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The Effect of Farmland Transfer on the Technical Efficiency of Farm Households in China: An Empirical Result of External Environmental Factors

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Abstract: In the context of food security, the market-oriented allocation of factors under the collective ownership system has had a profound impact on agricultural production. As a hot issue under the Household Responsibility System (HRS), the impact mechanism of farmland market transaction on agricultural production efficiency deserves discussion. Based on the stochastic frontier production function model, this paper analyzes the impact of farmland transfer on farmers' production technical efficiency under the external environmental factors by using the moderating effect and threshold effect. The study found that farmland transfer can improve farmers' technical efficiency. The market price of agricultural products and farmland transfer subsidies have a positive moderating effect on the impact of farmland transfer on technical efficiency. Furthermore, farmland transfer subsidy shows a nonlinear effect on the impact of technical efficiency.

Keywords: farmland transfer; technical efficiency; stochastic frontier analysis

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1. Introduction

In the decades from the founding of P.R. China to the reform and opening up, in front of the economic recession caused by years of war and famine, the Chinese government had formulated a series of economic policies, believing that increasing agricultural output is a top priority. For example, it introduced technology to achieve agricultural modernization. The subsequent market-oriented reform is the transitional period to the socialist market economy. On the premise of adhering to socialism and communism, the elements of a market economy could be developed. Taking the opportunity of joining the WTO, China began to integrate into the global market economy, which enabled China to gradually establish a socialist market economy. A socialist market economy is different from market socialism and a capitalist market economy. It is the specific economic system of a particular country to define the production, distribution and allocation mechanisms of its goods, services and resources. Within the structural transformation of an economy, the role of agricultural transformation is essential [1]. Therefore, China's agricultural development under the socialist market economy also has its corresponding characteristics.

Agriculture is the basic industry in China. It controls the lifeline of national economic development. In the book "*China's 40 Years of Reform and Development (1978–2018)*", Chow, G.C. introduced that the reform of Chinese agriculture initially occurred between 1978 and 1979 [2]. The practice took place when some farmers found that they could fulfil output quotas by reorganizing the commune internally. This was the reorganizing embryonic form of the "household responsibility system" (HRS), and it has the economic characteristics of private farming in a market economy. Although the annual growth rate of total agricultural output has doubled several times through reform, the HRS only deals with the production part of the market, greatly improving farmers' production incentives and productivity [3].

Besides the HRS, there were some other institutional changes involved which played a key role in improving agricultural productivity, such as giving farmers the freedom to rent land and allocate their labor in response to market signals [3]. Laborde et al. summarized the experience of agricultural transformation driven by government policies and public investments in Africa, Asia and Latin America, finding that the availability of agricultural land is one of the cores of the role of agriculture in economic transformation [1]. As a socialist country, China practices a socialist market economic system. The land property rights market system is one of the most important parts of the socialist market economic system. The establishment of the land property rights market is related to the efficiency of the allocation of land property rights and other property rights, as well as to the improvement of the socialist market economic system and the role of the market mechanism. Under the premise of a two-tier management system based on household contracting and combining unified and decentralized management, China's rural land comprises the part owned by peasant collectives and the part owned by the State but used by peasant collectives, as well as other land used for agriculture according to the law. Under this land ownership, Chinese peasants implement a contract management system for the use of rural land and adopt household contracting within rural collective economic organizations.

Although China's economy has been committed to the transition from a planned economy to a market economy since the reform and opening up in 1978, the market-oriented reform has been slow to take place under the collective ownership of China's rural land. In recent years, China's rural land system has undergone a reform from "separation of two rights" to "separation of three rights", from the division of land ownership and land contracted management rights to the separation of collective ownership, farmers' contracting rights and land management rights. Under the premise of protecting collective ownership and farmers' contracting rights, the transfer of land management rights is allowed in accordance with law, voluntarily and with compensation.

"Separation of rights" is a self-improvement of the basic rural management system. In order to ensure food security under the constraints of limited total land area, it is necessary to rationally allocate agricultural production factors. To achieve food security, in addition to curbing the trend of rapid decline of arable land, agricultural production efficiency should also be vigorously improved. Lin has argued that household responsibility system (HRS) can have a long-term, dynamic impact on agricultural productivity [4]. His research suggests that family farms have their own advantages in making more efficient use of inputs and may be a more appropriate system for agricultural growth in developing countries. In recent years, against the background of the rapid development of the market economy and accelerated urbanization, along with the transfer of rural labor, promoting farmland transfer and developing large-scale operation are considered to be important ways to realize China's agricultural modernization. The state has implemented farmland transfer policies, the rate of which in China is increasing year by year. With the land system as the core, the reform of the agricultural management system begun in the late 1970s has promoted the process of agricultural modernization in China and achieved rapid development of agriculture. Lohmar et al. analyzed the land rental transactions in rural China and estimated the impact of land rental activity on agricultural production; they found that the development of land rental market could be profitable for further increases in agricultural production in China [5]. Deininger and Jin also argued that land rental markets are more effective in reallocating land to those with lower endowments and have a bigger productivity—enhancing effect [6].

As a major way to optimize the allocation of land resources, there is an urgent need to study whether farmland transfer is conducive to improving the technical efficiency of farmers, and what are the mechanisms by which farmland transfer affects farmers' technical efficiency. Throughout the existing studies on the impact of farmland transfer on the technical efficiency of farm households, scholars have not reached a consensus.

A part of scholars believe that farmland transfer is beneficial to agricultural production efficiency. Most of them start from the perspective of factor endowment, arguing that the fine-grained, fragmented farmland or imperfect land market limits the development of agricultural production and operation scale, resulting in low efficiency in the allocation of production factors. Tenaye concluded that attributes of land factors such as farm size, land fragmentation and land quality affect technical efficiency [7]. Chamberlin and Ricker-Gilbert also found evidence that the land rental market is beneficial for efficiency gains within the smallholder sector through the mechanism which transfer land from less able to more able producers [8]. Huy and Nguyen obtained a similar conclusion in evaluating a nationally representative sample dataset in Vietnam that cropland rental transactions promote farms' technical efficiency owing to the rental market's transfer of cropland from less to more efficient producers [9]. Qiu et al. also argued that rented-in land could make farm households achieve higher farm productivity [10]. Additionally, the research provided further evidence to point out that rented-in land size is insignificant in affecting farm productivity. Britos et al. argued that the aggregate output of maize and beans is 19% below its efficient level due to land market imperfections [11].

Some studies demonstrate that farmland transfer does not contribute to agricultural production efficiency. This view holds that agricultural production efficiency is a comprehensive embodiment of the combination changes in multifactor inputs and cannot be evaluated on the basis of a single factor. For instance, Liu et al. designed the analysis from the perspective of land cost and demonstrated that land transfer would have a negative impact on technical efficiency [12].

A few scholars believe that the direction of the impact of farmland transfer on agricultural production efficiency is uncertain. Qian and Hong constructed an analytical framework for nonfarm employment, farmland transfer and agricultural production efficiency, and the study pointed out that the direction of farmland transfer has an inverse impact on agricultural production efficiency, in which transfer-in will improve agricultural production efficiency, and transfer-out will reduce it [13]. Gao and Zhang analyzed from the perspective of the differences in part-time employment of farmland transfer farmers and concluded that part-time division affects the production efficiency of farmland transfer farmers from different directions [14]. Zhang et al. used a multinomial endogenous switching treatment regression technique to investigate the impact of farmland transfer on productivity. They found that if rural households transfer-in farmland, then agricultural productivity would increase by about 55%, whereas the agricultural productivity would be lowered by 13% if rural households transfered-out farmland [15]. The existing research provides a solid theoretical basis for further research in this paper, but there are still some shortcomings, and the exact impact of farmland transfer on technical efficiency has not yet been determined.

