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Farmland Transfer, Scale Management and Economies of Scale Assessment: Evidence from the Main Grain-Producing Shandong Province in China

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Abstract: Promoting farmland transfer through the farmland rental market is an essential instrument to achieve the centralized scale operation of farmland in China. However, few studies have explored or verified the economies of scale after land concentration. This study uses face-to-face interviews to randomly select 395 farmers engaged in land scale management in 68 villages of 11 cities in Shandong Province. Based on these data, a production cost function model is used to measure the cost elasticity of farmland scale management and further empirically test whether farmland scale management can achieve economies of scale in actual agricultural production. The empirical results show that the development of farmland scale operation can reduce production costs and realize the economy of scale. In other words, the scale of farmland management still has the possibility of further expansion. More importantly, we find the operation cost of farmland is significantly influenced by the price of farmland transfer, fixed capital input and labor input, especially the scale operator with rich planting experience and good cultural quality is an important human capital stock, which can make significant contribution to reducing production cost and developing the positive effect of scale operation. To promote farmland scale management in China, we should pay attention to reducing the transferring cost and transaction cost of farmland by building the land transfer market trading platform, increasing the subsidies for farmland transfer and developing agricultural mechanization, which is helpful to improve agricultural productivity and realize the scale economy. This research can provide a reference for rational land scale management and land use policymaking.

Keywords: farmland transfer; scale management; cost elasticity; economies of scale

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1. Introduction

Appropriate scale management of farmland is an important way to promote the development of agricultural industrialization and rural revitalization in China. Since 1982, when the first Central Document No. 1 (as the first policy statement released by Chinese central authorities each year, the document is seen as an indicator of policy priorities) introduced the system of responsibility for a joint production by the family, the single-farm family has become the basic unit of agricultural production in China. However, this family management system has resulted in the fragmentation and decentralization of agricultural operations in China. The "big country, small farm" has been the basic model of Chinese agriculture. According to China's third agricultural census, there are about 230 million farming households in China, with an average household size of 7.8 mu (or 1.28 acres). In comparison, 210 million farming households have less than 10 mu (or 1.65 acres) of arable land, which indicates that China is a small-scale or even super-small-scale operation pattern.

In order to speed up the construction of a new agricultural management system in line with China's rural development, and to alleviate the inefficiencies caused by the fragmentation of arable land due to the small-scale operation model of China's even-field

system through reform, the Chinese government issued the "Opinions on Guiding the Orderly Transfer of Land Management Rights to Develop Moderate Scale Agricultural Operations" in 2014, which clearly proposed to reasonably determine the scale of land management and develop various forms of moderate scale agricultural operations. In 2021, the Chinese government issued a document that further emphasized the importance of "grasping family farms and farmers" cooperatives as the main business entities and encouraging the development of various forms of moderate scale operations. In the future, farmland moderate scale management may be an important way to improve land production efficiency [1]. Researchers show that land transfer can be used to transfer land from low-productivity households to high-productivity households [2], or from farmers who cannot cultivate land to those who need land for agricultural activities [3,4]. Land transfer can improve the efficiency of resources allocation [5]. However, theoretically, a larger scale is not better and land scale management is based on the realization of scale economy. The international agricultural economics community has witnessed the trend that agricultural productivity decreases as the scale of farmland operations increases and that simply expanding the scale of farmland operations can easily lead to diseconomies of scale. Therefore, it is of great practical significance to verify whether land scale management operators (e.g., family farms or farmers' cooperatives) really achieve scale economies to realize large-scale management.

In the studies of farmland transfer and scale management, the existing literature is divided into two main perspectives around whether farmland transfer is efficient or not. Most theoretical studies believe that land transfer is efficient and can solve the problems of small-scale land operation and fragmentation of farmland [6], and the intensive development of farmland is an inevitable trend [7,8]. However, there are still a considerable number of scholars represented by Schultz who question the scale operation of rural land, and they believe that the development of agricultural scale operation does not improve agricultural productivity and may not enhance economic efficiency [9]; some Chinese scholars also believe that the economies of scale effect of agricultural production are not significant [2,10], the expansion of the scale of farmland operation has not achieved incremental payoffs, and there is no economy of scale phenomenon [11,12]. Some scholars argued that it was difficult to apply the theory of "economies of scale" in the agricultural production [13,14]. Scholars in recent studies no longer base their attitudes on the efficiency of farmland transfer only but pay more attention to the scale economy of farmland scale management formed after farmland transfer, treating farmland scale management as an important part of agricultural supply-side reform and the integration of farmland scale economy and service scale economy as the direction of future transformation of China's agricultural operation methods [15–17]. These research results suggest that the development of moderate scale farmland should proceed according to local conditions and promote the reform of China's farmland management mode [18,19], cultivating new types of professional farmers, developing moderate scale concentration of farmland to help build the modernization system of the agricultural industry, and taking moderate scale operation of farmland as the focal point of rural revitalization [20].

The second is the empirical study on the effect of land scale management. Some studies conclude that there is an inverse relationship between land output and land management area [21,22], which denies the positive effect of farmland scale management [23–25], and that land moderate scale management does not promote but rather inhibits land productivity. Empirical evidence from more than a dozen developing countries, including China, has largely rejected the existence of the law of increasing returns to scale [26–29]. However, these empirical results have not changed the supportive attitude of many researchers. Recent studies have analyzed and suggested that the moderate expansion of land operation scale has positive effects on the improvement of agricultural production performance from the perspective of resource allocation [30,31] and that land scale management is conducive to the improvement of grain yields [32], significantly increases the level of farmers' inputs to agricultural social services [33,34], motivates farmers to participate in collective action [35],

and releases rural labor [36]. Most importantly, with the continuous concentration of land, the number of new land operator is constantly expanding. As family farm, which is a production and scale management unit in China, solves a series of problems such as difficulties in upgrading China's rural agricultural industry [37], invisible unemployment [38], low-income levels [39] and the realization of agricultural modernization [40]. Professional cooperatives as another land scale operator can provide skills training and technical services to small-scale farmers in China, which can better solve the contradiction between small farmers and large markets [41–43] and achieve sustainable development of small-scale farmers [44,45]. Currently, some studies focus on the green production efficiency and welfare of land scale operators [46–48]. Although they provide some ideas and basis for this paper, they still have some problems. First, they lack a systematic analysis combining qualitative and quantitative analysis. Second, the farmland situation in China is complex and diversified, but they may ignore the assessment of scale economies of land renting-in operators, which may impact land transfer and scale management policymaking.

