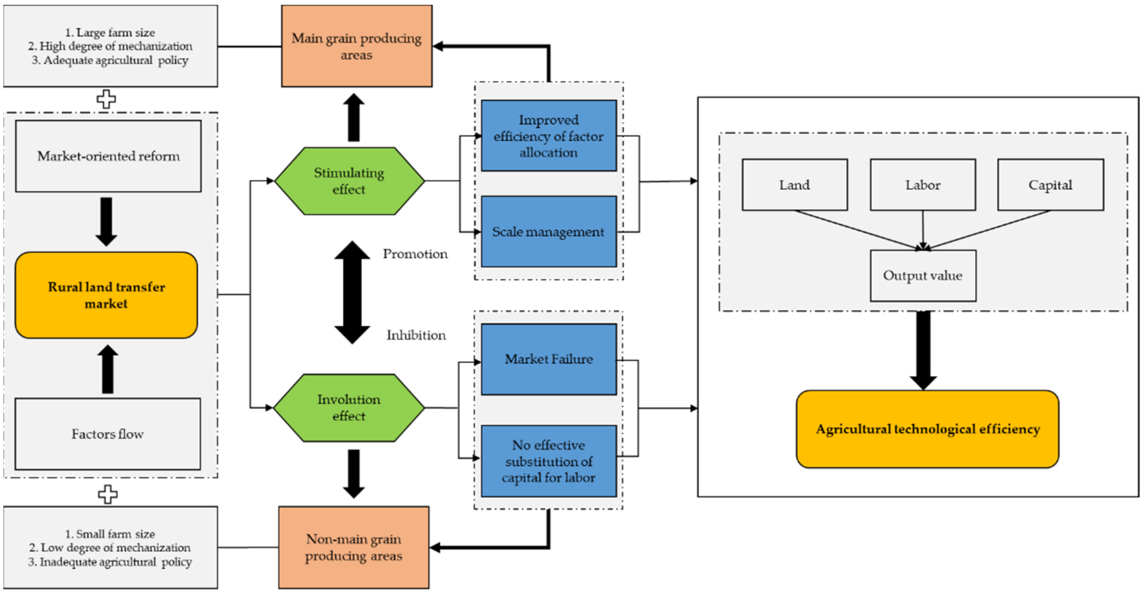


Figure 2. Theoretical framework.

Hypothesis 2. *The stimulating effect of the rural land transfer market occurs mainly in main grain producing areas, while the involution effect of the rural land transfer market occurs mainly in non-main grain producing areas.*

4. Data Description and Model Construction

4.1. Data

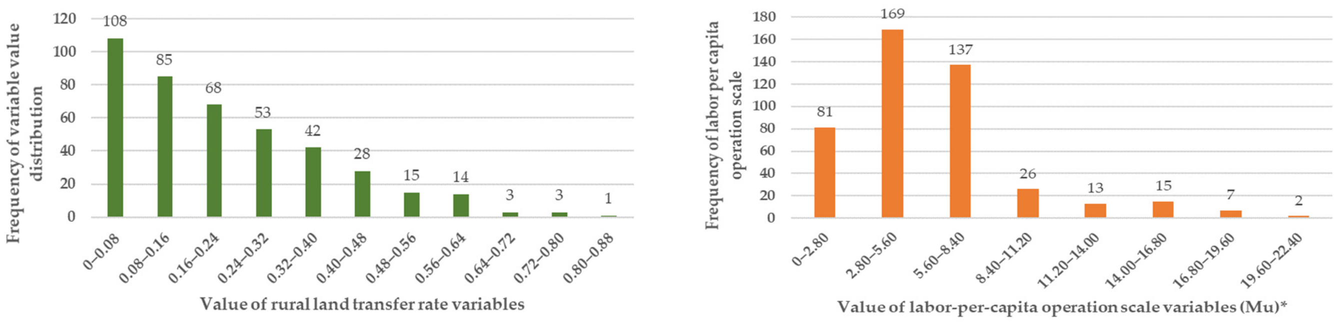
This study took the provincial administrative divisions of China as the data collection objects. Considering the availability of data, Hong Kong, Macao, Taiwan, and Tibet were not included in the empirical study. The data required for the variables are obtained from "China Statistical Yearbook", "China's rural management statistical yearbook", "China's rural policy and reform the statistical yearbook", statistical yearbook of provinces and cities, etc. Panel data related to agricultural technical efficiency and the rural land transfer market in 30 provinces of China were collected from 2005 to 2020. The data selected for the study are macro-panel data for 30 provinces, avoiding the sampling bias arising from the selection of micro-data, and can better illustrate the impact of the rural land transfer market on agricultural production efficiency. In addition, the empirical analysis includes separate regressions for China's main grain producing areas and non-main grain producing areas, and a total of 13 provinces in China have been designated as main grain producing areas (Figure 3). The main food production area is an exclusive economic zone with geographical, soil, climatic, and technological conditions suitable for growing food crops and with certain economic advantages.

