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Original Research

The Impact of Farmland Transfer on Agricultural Production Efficiency: Scale Effect or Selection Effect?

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Abstract

Based on the data of 2015 China Household Finance Survey (CHFS), this paper applies the intermediary effect model to identify the intermediate transmission mechanism in which farmland transfers affect agricultural production efficiency. The results show that the output value of households that have transferred farmland is increased by about 27% more than those that have not. In addition, the transfer of farmland has a more significant impact on the agricultural production efficiency of young and middle –aged families. The transfer of farmland from grain production areas has an increased tendency to household output value. The mechanism analysis shows that the transfer of farmland affects agricultural production efficiency in the following two ways. On the one hand, the transfer of farmland can help realize the effective replacement of labor by machinery, increase the mechanization degree of agricultural production, and realize the scale effect of farmland. On the other hand, based on the maximization of their own interests, farmers prefer to plant cash crops and improve agricultural production efficiency through the selection effect. By comparing the above two effects, we found that the planting selection behavior of compacting grain and expanding economic growth is more prominent. Therefore, this article proposes to promote the development of the farmland transfer market and make use of scale advantage. Meanwhile, the self-selection behavior of transferred farmers in planting crops should be valued and young people with advanced concepts to engage in agricultural production activities should be introduced, which inject "fresh blood" into agricultural modernization. However, we should also keep the red line of farmland and alert the phenomenon of "non-agricultural" and "non-grain" in the transfer of farmland.

Keywords: farmland transfer, agricultural production efficiency, scale effect, selection effect, China

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Introduction

The report of the 19th National Congress of the Communist Party of China proposed to develop various forms of appropriate scale management and cultivate new types of agricultural management subjects [1]. In 2021, the central "No. 1 document" once again pointed out that it will encourage the development of various forms of moderate scale management, implement the family farm cultivation plan, cultivate large-scale agricultural households into dynamic family farms, and promote the construction of a modern agricultural management system. The traditional agricultural production organization in China is mainly small-scale peasant management, and peasant households are the basic contracted management units of land [2]. However, with the acceleration of the urbanization process, the transfer of rural labor force has become more and more obvious, and farmers who are fully engaged in agriculture have gradually changed to part-time households mainly based on agriculture, and then to part-time households mainly based on non-agricultural operations [3], and the transformation of small-scale peasant management to large-scale management is a general trend [4]. The data of the third national agricultural census show that there are 230 million households in China, the total area of farmland is calculated according to 2.025 billion mu, and the average household management scale is 8.8 mu [5]. In 2016, the cultivated area of large-scale agricultural operation accounted for 28.6% of the total actual farmland volume, and by the end of 2018, the country's farmland circulation area exceeded 530 million mu [6].

According to the practice of developed countries, agricultural development depends on science and technology, but also dependent on land, China's "13th Five-Year Plan" also clearly put forward the implementation of "grain storage in the land, grain storage in technology" strategy, and whether it is the choice of technology or land use, behind it can not be separated from the organization of agricultural production [7]. Land transfer and moderate scale management are the only way to agricultural modernization [8], which is conducive to the contiguity and organization of agricultural production layout, thereby improving agricultural productivity, promoting agricultural efficiency and increasing farmers' income [9]. Under the basic national conditions of large population and less land, the transfer of farmland management rights is entrusted with the important task of expanding scale management, improving agricultural production efficiency and realizing agricultural modernization [10]. Therefore, the question that needs to be considered is, what is the mechanism of the transfer of farmland management rights affecting agricultural production efficiency? Is it due to the "scale effect" brought by the land contiguous or the "selection effect" produced in the process of the operator's main change? To clarify the internal mechanism and the complex nonlinear relationship between variables is of great significance for our country to deepen our understanding and take accurate measures.

Literature Review and Research Hypothesis

Literature Review

Land transfer is actually the transfer of land management rights, which is the economic behavior of transferring farmers' land management rights to other farmers or organizations under the premise of ensuring the unchanged land contract rights [11]. The relationship between land circulation, scale management and agricultural production efficiency is a classic issue in the field of development economics [12]. Due to the temporal and spatial differences in agricultural development, land management scale and productivity may present diversified characteristics [13]. For example, developed countries have entered the stage of modern agriculture, and mechanization and information technology have been widely promoted in the process of agricultural production, and the phenomenon of increasing returns to scale is obvious [14]. However, in some developing countries, due to the differences in the production capacity and soil quality of the transferred households in the process of land transfer, there are conflicting conclusions in the empirical studies [15]. In this regard, the relevant discussions include the following aspects.

First, taking Russia, India, Brazil, Malaysia and other countries as samples, it is found that small farms in these countries have higher yields per mu, and there is an "inverse relationship" between land productivity and agricultural production scale. Wei et al. (2020) [16] found in his study on Zhejiang that as high-ability farmers withdrew from agriculture, the transfer of farmland might lead to the land flowing into the hands of inefficient farmers. At the same time, unstable land rights may reduce farmers' expectations of investment returns brought by transferred land, weaken farmers' motivation to increase investment, and reduce agricultural production efficiency. However, this relationship is not absolute. After Sam Desiere and Dean Jolliffe (2018) [17] introduced land quality into the model, the inverse relationship weakened. Xiaojun Deng (2020) [18] found that the inverse relationship between output and production scale was only valid in traditional agriculture without considering technical factorsSecond, it believes that there is a significant positive correlation between the scale of operation and agricultural production efficiency [19], based on the fact that the expansion of the scale of operation can reduce the degree of land fragmentation and alleviate the indivisibility of agricultural machinery and other factors, so as to achieve economies of scale [20]. Lu et al. (2018) [21] believes that farmers' transfer to adjacent plots of their own plots can effectively solve the current problem of farmland fragmentation and contribute to

the use of advanced machinery and equipment. Lu et al. (2022) [22] found that with the promotion of large-scale agricultural land management, China's grain yield per unit area increased from 5,553 kg/ha in 2015 to 5,621 kg/ha in 2018. With the promotion of new agricultural technology, the adjustment of agricultural management mode and the rapid development of labor and land market, the input quantity and structure of agricultural production factors will change, and the inverse relationship between agricultural land management scale and land productivity will gradually disappear [23]. According to the study of Liu et al. (2022) [24], the differences in land productivity of farmers of different scales in the process of land transfer may be due to the heterogeneity of farmers and land, and the expansion of land management scale will not affect grain yield per unit area in general.