Previous studies on farmland transfer of rural households have focused on analyzing the influencing factors of transaction willingness and behavior from the perspective of land property rights, labor transfer, intergenerational differences, regional differentials, social security and identity class differentiation. In their report, Laborde et al. also argued that price policies play a key role in agricultural transformation, and significantly expanding public investment in support of agricultural development is key for China [1]. In essence, the farmland transfer behavior of rural households is the result of a comparison between the benefits of land management and the costs of agricultural production, which is not only affected by the resource endowment and household characteristics of micro-farming households but also closely related to the market and policy environment of China's agricultural and rural development.

To this end, this paper aims to answer the following questions: How do market and policy factors affect rural households' farmland transfer decisions and thus improve their technical efficiency? For the time being, the two types of factors have not been included in the framework for analyzing the impact and exploring the mechanism of farmland transfer on technical efficiency. It is of great significance to investigate these related issues to explore the affecting mechanism of farmland transfer on technical efficiency. Given this, this article is the first attempt to focus on the impact of farmland transfer agricultural production efficiency under the external environmental factors, so as to provide a new perspective and further evidence for explaining the relationship between farmland and agricultural production.

2. Theoretical Framework

In many countries with semi-public land ownership, the farmland endowment distributed by the government may show characteristics such as inequality and low efficiency. The farmland rental market and farmland transfer are favorable ways to adjust farmland allocation and improve fairness and efficiency. The previous literature shows that farmland transfer is influenced by multiple factors such as regional economic development level, physical capital inputs, human capital inputs and quality, contract selection method, performance mechanisms, neighborhood effects, government subsidies, clan networks, stability of land rights and development of farmland transfer markets [16,17]. Based on Bangladesh facts, Rahman found that a number of socio-economic factors affect farmers' participation in the land rental market [18]. For instance, the farmers with inadequate cultivable land but higher levels of livestock, and those located in areas with developed infrastructure and fertile soils, are inclined to renting-in land. Land scarcity played a significant role in driving land rental market development in comparison with densely populated Malawi and lower-density Zambia [8]. Focused on the impact of CAP payments into land rental rates, O'Neill and Hanrahan explored the effect of coupled and decoupled subsidy payments to capitalized land rental rates in Ireland. The results show that the CAP reform did not influence the area rented by farms [19].

Due to the literature review and the problems we presented, this paper examines the effect of farmland transfer on rural households' technical efficiency from two dimensions: market factors and policy factors.

2.1. Characteristics of Smallholder Agricultural Production in China

The most basic economic unit of China's rural society has always been the peasant household, rather than the individual workers, and the main body of its agricultural production is still almost exclusively small farmers with a few acres of land per person. Under the pressure of scarce land endowment, the small farmers have more tenacious economic competitiveness than the large-scale production by employees because of their special economic and organizational structure. This kind of competition is not only the competition between peasant families and management farms but also the competition between household production combining the agriculture and handicraft industry and the competition divided into the rural agriculture and urban handicraft industry. According to neoclassical economics, agricultural production decision making involves three specific production relations of "factor–output", "factor–factor" and "output–output" [20]. A small-scale peasant economy is mainly based on family labor, lacks the systematic concept of return on capital, rarely conducts economic accounting and sometimes it is difficult to distinguish between productive and consumption activities. It can be understood from two angles: first, the land system is the ownership of small farmers, whose owners have less land resources; second, agricultural operations are small in scale, and land is leased or contracted to small farmers or family farms for cultivation. As for smallholder management, Huang believed that it is necessary to analyze smallholder management by using the profit maximization theories of Western economics and the decision making of enterprises and consumers [21,22]. The fundamental difference is that smallholder management should be understood as a unit integrating production and consumption. Smallholders are self-sufficient, and a large part of their agricultural output is directly consumed instead of entering the market, which makes smallholders only partially participate in the market.

Agricultural production is the interweaving process of natural reproduction and social reproduction. Land (cultivated land) determines the mode of agricultural production.

The agricultural production process has significant seasonal characteristics: agricultural production has been affected by weather and climate; weather and climate change have the characteristics of uncertainty and georational change. Therefore, there are no commonly used crop types, agricultural production methods or agricultural techniques. Another characteristic of agricultural production is market instability, mainly, partly unstable agricultural markets and agricultural income will also bring problems to the allocation of agricultural resources with price as the signal. Agricultural production has the characteristics of continuity and seasonality, and the cycle of agricultural production is long. The periodicity of agricultural production determines that agricultural production cannot be decomposed into a departmentalized "assembly line" type of industrial operation. The limitation of the division of labor in agricultural production has brought suffering to the main body of agricultural production and management. Supervision of agricultural labor is costly. Farm cycle farming, nonagricultural production, nonfixed planting variety selection and the use of fertilizers, pesticides, etc., are to prevent agricultural diseases and pests and maintain the soil nutrient balance. Industrial machinery is used in fixed locations and processed materials can be moved, but the dependence of crops on land makes it necessary to choose different machinery for different regions and different crop types.

2.2. Agricultural Production Technical Effficiency

At the microlevel, the research on production efficiency and its influencing factors has become one of the key fields that academia and policy makers pay attention to. In the simple case, productivity for the producer can be simply defined as a ratio of output to input. The research on production function can be traced back to the analysis of production theory by Cobb and Douglas, who simplified the production model to include only the relationship between the two input factors of labor and capital and the one output factor [23]. In the early production theory literature, Abramovitz, Solow and Stone believed that the fluctuation of production relations reflected people's "ignorance", just like the error term in the regression model [24–26]. The research perspective of scholars focuses on weakening this residual effect. Griliches detailed the method of "nerfing" [27]. Efficiency and inefficiency are a group of relative concepts in production theory. Koopmans gave the definition of technical efficiency [28], and Debreu and Farrell introduced the measurement of technical inefficiency (or technical efficiency) [29,30]. Unfortunately, the theoretical model of non-efficiency has not been strictly given in the academic circle so far [31]. In the macrolevel analysis, with the development of the growth accounting framework, Solow proposed the total production function and growth equation with the invariable characteristics of returns to scale, forming the meaning of "total factor productivity" based on the neoclassical production theory, which was attributed to technological progress [25,32]. After roughly reviewing the research methods of Schmookler [33], Leontief [34], Davis [35], Abramovitz [24], Kendrick [36], Solow [25] and others on production efficiency, Domar mainly discussed the efficiency measurement methods of Solow and Leontief [37]. In his research, he argues that efficiency is the part of output that cannot be explained by the inputs of capital, land and labor. Debreu and Koopmans also focused on resource utilization efficiency in enterprise production [28,29]. Farrell introduced efficiency measurement into the study of agricultural production for the first time [30]. He measured the technical efficiency for the first time with the method of production possibility set graph and analyzed that the technical efficiency is composed of pure technical efficiency and scale efficiency. Farrell's measurement of technical efficiency is very similar to Debreu's resource utilization coefficient [29,30]. Leibenstein defined the technical efficiency of production from the perspective of output [38].