Figure 3. Data areas.

4.2. Variables

In this study, agricultural output value was selected to represent output, and crop sown area was used to represent land factor input. The number of employees in the primary industry was selected to represent labor factor input. Agricultural capital stock and intermediate input of capital goods were, respectively, represented by the total power of agricultural machinery and the amount of fertilizer application. The effective irrigated area represented the irrigation input in agricultural production, and agricultural technical efficiency was calculated as the explained variable. To reduce the calculation error caused by the price index increase, the agricultural output value over the years was converted to a comparable price in 2005.

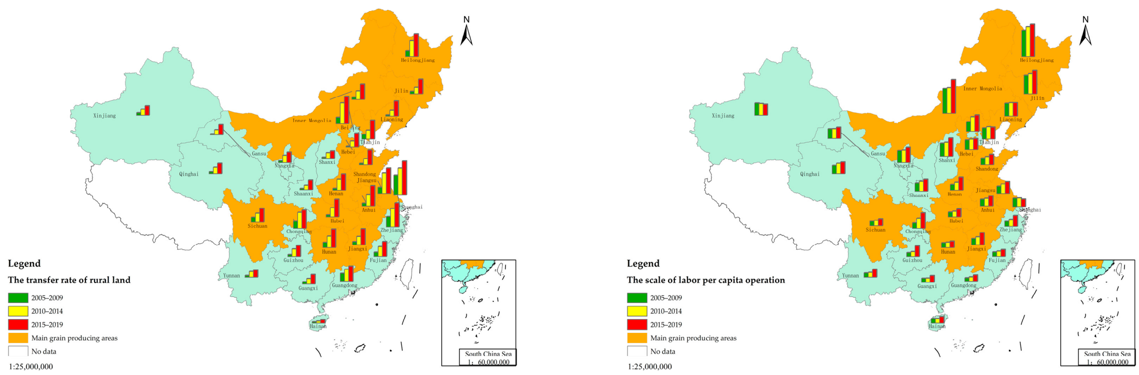
The core explanatory variable was the rural land transfer market. The ultimate goal of the rural land transfer market was to realize the optimization of factor allocation structure and large-scale operation. The transfer rate of rural land and labor-per-capita operation scale can directly represent these two purposes. Therefore, in this study, the transfer rate of rural land and the labor-per-capita operation scale were selected as the proxy variables of the rural land transfer market. The transfer rate of rural land was obtained by dividing the total area of the family-contracted farmland by the area of the family-contracted farmland, and the scale of labor-per-capita operation was obtained by dividing the area of the family-contracted farmland by the number of primary industry employees. The frequency histogram of the rural land transfer rate is shown in Figure 4a, and the frequency of the rural land transfer rate variable is distributed mostly in the range of 0–0.08. Then, the frequency decreases gradually as the rural land transfer rate increases, and the frequency histogram of labor-per-capita operation scale is shown in Figure 4b, and the frequency of labor-per-capita operation scale is concentrated in the range of 0–8.40 mu. From the perspective of labor-per-capita operation scale, China's agriculture is still in the mode of small-farmer operation. In general, China's rural land transfer market is still under development.



(**a**) (**b**)

Figure 4. Frequency diagram of the distribution: (**a**) the value of rural land transfer rate; (**b**) the value of labor-per-capita operation scale; * 1 Mu = 1/15 Ha.

The development of China's rural land transfer market has gone through a rapid process, and the spatial distribution of rural land transfer rates has also changed significantly (Figure 5a). In 2005–2009, the provinces with a higher rural land transfer rate were Shanghai, Zhejiang, and Guangdong provinces, and in 2010–2014, the provinces with a higher rural land transfer rate were Shanghai, Beijing, Jiangsu, Zhejiang, Chongqing, and Heilongjiang. In terms of national distribution, the differences between the north and south of China were obvious, and the rural land transfer rate in the southern part of China was generally higher than that in the northern part. In 2015–2019, the provinces with a higher rate of rural land transfer were mainly Shanghai, Beijing, Jiangsu, Zhejiang, and Heilongjiang. In terms of national distribution, the differences between the east and west of China were obvious, and the rural land transfer in the eastern part of China was generally higher than that in the western part. There has also been a significant change in the labor-per-capita operation scale, a change that is gradually advancing from the north to the south of China (Figure 5b). In 2005–2009, the provinces with a high labor-per-capita operation scale were mainly concentrated in the north of China, which is also related to the natural resource endowment of the north. In 2010–2014, the expansion of the labor-per-capita operation scale had a clear tendency to spread to the south, and at this time, the scale of the labor-per-capita operation in the Yangtze River basin, Chongqing and Jiangsu, had significantly increased. In 2015–2019, the provinces with significant expansion of the labor-per-capita operation scale have broken through to the south of the Yangtze River, such as Guizhou.



