Transfer of farmland operation rights and improvement of productivity of farmers: theory and empirical evidence

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Abstract

Purpose – The results of this study have significant policy implications for charting a new course toward enhancing agricultural productivity among Chinese farmers.

Design/methodology/approach – By establishing a rural household decision-making model based on the transfer market of farmland operation rights, this paper systematically analyzes the effects of land transfer-in and land transfer-out on the productivity (per labor income) of rural households. The authors conducted basic regression analysis and robustness tests using propensity score-matching and proxy variable approaches based on the micro survey data from rural households in 30 counties in 21 provinces/municipalities/autonomous regions in 2013.

Findings – After the completion of land transfer, the total productivity of rural households transferring in lands will increase with an increase in the agricultural productivity; the total productivity of rural households

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transferring out land will increase due to a rise in non-agricultural productivity and the absolute total productivity of rural households not involved in land transfer will remain unchanged.

Originality/value – Unlike previous literature, this paper discusses the impacts of land transfer-in and transfer-out on total productivity, agricultural productivity and non-agricultural productivity among various rural households (i.e. those transferring in land, transferring out land or which are self-sufficient).

Keywords Transfer of land operation rights, Total household productivity,
Household agricultural productivity, Household non-agricultural productivity

Paper type Translated paper

1. Introduction

Boosting farmers' productivity is the key to increasing their income. China's rural reform started early, and farmers' income grew fast with the rapidly increasing agricultural productivity [1]. Since the mid-1980s, the farmers' non-agricultural productivity has accelerated; however, due to the slow growth of agricultural productivity, the income level of farmers has not effectively improved, resulting in a widening urban-rural income gap. In order to effectively boost the farmers' productivity and income and narrow the urban-rural income gap, the Party and the government began to promote the transfer of land operation rights. For example, the third plenary session of the 18th CPC Central Committee explicitly proposed for the first time "granting farmers the right to possess, use, benefit from, transfer and mortgage and guarantee contractual operation rights", "encouraging the transfer of contractual operation rights to major specialized households, family farms, farmers' cooperatives and agricultural enterprises in the open market, and developing various forms of scale operations", "giving farmers more property rights" and "exploring channels for farmers to increase their property income" while emphasizing "stabilizing the contractual relationship of rural land and keeping it unchanged for a long time". In November 2014, the "Opinions on Guiding the Orderly Transfer of Rural Land Operation Rights and Developing Moderate Scale Agricultural Operations" issued by the General Office of the CPC Central Committee and the General Office of the State Council further stressed "adhering to collective ownership of rural land, realizing the separation of ownership, contracting and operation rights, and guiding the orderly transfer of land operation rights".

In general, technological advances in agriculture, improvements in agricultural technical efficiency, accumulation of human capital, and effective transfer of surplus labor force of household are effective ways to increase farmers' productivity level. Obviously, the first three items can effectively contribute to a higher level of agricultural productivity, thus increasing farmers' agricultural business income and improving their total productivity (Fleisher and Liu, 1992; Wei and Li, 2012; Wang, 2007); and the achievement of the last two items can give farmers the opportunity and ability to earn higher income from non-agricultural work, raise their non-agricultural productivity and thus increase their total productivity (Chen and Yang, 2005; Jiang and Huang, 2006; Zhong and Ji, 2009; Zhang and Xu, 2011).

Most literature has focused on the factors affecting farmers' productivity from the above perspectives. However, all ignore a prerequisite—the effective transfer of land resources. For one thing, only through the effective transfer of land resources can concentration and large-scale operation of farmland be achieved and further promote agricultural technology and technical efficiency improvement (Nguyen *et al.*, 1996; Huang and Chen, 1998; Tian and Fang, 2013). For another, after the effective transfer of land resources, laborers with a strong willingness and ability to engage in agricultural production will continue to farm, while those with a strong willingness to engage in non-agricultural sectors may enter non-agricultural sectors, [2] thus achieving effective transfer of surplus rural labor (Kung, 2002; You and Wu, 2010). Therefore, a question worth paying attention to is: Can land circulation [3] effectively promote the improvement of farmers' productivity? If land circulation can indeed effectively improve agricultural or non-agricultural productivity, then it will effectively improve the

total productivity of farmers. This paper analyzes this question in detail from both theoretical and empirical levels.

Before introducing this paper, it is necessary to review the literature on the efficiency impact of land circulation on the efficiency of farmers. According to existing literature, there are few papers directly studying the impact of the land transfer on farmers' productivity, and most of the papers focus on the relationship between land transfer and farmers' income. For example, Deininger and Jin (2005), found that marketized land transfer can better promote the improvement of household agricultural business income based on agricultural data from the three poorest provinces in China. Xue *et al.* (2011) tested the relationship between land transfer and farmers' income using a difference-in-differences (DID) model based on the survey data of rural households in Ordos, Inner Mongolia Autonomous Region and found that land transfer can significantly increase the per capita net income of households. Li (2013) analyzed the relationship between land transfer and different types of farmers' income using DID based on a household tracking survey in Shaoyang City, Hunan Province and found that land transfer can significantly increase rural households' per capita net income, per capita net income from non-agricultural work, and per capita net income from rural land lease, while significantly reducing the per capita net income from crop planting. Based on national household micro-survey data, Mao and Xu (2015) empirically tested the relationship between land transfer and the growth of farmers' income using the average treatment effect (ATE) method and the average treatment effect on the treated (ATT) method. They found that land transfer significantly increased the total income level of any rural household and that farmers transferring in or out lands had a higher increase in total household income after participating in land transfer than any rural household.

The above literature examines the impact of land transfer on the household income of rural households and is very informative. However, unlike total household income, household productivity represents the average output per unit of labor (i.e. per labor income [4]). A high level of household income does not imply a high level of productivity, but a high level of household productivity does indicate a high level of income. For example, if the surplus labor of a household cannot be effectively transferred to the non-agricultural sector, the household will have too much labor "attached" to its land. In this case, the household agricultural business income is high, and the household's total income is high accordingly; however, the total household productivity may be rather low. In addition, although the above literature has discussed the impact of land transfer on farmers' income in detail (e.g. Mao and Xu, 2015), it has not specifically tested the mechanism of the impact of land transfer on income growth, nor has it deeply analyzed the effect of land transfer on household agricultural business income and non-agricultural wage income of different types of rural households.

To accurately reveal the mechanism of how land transfer affects farmers' income, the paper supplements and deepens the existing literature (e.g. Mao and Xu, 2015; Deininger and Jin, 2005) by selecting household productivity as the object of study and further discusses and examines the mechanism of how land transfer impacts on total household productivity, agricultural productivity, and non-agricultural productivity of different rural households. Specifically, this paper first constructs a theoretical model that introduces land transfer into the income determination equation of rural households, establishes the optimization goal of rural households and analyzes their decisions on whether to participate in the transfer of farmland operation rights and choosing the optimal transfer scale. The model's conclusion shows that after the land transfer, the total productivity of rural households transferring in land increases due to the improvement of agricultural productivity, and the total productivity of rural households transferring out land increases for the improvement of non-agricultural productivity.

In order to verify the theoretical analysis results, we also conducted a corresponding empirical study. We first conducted a basic regression analysis through the Average Treatment Effect (ATE) method with data from a micro-survey of rural households in 30

counties in 21 provinces/municipalities/autonomous regions in 2013. Considering that agricultural productivity may directly affect the decision of rural households to participate in land transfer, i.e. whether households participate in land transfer is a "self-selecting" and "non-random" act, this may cause an endogenous problem in model estimation. For this reason, we chose the Propensity Score Matching (PSM) method to complement the basic regression analysis and further adopted the proxy variable approach (Levinsohn and Petrin, 2003) for a robust test. The results of the robust test and those of the basic regression analysis are consistent and support the conclusions of the theoretical model.

