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# Land endowment and education investment behavior of rural households: a field survey based on 887 administrative villages in 31 provinces of China

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**Abstract**

This paper analyzes the influence of land endowment possessed by the rural household on education decisions under the condition of insufficient rural land circulation and rural labor transfer. Results show that land endowment influences education decisions through two effects: income and substitution. For most rural households, the substitution effect of land endowment on educational investment is dominant. Meanwhile, the impact of household land size and the education level of the labor force on rural household income show "interval difference"; i.e., only when the logarithm of household land size is higher than the threshold of 2.014 can land endowment and educational investment be effectively allocated and raise rural household income. We suggest that limitation of land circulation be removed and the system be farmer-centered so that farmers' income will be raised and rural labor will be better employed in urban areas.

**Keywords:** Land, Education, Urban employment

## Introduction

Continuous socio-economic development has strengthened China's dual economic structure. At the same time, the income gap between urban and rural residents has also been widening. China's urban-rural income gap has risen by more than 50% since the Reform and Opening-Up in terms of urban-rural income ratio, which came to 3.1 in 2012 (National Bureau of Statistics, 2013). In the historical experience of developed countries, the rural-urban income gap is the driving force for the rural labor force to migrate to cities (Todaro, 1969). However, since 2003, China has experienced a "migrant worker shortage" in skilled and technical labor, that is, a continual labor shortage in a broader sense. Since 2005, the labor market no longer has an oversupply of urban labor force (Cai and Du, 2011). Why does the rural-urban income gap continue to increase in China while urban areas cannot attract enough rural laborers who exhibit knowledge and skill? Some scholars believe that the transfer of surplus rural labor to urban areas has almost completed, and the Lewis turning point has been reached (Cai, 2010). However, other studies suggest that surplus rural labor migration is influenced by economic fluctuations and flexible decisions about employment in either urban or rural area (Chen and Yuan, 2012). Results from the Monitoring Survey of National Bureau of Statistics (2013) show that the total number in the rural labor force in 2010 amounted to 242 million, of which 153 million were migrant workers and 89 million were local non-agriculture employees. It is evident that surplus rural labor has not completely transferred to urban areas.

Under the current condition of agricultural land size, agricultural technology, agricultural product price, and the income structure of rural households, it is obvious that income from agricultural production and operation is unlikely to become a continuous source of rural household income growth. Meanwhile, the choice about labor migration is affected by local wage level and cost of living, as well as knowledge, skill, and the number of wage earners in the household. If the improvement to rural households' income mainly relies on emigration, the agricultural sector will inevitably shrink.

Now, we are faced with a dilemma: there are separate pressures from farmers' income, stable development of the agricultural sector, and effective transfer of rural labor force, etc. In terms of the employment intentions of rural youth, this survey shows that more than half of secondary and high school graduates from eastern rural areas choose to pursue further schooling, whereas about 1/5 choose to migrate to begin a career, and only less than 8% choose to farm. In China's central region, these proportions are approximately 40%, 33%, and more than 10%, while the proportions are respectively 33%, 33%, and 16.5% in the western provinces.

If a large number of educated rural youths follow a one-way path away from agricultural production, rural areas will hollow out, causing a devastating impact on China's sustainable agricultural development. Therefore, for at least the 13th Five-Year Plan period or perhaps even longer, breakthrough reform is needed for the rural management system, agricultural land transfer, rural education, technology, etc., to meet the needs of national economic development and to guarantee the sustainable development of agriculture.

We believe that there are two options for surplus rural labor as they decide about their employment: to enter the urban labor market or to stay in agriculture. If one stays in agriculture, the land owned by the household as the main means of production can provide a stable income, thus replacing income from urban employment (Feng and Heerink, 2008). Therefore, rural households with larger land endowments may reduce their education investment and be less willing to send their children to work in cities. In other words, land holdings have a substitution effect on education. However, from another point of view, income from agricultural production and management brought by the land also eases the budget constraints for children's education, thus producing an income effect.

There has been a great deal of research on the educational investment and decision-making, mainly focused on the interactive process between education decision-making and demographic characteristics, and household background and social environment. Less research has discussed the impact of land size on the educational investment of rural households, from the perspective of surplus rural labor transfer. This paper incorporates land endowment into the traditional theoretic model of human capital to discuss to what extent it affects decision-making about education and rural household income. The agricultural land scale influences the education and income of rural households in two primary ways. Firstly, for those household whose land size is less than the threshold value, the agricultural efficiency is low and they have to devote so much labor to agricultural production that they reduce the willingness of investment in education and of migration for work. At this point, the substitution effect of land on education dominates. Secondly, when land size increases to a certain extent, labor force will be released from the agricultural sector and the labor force will be replaced by advanced technology, thus optimizing allocation of resources, increasing rural households' income and further alleviating the budget constraints in providing for the education of their children. At this point, we believe that the income effect of land on education becomes more important. Then, in the current changes to China's dual economy structure, does the substitution effect or the income effect dominate? Does the allocation of rural households' land endowment and human capital maximize net income? Does the scale promote the urban employment of surplus rural labor? These are the questions to be answered in this paper.