(**a**) (**b**)

Figure 5. The distribution map: (**a**) the transfer rate of rural land; (**b**) the scale of labor-per-capita operation scale.

In order to more accurately measure the correlation between independent variables on dependent variables, corresponding control variables were set up. The variables of crop affected area (crop affected area/crop sown area), financial support to agriculture (financial expenditure on agriculture, forestry, and water/local general public budget expenditure), education level (number of rural population with junior high school education and above/number of population aged six and above), producer price index of the planting industry (with 2005 as the base period), and grain sown area (grain sown area/crop sown area) were used as control variables. The variation coefficients of the research data were all less than 1, within a range of moderate variation, and were relatively stable in terms of dispersion in time and space, as detailed in Table 1.

Table 1. Descriptive statistics of variables.

Data Classification	Variable Code	Variable Meaning	Minimum	Maximum	Mean	Std. Dev.	Variable Coefficient
Output	output	Agricultural output value (unit: CNY 100 million).	35.2115	3574.3345	943.8076	704.6391	0.7466
Input	land	Crop Sown Area (unit: 1000 Ha).	88.6000	14,910.1000	5404.854	3713.6080	0.6871
	labor	Primary industry employees (unit: ten thousand).	37.0900	3050.0000	872.2232	623.0488	0.7143
	machinery	Total power of agricultural machinery (unit: million kW).	94.0000	13,353.000	3184.9100	2846.5360	0.8938
	fertilizer	Chemical fertilizer application amount (unit: ten thousand tons).	5.5000	716.0900	186.2003	142.9647	0.7678
	irrigated	Irrigated Area (unit: 1000 Ha).	109.2430	6177.5900	2101.5850	1585.3430	0.7544
The rural land transfer market	rate	The transfer rate of rural land.	0.0136	0.8734	0.2273	0.1751	0.7703
	scale	The scale of labor-per-capita operation (unit: Mu). *	1.5544	20.8014	5.7913	3.5425	0.6117
Control variable	affected	The proportion of affected area of crops (affected area of crops/sown area of crops).	0	0.9356	0.2046	0.1483	0.7248
	support	The proportion of government funds supporting agriculture and rural areas (expenditure on agriculture, forestry, and water conservancy/expenditure in local general public budgets).	0.0213	0.1897	0.1048	0.0332	0.3168
	education	Education level (proportion of the rural population with junior high school education or above).	0.2553	0.7939	0.5454	0.1015	0.1861
	price	The agricultural producer price index.	98.7500	235.0130	153.2206	33.0766	0.2159
	sown	The proportion of grain sown. Area (grain sown area/crop sown area).	0.3281	0.9708	0.6546	0.1302	0.1989

* 1 Mu = 1/15 Ha.

4.3. Model

In order to investigate the impact of the rural land transfer market on agricultural technical efficiency, this study used the SFA in conjunction with the Tobit model. Firstly, the stochastic frontier production function was used to calculate the intermediate variable of agricultural technical efficiency according to the panel data of agricultural input and output of each province. Then, the Tobit model was used to calculate the impact of the rural land transfer market on agricultural technical efficiency.

The basic model of the SFA model is:

$$\ln Y_{it} = \ln f(X_{nit}, \beta) + (v_{it} - \mu_{it}) \tag{1}$$

Formula (1) evaluates the agricultural technical efficiency of 30 provinces, taking each province as a decision-making unit ($i = 1, 2, \ldots, 30$). Each province has n input variables ($n = 1, 2, 3, 4, 5$), and X is a series of input variables such as sown area of crops, agricultural employees, total power of agricultural machinery, fertilizer application amount, and irrigation area. Y is the output variable of agricultural output value, and β is the parameter vector to be estimated. $\mu_{it} \sim iidN^{+}(m_{it}, \sigma_u^2)$ is a non-negative random variable, representing the efficiency loss between the combination of agricultural production factors in each province and the optimal frontier. $v_{it} \sim N(0, \sigma_v^2)$ is a random disturbance term, indicating the interference caused by uncontrollable factors such as omitted variables and statistical errors. v_{it} and μ_{it} are independent of each other.