With regard to productivity assessment, it has been recognized that agricultural productivity growth plays an important role in institutional development, leading to structural changes within the rural agricultural sector and between that sector and modern manufacturing and services [39]. International research on agricultural productivity has focused on international differences, and cross-country differences in the amount of food produced per worker are vast, as large as the differences in the entire agricultural sector between countries. Thus, large differences in agricultural labor productivity are real [40]. When the direction of technological change is labor-saving, even in open economies, increased agricultural productivity leads to a shift and reallocation of labor to the industrial sector [41]. Productivity growth in the agricultural sector is considered to be an important driver of structural transformation and economic growth in backward countries [42]. At the same time, farmers in developing countries have failed to use high levels of modern inputs and to adopt improved farming practices, thus holding back the development of agricultural productivity. Fertilizer is a frequently cited example [43]. There are several explanations for the limited modernization inputs and failure to adopt improved farming practices, delays and time-inconsistent preferences: high transaction costs due to poor infrastructure and lack of information and learning difficulties, as well as lack of formal insurance. The effect of adopting new varieties with flood tolerance on improving agricultural production efficiency comes from two aspects [44].

In the study field of production efficiency, many scholars put forward different indicators to measure production efficiency, including labor productivity, land productivity, total factor productivity, technical efficiency, scale efficiency, etc. Different indicators represent different economic significance and policy implications. It is not the productivity of a single factor of production that directly determines the level of agricultural production development but the productivity of production efficiency, which is a comprehensive index showing the achievements of production development. It not only shows that people directly use the factors of production to develop the results of production but also shows the factors of production according to scientific law and economic law of organization cooperation to achieve the maximum economic benefits of the management results. Therefore, the agricultural production efficiency studied in this paper is the technical efficiency with the specific evaluation content of farmer's production, which specifically refers to the gap between the actual output and the potential output combined with the input of land, labor, capital, technology, etc., which can comprehensively show the utilization of all input factors and their effects.

2.3. Market Factor

From the perspective of the supply side of agricultural production, the external environment will have an important impact on farmland transfer behavior and production and operation mode through the cost–benefit mechanism. China's agriculture products' prices have gone through a substantial increase in the past and will continue to rise in the future as agricultural costs and residents' incomes increase and consumption structures changes. Rising agricultural prices raise the marginal return on land, thereby increasing the demand for households to expand the scale of land management [45]. With rising agricultural labor costs, increasing residents' incomes and changing consumption structures, agricultural products prices will continue to rise in the long term. In the process of farmland transfer, changes in agricultural business returns brought by the price of agricultural products are closely related to the farmland transfer rent, that is, the cost of land, and thus the role of the level of income distribution between agricultural producers and landowners on agricultural income should not be ignored. In recent years, the prices of grain (rice, wheat and maize), vegetables and farmland transfer rents have shown a consistent upward trend, and farmland rents have not fallen due to the large-scale migration of rural labor but have continued to rise. Higher agricultural product prices mean higher returns from land management, and when the multiplanting index and yield cannot be significantly improved, farmers with the conditions and ability are willing to expand the land management scale to increase the total output.

A large and stable supply of nonfarm employment opportunities in the external market is a necessary condition for the transfer of rural labor force and the increase in land supply, in which "large" refers to the large number of employment opportunities absorbing rural labor force, and "stable" refers to the high stability of nonfarm employment and low threshold for settlement. Both are unlikely to change qualitatively in the short term, so this paper focuses on the impact of farmland rent changes due to farmers' demand to transfer-in farmland. Under the circumstance that farmland transfer is basically marketized, the transferable land will eventually flow to the farmers who are willing and able to pay the highest land rent, that is, to the farmers with the highest remuneration for land management, which can be interpreted as the difference between the income from land management, material costs and labor opportunity costs. The variables involved are the agricultural products price, input factors price and labor conditions; furthermore, the proportion of economic crop planting and the characteristics of rural households affect both land management income and labor opportunity cost.

The agricultural products' price influences the farmland transfer rent through two mechanisms of current operating income and future price expectation [46]. On one hand, the increase in current land operation income is mainly due to the increase in agricultural prices. When the price of production factors is certain, and there are no significant technological advances or efficiency improvements, farmers with the conditions and capabilities are willing to expand the scale of land management to increase the total output and thus production profits. Correspondingly, the improvement of per capita cultivated land area can effectively increase the marginal productivity of labor, creating economies of scale in labor and increasing agricultural returns, and the increase in the enthusiasm for transferring land will positively affect the rent of circulating land. On the other hand, the steady upward trend in agricultural prices has strengthened farmers' confidence in expected returns. The cobweb theory suggests that farmers tend to make sowing area decisions based on the previous year's price and yield, and when the yield is certain, farmers will decide to expand the sowing area to the rising agricultural prices in recent years to increase the expected return. Therefore, it is reasonable to assume that the increase in current and expected returns will positively affect the farmland transfer behavior of rational decision makers, and the increase in demand for farmland will have a positive impact on the rent of circulation land.

Based on the above analysis, this paper proposes the following research hypothesis:

Hypothesis (H1). *Farmland transfer with high agricultural product prices will improve technical efficiency more significantly*.

2.4. Policy Factor

Among policy support for agriculture, the subsidy instrument is a commonly used agricultural support policy. Zhu and Lansink suggests that subsidies may have an impact on efficiency through income effects, which can be expected to improve technology efficiency if they provide farmers with the necessary financial supplement to keep technology up to date or invest in improving the organizational efficiency of farms [47]. If farmers have no incentive to earn more income due to subsidies, technological efficiency may decrease with subsidies' increase. Inspired by them, we are concerned about the possible impact of agricultural subsidies on the technical efficiency of production. In recent years, with the deepening of urbanization and the massive migration of rural labor, agricultural production and operation have fallen into the dilemma of "unprofitable land cultivation and weak income generation". In order to get out of this dilemma, many local government departments have focused on promoting farmland transfer and developing large-scale operations, and the subsidy policy is regarded as the most effective policy instrument to promote farmland transfer.

Existing theories and policies provide a basis for government departments at all levels to formulate and implement farmland transfer subsidy policies. According to the theoretical model of factors influencing the level of agricultural support, factors such as GDP per capita, proportion of agricultural added value in GDP, proportion of agricultural labor force in total and cultivated land area of per agricultural labor force are the key factors affecting the structure, purpose and size of agricultural subsidies. This provides a theoretical basis for local governments to introduce farmland transfer subsidy policies and develop agricultural scale management based on land agglomeration [48]. At the same time, a series of central documents have been issued successively, which also provided a policy basis for governments at all levels to implement the farmland transfer subsidy policy. Although China's farmland transfer subsidy policy promotes large-scale agricultural operations, it may also give rise to a series of problems. In the short term, the implementation of the farmland transfer subsidy policy may promote a rapid improvement in the level of large-scale operations.

The farmland transfer subsidy policy is a branch of the agricultural subsidy policy, which mainly subsidizes the factors at the production end, with a view to achieve support for the production process and related subjects. Existing studies have not yet reached a unified conclusion on the impact of subsidies on farmland transfer. Most views believe that government subsidies have a significant positive effect on the paid transfer of farmland. The farmland transfer subsidy policy is an exploration and innovation carried out by local governments to adapt to the situation of rural labor migration, maintain national food security and develop agricultural scale management on the basis of the central government's policy of direct grain subsidy, seed subsidy, agricultural machinery purchase subsidy and agricultural material comprehensive direct subsidy [49].