The rest of the paper is organized as follows: Section 2 is about constructing a theoretical model based on the farmland transfer market, Section 3 for the description of the relevant data, Section 4 for the basic regression analysis, Section 5 for a further robustness test, and finally the conclusions and policy implications.

2. Theoretical model

Drawing on the basic models of Carter and Yao (2002) and Conning and Robinson (2007) and making certain improvements to them, the paper constructs a rural household decision-making model based on the farmland transfer market to explore the intrinsic logic between farmland transfer and the growth of rural household productivity.

2.1 Basic assumptions of the model

Suppose the agricultural production function of a typical rural household i is $f(A_i, T_i, L_{ia}) = A_i T_i^\beta L_{ia}^{1-\beta}$, where A_i is the agricultural productivity of the household, T_i the area of land cultivated by the household, and L_{ia} the household labor input on the land. Suppose that the production function $f(A_i, T_i, L_{ia})$ of each rural household satisfies $f' > 0$, $f'' < 0$ and $f_{TL} > 0$ for T_i and L_{ia} and satisfies the Inada condition, i.e. $f'(0) = +\infty$ and $f'(+\infty) = 0$. It should be noted that given the attachment of agricultural capital to land in agricultural production, to simplify the model, we only incorporated the area of farmland T_i into the agricultural production function without taking into account the impact of agricultural capital (Conning and Robinson, 2007).

In this paper, we assumed that there exists a farmland transfer market [4] in which farmland operation rights can be transferred, and the parties to the transaction sign a contract to specify the transfer period and price of the farmland operation rights. We assumed that the general price of agricultural products is P, the working efficiency of each unit of labor in the non-agricultural sector is the same, the wage is W, and the transfer price of land [5] in the farmland transfer market is r. The transaction cost of the land transferee and land transferor for transferring each unit of land is indicated by c_d and c_s, respectively. The transaction costs are related to the degree of perfection of the land transfer market and will gradually decrease as the market develops and improves.

Assuming that the rural household i initially owns T_{i0} units of land and L_{i0} units of labor, and each rural household can allocate its labor force to the agricultural and non-agricultural sectors. The size of the agricultural and non-agricultural labor force of the household i is indicated by L_{ia} and L_{in}, respectively. T_{id} denotes the size of the land transferred in by the rural household, and T_{is} is the size of the land transferred out. Second, with the time of transaction occurrence as the node, the cycle of each transfer transaction can be divided into three periods, i.e. pre-transaction period, transaction period, and post-transaction period. Finally, it is assumed that farm product price P, wage from the non-agricultural sector W, the transaction price of farmland r, the transaction costs c_d and c_s and the size of labor owned by the rural household L_{i0} are all exogenous given variables and remain unchanged.

2.2 Market entry and transfer of land operation rights
Generally speaking, the decision goals of rural households are to maximize total household income. Depending on the productivity level of their farmland and wage levels in the non-agricultural sectors, households should adjust the scale of land operations through land transfer transactions and allocate labor forces accordingly to maximize total household income. A typical optimization problem encountered by the rural household i can be formulated as follows:

$$\underset{\{T_{id}, T_{is}, L_{ia}\}}{Max} \ Pf(A_i, T_i, L_{ia}) + WL_{in} - (r + c_d)T_{id} + (r - c_s)T_{is} \tag{1}$$

$$st: T_i = T_{i0} + T_{id} - T_{is}$$

$$L_{ia} + L_{in} \leq L_{i0}$$

$$0 \leq T_{is} \leq T_{i0}$$

$$0 \leq T_{id}$$

The first-order conditions for income maximization are:

$$T_{id}: \quad Pf_{Ti}(A_i, T_i, L_{ia}) + (r - c_d) \leq 0 \tag{2}$$

$$T_{is}: \ -Pf_{Tia}(A_i, T_i, L_{ia}) + (r - c_s) \leq 0 \tag{3}$$

$$L_{ia}: \quad Pf_{L_{ia}}(A_i, T_i, L_{ia}) = W \tag{4}$$

Since we assumed that the land is homogeneous, the equal sign cannot hold water simultaneously in equations (2) and (3), i.e. a rural household cannot transfer the land in and out simultaneously. For rural households transferring in land, $T_{id}^* > 0$, $L_i = L_{i0} + T_{id}^*$; For rural households transferring out land, $T_{is}^* > 0$, $L_i = L_{i0} + T_{is}^*$; For self-sufficient rural households, $L_i = L_{i0}$. Therefore, T_{is}^*, T_{id}^*, and T_{ia}^* meet the following first-order conditions:

$$\text{For rural households transferring in land,} \quad Pf_{Ti}(A_i, T_i, L_{ia}) = r + c_d \tag{5}$$

$$\text{For rural households transferring out land,} \quad Pf_{Ti}(A_i, T_i, L_{ia}) = r - c_s \tag{6}$$

$$\text{For self-sufficient farmers,} \quad (r - c_s) < Pf_{Ti}(A_i, T_i, L_{ia}) < r - c_d \tag{7}$$

Combining equations (5), (6) and (7), we can derive the expressions for the critical values of agricultural productivity of rural households with the ability and willingness to transfer in land and of rural households with the willingness to transfer out land in the farmland transfer market, i.e. A_U and A_L: $A_U = \frac{1}{P}\left(\frac{W}{1-\beta}\right)^{1-\beta}\left(\frac{r+c_d}{\beta}\right)^{\beta}$, $A_L = \frac{1}{P}\left(\frac{W}{1-\beta}\right)^{1-\beta}\left(\frac{r-c_s}{\beta}\right)^{\beta}$. In other words, if a rural household's $A_i \geq A_U$, then the rural household will transfer in land in the market. If $A_i \leq A_L$, then the rural household will transfer out land in the market. If A_i is within the interval (A_L, A_U), then the rural household will be self-sufficient in agricultural production and will not participate in farmland transfer. It can be seen that A_i, the agricultural productivity of rural households transferring in land, is relatively high, while that of rural households transferring out land is comparatively low. The result of farmland transfer is that land operation rights flow from rural households with low agricultural productivity to those with high agricultural productivity.

2.3 Transfer of farmland operation rights and productivity of rural households
Upon completion of land transfer, some rural households transfer in lands, while others transfer out land or maintain their current arable farming acreage. At this point, the land will

be relatively more concentrated, and rural households of different types will redistribute their labor input between the agricultural and non-agricultural sectors. Accordingly, their household productivity will change. If Y and $Y_n (Y_n = WL_n)$ represent a household's total income and income from non-agricultural work, respectively, then the household's total productivity and non-agricultural productivity can be expressed as Y/L_0 and Y_n/L_n (W), respectively. The agricultural productivity of the household is still quantified by A_i.

According to the above assumption, each cycle of farmland transaction can be divided into the pre-transaction period, the transaction period, and the post-transaction period. To better analyze the changes in household productivity of rural households, we used L_{ia1} to represent the size of labor that the rural household i invests into agricultural production before land transfer-in (pre-transaction period). Accordingly, we used L_{ia2} and L_{ia3} to represent the household labor input on agricultural production after land transfer-in (i.e. transaction period) and post-transaction period. We calculated the productivity of three types of rural households at all stages of the cycle of land transaction separately and made a detailed comparison.