This study adopts the SFA model proposed by Battese [51]. Using a transcendental log production function, which avoids the assumption that the Cobb–Douglas production function is technology-neutral and output elasticity is constant, making the study more general, and the specific model is set as follows:

$$\begin{aligned} \ln output_{it} &= \beta_0 + \beta_1 \ln land_{it} + \beta_2 \ln labor_{it} + \beta_3 \ln machinery_{it} + \beta_4 \ln fertilizer_{it} + \beta_5 \ln irrigated_{it} + \beta_6 \ln land_{it} \ln labor_{it} + \\ &\beta_7 \ln land_{it} \ln machinery_{it} + \beta_8 \ln land_{it} \ln fertilizer_{it} + \beta_9 \ln land_{it} \ln irrigated_{it} + \beta_{10} \ln labor_{it} \ln machinery_{it} + \\ &\beta_{11} \ln labor_{it} \ln CFA_{it} + \beta_{12} \ln labor_{it} \ln irrigated_{it} + \beta_{13} \ln machinery_{it} \ln fertilizer_{it} + \beta_{14} \ln machinery_{it} \ln irrigated_{it} + \\ &\beta_{15} \ln fertilizer_{it} \ln irrigated_{it} + \beta_{16} (\ln land_{it})^2 + \beta_{17} (\ln labor_{it})^2 + \beta_{18} (\ln machinery_{it})^2 + \beta_{19} (\ln fertilizer_{it})^2 + \\ &\beta_{20} (\ln irrigated_{it})^2 + (v_{it} - \mu_{it}) \end{aligned} \tag{2}$$

In Formula (2), $output_{it}$ represents the agricultural output value of the province i in the period t, $land_{it}$ represents the sown area of crops in the province i in the period t, $labor_{it}$ represents the number of primary industry employees in the province i in the period t, $machinery_{it}$ represents the total power of agricultural machinery in the province i in the period t, $fertilizer_{it}$ represents the fertilizer application amount in the province i in the period t, and $irrigated_{it}$ represents the irrigated area in the province i in the period t. $\mu_{it} \sim iidN^{+}(m_{it}, \sigma_u^2)$ is a non-negative random variable, and $v_{it} \sim N(0, \sigma_v^2)$ is a random interference term.

$$TE_{it} = \frac{Y_{it}}{\exp(X_{it}\beta)} = \exp(-\mu_{it}) \tag{3}$$

Since most of the agricultural technical efficiency results measured in this paper are distributed between 0 and 1, the Tobit model is selected to study the impact of the rural land transfer market on agricultural technical efficiency. For the Tobit model with fixed effects, the conditional maximum likelihood estimation cannot be performed because sufficient statistics of individual heterogeneity cannot be found. Therefore, this study only considers the Tobit model with random effects. Considering the endogeneity between the rural land transfer market and agricultural technical efficiency, the model's independent variables are treated with a one-period lag. Meanwhile, since there may be an impact between the transfer rate of rural land and the scale of labor-per-capita operation, two equations are established, respectively. The impact of the transfer rate of rural land and the scale of labor-per-capita operation on the rural land transfer market on agricultural technical efficiency were studied, respectively, and the model was constructed as follows:

$$TE_{it} = \beta_0 + \beta_1 rate_{i,t-1} + \beta_2 affected_{i,t-1} + \beta_3 \mathrm{sup}port_{i,t-1} + \beta_4 education_{i,t-1} + \beta_5 price_{i,t-1} + \beta_6 sown_{i,t-1} + \varepsilon_{i,t-1} \tag{4}$$

$$TE_{it} = \beta_0 + \beta_1 scale_{i,t-1} + \beta_2 affected_{i,t-1} + \beta_3 \mathrm{support}_{i,t-1} + \beta_4 education_{i,t-1} + \beta_5 price_{i,t-1} + \beta_6 sown_{i,t-1} + \varepsilon_{i,t-1} \tag{5}$$

In Formula (4), $rate_{i,t-1}$ represents the transfer rate of rural land in the province i in the period $t-1$, $affected_{i,t-1}$ represents the proportion of crop affected area in the province i in the period $t-1$, $\mathrm{support}_{i,t-1}$ represents the proportion of agriculture, forestry, and water expenditure in the province i in the period $t-1$, $education_{i,t-1}$ represents the proportion of the rural population with junior high school education or above in the province i in the period $t-1$, $price_{i,t-1}$ represents the producer price index of planting industry in the province i in the period $t-1$, $sown_{i,t-1}$ represents the proportion of grain sown area in the province i in the period $t-1$, and $\varepsilon_{i,t-1}$ is a random interference term. In Formula (5), $scale_{i,t-1}$ represents the scale of labor-per-capita operation in the province i in the period $t-1$, and other variables are the same as those in Formula (4).

5. Empirical Analysis Results

5.1. Agricultural Technical Efficiency

In this study, the stochastic frontier analysis software Frontier 4.1 was used to estimate the production function and technical efficiency losses (Table 2). The overall results of the model fit well. From the parameter estimation results, most of the estimates passed the *t*-test, the model had strong explanatory power, the technical inefficiency term γ passed the *t*-test at the 1% significance level, γ was 0.9490, indicating that the compound error mainly came from the management error σ_u^2, and the random error σ_v^2 only accounted for 5.1% of the compound error. The quadratic and cross terms were significant, indicating that the transcendental logarithmic form of the production function was reasonable.