Third, Feng et al. (2021) [25] believe that with the expansion of agricultural land scale, the diversity and complexity of on-site processing of agricultural production will exceed the ability of family management, resulting in an increase in organizational management costs, which may lead to the phenomenon of agricultural land scale diseconomy. There is not a simple linear relationship between operation scale and agricultural production efficiency, but there is an "optimal" farmland operation scale. Abdulhakim Mohamed Abdi (2020) [26] found that current studies on agricultural land management scale and productivity are often limited to a single scenario of small or large scale, and cannot identify changes in agricultural productivity during the transition from small scale to large scale.The contradictions of the existing research conclusions indicate that the relationship between land transfer and agricultural production efficiency still needs to be further deepened and expanded under the new framework [27]. First of all, most of the existing studies adopt the “black box” analysis model, which fails to investigate the channels through which land transfer affects agricultural production efficiency from the mechanism [28]. Although some scholars have discussed the role of farmland transfer in optimizing the allocation of farmers' farmland resources, most studies have failed to further investigate whether this mechanism has brought about the improvement of the average output value of households per mu at the micro level [29]. Secondly, whether households participate in land circulation is a "self-selection" and "non-random" behavior, which may cause endogeneity problems in model estimation [30]. In this regard, this paper uses the intermediary effect model to measure the intermediate transmission mechanism of farmland management right transfer affecting agricultural production efficiency, and complements and improves the existing research. In order to avoid the endogeneity problem caused by sample selection, this paper chooses the propensity score matching method to get more consistent and reliable conclusions. At the same time, further deepen the understanding of the internal mechanism of farmland transfer affecting agricultural production efficiency, and make up for the deficiency of the existing literature on the effect of farmland transfer.

Research Hypothesis

There are differences in the influence on agricultural production efficiency before and after the transfer of farmland management rights [31]. To be specific, under the household contract responsibility system, most areas in China have adopted a land distribution method based on population, which greatly liberates productivity, but also causes serious fragmentation and decentralization of farmland, hindering the improvement of agricultural production efficiency [32].

The transfer of farmland management rights promotes the centralized and large-scale cultivation of farmland, which is conducive to the introduction and use of agricultural machinery, the effective replacement of labor force, the reform of backward agricultural production mode, and then the scale effect of farmland management and the improvement of agricultural production efficiency [33]. Accordingly, this paper proposes:

Hypothesis 1: The transfer of farmland management rights improves agricultural production efficiency through scale effect.

According to the basic theory of agricultural economics, the most direct impact of the transfer of land management rights is to change the planting behavior of farmers, and then affect the agricultural production efficiency [34]. Before the management right of family farmland was transferred, most farmers kept their own “one mu and three plots”, and farmland resources were mostly used for planting their own food crops and a few were used for planting cash crops [35]. After the transfer of farmland management rights, farmers, as rational economic people, will change their agricultural production goal from maximizing output to maximizing income, which will also cause farmers’ planting behavior to tilt and change to cash crops, and improve agricultural production efficiency by planting cash crops with high added value [36]. Accordingly, this paper proposes:

Hypothesis 2: The transfer of farmland management rights improves agricultural production efficiency through selection effect

Due to the large differences of domestic farmers, the effect of the transfer of farmland management rights on agricultural production efficiency may be affected by the heterogeneity of farmers [37]. Generally speaking, the age of farmers can indirectly reflect the time and experience of farmers engaged in agricultural production, and farmers with more experience may have better agricultural production technology, thus improving agricultural production efficiency. However, older farmers may be less sensitive to market prices, and it is difficult to adjust their production structure according to changes in agricultural prices. Young

and middle-aged households may be more sensitive to changes in market prices, and timely adjust the choice of planting high value-added cash crops, so as to improve agricultural production efficiency [38]. Therefore, this paper concludes that the transfer of farmland management rights has a more significant effect on the agricultural production efficiency of young and middle-aged households than that of elderly households. In addition, compared with non-grain main producing areas, the level of resource endowment and material equipment in major grain-producing areas are higher than that in non-grain main producing areas, and farmers may be more affected by the transfer of farmland management rights. Therefore, this paper concluded that the transfer of farmland management rights has a trend of improving the household agricultural production efficiency in the main grain producing areas compared with the non-main grain producing areas. Accordingly, this paper proposes:

Hypothesis 3: The transfer of farmland management rights to young and middle-aged farmers has a more obvious effect on improving agricultural production efficiency. The transfer of farmland management rights in major grain producing areas may have a more obvious effect on the improvement of agricultural production efficiency.

Materials and Methods

Data Sources

The data used in this paper are from the 2015 China Household Finance Survey (CHFS). China Household Finance Survey data has been carried out since 2009, and the China Household Finance Survey is conducted every two years. The third round of survey in 2015 covered 29 provinces, 351 counties (districts and county-level cities), and 1,396 village (residential) committees, with a sample size of 37,289 households. The database has a wide range of information, and the questionnaire records agricultural subsidies, individual characteristics of farmers, household income of farmers, land area owned by farmers, agricultural input and other information in detail, which provides good data support for this paper to analyze the impact of the transfer of farmland management rights on agricultural production efficiency. Since the transfer of farmland management rights, a peasant household behavior, mainly involves households engaged in agricultural production activities, the sample excluded households that did not participate in agricultural activities, and finally obtained an effective sample size of 5555 households in 2015. In the actual analysis, due to the absence of some variables, the valid sample will be differeVariables selection

Explained variable: agricultural production efficiency. In previous studies, some scholars used total factor productivity and some used single factor productivity, but the focus of this paper is not TFP, so single factor productivity is adopted. Although some studies use crop yield per unit of land to express production efficiency, the average output value per mu can better indicate the ability of farmers to obtain income from agricultural production. Therefore, the average output value per mu is selected as the agricultural production efficiency in this paper, and based on the situation of “your family’s conversion to farmland" in the questionnaire in 2015, it is known that farmers are mainly engaged in grain planting and cash crop planting after transferring to farmland, while the proportion of farmers engaged in animal husbandry and fishery breeding is relatively small. Therefore, the sum of the output value of food crops and the output value of cash crops is selected as the total agricultural output value in the narrow sense, and the average output value per mu is obtained from (the total agricultural output value/farmland area in the narrow sense).