Therefore, the research on whether farmland can achieve economies of scale needs to be further enriched. The marginal academic contributions of this paper are: (1) Under the framework of the scale economy theory, we construct an agricultural production cost function model to verify whether farmland scale operators achieve economies of scale. (2) Using micro-survey data, this paper will analyze the heterogeneity of scale economies among different scale operators and provide an empirical test of which scale operator is more efficient, family farms or professional cooperatives. (3) Based on the perspective of farmers, we analyze the factors influencing farmland scale operators and provide reference to promote the farmland transfer and scale management in China.

The rest of the paper is organized as follows: In Section 2, we discuss the theoretical basis of this study and construct a cost function model to estimate cost elasticity to specifically examine the economies of scale in farmland scale operations. In Section 3, we focus on the study site, data collection procedures, and descriptive statistics. In Section 4, we discuss the estimation of the total cost equation and cost elasticity measures for the sample farm households and discuss the estimation results of the model. In Section 5, we show our discussion and conclusions based on the empirical results.

2. Theoretical Analysis and Methodology

2.1. Theoretical Analysis

This paper is based on Simon's hypothesis of the "finite rational economic person", that is, farmers will choose the solution with the greatest economic utility based on the goal of maximizing their own economic benefits, but due to the limitations of their own ability and objective conditions, farmers will only obtain under the condition of limited rationality. The research hypothesis of this paper is that the incentives for farmers to engage in scale operations are determined by both economic motives for production and objective conditions. Since farmers are self-interested, the purpose of conducting production activities is to maximize economic rewards, and expanding the business area for scale operation is actually a risky investment, when the expected return from expanding the scale for production is lower than the return from the original production scale, farmers will tend to avoid risks [49] and then choose to withdraw from scale operation production to return to the original farmland production mode.

In microeconomics and production economics, any industry needs certain inputs and combinations of production factors to produce a product. The products of any industry under the market economy are transformed by the production factors of input; thus, the input resources and output of farmland scale operation needs to be economically measured and judged to provide a basis for policymakers and farmers on whether further to implement the scale operation of farmland. In terms of the production function, in a production process, the movement of land reward is generally expressed in three forms of increasing, fixed, and decreasing reward. Fixed compensation as a kind of equal productivity is not common in actual production activities, so this paper incorporates it into the increasing

land compensation form. It is easy to see from Figure 1 that in the first stage of farmland production, the marginal production curve MPP reaches the most point M, and the corresponding input quantity is I. The section of the total production curve TPP from point O to point I which is convex downward is the stage of increasing payoff, and the production elasticity at this time is greater than 1; from the point I the TPP curve is convex upward into the stage of decreasing marginal payoff, and the corresponding production elasticity also begins to decrease. In the second stage, both marginal and average production decrease with the increase of variable resource inputs until the marginal production is 0. At this time, the production elasticity decreases to 0 and the total production reaches its highest point. After the total output reaches the highest point under the current production technology level, it means that the amount of variable resource input has also reached the optimal state, and it is not suitable for additional input at this time. In the third stage, the continued increase of variable resource input not only decreases marginal and average output but also decreases total output. This indicates that the resource input is meaningless at this time, so the input should be stopped at this time to reduce the loss.

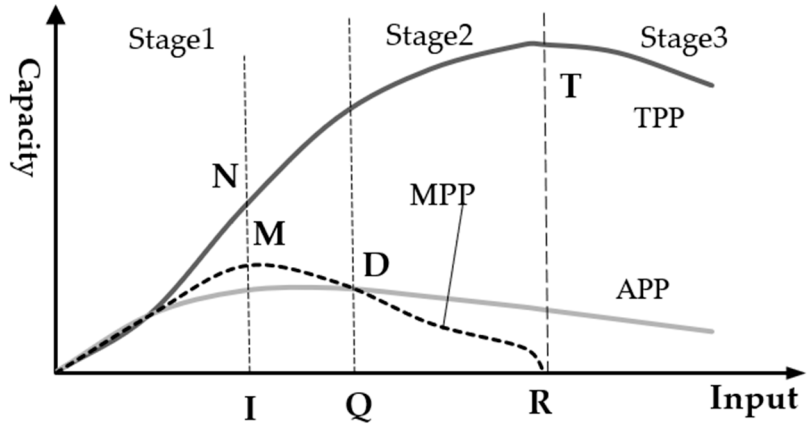


Figure 1. Three stages of land reward change.

Economies of scale generally show that large-scale production is superior, but it does not mean that the larger the scale is the better. As the scale of operation changes, the benefits for farmers are in the order of increasing, constant and decreasing states. When the reward of land scale is in the condition of incremental or constant, it is called land scale economy. Economies of scale indicate that a moderate scale is needed for farmland scale operation. The three stages of land scale payoffs (Figure 1) show that the scale of land operation is the optimal scale of operation when the land scale payoffs are constant. However, in the actual production process, due to the constraints of subjective and objective conditions, the scale of farmland operation is not always at the lowest point of long-term production cost, which means that the scale of farmland production and operation is not always at the optimal scale, so the principle of the moderate scale of land operation should be adhered to. In a certain period, as long as the land resources are fully utilized and the amount of production resources is moderate, the scale payoff of land is increasing or unchanged, not decreasing, i.e., the production elasticity is greater than or equal to 1, and the farmers' expansion of production scale will bring increasing land payoff, then it can be considered that the farmers have realized the scale economy, and conversely, if the production elasticity is less than 1, the farmers' expansion of production scale will bring If the production elasticity is less than 1, the farmers' expansion of production scale will bring decreasing returns to land scale, and the production operation is at the stage of scale diseconomies.

2.2. Methodology

The above theoretical basis of scale economy provides theoretical guidance and methodological reference for studying the economic effects of land scale management.

In fact, the development of land scale management should ultimately be based on new agricultural management subjects, such as family farms and farmers' professional cooperatives, and new agricultural management subjects, as "finite rational economic agents", decide that their motivation to carry out land scale management is to achieve economies of scale, so this paper introduces a cost function and estimates the cost elasticity. Therefore, this paper introduces a cost function and estimates the cost elasticity to examine the scale economy of land management.