Table 2. Empirical Analysis Results of the Agricultural Technical Efficiency.

	Coefficient	Standard Error	T-Value
Constant term	−2.1796 ***	0.8682	−2.5106
ln*land*	0.0827 **	0.2370	2.3487
ln*labor*	1.6926 ***	0.2053	8.2441
ln*machinery*	0.3813 *	0.2219	1.7181
ln*fertilizer*	1.2207 ***	0.3939	3.0987
ln*irrigated*	−0.4331	0.3193	−1.3563
ln*land*ln*labor*	0.0010	0.0351	0.0290
ln*land*ln*machinery*	−0.0750 ***	0.0217	−3.4572
ln*land*ln*fertilizer*	−0.1641 ***	0.0312	−5.2526
ln*land*ln*irrigated*	0.0937 *	0.0530	1.7682
ln*labor*ln*machinery*	−0.0067	0.0411	−0.1622
ln*labor*ln*fertilizer*	−0.3379 ***	0.0448	−7.5395
ln*labor*ln*irrigated*	0.2487 ***	0.0776	3.2038
ln*machinery*ln*fertilizer*	−0.1603 **	0.0698	−2.2981
ln*machinery*ln*irrigated*	0.1582 *	0.0836	1.8926
ln*fertilizer*ln*irrigated*	0.0982 **	0.0413	2.3811
$(\ln land)^2$	0.1592 ***	0.0569	2.7984
$(\ln labor)^2$	0.0053 *	0.0518	1.9016
$(\ln machinery)^2$	−0.0785 **	0.0657	−1.9947
$(\ln fertilizer)^2$	0.0536	0.0588	0.9113
$(\ln irrigated)^2$	−0.1680 *	0.0927	−1.8118
σ^2	0.0544 ***	0.0035	15.6198
γ	0.9490 ***	0.0064	148.7661
log likelihood function		607.5737	
LR test of the one-sided error		987.5726	

Notes: ***/**/* indicate significance at the 1%/5%/10% levels.

In general, the average agricultural technical efficiency for all regions in all periods did not reach 1, indicating that agricultural output has more room for growth from the production optimal frontier. The average value of agricultural production efficiency in each province of China is shown in Figure 6. The average agricultural technical efficiency in China shows a clear downward trend, and the average agricultural technical efficiency in China's main grain producing areas shows a clear upward trend, but the average agricultural technical efficiency in non-main grain producing areas shows a downward trend, which shows that the decline in China's average agricultural technical efficiency is mainly influenced by non-main grain producing areas.

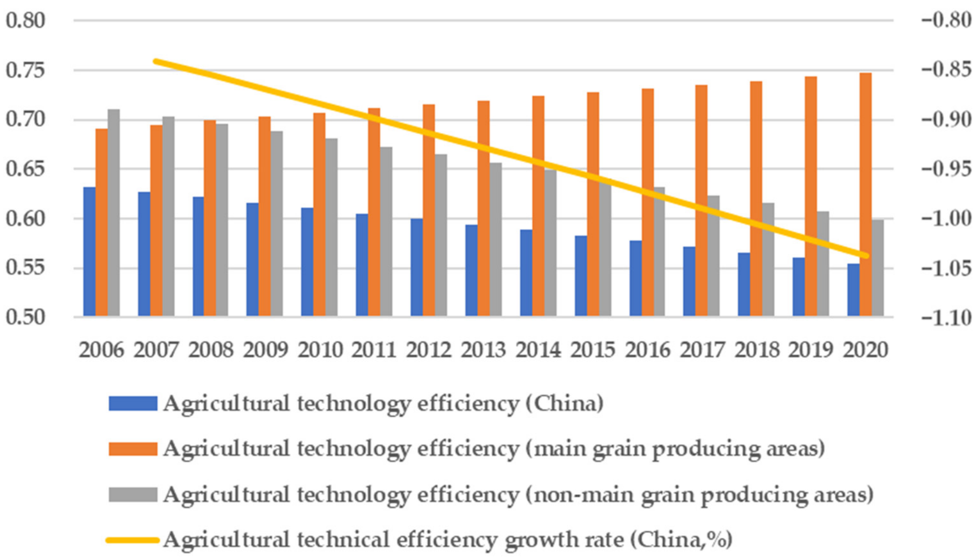


Figure 6. Average technical efficiency of agriculture by region in the period of 2006–2020.

From the national region (Figure 7), in 2006–2010, the provinces with higher agricultural technical efficiency were concentrated in Heilongjiang, Sichuan, and Hubei. In 2010–2015, the provinces with higher agricultural technical efficiency were concentrated in Qinghai, Heilongjiang, Sichuan, and Henan. In 2016–2020, the provinces with higher agricultural technical efficiency were concentrated in Guizhou, Heilongjiang, and Sichuan. In general, most of the coastal provinces do not have high agricultural production efficiency, and the areas with high agricultural production efficiency are concentrated in the main grain producing areas.