1. Core explanatory variable: whether to transfer to farmland management right. The land transfer system provides space for farmers to allocate resources more reasonably. The 2015 CHFS questionnaire designed 'At present, is your home transferred to farmland?' and 'At present, is your family's farmland management right transferred to others or institutions? The family with the answer of yes to the former is set as the treatment group. The control group refers to the family that has neither transferred into nor transferred out the management right of farmland.

2. Other control variables: Referring to the selection of control variables in existing literature, four groups of control variables are selected in this paper. The first group of control variables is the family demographic characteristics, which mainly analyzes the behavior of farmers from the family level. The decisions of farmers are mostly joint decisions at the family level, including the total population of the family, the number of full-time farmers in the family, the average age of the family, the number of party members in the family, the number of family members with high school education and the number of family members with college education or above. The second group of control variables is the resource endowment characteristics of rural households, including the amount of agricultural subsidies received by the household, the type of agricultural production and operation, the quality of farmland, whether the household has livestock for agricultural production, whether the family uses agricultural machinery for production, and the number of people with pension insurance. The research shows that the richer the existing material resources and planting experience of rural households, the greater the impact on agricultural production efficiency. The third group of control variables is the characteristics of family risk preference, which mainly includes whether the family is willing to take risks. The fourth group is a regional dummy variable. The sample data is not evenly distributed in each province, and the economic development level of each province is unbalanced. The development of

economic level restricts the willingness and enthusiasm of local farmers to participate in land transfer. Therefore, the paper added provincial fixed effect, whether it is rural or not, and other regional characteristic variables, and empirically tested the possible impact of the transfer of farmland management rights of farmers in different regions on agricultural production efficiency.

Table 1 provides the descriptive statistics of the treatment group, the control group and the total sample in 2015, respectively. The treatment group refers to the families that have transferred the management right of farmland, and the control group refers to the families that have not transferred the management right of farmland. By comparing the treatment group with the control group, it is found that the treatment group has higher average output value per mu compared with the control group, which is consistent with the theoretical expectation. Although it can be seen from the data description that the average output value per mu will increase after the family transfers to the management right of farmland, whether the two are related still needs rigorous empirical analysis.

Model Specification

This paper mainly studies the effect of the transfer of farmland management rights on agricultural production efficiency. There may be significant differences in household population characteristics and resource endowments between the families whose farmland management rights have been transferred (the treatment group) and the families whose farmland management rights have not been transferred (the control group), so there may be sample self-selection problem. In this case, if only the traditional analysis method is used for regression, the estimation results will inevitably be biased. In this paper, propensity matching score method was first adopted to achieve data balance, so that there was no significant difference between the treatment group and the control group in the observable feature variables, and the endogenous bias caused by sample selection was solved as far as possible. Another advantage of using propensity scores is that if the observable variables in the household are quite different, the non-observable variables are more likely to be quite different. Therefore, the influence of these unobservable variables with large differences on the estimation results can be reduced by propensity score matching. There are many kinds of matching methods for propensity score, such as near neighbor matching, radius matching, Markov matching and kernel matching. In this paper, the nearest neighbor combined radius matching method is used to ensure the robustness of data matching results and achieve data balance, and the kernel matching method is used to test the robustness of robustness analysis. The nearest neighbor combined radius matching method is a one-to-one matching strategy. First, the samples of the processing group are randomly sorted, and then a control group with the closest distance is found for each processing group according to the random order, and a propensity score range is set. Samples exceeding the range will be eliminated and a new sample data will be formed. The nearest neighbor association radius matching method needs to control the propensity score between the matching samples within a certain range. Secondly, in order to investigate the impact of the transfer of farmland management rights on agricultural production efficiency, this paper constructs the following benchmark model:

$$\mathrm{L}n(Per\_value_i) = \beta_0 + \beta_1(dum\_area_i) + \sum \beta_m X_{mi} + \varepsilon_i$$

Where, L$n(per_value_i)$ represents the average output value per mu of farmer family i in logarithmic form. dem_area_i represents the dummy variable of whether family i is transferred to the management right of farmland. β_1 represents the regression coefficient, which measures the effect of household transfer of farmland management rights on agricultural production efficiency. X_{mi} represents the control variable, β_m is the regression coefficient of the control variable, and ε_i is the random disturbance term.

Results

In the study of the impact of the transfer of land management rights on agricultural production efficiency, there may be significant differences in population characteristics and resource endowment between the transfer of land management rights (the treatment group) and the households without the transfer of land management rights (the control group). Therefore, there may be a sample self-selection problem. In order to solve this problem, this paper adopts propensity score matching method. To be specific, logistic regression and maximum likelihood estimation are used to take whether the management right of farmland is transferred as the dependent variable, and all independent variables are only taken as the primary term as the basic model. The quadratic term and interactive term of each variable are added one by one by using progressive regression, and LR values of the embedded model and the basic model are compared to determine whether the quadratic term or interactive term should be included in the model. The LR model value of the entry threshold of the independent variable is 1. When LR>1, the variables selected were total population of the family, average age of the family, number of family members with high school education, whether they were large professional households, whether they were agricultural cooperatives, whether they had livestock used for agricultural production, and whether the family was willing to take risks. Similarly, the LR value of the quadratic term of the independent variable (including the interaction term) entering the match is 2.71. When LR>2.71, the interaction items selected are: whether the family has

Table 1. Descriptive statistics of variables.