## Literature review

The mechanism that affects the choice of education has been revealed in many literatures. There are two primary theories in related research. The first theory holds that the amount of cultural capital, social capital, and economic capital possessed by rural parents will greatly impact rural children's education choices. Therefore, for children from migrant working families with low socio-economic status, who are transitioning from their parents' "temporary migration" status between the city and the rural area to a "permanent migration" status in the city, their choice about pursuing higher education is often inherently constrained by factors like household background and social class (Wang and Wang, 2013). Yang and Duan (2008) compare the educational opportunities of left-behind children and their counterparts in rural areas and find that migrant non-agricultural employment can improve rural households' socio-economic status and change parents' cultural values, thus improving children's educational opportunities. This view is based on the perspective of household capital and emphasizes the impact of the floating population's social background and educational attitudes on the decision to pursue an education.

The second theory illustrates the current condition and major problems facing those who migrated and those who remained, in aspects like the cost to migrate, income in the city, and social institution. This theory analyzes countermeasures to these problems by focusing on the optimal decision-making regarding educational investment. Shryock Jr and Nam (1965) illustrate that surplus labor that chooses to transfer has higher education and skill level, a pattern supported by evidence from China (Guo and Li, 2009). Level of human capital, as represented by education level, is a core variable in understanding the development structure of urbanization. Many researchers use the transfer and relocation of human capital as proxies to judge the extent of the labor migration from agricultural to modern sectors. As to the impact of labor transfer on educational decision-making, the theoretical framework of human capital accumulation proposed by Kanbur and Rapoport (2005) has been widely adopted. This framework suggests that disparity in technical conditions and the rate of human capital return exist between the former residence and destination of labor migration. Some scholars (Beine et al., 2008) have also verified this with data from 127 countries. In fact, these two arguments are not contradictory. In effect, both consider education choice as a type of profit maximization given household (or personal) endowment.

For rural households, the land is the most important natural capital and significantly impacts decision-making regarding labor transfer. Shi and Yang (2012) established an empirical model based on survey data from rural households in Hubei and Henan provinces. They found that land provides material support for migrant workers; however, rich land will encourage labor flows back to the countryside. Mao and Wang (2006) believe that rural labor transfer can be promoted by substituting and weakening land's role in economic security and social security. Drawing from the human capital model framework regarding labor mobility decision-making, the amount of land influences the education investment of rural households through three mechanisms. First, in the free land market, the scope of land managed by a household will gradually reach an optimal level where the marginal benefit from agriculture equals the marginal benefit from education. Thus, allocation of human capital becomes more efficient (Benjamin and Brandt, 2002). Second, based on differences in land endowment, labor ability, and productivity, laborers with a comparative advantage in the agricultural sector will flow to the urban sector, and vice versa, in order to maximize income. Those who transfer into the agricultural sector are less motivated to invest in education, while those who transfer into the non-agricultural sector are more motivated to invest in education (Berry and Glaeser, 2005; Guo and Li, 2009). Third, in the agricultural sector, marginal income from farming improves as the amount of land increases (Benin et al., 2005). On the one hand, this increased income will ease the constraint for agricultural workers' education budget. On the other hand, having more land can also prevent agricultural workers from moving into cities and increase the cost of their educational investment (Wei et al., 2003). Through survey data, Li and Zhong (2010) find that farmers who have lost their land face difficulty in occupational adjustment and therefore hope to get educational training and professional guidance.

At present, there is an increasing body of empirical literature that aims to understand the relationship between the amount of land and the decisions that rural households make about education, but no convincing conclusion has been reached yet. Most scholars believe that land is not only a type of wealth that reduces farmers' poverty (Rigg, 2006) and generates more income for education investment (Su and Ding, 2007), but also a reliable safeguard mechanism that enhances rural households' ability to bear the risks inherent in education investment (Li et al., 2002). However, some scholars believe that land has a substitution effect for education. Jensen and Nielsen (1997), using basic education data from Zambia, find that land ownership has a negative effect on school enrollment rate. The authors attribute such effect to the fact that landowners need agricultural labor for farming, but do not use the land for investment to obtain financial income.[1] Nkamleu (2006) analyzes data from 1501 households in Cote d'Ivoire and finds that the higher the marginal returns of children engaging in agricultural work, the lower the school enrollment rate. Rosenzweig (1977) proposes an opportunity cost hypothesis to explain the substitution effect of land on education and argues that increases in land rent payments would increase the opportunity cost from education investment and thereby would reduce school enrollment rate. In China, Chen and Yuan (2012) think that the substitution effect of land on education comes from its function as "uncashable unemployment insurance." In discussing the problem of agricultural efficiency in the process of China's urbanization, Li (2001) argues that land and human capital should comply with a reasonable "domain" of allocation. Surplus land leads to a decline in land productivity, while surplus human capital affects technological progress and labor productivity. In particular, after a systematic review of existing literature, to the best of our knowledge, there is no study that links the income effect and the substitution effect of the amount of land owned on household education investment.