The data in this paper are obtained from land scale operators in Shandong province. Since the selling price of agricultural products is passively accepted, and thus the price of agricultural products is assumed to be exogenous, the cost function is as follows.

$$C = C(S, P) \tag{1}$$

where C is the total cost of farmland production. S is the area of farmland operation, and P is the price vector of each input factor. Assuming that P includes land (P_1), labor (P_2) and capital (P_3), that model of cost function is set in the form of beyond logarithm function, i.e., Translog function, which is more flexible than the C-D function to determine the elasticity coefficient of output to cost and thus has wider application in practical research. The specific expressions are.

$$LnC = \alpha_0 + \sum_{\mathrm{i}} \partial_{\mathrm{i}} \ln P_{\mathrm{i}} + \frac{1}{2}(\sum_{i} \sum_{j} \alpha_{ij} \ln P_i \ln P_j) + \gamma \tag{2}$$

In Equation (2), LnC is the logarithmic form of the total cost of farmland production, α_0 denotes the constant, LnP_i is the logarithmic form of each input factor price vector, ∂_{i} is a set of vectors of estimable parameters for each input factor in logarithmic form, $\ln P_i \ln P_{\mathrm{j}}$ is the interaction term between input factor P_{i} and input factor P_{j} in logarithmic form, and α_{ij} is the vector of estimable parameters of the interaction term.

Based on the Taylor expansion, the second order approximation is obtained as

$$\begin{aligned} LnC = \quad & \alpha_0 + \alpha_s \ln S + \tfrac{1}{2}\alpha_{ss}(\ln S)^2 + \alpha_{s1} \ln S \ln P_1 + \alpha_{s2} \ln S \ln P_2 + \alpha_{s3} \ln S \ln P_3 + \\ & \beta_1 \ln P_1 + \tfrac{1}{2}\beta_{11}(\ln P_1)^2 + \beta_{12} \ln P_1 \ln P_2 + \beta_{13} \ln P_1 \ln P_3 + \beta_2 \ln P_2 + \\ & \tfrac{1}{2}\beta_{22}(\ln P_2)^2 + \beta_{23} \ln P_2 \ln P_3 + \beta_3 \ln P_3 + \tfrac{1}{2}\beta_{33}(\ln P_3)^2 \end{aligned} \tag{3}$$

By applying the Shephard Lemma to the first-order partial differentiation of the input factors in (3) and the first-order partial differentiation of the farmland operation scale, the cost elasticity expression of the farmland operation cost of the scale operator is obtained.

$$E_{\mathrm{s}} = \frac{\partial \ln C}{\partial \ln S} = \alpha_s + \alpha_{ss} \ln S + \alpha_{s1} \ln P_1 + \alpha_{s2} \ln P_2 + \alpha_{s3} \ln P_3 \tag{4}$$

E_s denotes the impact of a 1% change in the scale of production of farmland of farmers on the total cost. When E_s is less than 1, it means that the impact of a 1% change in farmland operation scale on total cost is less than 1%, which is at the stage of scale economy; conversely, it is at the stage of scale diseconomies; When E_s is equal to 1, for every 1% change in farmland operation scale, total production cost also changes 1%, which is at the critical point of scale economy and scale diseconomies. In Equation (4), α_s is the estimated coefficient of $\ln S$, α_{ss} is the estimated coefficient of $\ln S \ln S$, $\ln S$ is the logarithmic form of the farmer's operating area, α_{s1}, α_{s2}, α_{s3} are the estimated coefficients of the interaction term between the operating area of farmland and each input factor vector in logarithmic form, and $\ln P_1$, $\ln P_2$, $\ln P_3$ are the logarithmic forms of different input factor price vectors. The measurement process in this paper is to first estimate the regression of Equation (3), and then substitute the obtained parameter values into Equation (4) to obtain the final measurement results of cost elasticity of farmland production scale.

3. Survey and Data

3.1. Study Site

Located on the eastern coast of China, Shandong is a largely agricultural province and one of the most densely populated provinces in China, with highly dispersed small farms and land with an area of about 157,100 km^2. At the same time, Shandong is an important agricultural province and a major grain producer, with a total grain production of 55,007,000 tons in 2021, ranking third in the country and accounting for 8% of the national total (Figure 2). the total agricultural output value of Shandong reached 581.45 billion yuan in 2021, ranking second (Figure 3). Shandong is thus a typical representative region of the eastern plain of China and an important production base for achieving food security strategies.

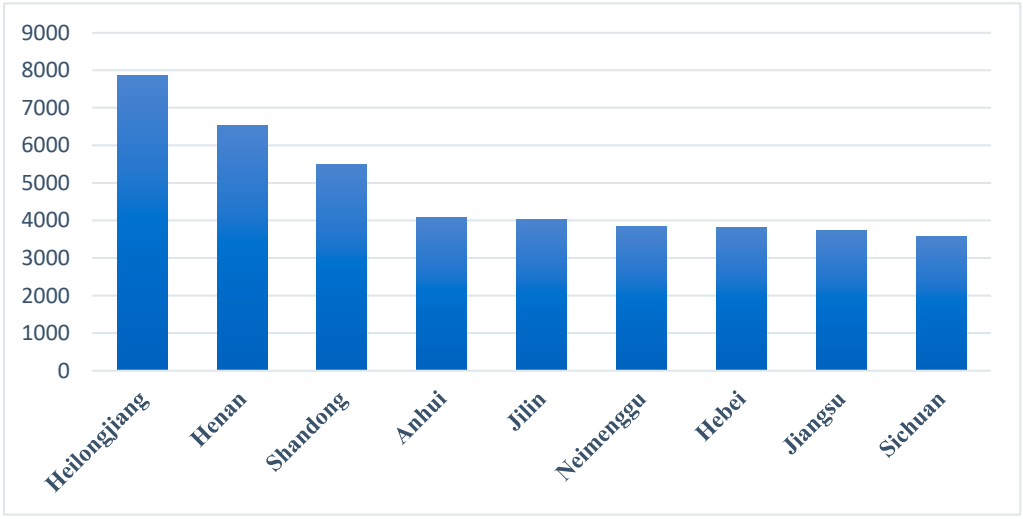


Figure 2. Total grain output by province (top9) in China in 2021. Unit: ton. Data Source China National Bureau of Statistics (CNBS).