Variable	Treatment group		Control group		Total sample	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Average output value per mu (logarithmic form)	7.38	1.10	7.09	0.97	7.15	1.01
Net output value per mu (Yuan)	1378.90	2717.24	1077.72	2242.59	1140.29	2351.38
Total family population	4.09	1.63	3.93	1.73	3.97	1.71
Average family age	40.14	11.87	42.84	13.13	42.28	12.92
Number of family members with high school education	3.22	1.51	3.07	1.54	3.10	1.53
Number of family members with university degree or above	0.01	0.08	0.o1	0.08	o.o1	0.08
Household party membership	0.14	0.36	0.15	0.38	0.15	0.38
Whether it is an agricultural enterprise	0.00	0.05	0.01	0.07	0.00	0.06
Whether it is an agricultural cooperative	0.02	0.13	0.o1	0.09	0.01	0.10
Whether it is a professional big family	0.02	0.14	0.00	0.06	0.01	o.09
Whether it is a family farm	0.00	0.05	0.00	0.07	0.00	0.07
Quality of farmland	2.69	0.99	2.70	0.97	2.70	0.97
Agricultural subsidy amount	717.95	1450.51	532.36	2044.73	570.78	1938.87
Whether to use agricultural machinery production	0.57	0.50	0.33	0.47	0.38	0.49
Whether it is used for agricultural production of livestock	0.17	0.37	0.11	0.32	0.13	0.33
Number of full-time farmers	7.12	3.59	6.70	3.76	6.79	3.73
Whether families are willing to take risks	0.25	0.43	0.24	0.43	0.24	0.43
Whether it is a major grain producing area	0.63	0.48	0.60	0.49	0.60	0.50
Originally owned arable area	23.49	177.11	10.25	54.31	12.98	94.00
N	1144		4411		5555	

livestock used for agricultural production × average age of the family, average age of the family × whether the family is willing to take risks, whether the family has livestock used for agricultural production × whether the family is willing to take risks and whether the family has livestock used for agricultural production × Number of family members with high school education.

Fig. 1 shows the propensity score probability density distributions of the treatment group and the control group before and after matching under the application of nearest neighbor matching. Before matching, the propensity score probability distribution of the treatment group and the control group was obviously different, but after matching, the propensity score of the treatment group and the control group had a broad enough common support area, and the nearest neighbor matching was almost overlapping, indicating that the treatment group and the control group had enough matching samples.

The final goal of propensity score matching is to form sample data with no significant difference between the treatment group and the control group. Table 2 shows the results of the balance test. When evaluating whether the matching results are good, two criteria are generally used: one is to see whether the standard deviation reduction after matching is greater than 5%; the other is to see whether the difference between the control group and the treatment group is significant after matching. If the difference is not significant, it indicates that the balance hypothesis of the data is satisfied. It can be seen from the table that, except for total family population, the mean difference of other variables after matching was not significant, indicating that propensity matching score method limited reduced the difference between the treatment group and the control group. For the variables that do not pass the balance test, this paper will control them in regression.

Effect of Transfer of Farmland Management Rights on Agricultural Production Efficiency

Table 3 reports the basic estimates of the model. As can be seen from the first column of Table 3, traditional OLS may cause bias in the estimation results, while propensity score matching method further improves the estimation results. By using the nearest neighbor matching strategy, the average output value per mu of households transferred to farmland

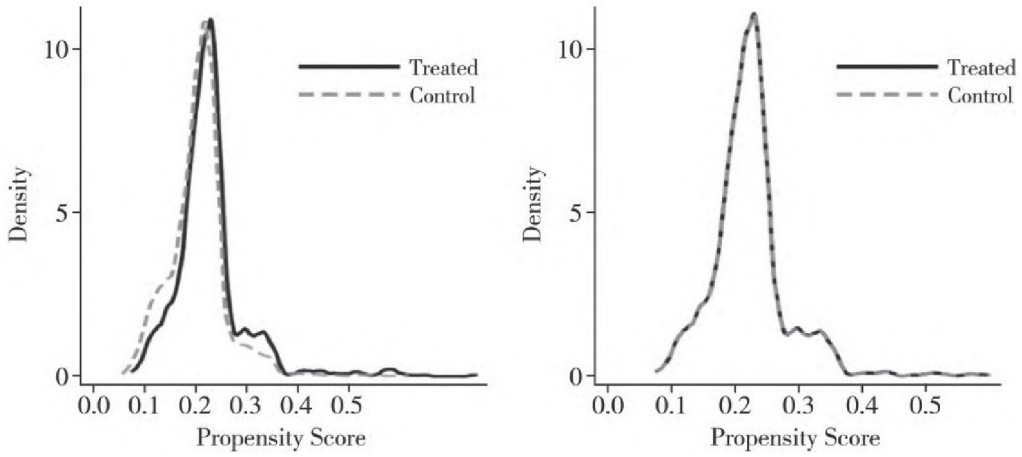

Fig. 1. Common support area.

Table 2. Data balance check.

Variable	Before match	Mean		S.D. (%)	S.D. Reduction range (%)	T test	
	After match	Treatment group	Standard deviation Reduction range			T	Significance level
Total family population	U	4.10	3.96	8.6	9.8	2.48	0.01
	M	4.09	3.97	7.8		1.86	0.06
Average family age	U	39.90	42.42	-20.4	91.4	-5.78	0.00
	M	39.99	40.21	-1.7		0.42	0.67
Number of family members with high school education	U	3.23	3.08	10.1	42.5	2.93	0.00
	M	3.23	3.15	5.8		1.36	0.18
Whether it is a professional big family	U	0.02	0.00	13.6	100.0	5.02	0.00
	M	0.00	0.00	0.0		0.00	1.00
Whether it is an agricultural cooperative	U	0.02	0.00	9.6	100.0	3.23	0.00
	M	0.01	0.00	0.0		-0.00	1.00
Whether it is used for agricultural production of livestock	U	0.17	0.11	15.8	86.0	4.86	0.00
	M	0.17	0.15	2.2		0.47	0.64
Whether families are willing to take risks	U	0.25	0.24	3.7	-7.1	1.10	0.27
	M	0.25	0.24	4.0		0.91	0.36

Note: The variable of total household population does not pass the balance test and is therefore controlled as a control variable in the regression below

management rights increased by about 27% compared with that of households without farmland transfer, and the result was statistically significant at the level of 1%, indicating that hypothesis 1 was verified. This result shows that households transferred to farmland management have a significant and positive impact on agricultural productivity, which is consistent with the existing results. From column 3 of the table, it can be seen that the average net output value per mu of households with the transfer of farmland management rights increased by 316.23 yuan compared with those without the transfer of farmland, and was statistically significant at 5% level. The net output value here is calculated by deducting the total output value from the input of agricultural production materials such as seeds, fertilizers, pesticides, machinery and employment costs. Therefore, the concentration of land use rights and large-scale management brought by the transfer of farmland management rights are conducive to improving agricultural production efficiency, thus promoting the increase of farmers' income.