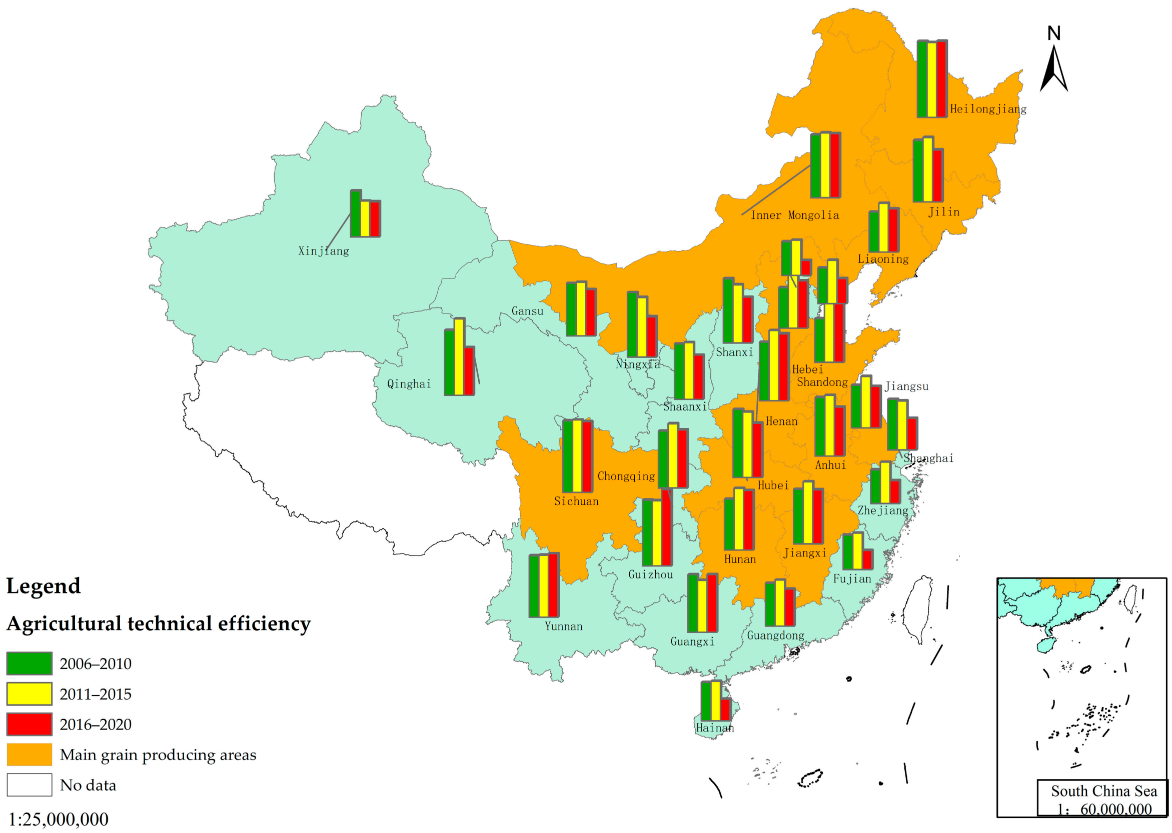


Figure 7. The distribution map of agricultural technology efficiency.

5.2. The Full-Sample Regression

Model 1 tested the effect of farmland transfer rate on agricultural technical efficiency, and Model 2 tested the effect of the scale of labor-per-capita operation on agricultural technical efficiency. Based on the data from 2006 to 2020, the model has passed the significance test and was reliable (Table 3). The transfer rate of rural land has passed the *t*-test at the level of 1%, and the coefficient was negative, indicating a decreasing trend in agricultural technical efficiency as the rural land transfer rate increased. The scale of labor-per-capita operation passed the *t*-test at the level of 1%, and the coefficient was negative, indicating that with the increase in the scale of labor-per-capita operation, agricultural technical efficiency showed a downward trend. The affected area of crops has passed the *t*-test at the level of 1%, and the coefficient was positive, indicating that the higher the proportion of the affected area of crops was, the higher the agricultural technical efficiency would be in the following year. The proportion of the rural population with junior high school education or above has passed the *t*-test at the 1% level, and the coefficient was negative, indicating that the technical efficiency of agriculture gradually decreased as the education level of the rural population increased. The possible reason was that the higher the cultural degree of the rural population was, the more people were engaged in nonagricultural industries, which reduced the agricultural technology efficiency. The agricultural producer price index has passed the *t*-test at the level of 1%, and the coefficient was negative, indicating that the higher the agricultural producer price index was, the lower the agricultural technical efficiency was. The increase in agricultural producer price index will reduce farmers' willingness to invest in capital factors and further cause the decline of agricultural technical efficiency.