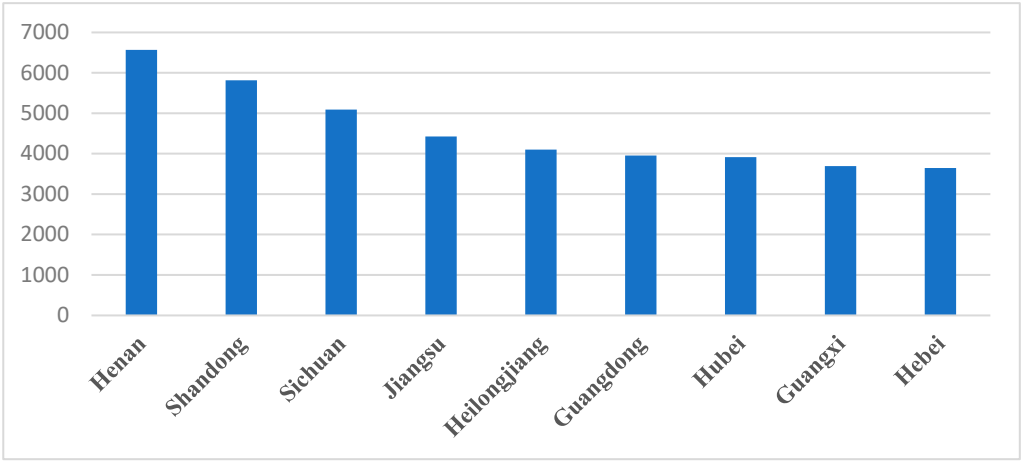


Figure 3. China's total grain output by province (top9) in 2021. Unit: billion CNY. Data Source China National Bureau of Statistics (CNBS).

Since 2014, the Chinese government has been promoting the reform of rural land property rights, including liberalizing land use rights, promoting the orderly transfer of rural land, and supporting the development of new rural business entities to promote large-scale rural land operations. Shandong has also made many positive attempts to promote the centralized transfer of rural land to large professional households or professional cooperatives and integrate idle land resources to develop large-scale farming operations; however, for productive farmers, leasing the land to develop scale management requires

consideration of cost inputs. Therefore, the cost elasticity of developing large-scale rural land management and whether it can bring economies of scale need to be assessed in terms of micro-operators.

3.2. Data Collection

The data used in this paper come from a socioeconomic survey conducted by the subject group on farm households in Shandong Province on four separate occasions in July–August and November 2020. The questionnaire of this study was divided into 2 parts with 32 questions, of which the first part was the basic situation of the household with 12 questions, and the second part was the land management situation, including 6 questions on the basic situation of farmland and 14 questions on the transfer of farmland. The survey collected detailed information on the socio-economic of farm households, including household resource endowments, individual characteristics of household members, factor inputs and outputs, land transfers, and off-farm employment. To ensure that the sample reflects the overall situation in Shandong Province as comprehensively as possible, the team randomly selected two administrative townships in Qingdao, Rizhao, Dezhou, Liaocheng, Zibo, Zaozhuang, Heze, Yantai, Dongying, Weifang, and Linyi, and in principle, three administrative villages were randomly selected from each sample township. Since the land transfer rate in Qingdao exceeded 40% and the scale operation in its sample area reached more than 75%, four administrative villages were selected in each of the sample townships in Qingdao. Finally, to ensure the validity of the questionnaire, improve the response rate and guarantee the accuracy of the data, the team chose a face-to-face survey to collect the data. In the survey process, one investigator took 1–2 h to complete a questionnaire, giving farmers sufficient time to recall information about agricultural production, and each investigator completed 2–3 questionnaires per day. To ensure the authenticity of the data, survey respondents were randomly selected in the sample villages. Since the research subjects of this paper are new large-scale management subjects, i.e., professional cooperatives and family farms, only land-lease entry households in the sample villages were interviewed, and which type of management subjects were identified by whether they formally participated in cooperatives. Our study was conducted using a random sampling method to determine the sample townships and sample administrative villages, and 10 respondents were interviewed in each administrative village by face-to-face survey, and a total of 680 farm households were surveyed, including 426 farmland rental into household questionnaires, including 146 professional cooperatives and 280 family farms. Excluding some samples with unclear production cost values, there were 395 samples of large-scale business entities, including 142 professional cooperatives and 253 family farms. The survey questions we used and related definitions are shown in Table 1. The data cover 395 scale management subjects in 68 villages of 11 cities in Shandong Province, which can reflect the current scale management situation in Shandong Province on the whole (Figure 4).

Table 1. Definition of relevant indicators.

Definition	Subitem	Abbreviation
householder characteristics	1. The age of householder	Age
	2. The education of householder	Edu
characteristics of farming households	1. The ratio of family members' off-farm employment to farm employment	Rate
farmland management	1. The operating area of farmland	S
	2. The price of renting farmland	R
	3. The price of fixed asset investment	K
	4. The price of hired labor	L
the external environment	1. The distance from the village to the city	Distance
	2. Whether to join a cooperative	Organization

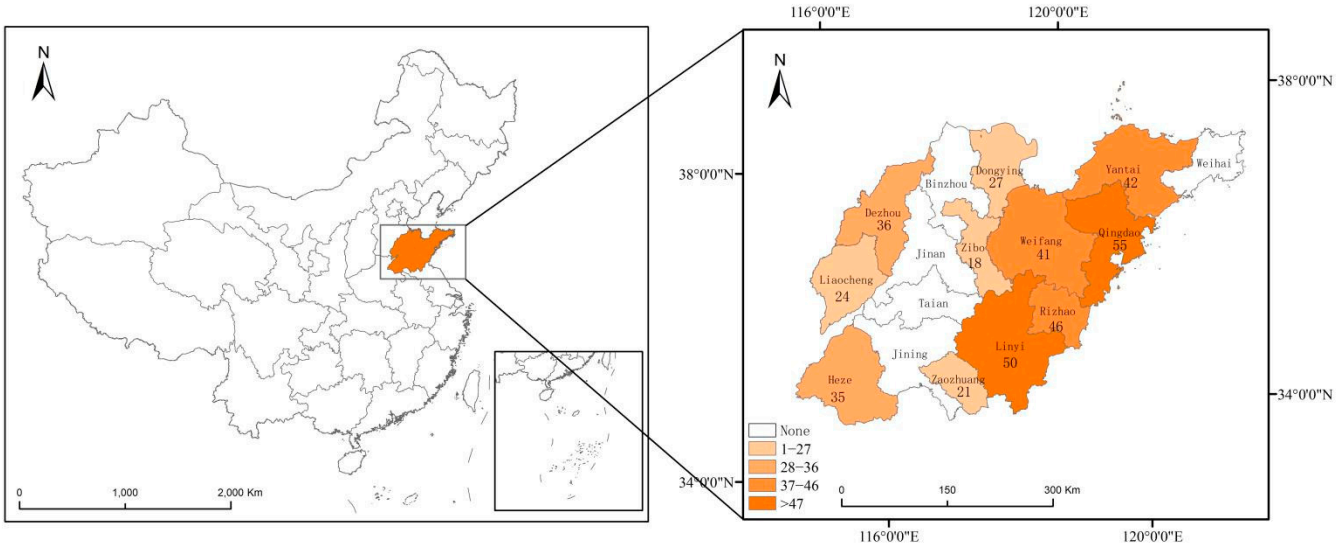


Figure 4. Map of sample area and sample size distribution.