From the perspective of economic effects, farmland transfer subsidies will have an impact on the balance of farmland transfer transactions. Access to subsidized land transfer funds increases the market price that land-inflow is willing to accept, thereby increasing the demand for farmland transfer and pushing the land transaction market to reach a new equilibrium point, thereby driving up farmland transfer price. Existing studies provide support for the price effect of farmland transfer subsidies, with some pointing out that the continuous implementation of farmland transfer subsidy policy is conducive to increasing the property income of the farmland transfer party and seems to be beneficial to maintaining the contracting rights; it is not helpful to the reduction in the operating cost of the farmland transfer party, and may also face the ratchet effect of rent premiums [50].

From the perspective of operation effects, farmland transfer subsidies may stimulate the enthusiasm of farmers to transfer-in more farmland and expand their scale of operation. Farmers incentivized by farmland transfer subsidies and income expectations will choose to transfer-in more land and expand their scale of cultivation, which in turn will encourage farmers to allocate more production resources to agricultural production, thus generating scale economy and improving farmers' technical efficiency. On the other hand, farmland transfer subsidies change farmers' expected decision making by increasing household wealth and weakening income fluctuations and, out of the pursuit of maximizing benefits, farmers who receive farmland transfer subsidies may use this extra income for consumption or productive investment, which may allocate more resources to agricultural production and operation, increase agricultural production factors and capital inputs, reduce production costs and thus improve farmers' technical efficiency.

Based on the above analysis, this paper proposes the following research hypothesei:

Hypothesis (H2). *Farmland transfer subsidies have nonlinear characteristics in the impact of farmland transfer on farmers' technical efficiency, and there is a threshold effect.*

3. Data and Models

3.1. Data Sources

The research data used in this paper are large sample data from the Rural Household Survey at fixed observation points in rural areas across China. Established in 1984, the National Rural Fixed Observation Point Survey System is a typical survey system for the rural social economy in China, involving 368 counties and 375 sample villages in 31 provinces (autonomous regions and municipalities) across the country. There are 23,000 bookkeeping farmer (herdsmen) households and more than 1600 new agricultural business entities that keep accounts.

According to the research topic which we focused on in this paper, it is the smallholders who is carrying out agricultural production in China. According to the view of British agricultural economist Frank Ellis, smallholders are defined as "farmers who use family labor, obtain means of living from agriculture and production, and do not fully participate in the market" [20]. This is a qualitative definition of smallholders. In terms of quantity, according to the statistical caliber of the Ministry of Agriculture and Rural Affairs, PRC, the agricultural operation scale is used to classify farmers. Farmers who operate fewer than 50 Mu[1] of farmland are defined as small farmers. In this paper, the samples are selected by the operating scale, in which contracted farmland should be fewer than 20 Mu and transfer land fewer than 30 Mu, thus the total operation scale was limited to below 50 Mu. As a research sample, the farmers of 50 Mu are in line with the academic definition of small farmers in terms of quality and quantity. In addition, the samples in this paper are limited to farmers who transfer-in the land, and no farmers who transfer-out of the land are selected. Due to data availability and other reasons, this paper selected the cross-sectional data of 10 provinces, autonomous regions and cities in the main indica rice-producing area in year 2019, and finally obtained the sample size of 1519 households after data cleaning.

3.2. Variable Selection

1. Explained variable

The explained variable in this paper is households' technical efficiency, which is measured by using the stochastic frontier production function model proposed by Aigner et al. and Meeusen and van den Broeck, whose general equation is

$$\begin{aligned} lny_i = f(x_i;\beta) + v_i - u_i \\ v_i \sim N\left(0, \sigma_v^2\right) \end{aligned} \tag{1}$$

where y_i is the actual amount of output, $f(\cdot)$ is the value of potential output, x_i denotes the input factor vector, v_i is the random error term and u_i denotes the technical inefficiency term. Assuming y_i^* is the potential output, then

$$lny_i^* = f(x_i;\beta) + v_i \tag{2}$$

$$lny_i = lny_i^* - u_i \tag{3}$$

$$\exp(-u_i) = \frac{y_i}{y_i^*} \tag{4}$$

Therefore, $\exp(-u_i)$ gives the ratio of actual output to the maximum possible output. The ratio is referred to as the technical efficiency of i.

2. Random Frontier production function variables

This paper constructs a stochastic frontier production function model to measure the technical efficiency of medium indica rice. The variables used in the model include 2 categories:

(1) Output variables. For the output variable, referring to the existing research results, this paper uses the main product value of medium indica rice (that is, the main product yield × unit price).
(2) Input variables. For input variables, we select intermediate product input, machinery operation cost, total labor input and land sown area for measurement. Among them, intermediate inputs include seed and seedling costs, farm manure discounts, fertilizer costs, agricultural film costs, pesticide costs, irrigation power costs and livestock costs. It is worth noting that most of the measurement of the means of production in this paper uses value variables, because it can simultaneously reflect the quantity and quality of inputs to the means of production.

3. Core explanatory variables

This paper mainly explores the effect of farmland transfer on the technical efficiency of households. Therefore, the core explanatory variable is farmland transfer, which is measured by whether the household transfers-in the farmland for medium indica rice cultivation, and when there occurs transfer-in farmland for medium indica rice planting, the value is assigned to 1. Otherwise, the assignment is 0.

4. Moderating variables

According to the above analysis, this paper uses market price to characterize market factor variables and farmland transfer subsidy to characterize policy factor variables. Among them, the variable market price refers to the price of indica rice sold by farmers in the market, which needs to be converted using the quantity and amount sold. Additionally, variable farmland transfer subsidy refers to the subsidies received by farmers who have transferred-in the farmland. In the household questionnaire, the variable market price needs some converting. We chose the indicators "sales quantity" and "sales amount" in the section of "agricultural product sales—grain: rice", and then the market price is equal to the ratio of "sales quantity /sales amount". The variable farmland transfer subsidy corresponds to "land transfer-in subsidy" in the section of "land situation".

5. Instrumental variables

Based on the previous analysis, this paper uses the instrumental variable method to deal with possible endogeneity issues and selects village group traffic conditions as the instrumental variable in model.

6. Control variables

In this paper, the characteristics of households and villages are selected as the control variables. Among them, the characteristics of rural households are characterized by variables such as the age, education level, health status and technical training of the head of the household, number of household labor force, whether they are a village cadre household, nonfarm income of the family, whether the family is registered as a family farm, etc., while the characteristics of the village are characterized by the agricultural operation segment in the village group and the supply of agricultural machinery services in the village group. Provincial dummy variables are also included in the production function model in order to capture the effects of unobserved economic, social and other factors. Descriptions of the above variable assignments and descriptive statistics are shown in Table 1.

Table 1. Description of model variables for the effect of farmland transfer on the technical efficiency of farm households.