Proposition 1. Among the rural households participating in the land transfer, the total productivity of rural households transferring in land will increase due to the improvement of household agricultural productivity, and the total productivity of rural households transferring out land will increase for the improvement of non-agricultural productivity of households. For self-sufficient rural households, their total household productivity remains unchanged.

2.3.1 Changes in productivity of rural household transferring in land. In the pre-transaction period, rural households that transfer in lands allocate their labor resources between the agricultural and non-agricultural sectors. According to the assumptions, the initial landholding size of the rural household is T_{i0}. Therefore, in the pre-transaction period, T_{i0} and L_{ia1} of this type of rural households satisfy equation (4). Thus, after simplification, the expression for the total productivity of these rural households in the pre-transaction period is as follows:

$$\frac{Y_1}{L_{i0}} = \frac{1}{L_{i0}} \left[WL_{ia1} \left(\frac{1}{1-\beta} - 1 \right) + WL_{i0} \right]$$

After land transaction, T_i and L_{ia2} also satisfy equation (4). Therefore, the expression for the total productivity of this type of rural households in the transaction period is as follows:

$$\frac{Y_2}{L_{i0}} = \frac{1}{L_{i0}} \left[WL_{ia2} \left(\frac{1}{1-\beta} - 1 \right) + WL_{i0} - (r + c_d) T_{id} \right]$$

At the same time, T_i and L_{ia2} of this type of rural households also satisfy equation (5), and $T_i = T_{i0} + T_{id}$. Therefore, the above equation can be further simplified as follows:

$$\frac{Y_2}{L_{i0}} = \frac{1}{L_{i0}} \left[WL_{ia2} \frac{T_{i0}}{T_i} \left(\frac{1}{1-\beta} - 1 \right) + WL_{i0} \right]$$

In the post-transaction period, the land size of this type of rural households is still T_i, but rural households will adjust their labor input on farmland accordingly with the change of A_i to make A_i, T_i and L_{ia3} satisfy equation (4). Since the transaction cost c_d is no longer required, the expression for the total productivity of this type of rural households is:

$$\frac{Y_3}{L_{i0}} = \frac{1}{L_{i0}} \left[WL_{ia3} \left(\frac{1}{1-\beta} - 1 \right) + WL_{i0} - WL_{ia2} \left(\frac{1}{1-\beta} - 1 \right) \left(1 - \frac{T_{i0}}{T_i} \right) + c_d T_{id} \right]$$

The following is a detailed comparison of the total productivity of households transferring in land over the different stages of the land transaction.

First, we simply assumed that A_i, the agricultural productivity of the rural household does not change, then according to equation (4), we got $\frac{T_{i0}}{L_{ia1}} = \frac{T_i}{L_{ia2}}$ and $L_{ia2} = L_{ia3}$. Therefore, $Y_1 = Y_2$, and $Y_3 = Y_2 + c_d T_{id}$. Obviously, $\frac{Y_3}{L_{i0}} > \frac{Y_2}{L_{i0}} = \frac{Y_1}{L_{i0}}$. At this point, after completing the land transfer, the total productivity of the rural household will increase $\left(\text{by } \frac{c_d T_{id}}{L_{i0}} \right)$ since the household is not required to pay the land transaction cost.

Second, consider a more realistic scenario, that is, A_i of such rural households continues to improve after the land transfer-in (i.e. in the transaction and post-transaction period). Generally speaking, with the concentration and large-scale operation of land, the promotion of new technologies will be simpler and more rapid, agricultural production and management will be more efficient, and the agricultural productivity A_i will inevitably increase accordingly [6]. When A_i improves continually, according to equation (4), $\frac{T_{i0}}{L_{ia1}} > \frac{T_i}{L_{ia2}}$ and $L_{ia3} > L_{ia2}$. Thus, $Y_2 > Y_1$, $Y_3 > Y_2 + c_d T_{id}$. Obviously, $\frac{Y_3}{L_{i0}} > \frac{Y_2}{L_{i0}} > \frac{Y_1}{L_{i0}}$. At this point, after completing the land transfer, the total rural household productivity will rise significantly with an increase in agricultural productivity A_i.

Therefore, in general, upon completion of farmland transfer, the total household productivity of the rural households transferring in land will increase as they are no longer burdened with the transaction cost c_d. Furthermore, considering the rise in agricultural productivity A_i after the land transfer, the total productivity of these rural households will significantly increase.

2.3.2 Changes in the household productivity of rural households transferring out land. For rural households transferring out lands, upon the completion of the farmland transaction, their landholding becomes T_i, and $T_i = T_{i0} - T_{is}$. The expression for the total productivity of this type of rural households at each stage of the transaction cycle can be obtained using a similar analysis as above. To simplify the description, the expressions for the productivity of this type of rural households in the pre-transaction period and transaction period are simply given below [7]:

$$\frac{Y_1}{L_{i0}} = \frac{1}{L_{i0}} \left[WL_{ia1} \left(\frac{1}{1-\beta} - 1 \right) + WL_{i0} \right]$$

$$\frac{Y_2}{L_{i0}} = \frac{1}{L_{i0}} \left[WL_{ia2} \frac{T_{i0}}{T_i} \left(\frac{1}{1-\beta} - 1 \right) + WL_{i0} \right]$$

Since T_{i0} and L_{ia1} and T_i and L_{ia2} all satisfy equation (4) separately, with the agricultural productivity of this type of rural households A_i remaining unchanged, [8] $\frac{T_{i0}}{L_{ia1}} = \frac{T_i}{L_{ia2}}$ and $L_{ia2} = L_{ia3}$. Therefore, $Y_1 = Y_2$, $Y_3 = Y_2 + c_s T_{is}$ [9]. Obviously, $\frac{Y_3}{L_{i0}} > \frac{Y_2}{L_{i0}} = \frac{Y_1}{L_{i0}}$. That means the total productivity of the rural household transferring out land will increase effectively after the completion of the land transaction.

In the model specification, to simplify the analysis, we assumed that the wages W in the non-agricultural sector (which is also the non-agricultural productivity of household denoted by Y_n/L_n) are exogenous and remain unchanged. In fact, upon the completion of the land transfer, with the guaranteed proceeds from the land transfer, the rural households transferring out land are able to input more labor into the non-agricultural sectors [10] and

invest more time and effort in the improvement of their vocational skills so that they could become "skilled" workers and earn higher non-farm wages W. According to the expression $\frac{Y}{L_0}$, we can infer that $\frac{\partial \frac{Y}{L_0}}{\partial W} > 0$. Thus, in the long term, the total productivity of the households renting out land will continue to increase with the rising non-agricultural productivity W.

In short, after the completion of farmland transfer, the total productivity of the rural households transferring out land will increase because they no longer need to bear transaction costs c_s, and will be improved further with the increase of the non-agricultural productivity of households.

2.3.3 Changes in the household productivity of self-sufficient rural households. These rural households do not participate in any farmland transfer transactions, and the size of their farmland will always remain T_{i0}. Likewise, we can obtain the expression for the total productivity of this type of rural households as follows:

$$\frac{Y_1}{L_{i0}} = \frac{1}{L_{i0}}\left[WL_{ia1}\left(\frac{1}{1-\beta} - 1\right) + WL_{i0}\right] \text{且} \frac{Y_3}{L_{i0}} = \frac{Y_2}{L_{i0}} = \frac{Y_1}{L_{i0}}$$

$$\frac{Y_1}{L_{i0}} = \frac{1}{L_{i0}}\left[WL_{ia1}\left(\frac{1}{1-\beta} - 1\right) + WL_{i0}\right], \text{and } \frac{Y_3}{L_{i0}} = \frac{Y_2}{L_{i0}} = \frac{Y_1}{L_{i0}}$$

It is evident that the total productivity of self-sufficient rural households remains constant throughout a transaction cycle.