3.3. Descriptive Analysis of the Sample

(1) In terms of the scale of land operation, it can be seen from Figures 5 and 6 that about 36.36% of the production scale of professional cooperatives are mainly concentrated in the range of 200–400 mu, with an average operation scale of 282.05 mu, while the production scale of family farms is relatively small, with about 70.91% concentrated in the range of 200 mu and below, with an average operation scale of 149.73 mu.

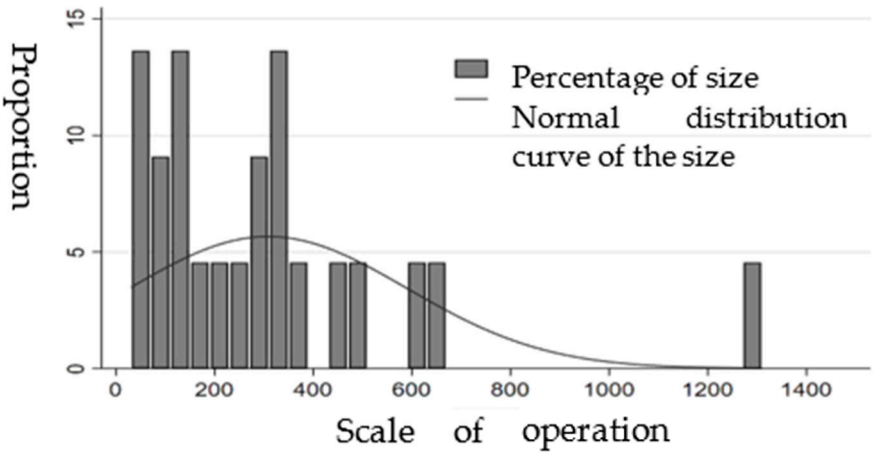


Figure 5. Distribution of professional cooperative.

(2) In terms of factor inputs (see Table 2), the operating area of professional cooperatives and family farms (*S*) differed significantly and passed the t-test at the 5% level. The mean values of total cost input (*C*) and the price of farmland transfer (*R*) in variable cost input of the two types of large-scale operators were significantly different and passed the *t*-test at the 1% level. The fixed capital input of professional cooperatives (*K*) was also significantly higher than the input cost of family farms, which might be due to the larger scale of professional cooperatives' operation and the greater demand for agricultural machinery facilities, and the large-scale concentrated operation are also provided the opportunity for Based on the consideration of production efficiency and production cost, investing zin agricultural machinery is a more rational and economic choice for professional cooperatives, while family farms are limited by the family economic conditions and relatively small operation area, and have a low demand for agricultural machinery facilities, but rely more

on human capital, which may also be the reason for the relatively small mean value of hired labor (*L*) inputs of the two types of large-scale operators. The reason for the relatively small absolute value of the mean difference.

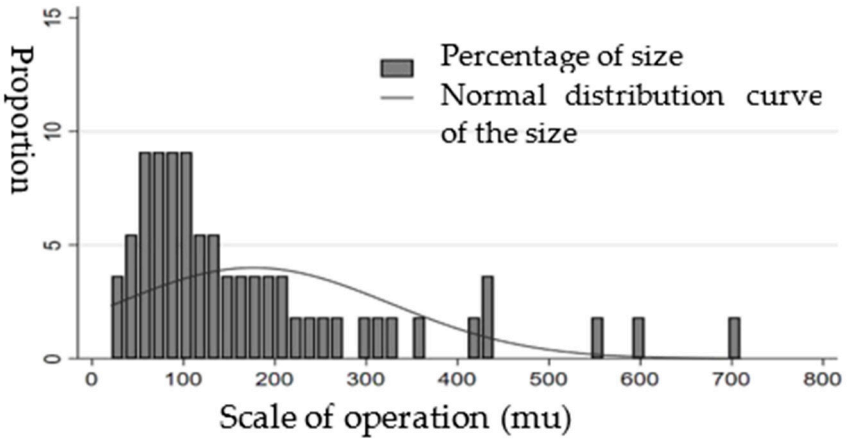


Figure 6. Distribution of family farm.

Table 2. Descriptive statistical characteristics and differences of the main variables.

Variables	Abbreviations	Total Household Operating on Scale Management		Professional Cooperatives		Family Farm		Mean Difference
		St.d	Mean	St.d	MeanA	St.d	MeanB	(H_0: A−B = 0)
Farmland operating area (mu)	S	203.72	214.22	282.05	308.30	149.73	176.60	131.77 **
Average annual total cost per unit area	C	1434.25	2352.86	1861.29	2943	1161.45	2117	826.77 ***
Farmland transfer price (yuan/mu)	R	309.95	616.38	454.79	764.60	205.53	557.10	207.51 ***
Fixed asset investment (yuan/mu)	K	1070.05	1255.54	1368.54	1572	908.76	1129	443.70
Hired labor (yuan/mu)	L	793.05	486.14	1205.85	620	556.30	432.60	187.40
Age	age	6.68	46.23	6.16	44.32	6.78	47	−2.68
Education	edu	0.88	2.57	1.08	2.73	0.79	2.51	0.22
Rate of household non-farm employment	rate	0.21	0.14	0.21	0.16	0.21	0.12	0.04
Distance from the city	distance	6.20	29.18	6.97	29.18	5.93	29.18	0