Variable Category	Variable Name	Variable Units	Variable Definitions
Explained variables	Households' technical efficiency	-	Technical efficiency of medium indica rice production
Random frontier production function variables	Output value	Yuan	Value of main products of medium indica rice
	Intermediate product input	Yuan	Total cost of seed, seedling, fertilizer, agricultural film, pesticide, irrigation power and animal power invested in medium indica rice planting
	Mechanical operation cost	Yuan	Operating cost of medium indica rice planting machinery
	Labor input	Day	Total input of medium indica rice planting
	Land input	Mu	Seeding area of medium indica rice

Table 1. *Cont.*

Variable Category	Variable Name	Variable Units	Variable Definitions
Core explanatory variables	Farmland transfer	-	Transfer-in farmland for medium indica rice cultivation = 1, otherwise = 0
Moderating variables	Market Price	Yuan	Market selling price of medium indica rice
Threshold variables	Farmland transfer subsidy	Yuan	Subsidies received by households who transfer-in farmland
Instrument variables	Traffic conditions	%	The proportion of the length of hardened roads to the total roads in the village
Control variables	Age	-	The age of surveyed farmers: 1~17 years old = 1, 18~27 years old = 2, 28~37 years old = 3 38~47 years old = 4, 48~57 years old = 5, 58~67 Years = 6 and >68 years = 7
	Education level	-	Educational attainment of surveyed farmers, primary = 1, junior high = 2, senior high = 3 and college degree or above = 4
	Health status	-	Farmers surveyed are in good health or good condition = 1, otherwise = 0
	Technical training	-	Farmers surveyed have participated in agricultural training hosted by government departments = 1, otherwise = 0
	Number of labor force	person	Number of household labor force
	Village cadre households	-	A member of the family who serves as village official
	Family farm	-	Household registered as a family farm = 1, otherwise = 0
	Non-farm income	%	The proportion of the amount of household nonfarm operating income to total income
	Agricultural business environment	%	The proportion of the amount of agricultural households to all households in village
	Agricultural machinery service supply	piece	Number of agricultural machinery operation service cooperatives in village groups
	Regional control variables	-	Provincial dummy variables

3.3. Model Specification

1. Measurement model of technical efficiency

The stochastic frontier analysis proposed by Aigner et al. and Meeusen and van Den Broeck was used, and the Cobb–Douglas production function model was constructed to measure the technical efficiency of agricultural production [51,52]. The models of stochastic frontier analysis and Cobb–Douglas production function are as follows:

$$Y = f(X)\exp(v - u) \tag{5}$$

$$lny_i = \beta_0 + \sum\nolimits_n \beta_n lnX_{ni} + v_i - u_i,\ i = 1, 2, \ldots, I \tag{6}$$

Under the hypothesis of the v and u, we use the method of maximum likelihood (ML) or adjust the least squares method (MOLS) estimated parameter and error term $v_i - u_i$; technical efficiency is obtained as $TE_i = \exp(-u_i)$.

2. Benchmark regression model

$$TE_i = \beta_0 + \beta_1 rent_i + \sum_{k=1}^{K} \beta_{2k} ctrl_{ik} + \delta_i \tag{7}$$

where TE_i denotes the efficiency of the households' production of medium indica rice, $rent_i$ denotes the farmland transfer variable and $ctrl_{ik}$ denotes the control variables. β_0 denotes the constant term of the model, β_1 denotes the coefficient to be estimated for the farmland transfer variable, β_{2k} denotes the coefficients to be estimated for each control variable and δ_i denotes the random error term of the model.

3. Treatment of endogenous problems

In order to deal with possible endogeneity problems, we implement this with the "instrumental variables". A valid instrumental variable should satisfy both correlation and exogeneity. Among them, correlation means that instrumental variables are related to endogenous explanatory variables; exogeneity requires that instrumental variables are not related to perturbation terms. The exogeneity of instrumental variables is sometimes referred to as an "exclusivity constraint", because exogeneity means that the only channel an instrumental variable influences the explanatory variable through is its associated endogenous explanatory variable, excluding all other possible channels of influence.

Considering the possible endogeneity problems of the model, the instrumental variable method (IV) is used for parameter estimation in this paper. "The proportion of hardened roads to the total length of the village" is chosen to represent "traffic conditions" as an instrumental variable for farmland transfer, because the traffic conditions of the whole village are affected by economic conditions. The more developed the traffic condition in the village, the more developed the agricultural products market, and both can form a market for agricultural products in the village in the face of unsatisfactory prices in the village and can go into the city on their own to find a more reasonable market; because the information is more symmetrical, agricultural products are easier to sell and can obtain reasonable prices. Therefore, the more developed the transportation of villages, the more adequate the conditions for agricultural production, and the willingness of rural households to transfer farmland increases. Therefore, it is theoretically reasonable to consider traffic conditions as instrumental variables.

4. The moderating effect of market factors

According to the above theoretical analysis, market factors may promote the transfer of farmland, and then the impact of farmland transfer on the technical efficiency of households may be affected by market factors. In order to verify the influence of the connection between farmland transfer and market factors on farmers' technical efficiency, this paper introduces market factor variables as moderating variables to analyze the possible moderating effect of market price on farmland transfer affecting farmers' technical efficiency. The model is set further to introduce a cross-term in the benchmark regression model to establish a moderating effect model to identify the moderating effect of market factors. In the equation,

$price_i$ represents the market price of medium indica rice sold by the farmer, and the rest of the code meanings are consistent with the benchmark regression model.

$$TE_i = \beta_0 + \beta_1 rent_i + \sum_{k=1}^{K} \beta_{2k} ctr_{ik} + \beta_3 price_i + \beta_4 rent_i \times price_i + \delta_i \quad (8)$$

5. The threshold effect model of agricultural subsidy policy

In regression analysis, we are often concerned with whether the coefficient estimates are stable, that is, if the entire sample is divided into several subsamples for regression and, roughly the same estimated coefficients can be obtained. For cross-sectional data, the sample can sometimes be split in two depending on the variables. If the variable used to divide the sample is not a discrete variable but a continuous variable, a criterion for division needs to be given, that is, a threshold value. In applied research, economic laws may be nonlinear, and their functional form may change with a variable (the "threshold variable").

Traditionally, the researcher subjectively determines a threshold and then divides the sample in two (or more subsamples) based on this threshold, without parametric estimation or statistical testing of its significance. Obviously, the results obtained in this way are not reliable. To this end, Hansen proposed the "threshold regression" model, which uses rigorous statistical inference methods to estimate and test the threshold value parametrically and hypothetically [53].

Assume that the sample data are $\{y_i, x_i, q_i\}_{i=1}^{n}$, where q_i is the threshold variable used to classify the sample, and q_i can be the explanatory variable x_i of the sample. Consider the following threshold regression model:

$$\begin{cases} y_i = \beta_1' x_i + \varepsilon_i, & if\ q_i \leq \gamma \\ y_i = \beta_2' x_i + \varepsilon_i, & if\ q_i > \gamma \end{cases} \quad (9)$$

where γ is the threshold value to be estimated. This segmentation function above can be combined and written as

$$y_i = \beta_1' \underbrace{x_i \cdot 1(q_i \leq \gamma)}_{=z_{i1}} + \beta_2' \underbrace{x_i \cdot 1(q_i > \gamma)}_{=z_{i2}} + \varepsilon_i \quad (10)$$

where $1(\cdot)$ is an indicative function; it takes the value 1 if the expression in parentheses is true, otherwise, it takes the value 0. Clearly, this is a nonlinear regression. It can be estimated using nonlinear least squares, minimizing the sum of squares of the residuals.