Table 3. Empirical analysis results of the impact of the rural land transfer market on agricultural technical efficiency.

	2006–2020					
	Model 1			Model 2		
	Coefficient	**Standard Error**	**Z-Value**	**Coefficient**	**Standard Error**	**Z-Value**
rate	−0.0831 ***	0.0055	−14.9900	-	-	-
scale	-	-	-	−0.0053 ***	0.0005	−10.7800
affected	0.0157 ***	0.0051	3.0800	0.0186 ***	0.0055	3.3600
support	0.0303	0.0331	0.9200	0.0369	0.0401	0.9200
education	−0.0686 ***	0.0151	−4.5300	−0.1138 ***	0.0259	−4.4000
price	−0.0003 ***	0.0000	−10.7300	−0.0004 ***	0.0000	−11.4300
sown	−0.0016	0.0096	−0.1700	−0.0394	0.0133	−2.9600
_cons	0.7568 ***	0.0100	75.9600	0.7597 ***	0.0148	51.4900
Log likelihood		1249.7393			1217.6068	
Wald chi2(6)		1924.2600			1567.5100	
Prob > chi2		0.0000			0.0000	
obs		450			450	

Notes: *** indicate significance at the 1% levels.

5.3. The Time Period Analysis

To investigate whether the rural land transfer market has constantly been inhibiting agricultural technical efficiency, this study conducted a staged regression on whether the rural land transfer market has technical efficiency in models 3–8 (Table 4). The transfer rate of rural land from 2006 to 2010 and from 2011 to 2015 was significant at the level of 1%, and the coefficient was negative, indicating that the transfer rate of rural land from 2006 to 2010 and from 2011 to 2015 has improved agricultural technical efficiency. The transfer rate of rural land in 2016–2020 was significant at the level of 1%, and the coefficients were all negative, indicating that agricultural technical efficiency declined with the increase in the transfer rate of rural land in 2016–2020, and the downward trend was apparent. The scale of labor-per-capita operation in 2006–2010 was significant at the level of 1%, and the coefficient was positive, indicating that agricultural technical efficiency increased with the increase in the scale of labor-per-capita operation. However, in 2011–2015 and 2016–2020, the scale of labor-per-capita operation was significant at the level of 1%, and the coefficient was negative. The results showed that the agricultural technical efficiency decreased with the increase in labor-per-capita operation scale. In terms of periods, the rural land transfer market has improved agricultural technical efficiency in the early period. However, in recent years, the rural land transfer market has brought an involution effect to agricultural technical efficiency, resulting in a decline in technical efficiency.

Table 4. Empirical analysis results of the impact of the rural land transfer market on agricultural technical efficiency in different periods.

	2006–2010 Model 3	**2011–2015 Model 4**	**2016–2020 Model 5**	**2006–2010 Model 6**	**2011–2015 Model 7**	**2016–2020 Model 8**
rate	0.0104 *** (0.0024)	0.0168 *** (0.0020)	−0.0236 *** (0.0058)	-	-	-
scale	-	-	-	0.0053 *** (0.0003)	−0.0007 *** (0.0001)	−0.0006 *** (0.0002)
affected	−0.0015 (0.0013)	0.0025 (0.0021)	−0.0055 (0.0038)	−0.0035 (0.0025)	0.0035 * (0.0021)	−0.0050 (0.0034)
support	0.0980 *** (0.0097)	0.0176 (0.0120)	0.0795 ** (0.0369)	0.1444 *** (0.0220)	0.0658 *** (0.0169)	0.0793 *** (0.0234)
education	−0.0012 (0.0024)	−0.0108 *** (0.0034)	−0.2708 *** (0.0075)	−0.1413 *** (0.0052)	−0.0126 *** (0.0046)	−0.2514 *** (0.0061)
price	0.0001 *** (0.0000)	0.0002 *** (0.0000)	0.00001 (0.0000)	0.0003 *** (0.0000)	0.0003 *** (0.0000)	−0.00001 (0.0000)
sown	0.0251 *** (0.0019)	0.0339 *** (0.0021)	−0.0154 (0.0095)	0.0182 *** (0.0064)	0.0354 *** (0.0039)	−0.0181*** (0.0067)
_cons	0.6661 *** (0.0020)	0.7564 *** (0.0033)	0.8147 *** (0.0151)	0.6713 *** (0.0055)	0.7515 *** (0.0046)	0.8029 *** (0.0101)
Log likelihood	563.3098	543.5896	475.5012	490.8162	534.4865	486.3330
Wald chi2(6)	527.4400	690.0500	3584.0800	1649.8100	537.1300	3597.5800
Prob > chi2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
obs	150	150	150	150	150	150

Notes: Figures in parentheses denote the standard errors of the respective coefficients, while ***/**/* indicate significance at the 1%/5%/10% levels, respectively.