Table 3. Estimation results of the impact of the transfer of farmland management rights on agricultural production efficiency.

Variable	(1)	(2)	(3)
	Full sample	PSM	
	Average output value per mu	Average output value per mu	Net output value per mu
Whether to transfer the management right of cultivated land	0.315*** (0.050)	0.275*** (0.046)	316.226** (118.274)
Total family population	-0.002	-0.022	-86.830**
	(0.023)	(0.015)	(37.202)
Number of families engaged in full-time farming	0.102 (0.022)	-0.020 (0.015)	-143.838** (63.171)
Quality of cultivated land	-0.136***	-0.101***	-234.427***
	(0.021)	(0.022)	(58.475)
Number of family members with university degree or above	0.051 (0.258)	-0.228 (0.244)	-618.525 (633.798)
Subsidy amount	0.000	-0.000	-0.050
	(0.000)	(0.000)	(0.051)
Household party membership	0.033	-0.024	-149.130
	(0.054)	(0.063)	(164.020)
Whether it is a family farm	0.408	-0.624	-749.276
	(0.275)	(0.354)	(919.285)
Whether to add variables that pass the balance test	YES	NO	NO
Province dummy variable	YES	YES	YES
Urban and rural dummy variable	YES	YES	YES
Constant term	8.584***	7.922***	2805.018***
	(0.382)	(0.345)	(893.805)
R2	0.081	0.098	0.056
Adjust R2	0.073	0.082	0.039
N	5520	2102	2102

Note: The value of the average output value per mu is correct, but the net output value per mu is not correct. In brackets is robust standard error; *, * * and * * * are significant at the 10%, 5% and 1% levels respectively. The same below

Whether the Samples Are grouped into Main Grain Producing Areas

In order to investigate whether the transfer of farmland management rights has a different impact on household agricultural production efficiency between major grain-producing areas and non-major grain-producing areas, this paper constructs a regression analysis of the interaction term between major grain-producing areas and core explanatory variables. As can be seen from the second column of Table 4, compared with non-major grain producing areas, the average output value per mu of households in major grain producing areas has a trend of increasing, which is close to the conclusion of Huang et al. (2013) [39]. It indicates that there is a possibility space for further expansion of the production scale in the main grain producing areas, and the synchronous improvement of grain production scale and efficiency can be achieved.

Age Group Sample

According to the age distribution of the samples, and referring to the studies of Su et al. (2019) [40], this paper defines households with a head under 50 years old as peasant households of young and middle-aged, and households with a head over 50 years old as elderly households. Table 5 reports the regression results with 50 years old as the grouping criterion. It can be seen from the table that the transfer of farmland management rights has promoted the agricultural production efficiency of China's middle-aged and young households compared with the elderly households whose head of household is over 50 years old. On the one hand, young and middle-

Table 4. The effect of transfer of farmland management rights on agricultural production efficiency: whether it is the result of grouping of major grain producing areas.

Variable	Average output value per mu	Average output value per mu
Whether to transfer the management right of cultivated land	0.275*** (0.045)	0.273*** (0.072)
Whether the management right of cultivated land is transferred × Whether it is a major grain producing area		0.002 (0.092)
Control variable	YES	YES
Constant term	7.922***	7.921**
	(0.345)	(0.345)
R2	0.098	0.098
Adjust R2	0.082	0.082
N	2102	2102

Table 5. The effect of the transfer of farmland management rights on agricultural production efficiency: age group results.

Variable	Average output value per mu	Average output value per mu
Whether to transfer the management right of cultivated land	0.275*** (0.045)	0.212*** (0.053)
Whether the family is transferred to the management right of farmland × Whether the family is young and middle-aged		0.144** (0.064)
Control variable	YES	YES
Constant term	7.922***	7.909***
	(0.345)	(0.344)
R2	0.098	0.100
Adjust R2	0.082	0.084
N	2102	2102

aged households may be more sensitive to the price of agricultural products, and will adjust the planting structure in a timely manner according to market prices. On the other hand, young and middle-aged families may have more advanced management ideas, which has a positive impact on agricultural production. Therefore, hypothesis 3 is verified.

Robust Analysis

In this part, we use kernel matching method to test robustness. Kernel matching is different from nearest neighbor matching, it belongs to global matching method. The matching object of each individual is all the samples of the control group, but different weights are assigned according to the distance of individuals (the weight of the near is heavy, the weight of the far is small, and the weight of non-participation is zero). Therefore, the use of diversified data balancing strategy and comparative analysis of data estimation results of multiple matched samples can achieve robust and accurate results under existing data conditions and measurement techniques.

Fig. 2 shows the estimated probability density of propensity scores before and after matching between households with transferred farmland management rights and those without farmland transfer under matching strategy II (logistic regression + kernel matching). Before matching, the propensity score probability distribution of the treatment group and the control group was obviously different, but the propensity score of the treatment group and the control group had a broad common support area. Among them, the kernel matching almost coincides, indicating that the processing group and the control group achieve data balance on the observable features.

As can be seen from the first column of Table 6, the average output value per mu of households

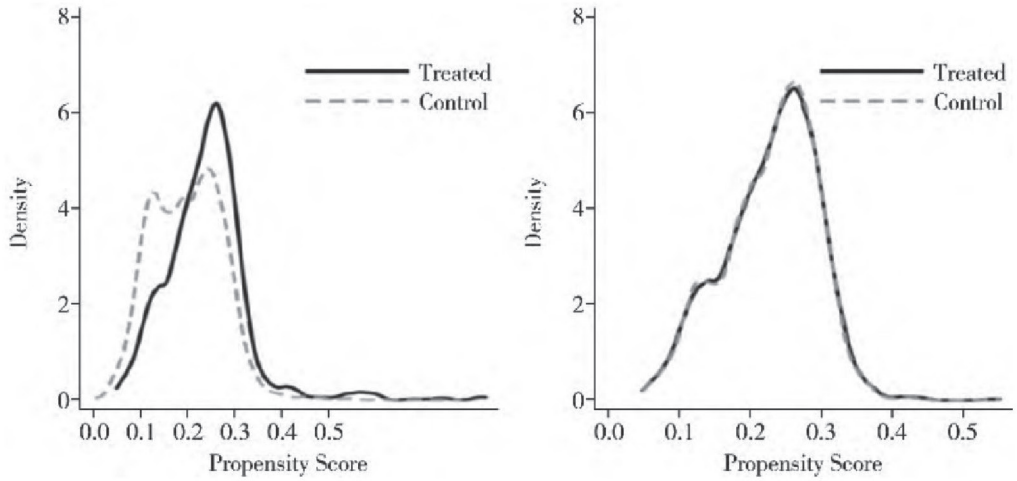

Fig. 2. Common support area.