2.4 Rethinking the theoretical model

In the theoretical model, we assumed the existence of a complete land transfer market. However, China's rural land transfer market has not fully matured. Although the land transfer market has experienced rapid growth in recent years, the rural land transfer marketization level remains low (Guan, 2011a, b). From the perspective of market development, this is mainly reflected in the following aspects (Guan, 2011a, b; Zheng, 2014): (1) uneven development and wide gaps in local land transfer markets; (2) lack of information intermediaries for land transfer, information asymmetry between supply and demand, high transaction costs, and a narrow scope of transfer (between acquaintances or within village collectives); (3) formal procedures for land transfer approval are excessively complicated, which hinders farmers' motivation to engage in such transfers; (4) the absence of standardized transfer procedures often leads to verbal agreements that complicate the assignment of responsibility and resolution of disputes, thereby impeding market effectiveness; furthermore, farmers' awareness regarding land transfers is weak. The issues above call for corresponding measures from government departments to improve the farmland market order and regulations governing farmland transfer, thereby expediting the marketization of farmland transfer.

Also, the model presupposes the existence of a fully functional and unrestricted labor market, thereby ensuring that changes in total household productivity are commensurate with changes in total household income. However, it is important to note that the transfer of surplus rural labor to non-agricultural sectors in China is often hindered by various factors such as land adjustment and the hukou system, which may result in disparities between changes in household income and productivity levels. For instance, the presence of a surplus labor force in households may result in the co-existence of a relatively high level of household agricultural business income and a comparatively low level of agricultural productivity. Therefore, to accurately measure changes in household income levels, this study focuses on household productivity as the object.

In addition, the theoretical model excludes the potential risks in agricultural and non-agricultural production for simplifying analysis. For instance, households renting in lands are subject to natural risks (such as severe weather) and market uncertainties (like changes in farm product prices), which can significantly affect their agricultural business income and total household productivity. Therefore, in the event of natural risks, governments should provide larger-scale agricultural subsidies to reduce the scope of those risks. In the case of market risks, the government should provide certain agricultural subsidies to alleviate losses. However, market risks are controllable—Governments should disclose relevant information about farm products on time to guide rural households to make rational decisions so as to prevent market risks and improve agricultural productivity effectively. For rural households renting out land, the risk of unemployment in the non-agricultural sectors will significantly impact their total household productivity. Therefore, governments should establish a relatively comprehensive unemployment security system and reduce labor transfer constraints like land adjustment and the hukou system to facilitate the transfer of surplus rural labor.

In conclusion, the establishment of rural land transfer markets results in the creation of three types of rural households: households transferring in lands, households transferring out lands, and self-sufficient households, and the total household productivity of rural households transferring in land will increase further with improved household agricultural productivity, the total household productivity of rural households transferring out land will increase with improved household non-agricultural productivity, and the total household productivity of rural households not involved in land transfer will remain constant. The above conclusions are all derived from theoretical analysis, and we conducted an empirical test in the following section using the corresponding microscopic data.

3. Data sources and description

The sample data used in this paper come from firsthand data obtained by the Shanghai University of Finance and Economics' project team of the 2013 "Thousand-Village Survey on Urban-Rural Transfer of Rural Workforce" ("Thousand-Village Survey") through door-to-door questionnaire survey and fixed-point survey in selected villages. Based on the sixth population census in 2010, the Thousand-Village Survey project team conducted scientific sampling from 25 provinces/municipalities/autonomous regions in China (excluding Hong Kong, Macao, Taiwan, Xinjiang, Tibet, Qinghai, Inner Mongolia, Ningxia and Hainan). Finally, 30 counties in 21 provinces/municipalities/autonomous regions were sampled for the fixed-point survey. The geographical distribution of the above 30 counties is shown in Table 1 below.

The project team selected sampled districts/counties from seven regions across China: East China, South China, Central China, North China, Northwest China, Southwest China and Northeast China. The registered agricultural population in the sampled districts/counties accounts for 88.71% of China's total agricultural registered population, while the rural population of the sampled districts/counties accounts for 88.72% of China's total rural population. The basic situations of rural households in these seven regions are diverse and representative. For this survey, the project team selected 6,203 rural households as the target of the fixed-point survey in a random manner and investigated the specific circumstances of 28,840 residents from those households. The sample size of this survey was relatively large. Furthermore, since this set of data contains detailed information on land transfer, income, capital input, labor input and intermediate input of rural households, it is complete and comprehensive.

Before conducting the empirical analysis, we excluded households without agricultural production and those with missing or distorted main variables from the samples. The final selection comprised 2,115 rural households across 30 counties. Relevant data for this paper's empirical study mainly includes households' land transfer status, area of cultivated land,

Province/municipality	Number of sample districts/counties	Province/municipality	Number of sample districts/counties
Henan	3	Zhejiang	1
	3		1
Hebei	2	Hubei	1
	2		1
Anhui	2	Guangxi	1
	2		1
Jiangxi	2	Chongqing	1
	2		1
Shandong	2	Guizhou	1
	2		1
Hunan	2	Yunnan	1
	2		1
Guangdong	2	Shaanxi	1
	2		1
Sichuan	2	Gansu	1
	2		1
Shanxi	1	Jiangsu	1
	1		1
Liaoning	1	Shanghai	1
	1		1
Jilin	1		
	1		

Table 1.
Geographical distribution of sampled districts and counties across provinces/municipalities

household income (including agricultural and non-agricultural income), household capital (including agricultural and non-agricultural capital), the number of household laborers (including farming and non-agricultural employed workforce), and intermediate input on household agricultural production (such as expenses on purchasing fertilizers, feed, pesticides, seeds, and electricity). Due to a large volume of data, we have chosen a representative province from each of the seven regions and presented the land transfer and arable farming situation in these provinces (columns 3–9) and the overall sample (column 2) in Table 2 below.

With economic development in recent years, local land transfer markets have gradually taken shape and developed rapidly. According to Table 2 above, 32% of the rural households in all samples have participated in land transfers. Among them, Jilin has the highest percentage (65.8%), while Shanxi has the lowest percentage (11.9%). Regarding the average land transfer size, Shandong boasts the largest average size at 50.9 mu, while Guangdong has the smallest at mere 1.9 mu. When it comes to the maximum scale of land transfer, Shandong also takes the lead with an area reaching up to 1,600 mu; in contrast, Guangdong's area of land transfer is no more than 4.5 mu.

4. Basic regression analysis

To test the conclusions of the theoretical model, we first examined the effects of land transfer-in and land transfer-out on rural household productivity separately by using the average treatment effect (ATE) method [11].