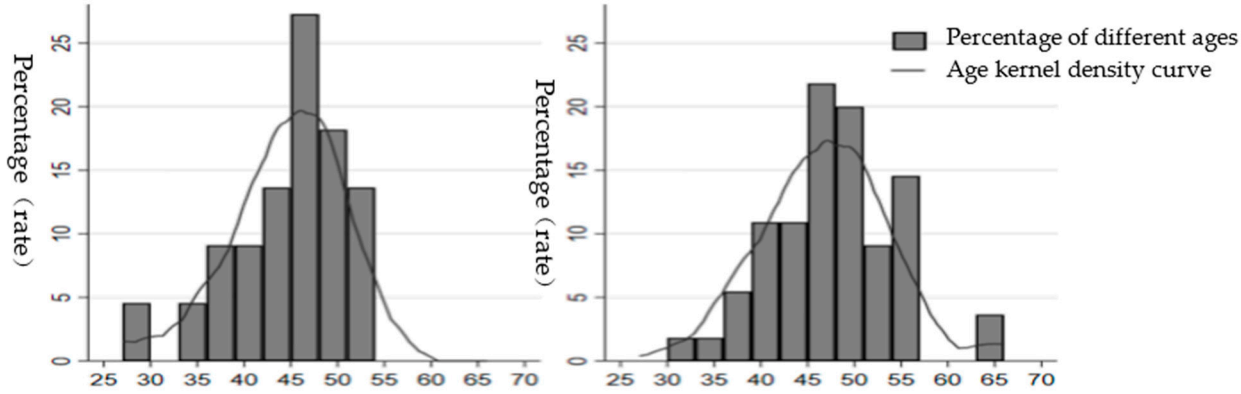
Note: *** indicates statistically significant at the 1% level, ** indicates statistically significant at the 5% level.

(3) In terms of control variables, compared with family farms, professional cooperatives have higher education level (*edu*) and nonfarm employment rate (*rate*), indicating the higher education level and more nonfarm employment opportunities, which to a certain extent represents higher overall quality of professional cooperative operators. The age distribution of both types of operators was "dromedary" (Figure 7).The average age of family farm operators is 47 years old, with a maximum of 65 years old and 24.3% of those older than 50 years old, while the average age of professional cooperative operators is 44.3 years old, with only 3.6% of those older than 50 years old, and there are no operators older than 55 years old. There are operators older than 55 years old, i.e., the aging problem of family farm operators is more serious than that of professional cooperatives.

3.4. Variable Selection and Data Testing

Strictly speaking, agricultural production is a complex production process, and its input and output forms are influenced by external factors such as technology and climate. Therefore, in this paper, "farmland operation scale" is set as the dependent variable, which is expressed by farmland operation area (*S*), and the independent variables include input factor vector and control variables of farmland operation, among which input factor vector is divided into "total operation cost per unit area" (*C*), variable cost price and fixed cost

price. Variable input costs include farmland transfer price (R) and labor input (L), while fixed costs (K) are other production factor inputs besides farmland transfer price and labor input, including seeds, fertilizers, agricultural fertilizers, agricultural films, pesticides, production utilities, hired (rented) machinery, depreciation and repair costs of fixed assets and other costs. To avoid omitted variables affecting the accuracy of the results, the following control variables were included in the model: operator's age (*age*), operator's education level (*edu*), the proportion of non-farm employment in the household (*rate*), and distance to urban areas (*dis* tan ce). Descriptive statistics for all of the above variables are presented in Table 2.



(**a**) Age of professional cooperatives (**b**) Age of family farm

Figure 7. Age kernel density of the two types of new agricultural management subjects.

4. Cost Elasticity Measure of Farmers' Farmland Scale Management

4.1. Analysis of Estimation Results

Before conducting the regression, it is first necessary to test for possible pairs of multicollinearity problems between the respective variables and analyze the correlation between the variables. The results of variance inflation factor (VIF) and tolerance level (TOL) measurement (Table 3) shows that the average variance inflation factor value of the total sample independent variables in this paper is 1.22, and the average variance inflation factors of the independent variables of the two types of business entities are 1.41 and 1.26, respectively, and the maximum VIF value is only 1.77, which is much less than 10. Therefore, the multicollinearity problem of this model is not serious, and the model is within the acceptable range, the model is within the acceptable range.

Table 3. Results of variance inflation factors and tolerance measures for each independent variable.

Total Household Operating on Scale Management			Professional Cooperatives			Family Farm		
Variables	**VIF**	**TOL(1/VIF)**	**Variables**	**VIF**	**TOL(1/VIF)**	**Variables**	**VIF**	**TOL(1/VIF)**
S	1.38	0.72	S	1.77	0.56	S	1.45	0.69
organization	1.32	0.76	distance	1.58	0.63	edu	1.43	0.70
age	1.25	0.80	K	1.49	0.67	age	1.36	0.74
distance	1.24	0.80	rate	1.48	0.68	K	1.21	0.83
edu	1.20	0.83	age	1.39	0.72	distance	1.21	0.83
R	1.15	0.87	edu	1.28	0.78	rate	1.18	0.85
K	1.11	0.90	R	1.25	0.80	L	1.12	0.89
L	1.07	0.94	L	1.06	0.94	R	1.09	0.92
Mean VIF	1.22		Mean VIF	1.41		Mean VIF	1.26	

To measure the economic effect, i.e., cost elasticity, of farmland scale operation in Shandong, in this paper, we use the software Stata16.0 to estimate the total cost Equation (3)

for the farmland operation sample. Because cross-sectional data may bring heteroskedasticity and thus affect the accuracy of the results, this paper performs robust standard error treatment based on the OLS model. It performs clustering standard error treatment for professional cooperatives and family farms based on a small sample OLS model. The results are shown in Table 4.

Table 4. Estimation results of the cost function of the scale business subject.