In turn, the threshold can be estimated by minimizing γ,

$$\hat{\gamma} = argmin S_1(\gamma) \quad (11)$$

Once an estimate is obtained for $\hat{\gamma}$, then the coefficient is $\hat{\beta} = \hat{\beta}(\hat{\gamma})$, the residual vector is $\hat{\varepsilon}^* = \hat{\varepsilon}^*(\hat{\gamma})$ and the variance of the residuals is $\hat{\sigma}^2 = \frac{1}{m(T-1)} S_1(\hat{\gamma})$. Once the optimal threshold estimate is obtained, it is important to test whether the threshold effect is significant and whether it equals its true value.

In fact, the above process only assumes the existence of a single threshold for the model, whereas in reality there are often double or multiple thresholds. The double threshold model can be set as follows.

$$y_i = \beta_1' x_i \cdot 1(q_i \leq \gamma_1) + \beta_2' x_i \cdot 1(\gamma_1 < q_i \leq \gamma_2) + \beta_3' x_i \cdot 1(q_i > \gamma_2) + \varepsilon_i \quad (12)$$

$$\mathrm{y_i} = \beta_1' \mathrm{x_i} \cdot 1(\mathrm{q_i} \leq \gamma_1) + \beta_2' \mathrm{x_i} \cdot 1(\gamma_1 < \mathrm{q_i} \leq \gamma_2) + \beta_3' \mathrm{x_i} \cdot 1(\mathrm{q_i} > \gamma_2) + \varepsilon_\mathrm{i} \quad (13)$$

In Equations (12) and (13), $\gamma_1 < \gamma_2$ is the threshold value, and the rest of the symbols have the same meaning as Equation (10). Following Hansen [54], first fix γ_2, the optimal threshold parameters, to be estimated according to the steps of the single-threshold model

$\hat{\gamma}_1$ and, fixing $\hat{\gamma}_1$, then estimate $\hat{\gamma}_2$; repeating the above steps eventually leads to the optimal threshold parameters.

According to the theoretical analysis, policy factors may promote farmland transfer, so the impact of farmland transfer on the technical efficiency of farmers may be affected by policy factors. In order to verify the influence of the connection between farmland transfer and policy factors on technical efficiency, this paper introduces the variables of policy factors as the moderating variables to analyze the possible moderating effect of farmland transfer subsidy policy on the impact of farmland transfer on farmers' technical efficiency. The model is set further to introduce a cross-term in the benchmark regression model to establish a moderating effect model to identify the moderating effect of policy factors. In the equation, sub_i represents the subsidy received by farmers who transfer-in the farmland, and the meaning of the rest of the codes is consistent with the benchmark regression model.

$$TE_i = \beta_0 + \beta_1 rent_i + \sum_{k=1}^{K} \beta_{2k} ctr_{ik} + \beta_3 sub_i + \beta_4 rent_i \times sub_i + \delta_i \quad (14)$$

In order to verify the nonlinear effect of farmland transfer subsidies on the technical efficiency of farmland transfer, this paper further develops a threshold effect model to carry out the analysis.

$$TE_i = \beta_{01} + \beta_{11} rent_i (sub_i \geq N) + \sum_{k=1}^{K} \beta_{21} ctrl_{ik} + u_i \quad (15)$$

$$TE_i = \beta_{02} + \beta_{12} rent_i (sub_i \leq N) + \sum_{k=1}^{K} \beta_{22} ctrl_{ik} + u_i \quad (16)$$

4. Results

4.1. Benchmark Regression

4.1.1. Model Testing

In this paper, the OLS and 2SLS estimation methods were used to estimate the model, and the regional fixed effect was controlled in the model estimation. Cross-sectional data are prone to heteroscedasticity, as well as multiple collinearities. The change trend of the graph is compared by comparing the scatter plot of the residuals with fitted values and the scatter plot of residuals with explanatory variables. It is found that the two types of graphs are consistent, indicating that heteroscedasticity may exist in the data. Furthermore, the BP test also rejects the original hypothesis of homoscedasticity. Therefore, the "OLS + robust standard error" approach was chosen to solve the heteroscedasticity problem. This paper then examines the multicollinearity problem of cross-sectional data, as shown in Table 2, and the VIF test (maximum of 2.51) is much smaller than the empirical VIF value (10), so there is no multiple collinearity problem.

Table 3 reports the effect of farmland transfer estimated using the instrumental variable method on farmers' technical efficiency. Model (1) is the ordinary OLS estimation result, while model (2) adds the instrumental variable (village group traffic conditions) to the model (1), and the coefficient of the instrumental variable is not significant and satisfies the exogenous requirement. The technical efficiency of farmers and the farmland transfer variables were regressed, and the residual series obtained from the regression were introduced into the equation regression as the independent variable. The results show that the coefficient of the residual series was significantly nonzero, so the model was endogenous, and further testing revealed that the farmland transfer variable was the endogenous explanatory variable. Model (3) is the estimation result of instrumental variables. In this paper, the variable of traffic conditions of a village is selected as the instrumental variables of farmland transfer, and the correlation between the instrumental variables and endogenous explanatory variables is tested. The 2SLS estimation passes the unidentifiable test, the weak instrumental test and Sargan test, indicating that there is no problem of overidentification or underidentification of instrumental variables. The estimation results of model (3) show that the transfer of farmland can significantly improve the technical efficiency of agricultural production. In terms of control variables, the number of household laborers, agricultural business environment and agricultural machinery service supply variables have significant positive effects on technical efficiency.

Table 2. Multicollinearity test of the model.

	VIF	**1/VIF**
Agricultural machinery service supply	2.51	0.398099
Agricultural business environment	2.3	0.434565
Traffic conditions	1.77	0.564559
Market	1.5	0.666303
Age	1.33	0.750502
Farmland transfer subsidy	1.26	0.792327
Health status	1.25	0.801031
Education	1.2	0.833168
Technical training	1.18	0.844421
Number of labor force	1.18	0.849263
Village cadre households	1.15	0.866927
Farmland transfer	1.12	0.89683
Family farm	1.1	0.913019
Nonfarm income	1.06	0.945468
Mean VIF	1.42	

Table 3. Effect of farmland transfer on farmers' technical efficiency (2sls).

	(1)	**(2)**	**(3)**
	ols	**ols**	**2sls**
Farmland transfer	0.0018 **	0.0013 **	0.0516 *
	(0.0008)	(0.0006)	(0.0307)
Family farm	−0.2256	−0.2280	−0.1988
	(0.1746)	(0.1740)	(0.1836)
Village cadre households	−0.0133 *	−0.0136 *	−0.0116 *
	(0.0073)	(0.0071)	(0.0064)
Number of labor force	0.0042 ***	0.0044 ***	0.0046 ***
	(0.0012)	(0.0012)	(0.0013)
Nonfarm income	−0.0021	−0.0010	−0.0041
	(0.0123)	(0.0123)	(0.0131)
Age	−0.0005	0.0002	0.0016
	(0.0023)	(0.0023)	(0.0026)
Education	0.0026	0.0030	0.0026
	(0.0032)	(0.0032)	(0.0033)
Health status	−0.0001	0.0003	0.0048
	(0.0047)	(0.0047)	(0.0058)
Technical training	0.0100	0.0110*	0.0110
	(0.0063)	(0.0063)	(0.0068)
Agricultural business environment	0.0175	0.0211	0.0380 *
	(0.0158)	(0.0162)	(0.0230)
Agricultural machinery service supply	0.0173 *	0.0177 *	0.0249 **
	(0.0091)	(0.0093)	(0.0115)
Traffic conditions		0.0003	
		(0.0033)	
Regional control variables	YES	YES	YES
_cons	0.8030 ***	0.7963 ***	0.7915 ***
	(0.0211)	(0.0209)	(0.0235)
Sample size	1519	1519	1519

1. The values in brackets are robust standard error; 2. ***, ** and * are significant at the statistical level of 1%, 5% and 10%, respectively.