4.1 Land transfer-in and the enhancement of rural household productivity

For rural households transferring in land, we define a binary random variable $renin_i$ to indicate whether the household i has made such a transaction. Specifically, $renin_i = 1$ denotes

Rural households	Total sample Overall situation	Southwest China Sichuan	Northeast China Jilin	South China Guangdong	Northwest China Shaanxi	North China Shanxi	Central China Henan	East China Shandong
1. Situation of land transfer (mu)								
The proportion of households involved in land transfer	32.0%	49.2%	65.8%	27.3%	14.1%	11.9%	35.1%	27.4%
Transferred area (max.)	1600	15	100	4.5	6.3	8	60	1600
Transferred area (min.)	0.2	0.3	2.1	0.6	1	1	0.5	0.5
Transferred area (average)	18.7	2.3	31.8	1.9	2.9	3.6	8.2	50.9
2. Situation of arable farming (mu)								
Land area (max.)	1611.5	12	181	3	10	10	18	1611.5
Land area (min.)	0.1	0.8	1.7	0.5	1	1	0.3	0.8
Land area (average)	10.5	3.7	24.6	1.5	5.2	3.9	5.1	14.4

Table 2.
Statistical parameters
of data

that the rural household has transferred in land, while $renin_i = 0$ indicates that the rural household is self-sufficient and not involved in any land transfer activities. At the same time, we utilized LP_i to represent the total household productivity of the observed rural household i, and employed LP_{1i} to indicate the household productivity of the said rural household after land transfer-in while LP_{0i} to denote the productivity of non-participating rural households in land transfer-in transactions. Therefore, $(LP_{1i} - LP_{0i})$ denotes the impact of land transfer-in on the total household productivity of the rural household i. However, it is not feasible to observe both LP_{1i} and LP_{0i} simultaneously in reality. Thus, LP_i can be defined as

$$LP_i = (1 - renin_i) \bullet LP_{0i} + renin_i \bullet LP_{1i} = LP_{0i} + renin_i \bullet (LP_{1i} - LP_{0i}) \qquad (8)$$

Therefore, $\alpha = E(LP_{1i} - LP_{0i})$ represents the impact of land transfer-in on total household productivity, i.e. the average treatment effect of land transfer-in. To estimate this effect, we developed the following basic empirical model:

$$ln\, LP_i = u_0 + \alpha \bullet renin_i + X_i'\beta + Z_i'\gamma + e_i \qquad (I)$$

In the theoretical model, we simplified the analysis by only considering the land area in the rural household agricultural production function, as it is assumed that the capital of rural households is primarily tied to land. Therefore, we excluded the capital factor. When it comes to the empirical analysis, we incorporated land and capital factors, respectively, to disentangle the impact of land transfer on rural household productivity. X_i in Model I includes lnT (natural logarithm of rural household land area) and lnK (natural logarithm of rural household capital input) as $X_i' = (ln\, T, ln\, K)$. The explained variable in this model is the natural logarithm of total rural household productivity (lnLP), which is calculated as the ratio of total household income to total household labor size. In addition, given that the sample encompasses 30 counties across 21 provinces, the regional dummy variable Z_i was incorporated into the model.

Since there is heterogeneity among rural households, including those transferring in land and those not), ignoring this may lead to biased model estimation results. Therefore, we extended Model I to create the empirical Model II:

$$ln\, LP_i = u_0 + \alpha \bullet renin_i + X_i'\beta + \left(X_i - \overline{X_i}\right)'\delta \bullet renin_i + Z_i'\gamma + e_i \qquad (II)$$

where $\overline{X_i}$ is the mean of X_i. Additionally, due to potential nonlinearity in the impact of the control variable X_i on household productivity, we utilized propensity score estimate $P(X_i)$ instead of linear functions, as seen in Models I and II, following Rosenbaum and Rubin's (1983) approach. This led us to establish the following empirical Model III:

$$ln\, LP_i = u_0 + \alpha \bullet renin_i + P(X_i) \bullet \beta + \left(P(X_i) - \overline{P(X_i)}\right)\delta \bullet renin_i + Z_i'\gamma + e_i \qquad (III)$$

where the estimates of propensity score $P(X_i)$ are obtained from the Probit model, and $\overline{P(X_i)}$ denotes the mean of $P(X_i)$.

We first assessed the impact of land transfer-in on total rural household productivity through empirical models I to III. The estimation results are presented in Table 3. Based on the estimation results of Models I to III in Tables 3, it is evident that the estimated coefficient for the land transfer-in variable $renin$ is significantly positive. On average, the estimated coefficient for $renin$ stands at 0.15, indicating an increase in the total rural household productivity due to land transfer-in by 16.2% (exp (0.15)−1), which also means that the total productivity of rural households transferring in land is about 16% higher than that of self-sufficient rural households on average. According to the analysis of the aforementioned

Explained variable	Model I	Model II	Model III
renin	0.143*** (0.050)	0.151*** (0.050)	0.158*** (0.052)
ln$T$	0.052 (0.039)	−0.021 (0.052)	–
			–
ln$K$	0.111*** (0.016)	0.09*** (0.018)	–
			–
propensity score	–	–	−1.068* (0.564)
	–	–	
dm_ln$T$	–	0.216*** (0.074)	–
	–		–
dm_ln$K$	–	0.065* (0.038)	–
	–		–
dm_*propen_score*	–	–	2.857*** (1.064)
Constant	8.657*** (0.798)	8.921*** (0.855)	10.159*** (1.005)
R^2	0.246	0.259	0.220
N	1860	1860	1860

Note(s): [1]Due to spatial constraints, the table omits the estimation results of the regional dummy variable. Values in parentheses represent standard deviations, while *, ** and *** denote significance at 10%, 5% and 1% levels, respectively. In the table, "dm_" signifies interaction terms between the net value of each explained variable minus its mean and renin (or renout in Tables 5 and 6). The relevant descriptions below are consistent with this footnote.

Table 3.
Impact of land transfer
on total household
productivity[1]

theoretical model, an increase in agricultural productivity serves as the primary driver for augmenting the total productivity of households that transfer in lands. To verify the conclusion, we employed Models I to III to scrutinize the influence of land transfer-in on household agricultural productivity and non-agricultural productivity, in which household agricultural productivity is measured by the total household factor productivity of agriculture while non-agricultural productivity is measured by the ratio of household non-agricultural wage income to the size of the household non-agricultural labor force [12]. The specific estimation results are presented in Table 4.

Table 4 displays that following land transfer-in, the rural household agricultural productivity experiences a significant increase of approximately 56% (exp (0.445) − 1), as evidenced by the estimation results in columns 2–4. This means that if self-sufficient rural households can afford to transfer in more land for arable farming during the land transfer process, the agricultural productivity of such households may increase by about 56% on average. The estimation results presented in the last three columns of Table 4 indicate that land transfer-in does not exert a statistically significant impact on the non-agricultural productivity of households. This is easily comprehensible. Given that households transferring in lands are inclined to allocate more time and effort towards agricultural production without augmenting their involvement in non-agricultural labor activities, their non-agricultural productivity will not change significantly. Overall, after the land transfer-in, rural households are able to engage in more intensive and large-scale farming practices, resulting in a significant increase in agricultural productivity. As a result, the total household productivity is greatly enhanced.