Total Household Operating on Scale Management				Professional Cooperatives				Family Farm			
Explanatory Variables	**Coef.**	**Coef. Estimates**	***p*-Value**	**Explanatory Variables**	**Coef.**	**Coef. Estimates**	***p*-Value**	**Explanatory Variables**	**Coef.**	**Coef. Estimates**	***p*-Value**
LnS	α_s	0.616	0.479	LnS	α_s	6.828	0.111	LnS	α_s	−0.648	0.42
LnR	β_r	−0.06	0.956	LnR	β_r	−0.563	0.803	LnR	β_r	−0.094	0.96
LnK	β_k	2.226	0.038	LnK	β_k	−17.813	0.034	LnK	β_k	0.034	0.967
LnL	B_l	−1.672	0.109	LnL	B_l	7.563	0.029	LnL	B_l	−1.298	0.178
LnSLnS	α_{ss}	−0.108	0.074	LnSLnS	α_{ss}	−0.144	0.31	LnSLnS	α_{ss}	0.034	0.079
LnSLnR	α_{sr}	0.091	0.391	LnSLnR	α_{sr}	−0.205	0.18	LnSLnR	α_{sr}	−0.019	0.824
LnSLnK	α_{sk}	−0.16	0.05	LnSLnK	α_{sk}	−0.172	0.334	LnSLnK	α_{sk}	−0.044	0.214
LnSLnL	α_{sl}	0.167	0.074	LnSLnL	α_{sl}	−0.509	0.148	LnSLnL	α_{sl}	0.131	0.061
LnRLnR	β_{rr}	0.164	0.086	LnRLnR	β_{rr}	−0.112	0.308	LnRLnR	β_{rr}	0.148	0.203
LnRLnL	β_{rl}	0.214	0.123	LnRLnL	β_{rl}	1.135	0.004	LnRLnL	β_{rl}	0.136	0
LnRLnK	β_{rk}	−0.46	0	LnRLnK	β_{rk}	−0.305	0.004	LnRLnK	β_{rk}	0.099	0.008
LnLLnL	β_{ll}	0.039	0.338	LnLLnL	β_{ll}	0.588	0.151	LnLLnL	β_{ll}	−0.176	0.112
LnLLnK	β_{lk}	−0.102	0.114	LnLLnK	β_{lk}	−0.097	0.609	LnLLnK	β_{lk}	−0.023	0.785
LnKLnK	β_{kk}	0.17	0	LnKLnK	β_{kk}	−0.107	0.13	LnKLnK	β_{kk}	−0.023	0.524
age	γ_1	0.004	0.629	age	γ_1	0.001	0.906	age	γ_1	0.006	0.01
edu	γ_2	−0.054	0.353	edu	γ_2	−0.138	0.133	edu	γ_2	−0.001	0.952
distance	γ_3	−0.005	0.555	distance	γ_3	0.038	0.044	distance	γ_3	−0.001	0.807
organ	γ_4	−0.2	0.12	rate	γ_4	−0.708	0.061	rate	γ_4	0.132	0.168
Constants	α_0	0.642	0.899	Constants	α_0	28.892	0.005	Constants	α_0	9.526	0.339
R^2		0.737		R^2		0.993		R^2		0.908	

From the estimated coefficients of the model, it can be seen that: (1) the coefficient signs of cost factor inputs of total scale operators are basically consistent with theoretical expectations, and LnK and LnL both pass the significance test, and among the interaction terms of LnS and the price vector of business area and each production factor input (R, K, L), all pass the significance test except $LnSLnR$, which does not pass the significance test. (2) In the analysis of the heterogeneity of new business entities, it can be seen that there are significant differences between the regression results of professional cooperatives and family farms, and only the coefficients of LnR among the four cost-related variables have the same sign. *age* For family farms, the negative coefficient value of LnS indicates that the larger the scale of operation, the lower the cost; the negative coefficient value of LnL and the positive coefficient value of LnK indicate that expanding the area of operation will increase the fixed capital investment, but not the cost of hired labor, because family farms rely more on their own family labor. Only the operator's age (*age*) passed the significance test at the 1% level and had a positive sign, indicating that family farms rely on the operator's accumulated farming experience to achieve cost savings and income increases. For professional cooperatives, LnK and LnL both pass the significance test, where the coefficient of LnK is negative, contrary to the coefficient of LnL. The distance from urban areas (*dis* tan *ce*) and the proportion of non-farm employment in the household (*rate*) are more significant among the control variables, which also show the importance of the employment cost of the operator and the degree of part-time employment on the scale management of farmland.

4.2. Economy of Scale Measurement and Heterogeneity Analysis

According to the estimation results of the cost function in Table 4, the cost elasticity results of scale operators in Shandong province are obtained by combining with Equation (4) (see Table 5), from which it can be seen that scale operators are in the stage of economy of scale as a whole, and the cost elasticity values of total scale operators and professional cooperatives are 0.49 and 0.63, which indicates that for every 1% expansion of production scale, their total production costs will increase by 0.49% and 0.63%, respectively The cost

elasticity value for family farms is −0.017, which indicates that for every 1% increase in production scale, the production cost will instead decrease by 0.017%. The above results show that no matter which scale management subject has the incentive to expand production scale in theory, the area of farmland scale management can continue to increase, and the expansion of farmland management scale can bring higher economic returns and can obtain the scale reward.

Table 5. Cost elasticity values of each scale operator.

	Total Household Operating on Scale Management	Professional Cooperatives	Family Farm
Cost elasticity value	0.49	0.63	−0.017

Based on the results of cost function estimation and cost elasticity measures, the following analysis can be made.

1. Overall analysis. The coefficient of *LnS* for total scale operators and professional cooperatives are positive because the cost of farmland will increase as the scale of farmland operation expands, while the sign of the coefficient of *LnS* for family farms is negative because they are at the stage of the economy of scale, and as the scale of operation gradually expands, factor inputs such as large machinery will be more fully utilized, and thus the cost per unit area will show a gradual decrease.

2. Comparative heterogeneity analysis. (1) Among the variables related to costs, for the sign of the coefficient of *LnSLnR*, the sign of the coefficient is positive for total scale operators and negative for both professional cooperatives and family farms. For total scale operators, the expansion of operation scale will inevitably require a land transfer, and most of the land transfer occurs within the transfer market, and the increase in land rent will inevitably bring about an increase in marginal cost; while for professional For professional cooperatives and family farmers, part of their expanded operation area comes from the internal transfer among members of the cooperatives or acquaintances, and the price is often slightly lower than the market price. Thus, the increase of land rental cost is not synchronized with the expansion of the operation scale. (2) For the coefficient sign of *LnSLnK*, all three coefficient values are negative. The unit fixed capital input reflects both the operator's investment level and, to a certain extent, the depreciation rate of fixed assets, which, in this paper, mainly contains direct material costs (such as seeds, fertilizers, pesticides, mulch, etc.) and other direct costs (such as machinery operation costs, irrigation costs, water and electricity costs, etc.), assuming that the production technology Assuming that the production technology remains unchanged and the unit direct material cost and irrigation and water and electricity costs do not change, the depreciation cost of fixed assets apportioned to the unit area by expanding the scale of operation is reduced, which is consistent with the theory of economy of scale, and the total number of scale operators *LnSLnK* also passed the significance test. (3) For the coefficient value of *LnSLnL*, the coefficient values of total scale management households and family farms are positive and significant, indicating that the increase of labor cost is synchronized with the expansion of operation scale, while the coefficient value of professional cooperatives is negative, which suggests that the use of agricultural machinery instead of labor will be the development direction of scale management of farmland, when more and more labor flows into the nonfarm employment sector, reducing the dependence of agricultural productions on labor, developing Mechanized agricultural production will make a significant contribution to cost saving and development of economies of scale. (3) For the coefficient signs of the control variables, the three coefficient signs of operator's age (*age*) and operator's education (*edu*) are consistent, which indicates that operators with rich farming experience and good education are an important stock of human capital and can bring a significant contribution to the positive effect of reducing production costs and developing scale management.