4.1.2. The Effect of Farmland Transfer on Technical Efficiency under the Influence of Market Factors

Table 4 reports the moderating effect of market factors on farmland transfer on farmers' technical efficiency. Model (4) is the estimation result of ordinary OLS, and model (5) adds instrumental variables (traffic conditions of village groups) on the basis of model (4), and the coefficients of instrumental variables are not significant to satisfy the exogenous requirement. The model (6) estimates the results for instrumental variables. The estimation results show that market prices can significantly improve the technical efficiency of farmers, which indicates that market factors have a role in promoting farmers' technical efficiency. The regression coefficient of the interaction between farmland transfer and market price was significantly positive, indicating that the market price of medium indica rice could promote the transfer-in of farmland and improve the technical efficiency of farmers. Among the control variables, the number of household laborers, the education level of farmers and the variables of agricultural machinery service supply have significant positive effects on the technical efficiency of farmers. The hypothesis H1 was tested.

Table 4. Moderating effect of market price on farmland transfer on farmers' technical efficiency.

	(4)	(5)	(6)
	ols	**ols**	**2sls**
Farmland transfer	0.0149 **	0.0143 **	0.1697 *
	(0.0070)	(0.0071)	(0.0898)
Market	0.0236 ***	0.0233 ***	0.0319 ***
	(0.0074)	(0.0074)	(0.0100)
Farmland transfer × market price	0.0032 **	0.0033 ***	0.0045 ***
	(0.0013)	(0.0013)	(0.0017)
Family farm	−0.2229	−0.2236	−0.1636
	(0.1809)	(0.1809)	(0.1970)
Village cadre households	−0.0093	−0.0094	−0.0102
	(0.0116)	(0.0116)	(0.0241)
Number of labor force	0.0031 **	0.0032 **	0.0032 **
	(0.0016)	(0.0016)	(0.0016)
Nonfarm income	0.0060	0.0060	0.0063
	(0.0132)	(0.0132)	(0.0232)
Age	−0.0027	−0.0025	−0.0128
	(0.0030)	(0.0030)	(0.0102)
Education	0.0074 *	0.0076 *	0.0049 *
	(0.0040)	(0.0040)	(0.0028)
Health status	0.0019	0.0022	0.0144
	(0.0053)	(0.0053)	(0.0132)
Technical training	−0.0049	−0.0050	0.0037
	(0.0069)	(0.0070)	(0.0150)
Agricultural business environment	0.0174	0.0182	0.0658
	(0.0257)	(0.0266)	(0.0578)
Agricultural machinery service supply	0.0205 **	0.0185 **	0.0496 *
	(0.0082)	(0.0083)	(0.0290)
Traffic conditions		0.0002	
		(0.0025)	
Regional control variables	YES	YES	YES
_cons	0.7125 ***	0.7523 ***	0.7053 ***
	(0.0451)	(0.0326)	(0.0580)
Sample size	1519	1519	1519

1. The values in brackets are robust standard error; 2. ***, ** and * are significant at the statistical level of 1%, 5% and 10%, respectively.

4.1.3. The Effect of Farmland Transfer on Technical Efficiency of Farmers under the Agricultural Subsidy Policy

Table 5 reports the moderating effect of policy factors with farmland transfer on farmers' technical efficiency. Model (7) is the estimation result of ordinary OLS, and model (8) adds instrumental variables (traffic conditions of village groups) on the basis of model (7), and the coefficients of instrumental variables are not significant to satisfy the exogenous requirement. Model (9) estimates results for instrumental variables. The estimation results show that the farmland transfer subsidy has a significant positive impact on the technical efficiency of farmers and can significantly improve the technical efficiency of farmers. The regression coefficient of the intersection between farmland transfer and farmland transfer subsidy is significantly positive, indicating that the payment of subsidies to farmers who transfer land is conducive to farmers transferring to land, thus improving the technical efficiency of farmers. Among the control variables, the variables of household labor force, technical training and agricultural machinery service supply have significant positive effects on the technical efficiency of farmers.

Table 5. The moderating effect of farmland transfer subsidies on farmland transfer on the technical efficiency of farmers.

	(7)	(8)	(9)
	ols	**ols**	**2sls**
Farmland transfer	0.0187 **	0.0175 **	0.1891 *
	(0.0081)	(0.0077)	(0.1028)
Farmland transfer subsidy	0.0190 ***	0.0190 ***	0.0311 *
	(0.0051)	(0.0051)	(0.0165)
Farmland transfer × Farmland transfer Subsidies	0.0026 **	0.0021 **	0.0077 **
	(0.0013)	(0.0011)	(0.0046)
Family farm	−0.2307	−0.2328	−0.2376
	(0.1741)	(0.1725)	(0.1457)
Village cadre households	−0.0137 *	−0.0139 **	−0.0115 *
	(0.0071)	(0.0071)	(0.0067)
Number of labor force	0.0043 ***	0.0045 ***	0.0012 *
	(0.0012)	(0.0012)	(0.0006)
Nonfarm income	−0.0029	−0.0026	0.0172
	(0.0123)	(0.0123)	(0.0353)
Age	−0.0001	0.0003	−0.0037
	(0.0023)	(0.0023)	(0.0067)
Education	0.0024	0.0032	0.0061
	(0.0032)	(0.0032)	(0.0087)
Health status	−0.0011	−0.0012	−0.0004
	(0.0047)	(0.0048)	(0.0141)
Technical training	−0.0105 *	−0.0113*	0.0019 *
	(0.0060)	(0.0061)	(0.0011)
Agricultural business environment	0.0298 *	0.0313 **	0.2598
	(0.0156)	(0.0159)	(0.3219)
Agricultural machinery service supply	0.0190 **	0.0171 *	0.0417 *
	(0.0090)	(0.0092)	(0.0233)
Traffic conditions		0.0002	
		(0.0032)	
Regional control variables	YES	YES	YES
_cons	0.7882 ***	0.7935 ***	1.0795 ***
	(0.0213)	(0.0220)	(0.3187)
Sample size	1519	1519	1519

1. The values in brackets are robust standard error; 2. ***, ** and * are significant at the statistical level of 1%, 5% and 10%, respectively.