Table 6. Robustness test results.

variable	Average output value per mu	Net output value per mu
Whether to transfer the management right of cultivated land	0.267*** (0.035)	248.42*** (84.69)
Control variable	YES	YES
Constant term	7.495***	2106.026***
	(0.205)	(498.803)
R2	0.073	0.033
Adjust R2	0.067	0.026
N	4898	4898

transferred to the management right of farmland increased by about 27% compared with those without farmland transfer, and the result was statistically significant at 1% level. As can be seen from the second column of the table, the average net output value per mu of the households transferred to the management right of farmland increased by about 248.42 yuan compared with the households without farmland transfer, and the result was statistically significant at the level of 1%. Although there are slight changes in the estimated coefficients, the coefficient symbols are consistent with the previous results, and the relevant changes may be caused by different sample sizes. In general, this result is very robust under different measurement methods.

Mechanism Verification

The above analysis shows that the transfer of the family to the right of farmland management does have a positive impact on agricultural production efficiency, and there are certain differences between different age groups and whether the family is the main grain producing area. The further question is, how does the transfer of the family to the right of farmland management affect agricultural production efficiency? What is the mechanism of action? As previously analyzed, on the one hand, the transfer of farmland management rights promotes the centralized and large-scale production of farmland, is conducive to the introduction and use of agricultural machinery, realizes the effective replacement of labor force by machinery, and changes the backward agricultural production mode. On the other hand, after the family transfer to the management right of farmland, the planting behavior of farmers will also change and tilt to cash crops, and then form the scale effect and selection effect of farmland. Therefore, this paper selects two variables, whether households use agricultural machinery for production and whether they plant cash crops, to measure whether the transfer of farmland management rights will affect agricultural production efficiency through these factors. Refer to Grant et al. (2006) [41] for the test method of mediating effect. First, this paper analyzes the effect of whether the family transfers the right of farmland management to the intermediary variables, and then analyzes the effect of the family transfers the right of farmland management to the agricultural production efficiency through the intermediary variables, so as

to test the mechanism of the family farmland management right to affect the agricultural production efficiency.

Transfer of Farmland Management Rights, Scale Effect and Agricultural Production Efficiency

In order to investigate the impact of the transfer of household farmland management rights on whether agricultural machinery is used for production, the following measurement model is set up in this paper:

$$dum\_machine_i = \alpha_0 + \alpha_1(dum\_area_i) + \sum \alpha_2 control_i + \varepsilon_i$$

Where, $dum\_machine_i$ indicates whether family i uses agricultural machinery for production, and dum_area_i indicates whether family i transfers to the management right of farmland. $control_i$ is a control variable, including the personal characteristics of the household head and other control variables. α_1 and β_1 represent regression coefficients, which respectively measure the effect of the transfer of farmland management rights on whether households use agricultural machinery for production, and ε_1 is a random disturbance term.

For Equation (2), the logistic model was used for regression, and the regression results were shown in Table 7. The second column of Table 7 shows the estimated results of the impact of the transfer of farmland management rights on whether households use agricultural machinery production. It can be seen that the estimated coefficient of the transfer of farmland management rights is positively significant at the 1% level, that is, the probability of the families transferring farmland management rights using agricultural machinery is 76% higher than that of the families without farmland transfer. Secondly, in order to verify the impact of household use of agricultural machinery on agricultural production efficiency, the following equation is adopted in this paper:

$$Ln(per\_value)_i = \alpha_0 + \alpha_1(dum\_machine_i) + \alpha_2(dum\_area_i) + \sum \alpha_3 control_i + \varepsilon_i$$

Table 7, column 3, reports the estimated results of household farm machine production, which can significantly improve agricultural production efficiency. Further analysis shows that the indirect effect of increasing the average output value per mu of the families transferred to the management right of farmland through the scale effect is about 0.025, which accounts for about 10% of the total effect. This result shows that the expansion of farmland management scale by families is conducive to the effective replacement of labor force by machinery, the reform of backward agricultural production mode, and the improvement of agricultural production efficiency.

Transfer of Farmland Management Rights, Selection Effect and Agricultural Production Efficiency

In order to investigate the impact of the transfer of family farmland management rights on whether to plant cash crops, the following econometric model is set up in this paper:

$$dum\_cash\_crops_i = \gamma_0 + \gamma_1(dum\_area_i) + \sum \gamma_2 control_i + \varepsilon_i$$

For Equation (6), logistic model was used for regression, and the regression results were shown in

Table 7. Scale effect estimation results.

Variable	(1)	(2)	(3)
	Average output value per mu	Whether to use agricultural machinery production	Average output value per mu
Whether to transfer the management right of cultivated land	0.275***	0.760***	0.250***
	(0.045)	(0.099)	(0.045)
Whether to use agricultural machinery production			0.137*** (0.048)
Number of families engaged in full-time farming			
Control variable	YES	YES	YES
Constant term	7.922*** (0.345)	-2.458** (1.094)	7.913*** (0.344)
Pseudo R2		0.139	
R2	0.098		0.102
Adjust R2	0.082		0.086
N	2102	2102	2102

Table 8. Selection effect estimation results.

Variable	(1)	(2)	(3)
	Average output value per mu	Whether to grow cash crops	Average output value per mu
Whether to transfer the management right of cultivated land	0.275***	0.186***	0.243***
	(0.045)	(0.103)	(0.043)
Whether to grow cash crops			0.438*** (0.048)
Control variable	YES	YES	YES
Constant term	7.922*** (0.345)	-1.036* (0.754)	7.802*** (0.338)
Pseudo R2		0.100	
R2	0.098		0.134
Adjust R2	0.082		0.118
N	2102	2102	2102

Table 8. From the second column of Table 8, it can be seen that the probability of families with the transfer of farmland management rights to choose to plant cash crops is about 19% higher than that of families without farmland transfer. This shows that farmers, as rational economic people, have less and less comparative advantage in grain planting, and their planting behavior will tilt and change to cash crops with the expansion of cultivated land area.