5. Discussion and Conclusions

5.1. Discussion

5.1.1. Farmland Scale Management Should Be Fully Considered the Realization of Scale Economy

Compared to other industries, agricultural production investment is large, but returns are slow. Land scale management aims to use land resources and effectively reduce production costs, to increase grain yield and ensure food security and income of farmers. Many developed countries have large-scale farms, while according to China's National Bureau of Statistics, about 92.49% of China's farms are smaller than 30 mu (or 4.94 acres). In such a smallholder-dominated context, agricultural policies tend to encourage small farmers to transfer farmland to develop large-scale farm operations. In China, it has been argued that increasing agricultural productivity requires developing scale management through farmland transfer. These studies mostly focus on the expansion of agricultural land operation area, land production efficiency, agricultural land input and output, and the welfare of the micro main farmers [50–55], but further examination is needed to determine whether the scale operations formed after the transfer can achieve economies of scale. Some farmland scale operators may rely on government subsidies to develop scale operations. Without subsidies, their operations would be diseconomies of scale. This consequence is not conducive to the future Chinese land scale management.

5.1.2. China's Agricultural Modernization Should Cultivate New Scale Management Operators

In the case of Shandong Province, we have shown a possible path for shifting the flow of farmland from smallholders to efficient operators in developing countries, thus achieving economies of scale. First, cultivating new agricultural management subjects, such as professional cooperatives, which can allow for larger farmland scale. Second, reducing operating costs by developing agricultural mechanization and improving the quality of agricultural labor. Third, to form a healthy and orderly farmland transfer business ecology by building a farmland transfer platform, an organization that unites government, enterprises and farmers, which can effectively reduce the transaction costs of farmland transfer, save production costs and thus achieve economies of scale.

The modernization of agriculture in China has been carried out along two paths, one of which is the modernization of agriculture in the form of "enterprises + farmers", "cooperative economic organizations + farmers" and "large professional households + farmers". The other is the modernization of agriculture through land transfer in the form of scale management. The family farm with moderate scale management is the most suitable agricultural business unit in China, however, due to the special nature of agriculture, even the larger scale farm cannot internalize market-oriented services within itself, thus the marginal benefit growth of participating in professional cooperatives is greater, therefore, this paper considers the heterogeneity of family farms and cooperatives, and by comparing the cost elasticity coefficients of the two, it is found that the current development of family farms with scale operation degree is lower than that of cooperatives. Secondly, it is very much worth observing and warning that farmland rent is an important factor that cannot be ignored, and it is rising sharply again after the farmland transfer tends to scale management. In the past, when small-scale farmers were engaged in business, farmland was a shadow cost. Now that farmland has been transferred to large-scale operators, the invisible cost of land has been made visible. If land rents are allowed to continue to rise, determined entirely by the market, it will certainly affect further large-scale farmland management, thus negatively affecting China's agricultural modernization and international competitiveness.

5.2. Conclusions

Taking Shandong province as an example, this paper estimated the cost elasticity value by constructing a cost function model and conducted an empirical analysis from a microscopic perspective on whether the scale operation after the transfer of farmland can

realize the economy of scale effect. The empirical results show that the cost elasticity of the scale operation subjects formed after the transfer of farmland is less than 1. Therefore, promoting the transfer of farmland and cultivating new agricultural management subjects can effectively promote the scale operation of farmland, save production costs and thus realize scale benefits.

The moderate concentration of farmland operation scale is the future development direction of Chinese agriculture and the inevitable result of future industrialization and urbanization. Given this approach in Shandong Province, the reality is that future Chinese policy should emphasize the following three areas: first, from the empirical analysis of this paper, it can be seen that the price of farmland transfer is a key factor affecting the cost of farmland operation, and the government should build a platform for farmland transfer to reduce the cost of farmland transfer and transaction costs, in addition to increasing the subsidies for farmland transfer, giving policy support and price subsidies, doing a good job of all-round subsidies, and effectively reducing the price cost of farmland transfer in multiple directions. The price cost of farmland transfer should be reduced in many aspects. Secondly, fixed capital input and labor input also significantly affect the cost of farmland operation. Under the premise of a fixed scale of farmland operation, the relationship between agricultural machinery and agricultural labor is mutually exclusive, the higher the degree of agricultural mechanization, the less labor is required for farmland operation accordingly. From the viewpoint of short-term production theory in economics, if sufficient mobile capital and labor are invested, even a small-scale farmland operation area can increase land productivity. From the long-term production theory, the larger the farmland operation, the more the fixed assets can be fully utilized and the lower the cost apportioned to the unit farmland area will be, and there are economies of scale. When the price of the labor factor increases, replacing labor input with capital factor can reduce production cost. Therefore, considering the long-term interests of the society, the government should strengthen the infrastructure construction of farmland and the level of agricultural mechanization, especially under the realistic background of China's rapid urbanization and the transfer of a large amount of rural labor to non-agricultural employment, increasing the proportion of capital input and developing agricultural mechanization can reduce operating costs and maximize economic benefits. Third, strengthen the scientific and technological training for business subjects, motivate high-quality talents to devote themselves to the agricultural production process, improve the comprehensive quality of local operators in all aspects, and cultivate new types of professional farmers. Improve the level of local socialized service construction to solve the problem of low production technology and lack of management experience of scale management subjects.

The limitation of our study is that the data come from some of the demonstration areas of land reform in Shandong province. The subsequent study can expand the sample scope to include more areas with different levels of economic development, and on the basis of more abundant data, we can study in groups according to different scales, so that we can have a deeper understanding of the impact of scale management on the operating costs of farmers of different scales.

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