4.2 Land transfer-out and the enhancement of rural household productivity
This section examines the impact of land transfer-out on rural household productivity. Similar to the aforementioned analysis, we treated whether the household i has transferred out land as a binary random variable *renout$_i$*. Specifically, *renout$_i$* = 1 denotes that the rural household has transferred out land, while *renout$_i$* = 0 indicates that the rural household has

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Explained variable	Impact on agricultural productivity			Impact on non-agricultural productivity		
	Model I	Model II	Model III	Model I	Model II	Model III
renin	0.443*** (0.052)	0.448*** (0.052)	0.446*** (0.052)	−0.141 (0.201)	0.144 (0.568)	−0.062 (0.220)
ln$T$	0.039 (0.045)	0.121** (0.060)	–	0.023 (0.135)	−0.052 (0.186)	–
ln$K$	−0.008 (0.018)	−0.015 (0.022)	–	0.116** (0.047)	0.078	–
					0.078	
propensity score	–	–	0.148** (0.054)	–	–	−14.871*** (2.817)
dm_ln$T$	–	−0.185** (0.091)	–	–	0.344 (0.239)	–
dm_ln$K$	–	0.023 (0.039)	–	–	0.094** (0.038)	–
dm_*propen_score*	–	–	−0.483 (0.980)	–	–	9.005* (4.663)
常数 Constant	5.904*** (0.499)	5.987*** (0.496)	5.903*** (0.571)	7.688*** (0.472)	7.601*** (0.750)	12.768*** (1.099)
R^2	0.377	0.381	0.317	0.188	0.152	0.111
N	1540	1540	1540	1309	1309	1309

Table 4.
Impact of land transfer-in on different types of household productivity

not engaged in any such transaction. We still used LP_i to denote the total household productivity of the rural household i, LP_{1i} the total household productivity corresponding to $renout_i = 1$, and LP_{0i} the household productivity corresponding to $renout_i = 0$. At this point, $(LP_{1i} - LP_{0i})$ represents the impact of land transfer-out on rural household productivity. We continued to employ Models I-III to estimate the impact of land transfer-out on household productivity, with corresponding estimation results presented in Table 5 below.

The estimation results presented in Table 5 demonstrate a significantly positive impact of land transfer-out on the total productivity of rural households. The estimated coefficient for *renout* indicates that, on average, land transfer-out leads to a substantial increase in rural household productivity by 21%. This also means that, on average, the total productivity of rural households transferring out land is 21% higher than that of self-sufficient rural households. Furthermore, we further conducted additional analysis to confirm the impact of land transfer-out on both agricultural and non-agricultural productivity at the household level. Please refer to Table 6 for the corresponding estimation results.

The estimation results in columns 2–4 of Table 6 indicate that land transfer-out does not significantly affect household agricultural productivity, meaning that rural households are less likely to allocate excessive time and effort to agricultural production following the land transfer-out process. The estimation results presented in the last three columns of Table 6 indicate that land transfer-out has a significant positive impact on the non-agricultural productivity of rural households, with an increase of approximately 92%. The increase in non-agricultural income among rural households who have transferred out their land has significantly contributed to the growth of non-agricultural productivity. This is evidenced by the statistical data, which indicates that rural households which have transferred out their land earn an average of CNY 75,924 in non-agricultural income, while self-sufficient households only earn an average of CNY 28,914. Furthermore, with the rapid development of China's non-agricultural economy, the wage income of non-farm workers has been ever-increasing, and working in urban areas has become a viable means for many rural households to improve their non-agricultural productivity (Zhong and He, 2007; Zhang *et al.*, 2012).

4.3 Rethinking the association between land transfer-in/out and household productivity
In the preceding section, we conducted an empirical analysis to examine the impact of land transfer-in and transfer-out on rural household productivity using the average treatment effect (ATE) method. However, it is crucial to satisfy the Conditional Mean Independence (CMI) assumption when applying the ATE approach. Given our research focus in this paper, we expressed this prerequisite as follows:

Explained variable	Model I	Model II	Model III
renout	0.199*** (0.071)	0.202*** (0.071)	0.175** (0.073)
ln$T$	−0.034 (0.047)	−0.027 (0.053)	–
ln$K$	0.106*** (0.017)	0.090*** (0.018)	–
propensity score	–	–	−1.089** (0.565)
dm_ln$T$	–	0.036 (0.126)	–
dm_ln$K$	–	0.082* (0.048)	–
dm_*propen_score*	–	–	0.773 (1.289)
Constant	8.757*** (0.835)	8.928*** (0.858)	10.165*** (1.007)
R^2	0.25	0.261	0.224
N	1570	1570	1570

Table 5.
Impact of land transfer-out on total household productivity

Explained variable	Effect on agricultural productivity			Effect on non-agricultural productivity		
	Model I	Model II	Model III	Model I	Model II	Model III
renout	−0.059 (0.099)	0.020 (0.113)	−0.050 (0.098)	0.653*** (0.149)	0.681*** (0.149)	0.617*** 0.617***
lnT	−0.042 (0.058)	0.113* (0.059)	–	−0.288*** (0.099)	−0.294*** (0.111)	–
lnK	−0.015 (0.020)	−0.014 (0.022)	–	0.053 (0.036)	0.017 (0.042)	–
propensity score	–	–	−0.259 (0.531)	–	–	−1.524 (1.382)
dm_lnT	–	−0.613*** (0.211)	–	–	0.083 (0.226)	–
dm_lnK	–	−0.005 (0.058)	–	–	0.186** (0.076)	–
dm_*propen_score*	–	–	−3.040 (2.241)	–	–	2.234 (2.311)
Constant	6.331*** (0.386)	5.717*** (0.455)	6.029*** (0.462)	9.377*** (1.115)	9.764*** (1.190)	10.177*** (1.145)
R^2	0.285	0.291	0.215	0.119	0.122	0.115
N	1204	1204	1204	1504	1504	1504

Table 6.
Impact of land transfer-out on different types of household productivity

$$E(LP_{ni}|X_i, rent_{in-out-i}) = E(LP_{ni}|X_i), \quad n = 0, 1$$

It is assumed that, after controlling for a number of productivity-related explanatory variables X_i, the decision of whether or not a rural household participates in land transfer ($rent_{in-out-i}$, denoting land transfer in/out, representing $renin_i$ or $renout_i$) is no longer associated with household productivity LP. In other words, the decision to participate in land transfer is linked to household productivity through X_i. The estimation results obtained using the ATE method are only reliable if the CMI condition is satisfied.

Given that the explained variable is $ln\,LP$, based on the theoretical model established in this paper and the derived expression for rural household productivity, it can be inferred that after controlling for X_i' in the empirical model I, the error term e_i also encompasses information pertaining to the agricultural productivity lnA_i of the rural household i, while agricultural productivity A_i influences the decision of rural households on the land transfer market. In other words, whether a household participates in land transfer or not is a non-random act that is "self-selected". If this factor is not considered, the CMI assumption of the ATE method may become untenable, resulting in endogeneity in the model and biased estimation results.

Addressing the aforementioned endogenous issues poses a significant challenge for academia. While instrumental variables are commonly used to tackle endogeneity, identifying suitable ones in empirical studies remains daunting. This problem also exists in this paper. Therefore, we employed the Propensity Score Matching (PSM) method within the basic analytical framework of ATE to address the endogeneity problem. The core of PSM lies in selecting one or several self-sufficient rural households that have not participated in land transfer before and matching them with those rural households that have transferred land in or out with similar characteristics, except for the decision to participate in the land transfer. In this way, the ATE estimates based on matched households can effectively mitigate the estimation bias caused by the self-selection issue.