According to the theoretical analysis and empirical tests, farmland transfer subsidies have a positive moderating effect on farmland transfer and farmers' technical efficiency, but whether there is heterogeneity and threshold conditions in the moderating effect of farmland transfer subsidies needs further analyzes. Using the threshold variable of farmland transfer subsidy as the single-threshold and double-threshold value tested, respectively, the results of the estimation of the threshold effect of farmland transfer subsidy were obtained by applying the "bootstrap" method proposed by Hansen [54], as shown in Table 6. It can be seen that the impact of farmland transfer subsidies on farmers' technical efficiency varies under different levels of farmland transfer subsidies. When the farmland transfer subsidy is at a lower level (farmland transfer subsidy $\leq$ 83.93) or at a higher level (farmland transfer subsidy $\geq$ 418.27), its effect on the farmers' technical efficiency was not significant. When the farmland transfer subsidy is at an intermediate level (83.93 $<$ Farmland transfer subsidy $<$ 418.27), its impact on farmers' technical efficiency is significantly positive, indicating that this level of farmland transfer subsidy has a significant role in promoting technical efficiency. Therefore, a low farmland transfer subsidy may not be beneficial to farmland transfer due to insufficient income effect, while a high farmland transfer subsidy may not promote farmland transfer due to rent effect. The results of the threshold effect analysis validate hypothesis H2 in this paper.

Table 6. Analysis of threshold effect of farmland transfer subsidy.

(10) Threshold Variable	
Explanatory variables	Estimated coefficients
Farmland transfer 1 (Farmland transfer Subsidy $\leq$ 83.93)	0.0463
Farmland transfer 1 (83.93 $<$ Farmland transfer subsidy $<$ 418.27)	0.0312 ***
Farmland transfer 1 (Farmland transfer Subsidy $\geq$ 418.27)	0.0247

*** is significant at the statistical level of 1%.

4.2. Robustness Test

Table 7 reports the effect of the market price of medium indica rice at different income levels using the instrumental variable method on farmland transfer and farmers' technical efficiency. Estimates show that the transfer-in of farmland can significantly improve technical efficiency, regardless of income level. Market prices have no significant impact on the technical efficiency of middle-income households, indicating that these farmers are less sensitive to the market price of agricultural products. Similarly, market prices only have a significant positive effect on the farmland transfer and technical efficiency of low- or high-income households. This shows that compared with middle-income farmers, low- and high-income farmers are more inclined to adjust their agricultural production and operation decisions and factor allocation according to market prices, which in turn affects their farms' technical efficiency.

Table 7. Moderating effects of market factors grouped by household income levels.

	(11)	**(12)**	**(13)**	**(14)**
	Q1	**Q2**	**Q3**	**Q4**
Farmland transfer	0.1121 *	0.0617 *	0.1040 *	0.0988 *
	(0.0593)	(0.0335)	(0.0517)	(0.0573)
Market	0.0543 *	0.0236	0.0379	0.0791 **
	(0.0276)	(0.0143)	(0.0347)	(0.0379)
Farmland transfer × market price	0.0351 *	0.0294	0.0173	0.0228 *
	(0.0189)	(0.0293)	(0.0119)	(0.0124)
Control variables	YES	YES	YES	YES
Regional dummy variables	YES	YES	YES	YES
_cons	0.7715 ***	0.7702 ***	0.8043 ***	1.2015
	(0.0722)	(0.0446)	(0.0631)	(0.1226)
Sample size	346	362	369	442

1. The values in brackets are robust standard error; 2. ***, ** and * are significant at the statistical level of 1%, 5% and 10%, respectively.

5. Conclusions and Discussion

Based on the overall theoretical analysis framework, this paper constructed the analysis framework of farmland transfer on farmers' technical efficiency and discussed the influence of market factors and policy factors on the technical efficiency of farmers. In view of the possible endogenous problems, this paper applies the instrumental variable method to conduct empirical tests to address the possible endogeneity issues. Through the estimation of the benchmark model, it is concluded that farmland transfer has a significant improvement effect on technical efficiency. By introducing market factors and policy factors into the benchmark model, respectively, the market factors measured by market price have a significant positive impact on technical efficiency, and they have a positive moderating effect on the improvement of farmers' technical efficiency in farmland transfer, showing that the selling price of agricultural products is conducive to promoting farmers' farmland transfer. The agricultural subsidy policy measured by farmland transfer subsidy has a significant positive impact on technical efficiency, and it has a positive moderating effect on the improvement of farmers' technical efficiency by farmland transfer, indicating that the policy is conducive to improving farmers' willingness to farmland transfer, thereby improving farmers' technical efficiency. Taking farmland transfer subsidy as the threshold variable, further analysis shows that, under the model specifically, the farmland transfer subsidy has a double-threshold value when the farmland transfer subsidy level is intermediate ($83.93 < \text{Farmland transfer subsidy} < 418.27$), which can promote farmland transfer and thus improve technical efficiency. The robustness test based on household income level groupings shows that market price has no significant effect on the technical efficiency of middle-income farmers and only has a significant positive moderating effect on the farmland transfer and technical efficiency of low- and high-income cohorts.

This conclusion indicates that the external environment has a significant moderating effect on the impact of farmland transfer on agricultural production efficiency. From the perspective of market factors, the market price of agricultural products has an important impact on farmers' land transfer intention and behavior through the cost–benefit mechanism. The rise of agricultural prices means the increase in farmland operation income. When the multiple cropping index and yield per unit area cannot be significantly improved, farmers with conditions and ability are willing to expand farmland operating area by transfer-in land, so as to improve agricultural production efficiency. From the perspective of policy factors, a subsidy policy is regarded as the most effective policy tool to promote farmland transfer. Farmland transfer subsidies may stimulate the enthusiasm of farmers to transfer, encourage farmers to flow into more farmland, expand the scale of operation, reduce production costs and improve agricultural production efficiency. However, the acquisition of farmland transfer subsidy funds may also make the farmland transfer-in party push up the transaction price, thus inhibiting the demand for farmland transfer. Therefore, farmland transfer subsidy has a nonlinear effect on the impact of farmland transfer on agricultural production efficiency.

Therefore, we suggest improving the production factor market from the perspective of optimizing the external environment. With the continuous progress of reform and opening up, China's economic transformation is also deepening. With the increasingly perfect market-oriented economy, the development of the production factor market in the agricultural sector plays an increasingly important role in the development of modern agriculture and the promotion of agricultural and rural modernization, and its improvement cannot be achieved without the important role of the external environment. Consequently, it is necessary to improve the external environment of the agricultural production factor market development from the two dimensions of market and policy. For market factors, an active link between the agricultural production factor market and the commodity market should be built, as well as promoting the development of the agricultural product market by improving the quality of agricultural products, thus leading to the demand for the agricultural production factor market, resulting in promoting the development of agricultural production factors and improving agricultural production efficiency. From the perspective of policy factors, the current policy orientation is directed to promote the development of the agricultural production factor market, which requires the formation of a good policy implementation and performance evaluation mechanism to ensure that policy factors play a role in the development of the agricultural production factor market, which is conducive to the improvement of agricultural production efficiency.

Restricted by data access, time, experience and ability, this paper inevitably has some limitations, and there are still some problems worth further investigation. For instance, in selecting variables, we just set farmland transfer as a binary dummy as the core explanatory variable. If the scales of farmland transfer could be included to be another aspect of the core explanatory variable, the analysis would be more thorough. In addition, since farmland transfer needs a certain market to improve the production efficiency of farmers, it would make the research more accurate if there were enough data to support our discussion on the market efficiency of farmland transfer. These problems need to be further studied in the future.

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Notes

[1] Mu: A municipal unit of land area in China. 1 Mu is equal to 1/15 hectare.

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