In order to verify the effects of household planting of cash crops on agricultural production efficiency, the following equation was adopted in this paper:

$$\mathrm{L}n(per\_value)_i = \gamma_0 + \gamma_1(dum\_cash\_crops_i) + \gamma_2(dum\_area_i) + \sum \gamma_3 control_i + \varepsilon_i$$

It can be seen from the third column of Table 8 that families transferring to the management right of cultivated land will increase the average output value per mu by planting high value-added cash crops, and it is statistically significant at 1% level. Further analysis shows that the indirect effect of planting cash crops on improving agricultural production efficiency is 0.03, accounting for about 12% of the total effect.

In general, households transferred to farmland management rights do have an impact on agricultural production efficiency through scale effect and selection effect. By comparing scale effect and selection effect, this paper finds that households transferred to farmland management rights choose to plant high value-added cash crops more obvious. In a sense, this is also an inevitable choice for farmers to optimize their decisions as rational economic people with the expansion of cultivated land area.

Conclusions

Based on the data of the China Household Finance Survey (CHFS) in 2015, this paper empirically studies the impact of household transfer of farmland management rights on agricultural production efficiency and its mechanism at the micro level. The study found that the transfer of farmland management rights by families can significantly improve agricultural production efficiency on the whole. The production efficiency of land transfer has strong heterogeneity. Compared with the elderly families, the transfer of farmland management rights has a more significant improvement on the agricultural production efficiency of young and middle-aged families. However, the average output value per mu in the main grain-producing areas has an increasing trend after the families transfer to the management right of cultivated land. Further mechanism analysis found that, on the one hand, the transfer of family to farmland management rights is conducive to the effective replacement of mechanical labor force and the reform of backward agricultural production mode. On the other hand, with the expansion of cultivated land area, farmers' planting behavior tilts and changes to cash crops, thus forming the scale of cultivated land and the "selection effect". By comparing the above two effects, this paper found that the planting choice behavior of "pressing grain and expanding warp" is more obvious.

Suggestion

The research conclusion of this paper has the following policy implications. First, weaken the impact of cultivated land circulation on the use of cultivated land "non-grain" to ensure food security in our country [42]. At the micro level, we should

enhance the enthusiasm of farmers to grow grain and improve their income level. At the macro level, more control measures should be introduced to prevent the planting structure from "excessive non-grain". Second, strengthening the construction of land transfer market is still an important means to solve the low efficiency of agricultural production and the distortion of agricultural factor allocation [43]. Improve the standard and efficient land trading market, improve the land transfer price manifestation mechanism, let the market force play a full role, and promote the flow of land to the main business with strong agricultural production capacity. Actively explore the diversification of land transfer methods and subjects, and create an environment for land transfer to optimize resource allocation in a larger scope [44]. At the same time, governments at all levels should vigorously develop the research and innovation of agricultural machinery, improve the application level of land mechanization, and promote the development of large-scale management of cultivated land. Third, we should introduce young people with advanced ideas, innovative ideas, and strong adaptability to promote agricultural modernization and inject "fresh blood" into the construction of new rural areas.

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Conflict of Interest

The authors declare no conflict of interest.

References

1. HANSEN M.H., LI H., SVARVERUD R. Ecological civilization: Interpreting the Chinese past, projecting the global future. Global Environmental Change, **53**, 8, **2018**.
2. FENG L., ZHANG M., LI Y., et al. Satisfaction principle or efficiency principle? Decision-making behavior of peasant households in China's rural land market. Land Use Policy, **99**, 22, **2020**.
3. LI L., KHAN S.U., GUO C., et al. Non-agricultural labor transfer, factor allocation and farmland yield: Evidence from the part-time peasants in Loess Plateau region of Northwest China. Land Use Policy, **120**, 15, **2022**.
4. LIAO W., ZENG F., CHANIEABATE M. Mechanization of Small-Scale Agriculture in China: Lessons for Enhancing Smallholder Access to Agricultural Machinery. Sustainability, **14** (13), 22, **2022**.
5. YIYUAN C., CHANGQUAN J. How agricultural contracting services are reshaping small-scale household farming in China. The Journal of Peasant Studies, **12**, 19, **2023**.
6. LIU Z., TIAN J., WANG K., et al. The impact of farmland circulation on the carbon footprint of agricultural cultivation in China. Economic Analysis and Policy, **78**, 9, **2023**.
7. XIAO X., SHANG L., LIU Y. Comparative Study on Farmland Circulation between Plains and Mountainous Areas in an Arid Region: A Case Study of Zhangye City in Northwest China. Land, **11 (4)**, 571, **2022**.
8. ZHANG Y., HALDER P., ZHANG X., et al. Analyzing the deviation between farmers' Land transfer intention and behavior in China's impoverished mountainous Area: A Logistic-ISM model approach. Land Use Policy, **94**, 15, **2020**.
9. DENG X., WANG G., SONG W., et al. An Analytical Framework on Utilizing Natural Resources and Promoting Urban-Rural Development for Increasing Farmers' Income Through Industrial Development in Rural China. Frontiers in Environmental Science, **10**, 10, **2022**.
10. LU S., CHEN N., ZHONG X., et al. Factors affecting forestland production efficiency in collective forest areas: A case study of 703 forestland plots and 290 rural households in Liaoning, China. Journal of Cleaner Production, **204**, 8, **2018**.
11. CHEN K., LONG H., LIAO L., et al. Land use transitions and urban-rural integrated development: Theoretical framework and China's evidence. Land Use Policy, **92**, 15, **2020**.
12. LU X HAI, JIANG X., GONG M QI. How land transfer marketization influence on green total factor productivity from the approach of industrial structure? Evidence from China. Land Use Policy, **95**, 15, **2020**.
13. CHEN Y., MIAO J., ZHU Z. Measuring green total factor productivity of China's agricultural sector: A three-stage SBM-DEA model with non-point source pollution and CO_2 emissions. Journal of Cleaner Production, **318**, 15, **2021**.
14. LIU Y., ZOU L., WANG Y. Spatial-temporal characteristics and influencing factors of agricultural eco-efficiency in China in recent 40 years. Land Use Policy, **97**, 15, **2020**.
15. GAO F., ANDERSON M., DAUGHTRY C., et al. A within-season approach for detecting early growth stages in corn and soybean using high temporal and spatial resolution imagery. Remote Sensing of Environment, **242**, 15, **2020**.
16. WEI L., LUO Y., WANG M., et al. Essential fragmentation metrics for agricultural policies: Linking landscape pattern, ecosystem service and land use management in urbanizing China. Agricultural Systems, **182**, 15, **2020**.
17. DESIERE S., JOLLIFFE D. Land productivity and plot size: Is measurement error driving the inverse relationship?. Journal of Development Economics, **130**, 14, **2018**.
18. DENG X. Influence of water body area on water quality in the southern Jiangsu Plain, eastern China. Journal of Cleaner Production, **254**, 15, **2020**.
19. MA L., LONG H., TANG L., et al. Analysis of the spatial variations of determinants of agricultural production efficiency in China. Computers and Electronics in Agriculture, **180**, 25, **2021**.
20. YAN J., CHEN C., HU B. Farm size and production efficiency in Chinese agriculture: output and profit. China Agricultural Economic Review, **11(1)**, 18, **2018**.
21. LU H., XIE H., HE Y., et al. Assessing the impacts of land fragmentation and plot size on yields and costs: A translog production model and cost function approach. Agricultural Systems, **161**, 8, **2018**.
22. LU H., CHEN Y., HUAN H., et al. Analyzing Cultivated Land Protection Behavior From the Perspective of Land Fragmentation and Farmland Transfer: Evidence From