To be specific, under the CMI assumption, we employed the PSM approach to estimate each entity's propensity score ($P(X_i)$) and match households transferring in/out land with those not involved in land transfer based on close scores (i.e. proximity to $P(X_i)$) in the matched group. We utilized the productivity of the matched group as an approximation for the missing productivity $E(LP_{0i}|rent_{in-out-i} = 1)$ of rural households which have transferred in/out land (treatment group). The Average Treatment Effect on the Treated (ATT) [13] can be estimated by comparing the values of explained variables among the matched rural households. In this paper, ATT indicates the impact of land transfer in/out on the productivity of rural households transferring in/out land.

$$ATT = E(LP_{1i} - LP_{0i}|rent_{in-out-i} = 1, X_i)$$
$$= E(LP_{1i} - LP_{0i}|rent_{in-out-i} = 1, P(X_i))$$

The estimation results of ATT exhibit higher accuracy compared to those of ATE. Generally speaking, the following expression for ATT holds true:

$$ATT = \frac{1}{N} \sum_{i=1}^{N} \left(LP_{1i} - \sum_{j \in C^0(p_i)} w_{ij} LP_{0j} \right)$$

where N denotes the number of sample entities in the treatment group, $C^0(p_i)$ the matched group of entity i in the treatment group, W_{ij} the weight of each entity j in the matched group of the entity i, and $\sum_{j \in C^0(p_i)} w_{ij} = 1$. Different matching methods yield different sets of $C^0(p_i)$ and w_{ij}. This paper primarily employs two matching methods—Kernel-based Matching and Nearest Neighbor Matching—to estimate ATT [14].

Based on the aforementioned methods, we estimated the impact of land transfer-in/out on total household productivity, agricultural productivity, and non-agricultural productivity, respectively. The ATT estimations using these two methods are denoted by ATT_K and ATT_N, correspondingly. The specific estimation results can be found in Table 7.

According to the estimation results presented in columns 3–4 of Table 7, land transfer-in is associated with an increase of 13.9 and 43.3% in total productivity and agricultural productivity, respectively, among rural households that have transferred in land, respectively. However, there appears to be no significant change in their non-agricultural productivity. According to estimation results in columns 5–6 of Table 7, land transfer-out is associated with an increase of approximately 49.2 and 130% in total productivity and non-agricultural productivity of rural households that have transferred out their land, respectively, without significant change in their household agricultural productivity. The ATT estimation results obtained through the PSM method are found to be largely consistent with the ATE estimation results presented in the preceding section.

In summary, upon completion of land transfer, rural households that transfer in land experience a significant increase in agricultural productivity and total household productivity, while rural households that transfer out land experience a significant increase in non-agricultural productivity and total household productivity. The basic regression analysis results support the theoretical model's conclusions.

5. Robust test

In the preceding sections, we verified the impact of land transfer-in and transfer-out on rural household productivity through basic regression analysis and obtained more accurate ATT estimation results by somewhat addressing potential endogenous problems through PSM. However, PSM is an indirect method that only partially addresses endogenous problems and does not allow us to directly examine the impact of other factors (such as land and capital) on household productivity. In this section, we employed the proxy variable approach, which is more direct, to conduct a robust test.

In contrast to the PSM approach, the core of the proxy variable approach utilizes a proxy variable as a partial substitute for productivity e_i, thereby extracting endogenous information from e_i. We employed the estimation method proposed by Levinsohn and Petrin (2003) to address the endogeneity problem arising from e_i and regarded the intermediate input in production as a proxy variable for observable productivity. As an illustration, we presented empirical model I:

Explained variable		renin estimated coefficient		renout estimated coefficient	
		ATT_K	ATT_N	ATT_K	ATT_N
Total household productivity	Coefficient value	0.111	0.152	0.408	0.392
	t-value	2.149	2.064	5.142	3.704
	p-value	0.032	0.039	0.000	0.000
Household agricultural productivity	Coefficient value	0.375	0.358	−0.063	−0.147
	t-value	7.603	4.804	−0.658	−1.190
	p-value	0.000	0.000	0.511	0.234
Household non-agricultural productivity	Coefficient value	−0.23	−0.134	0.815	0.900
	t-value	−1.222	−0.560	5.881	3.901
	p-value	0.222	0.576	0.000	0.000

Table 7.
Estimation results of ATT

$$ln\,LP_i = u_0 + \alpha \bullet rent_{in-out-i} + X_i'\beta + Z_i'\gamma + w_i + \eta_i$$

where $e_i = w_i + \eta_i$, with w_i represents observable agricultural productivity information and η_i contains unobservable technology shocks and measurement errors. In the context of actual agricultural production by rural households, a portion of their agricultural productivity (w_i) is observable in the current period, and based on this information, agricultural producers may make timely adjustments to their optimal mix of agricultural production factor inputs. Therefore, w_i may be associated with $rent_{in-out-i}$ and X_i (while unobservable factor η_i is extraneous to any of them). If a monotonic relationship is maintained between the intermediate input lnM_i and productivity $ln\,LP_i$ in agricultural production, and it is presumed that $lnM_i = M(lnK_i, w_i)$, then $w_i = w(lnK_i, lnM_i)$ and the following solution can be obtained:

$$ln\,LP_i = u_0 + \alpha \bullet rent_{in-out-i} + \beta_T lnT_i + Z_i'\gamma + \beta_k lnK_i + w_i + \eta_i$$
$$= \alpha \bullet rent_{in-out-i} + \beta_T lnT_i + Z_i'\gamma + \phi(lnK_i, lnM_i) + \eta_i$$

where $\phi(lnK_i, lnM_i) = u_0 + \beta_k lnK_i + w(lnK_i, lnM_i)$. To obtain the consistent estimates of α, β_T and γ, we can use a cubic polynomial approximation of $\phi(lnK_i, lnM_i)$ by lnK_i and lnM_i and incorporate it into the empirical model. The model I can be converted into:

After the aforementioned conversion, we obtained consistent estimates of α, β_T and γ. Although this method does not directly generate β_k, the consistent estimates of the coefficient of lnK_i [15] given that the focus of the empirical analysis is estimating α, it does not impede us from obtaining the desired results in this empirical analysis.

According to the aforementioned description, while utilizing the proxy variable approach to address the endogenous problem posed by e_i, we altered the composition of X_i. Following the adjustment, X_i now encompasses lnT_i and $(lnK_i)^c (lnM_i)^m$, while the residual term solely comprises the unobservable factor η_i. At this point, the residual term no longer pertains to $rent_{in-out-i}$ and X_i, thereby satisfying CMI assumptions for ATE methodology. After constructing the empirical model I', we can develop the adjusted empirical model II' similarly. As the proxy variable approach expands the control variable X_i under the linear hypothesis (that X_i has a linear impact on household productivity), we only adjusted the original empirical models I and II. In the subsequent robust test, we employed the adjusted empirical models I' and II' to examine the impact of land transfer-in and transfer-out on total household productivity, agricultural productivity, and non-agricultural productivity. The corresponding estimation results are presented in Table 8 below.

The estimation results presented in Table 8 exhibit a high degree of robustness when compared to the estimations obtained in Section 4 of this paper. Based on the estimation results presented in columns 2 and 3 of Tables 8, it can be concluded that land transfer-in has a significant positive impact on the total productivity of rural households, with an increase of approximately 15.6%, in which household agricultural productivity increases significantly

Explained variable	Estimated coefficient of renin		Estimated coefficient of renout	
	Model I	Model II'	Model I'	Model II'
Total household productivity	0.164*** (0.052)	0.126*** (0.048)	0.150** (0.065)	0.156** (0.068)
Household agricultural productivity	0.442*** (0.052)	0.438*** (0.052)	−0.054 (0.099)	−0.026 (0.103)
Household non-agricultural productivity	−0.123 (0.203)	−0.172 (0.211)	0.564*** (0.152)	0.518*** (0.188)

Table 8.
Test results of the
empirical models I'
and II'

by approximately 55% following land transfer-in, while non-agricultural household productivity remains unaffected. According to the estimation results presented in the last two columns of Table 8, land transfer-out has a significant impact on the total household and non-agricultural productivity of rural households, with an increase of 16.5% in total household productivity and a remarkable boost of 71.5% in non-agricultural productivity, while household agricultural productivity is not significantly affected.