5.4. The Regional Analysis

To investigate the impact of the regional effect on the rural land transfer market, this study conducted regression on the main grain producing areas and non-main grain producing areas, respectively, in models 9–12 (Table 5). From the main grain producing areas, the transfer rate of rural land and the scale of labor-per-capita operation were significant at the level of 1%, and the coefficient was positive, indicating that with the increase in the transfer rate of rural land and the scale of labor operation, agricultural technical efficiency has been significantly improved. From the perspective of non-main grain producing areas, the transfer rate of rural land and the scale of labor-per-capita operation were significant at the level of 1%, and the coefficient was negative, indicating that agricultural technical efficiency decreased with the increase in the transfer rate of rural land and the scale of labor-per-capita operation. From the overall regression results, the rural land transfer market in the main grain producing areas was efficient, but the rural land transfer market in non-main grain producing areas was inefficient.

Table 5. Empirical analysis results of the impact of the rural land transfer market on agricultural technical efficiency by region.

	Main Grain Producing Areas Model 9	Non-Main Grain Producing Areas Model 10	Main Grain Producing Areas Model 11	Non-Main Grain Producing Areas Model 12
rate	0.0998 *** (0.0087)	−0.1881 *** (0.0169)	-	-
scale	-	-	0.0062 *** (0.0008)	−0.0067 *** (0.0015)
affected	−0.0070 (0.0072)	0.0148 (0.0106)	−0.0160 * (0.0082)	0.0178 (0.0126)
support	−0.1000 ** (0.0466)	0.0850 (0.0842)	−0.0958 * (0.0549)	0.0584 (0.0998)
education	0.1275 *** (0.0320)	−0.1078 ** (0.0524)	0.1582 *** (0.0369)	−0.2080 *** (0.0609)
price	0.00001 (0.0000)	−0.0003 *** (0.0000)	0.0002 *** (0.0000)	−0.0006 *** (0.0001)
sown	−0.0341 (0.0222)	−0.0134 (0.0295)	0.0152 (0.0245)	−0.1013 *** (0.0360)
_cons	0.6837 *** (0.0269)	0.8034 *** (0.0574)	0.5592 *** (0.0484)	0.9415 *** (0.0618)
Log likelihood	580.6030	587.8498	555.4321	547.2447
Wald chi2(6)	666.7500	847.6600	461.0600	537.2300
Prob > chi2	0.0000	0.0000	0.0000	0.0000
obs	195	255	195	255

Notes: Figures in parentheses denote the standard errors of the respective coefficients, while ***/**/* indicate significance at the 1%/5%/10% levels, respectively.

6. Conclusions

The rural land transfer market is crucial to improving agricultural technical efficiency and promoting agricultural economic growth. The rural land transfer market had a significant stimulating and involution effect on agricultural technical efficiency. The stimulating effect was caused by the fact that the transfer of rural land improved the efficiency of factor allocation and brought large-scale operation, while the involution effect was caused by the market failure and the no effective substitution of capital for labor. The empirical analysis results of the SFA–Tobit model also verified this theoretical analysis: (1) From the perspective of the time difference, from 2006 to 2015, the rural land transfer market had a significant stimulating effect on agricultural technical efficiency; from 2016 to 2020, the rural land transfer market entered the involution stage. (2) From the perspective of regional differences, the stimulating effect of the rural land transfer market on agricultural technical efficiency was mainly concentrated in main grain producing areas, while the involution effect was mainly concentrated in non-main grain producing areas. (3) The rural land transfer market had a inhibition effect on agricultural technical efficiency from a comprehensive view of the overall trend.

According to the conclusion, the following policies are recommended: (1) In the incentive policy for the rural land transfer market, a government-led agricultural technology innovation and extension system must be constructed, and necessary technical guidance must be provided to large farmers in the transition to prevent the problem of involution. (2) The market mechanism for rural land transfer must be improved in order to enhance the efficiency of rural land transfer, and the government must formulate different rules for the transfer of rural land according to local conditions in view of the differences in resource endowment, allocation of production factors, and degree of agricultural technology application in different regions. (3) While paying attention to the rural land transfer market, the construction of other factor markets such as labor, capital, and technology must be paid attention to. With the increasing development of the rural land transfer market, agricultural socialization services, agricultural science, and technological development are needed to complement the rural land transfer market.

There may be some limitations in this study: Macro-data for analysis and provincial administrative regions as the research unit were used in this study, and it was not enough to grasp whether the rural land transfer on agricultural technical efficiency at the micro-scale also produced the phenomenon of involution, and the next step will be to use micro-data, consider the heterogeneity among farmers and appropriate models, further measure the impact of the rural land transfer market on agricultural technical efficiency, and provide more precise suggestions for rural land transfer market policies.

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