Farmers in Rural China. Frontiers in Environmental Science, **10**, 15, **2022**.
23. LI J., LI Y. Influence measurement of rapid urbanization on agricultural production factors based on provincial panel data. Socio-Economic Planning Sciences, **67**, 8, **2019**.
24. LIU Y., DAI L., LONG H., et al. Rural vitalization promoted by industrial transformation under globalization: The case of Tengtou village in China. Journal of Rural Studies, **95**, 15, **2022**.
25. MIN M., MIAO C., DUAN X., et al. Formation mechanisms and general characteristics of cultivated land use patterns in the Chaohu Lake Basin, China. Land Use Policy, **117**, 15, **2022**.
26. ABDI A.M. Land cover and land use classification performance of machine learning algorithms in a boreal landscape using Sentinel-2 data. GIS Science & Remote Sensing, **57(1)**, 20, **2020**.
27. BORRELLI P., ROBINSON D.A., PANAGOS P., et al. Land use and climate change impacts on global soil erosion by water (2015-2070). Proceedings of the National Academy of Sciences, **117** (36), 7, **2020**.
28. ELAHI E., KHALID Z., WEIJUN C., et al. The public policy of agricultural land allotment to agrarians and its impact on crop productivity in Punjab province of Pakistan. Land Use Policy, **90**, 15, **2020**.
29. DENG Q., LI E., ZHANG P. Livelihood sustainability and dynamic mechanisms of rural households out of poverty: An empirical analysis of Hua County, Henan Province, China. Habitat International, **99**, 15, **2020**.
30. QIAO S., HUANG G., YEH A.G.O. Who are the gig workers? Evidence from mapping the residential locations of ride-hailing drivers by a big data approach. Cities, **132**, 15, **2023**.
31. FEI R., LIN Z., CHUNGA J. How land transfer affects agricultural land use efficiency: Evidence from China's agricultural sector. Land Use Policy, **103**, 15, **2021**.
32. XU W., JIN X., LIU J., et al. Analysis of influencing factors of cultivated land fragmentation based on hierarchical linear model: A case study of Jiangsu Province, China. Land Use Policy, **101**, 20, **2021**.
33. CHRISTIAENSEN L., RUTLEDGE Z., TAYLOR J.E. Viewpoint: The future of work in agri-food. Food Policy, **99**, 15, **2021**.
34. LI B., SHEN Y. Effects of land transfer quality on the application of organic fertilizer by large-scale farmers in China. Land Use Policy, **100**, 20, **2021**.
35. SHANG H., YI X., YIN C., et al. How Does the Stability of Land Management Right (SLMR) Affect Family Farms' Cultivated Land Protection and Quality Improvement Behavior (CLPQIB) in China?. Land, **10** (10), 20, **2021**.
36. LU H., ZHANG P., HU H., et al. Effect of the grain-growing purpose and farm size on the ability of stable land property rights to encourage farmers to apply organic fertilizers. Journal of Environmental Management, **251**, 15, **2019**.
37. LIU Z., ROMMEL J., FENG S., et al. Can land transfer through land cooperatives foster off-farm employment in China?. China Economic Review, **45**, 9, **2017**.
38. ZHOU L., LU H., WU B. Identifying the effects of the stability of farmland transfer management rights on the use of organic fertilizer with different farmland scales and crop types. Frontiers in Environmental Science, **10**, 15, **2022**.
39. HUANG J., WANG X., ROZELLE S. The subsidization of farming households in China's agriculture. Food Policy, **41**, 8, **2013**.
40. SU Y., ZHANG Z., WU D., et al. Occurrence of microplastics in landfill systems and their fate with landfill age. Water Research, **164**, 15, **2019**.
41. GRANT K.E., COMPAS B.E., THURM A.E., et al. Stressors and child and adolescent psychopathology: Evidence of moderating and mediating effects. Clinical Psychology Review, **26** (3), 25, **2006**.
42. YANG Q., ZHANG D. The influence of agricultural industrial policy on non-grain production of cultivated land: A case study of the "one village, one product" strategy implemented in Guanzhong Plain of China. Land Use Policy, **108**, 15, **2021**.
43. LONG H., TU S., GE D., et al. The allocation and management of critical resources in rural China under restructuring: Problems and prospects. Journal of Rural Studies, **47**, 22, **2016**.
44. WU Y., XI X., TANG X., et al. Policy distortions, farm size, and the overuse of agricultural chemicals in China. Proceedings of the National Academy of Sciences, **115** (27), 15, **2018**.