Overall, the estimation results of the robust test are consistent with those of the basic regression analysis in the preceding section. These empirical findings collectively suggest that rural households transferring in land experience a significant increase in total productivity as their agricultural productivity improves during the land transfer process, while rural households transferring out land see a significant rise in total productivity as their non-agricultural productivity improves. The empirical findings strongly corroborate the conclusions of the theoretical model.

6. Conclusions and policy implications

Unlike previous literature, this paper discusses the impacts of land transfer-in and transfer-out on total productivity, agricultural productivity, and non-agricultural productivity among various rural households (i.e. those transferring in land, transferring out land, or which are self-sufficient). Both the theoretical model and empirical analysis findings suggest that land transfer can significantly enhance rural household productivity. In particular, rural households that acquire land operation rights through transfer experience a significant increase in agricultural productivity and, subsequently, an overall increase in household productivity. For rural households transferring out land, their non-agricultural productivity increases significantly after land transfer-out, leading to an overall boost in total household productivity.

The results of this study have significant policy implications for charting a new course toward enhancing agricultural productivity among Chinese farmers. Firstly, for one thing, to boost the total productivity of rural households which transfer in land, the government should actively encourage and facilitate the transfer of land operation rights to major specialized households, family farms, farmers' cooperatives and agricultural enterprises through open market mechanisms and develop diverse forms of large-scale operations. For another, the government should provide agricultural skills training to farmers engaged in agricultural operations and expedite the accumulation of human capital while promoting novel agricultural technologies to effectively enhance household agricultural productivity (Zhou et al., 2010).

Secondly, to enhance the total productivity of rural households who transfer out land, the government should focus on the linkage effect between urban and rural development and strive to promote urbanization and industrialization. More non-farm positions should be created to accelerate the effective transfer of surplus rural labor. Furthermore, the government should increase both the proportion and intensity of investment in rural vocational education. To be more specific, it should provide vocational technical training for farmers engaged in non-agricultural work to improve the non-agricultural productivity of households effectively.

Thirdly, in terms of rural households which have not participated in land transfer, their absolute productivity remains constant. Therefore, to increase their total household productivity, we believe that such rural households must proactively change their mindset, conform to market demands, and actively participate in farmland transfer: (1) If the rural households are inclined towards agricultural production, they should strive to enhance their agricultural productivity and augment the total household productivity by capitalizing on the returns to scale from farmland upon the land transfer-in; (2) if rural

households tend to engage in non-agricultural sectors, they can transfer out their land operation rights and receive steady rents while focusing on their non-agricultural work. They can increase their total household productivity by improving their non-agricultural productivity. In essence, rural households of this type are unable to enhance their productivity without participating in land transfer.

Notes

1. The average growth rate per annum of farmers' income from 1978 to 1984 was as high as 15.9% (Zhang and Wang, 2004).

2. The labor force in rural households may also remain in the agricultural sector but be employed by other rural households or modern agricultural companies to engage in agriculture. Since they receive wage income, similar to the income received by farmers working in non-agricultural sectors, for the sake of simplicity, this paper will refer to the narrow non-agricultural sectors and modern agricultural companies as "non-agricultural sectors".

3. All the farmland mentioned in this paper refers to arable land, not including rural construction land and residential land, etc. The terms "farmland", "rural land" and "land" appearing in the article refer to the same concept. The authors believe that the farmland operation rights should refer to the rights of possession, use, sub-contracting, leasing, exchange and equity participation, but not the right of transferring the farmland contracting right, i.e. changing the rural land contracting relationship.

4. Although a unified, formal land transfer market has not yet been formed in China, local land transfer markets have gradually formed and developed rapidly in recent years with economic development, and market-based land transfer transactions have become common. However, the development status of land transfer markets varies somewhat among different areas, which has also been verified by the sample data below (refer to Section 3 for details).

5. All lands in the model are "homogeneous" and the authors did not differentiate between lands herein.

6. This conclusion has also been supported by the empirical studies of Fleisher and Liu (1992), Zhong and Ji (2009), Xu et al. (2011) and Ni and Cai (2015).

7. This can be deduced from $\frac{Y_2}{L_{i0}} = \frac{1}{L_{i0}} \left[WL_{ia2} \left(\frac{1}{1-\beta} - 1 \right) + WL_{i0} + (r - c_s) T_{is} \right]$ and equation (4).

8. Since this type of rural households inputs more of its energy and time into work in the non-agricultural sectors and is less motivated to work in agriculture, its agricultural productivity does not change significantly. This hypothesis has been supported by empirical studies, such as Lohmar et al. (2001) and Brandt et al. (2002). The estimation results in the empirical analysis section of this paper also support this hypothesis.

9. In the post-transaction period, since this type of rural households no longer has to bear the transaction cost c_s, it can be inferred that $Y_3 = Y_2 + c_s T_{is}$.

10. Based on practical experience in China, land transfer (i.e. transfer of land operation rights) can provide rural laborers with a more secure way to maintain their contracting rights to land and reduce the need for them to return to rural areas for farming due to concerns about land readjustment affecting their land contracting rights. Thus, these laborers can be more comfortable working in the non-agricultural sector while earning rental income from the land transfer.

11. To gain a comprehensive understanding of the underlying assumptions of ATE and the rationale behind econometric models I-III, please refer to Wooldridge (2003, pp. 604–642).

12. Utilizing the sample data, we conducted a regression analysis on household agricultural business income and various factors including the size of the household agricultural labor force, agricultural capital, farmland and regional dummy variables. The residual term is the total factor productivity of households in agriculture. Non-agricultural wage income is defined as the sum of net income from local non-agricultural self-employment activities of all household members and any remitted or

brought back by all outgoing household members. The calculations of household agricultural productivity and non-agricultural productivity presented below are in line with this approach

13. It is worth noting that the ATT method can effectively exclude rural households that are unqualified or unable to participate in land transfer, thereby enhancing the credibility and precision of the estimation results. Additionally, it also measures the potential productivity growth for future qualified and able rural households participating in land transfers (i.e. households in the matched group).

14. For a comprehensive understanding of the principles and demonstration of ATT, please refer to Rosenbaum and Rubin (1983), Heckman *et al*. (1997), and Angrist (1998). In brief, Kernel-based Matching involves assigning different weights w_{ij} to each entity in the control group (i.e. all households not participating in land transfer) that are included in the matched group. Typically, $w_{ij} \propto K\left(\frac{P_i - P_j}{h}\right)$, where $K(\bullet)$ can be either a Gaussian or Epanechnikov kernel function (the authors employed the Gaussian kernel function), h denotes the bandwidth of the kernel estimate and P the propensity score. In terms of Nearest Neighbor Matching, the authors identified a control group entity with a propensity score closest to that of each treatment group entity as the matched object, assigning it a weight of 1.

15. In fact, Levinsohn and Petrin (2003) provide a method for estimating β_k; however, this is not the focus of this study. Therefore, the authors did not perform the second estimation step to obtain consistent estimates of β_k. The results obtained in the first step regarding α will not be affected by the second estimation step for β_k. Additionally, in Model I', it is noted that $c \in [0, 3]$ and $m \in [0, 3 - c]$, with neither variable being equal to 0 simultaneously.

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