There are several weaknesses in the existing literature. First, the mechanism of the impact of land on education is unknown. Land increases the budget for educational investment when rural children are of school age and, thereby, has an income effect on education. When rural children start working in agriculture early, it makes them less likely to consider out-migration and thus has a substitution effect on education. In addition to Basu et al. (2010) and Nkamleu (2006), most existing studies declare that land increases educational investment and income and affects the duration of rural children's education. However, the internal logic remains to be revealed. Second, the relative intensity of the income effect and substitution effect remains wanting. Research on the substitution effect of land on education demonstrates that land has a negative marginal impact on education by raising educational opportunity cost and providing insurance against unemployment. However, such research does not elaborate on the proportion of income effect and substitution effect. Therefore, it has no answer to the question of whether or not resource allocation caused by constrained land transfer can be optimized or how much efficiency is lost.

In view of these issues, this paper attempts to clarify the mechanism by which land impacts education. It also measures the interaction of income effect and substitution effect of land on education, both theoretically and empirically. Furthermore, this paper proposes policy recommendations on land transfer and the free flow of labor that aim at maximizing rural household income and optimizing the level of education. The rest of this article is arranged as follows: Section 3 puts forward the theoretical model and hypotheses; Section 4 elaborates data, variables, and measurement methods; Section 5 presents the empirical results; and Section 6 summarizes the findings and concludes with policy recommendations.

## Theoretical models and hypotheses

According to the existing research, one's decision to move from rural to urban areas exerts direct effect on the decision of investment in education. In our survey, we find that despite intensive labor transfer from rural to urban areas, a considerable number of farmers prefer staying in rural areas. The reason for this preference is two-fold: for one thing, urban areas have limited capacity, and the income of migrant workers is relatively low; for the other, income from the small-scale agriculture can provide decent supports for life. In addition, as mentioned above, education is required when rural labors transfer to urban areas. Thus, even though 98% of our interviewees realize the importance of education, the overall education level of rural population is still relatively low. Moreover, 36% of our interviewees are reluctant to continue their education even if they could afford to do so. Obviously, our interview shows that the decision of investing in education is influenced by the decision of moving from rural to urban areas. Therefore, our model, which links land size and education level, provides a novel perspective to explore how the size of managed land influences the optimization of education and the mobility of rural labor.

In our model, education is a form of investment that maximizes lifetime income for both individuals and households (Becker and Lewis, 1973). We express the income function as $y(e, L)$, where $y$ is the present value of household income, $e$ is the years of children's education, and $L$ is land endowment. Assume that the farmer (individual or household) is faced with a trade-off between the cost of education (including direct costs and opportunity costs) and future earnings (current value of household income flow), their children's optimal period of education $e^*$ maximizes the present value of household income. With the optimal education period, the present value of the income of unit farmer household is $y^* \equiv y(e^*, L)$.

The present value of lifetime income, which is the sum of the discounted value of income in each period $\tilde{y}(e, L, t)$, is expressed as

$$y(e, L) = \int_e^\infty \beta(t)\tilde{y}(e, L, t)dt - \hat{c}(e) \tag{1.1}$$

where $t$ is the time, $\beta(t)$ is the time preference of the household, and $\hat{c}$ is the opportunity cost of receiving education and education investment.

Let the marginal benefit of education be $b(e, L)$ and the marginal cost be $c(e, L)$. Following common practice, we assume that, with the increase of education period, the marginal benefit $b(e, L)$ declines while the marginal $c(e, L)$ goes up. Let $b_{ee}$ and $c_{ee}$ equal to the second-ordered partial of marginal benefit and marginal cost, respectively. Then, $b_{ee} < 0$ while $c_{ee} > 0$.

In order to maximize the present value of lifetime income, the farmer (individual or household) pays for education until marginal benefit equals marginal cost, i.e., $b(e, L) = c(e, L)$, where schooling year is the optimal education period. Further, we represent the intensity of the two effects as

$$\frac{de^*}{dL} = -[(b_{eL} - c_{eL})/(b_{ee} - c_{ee})] \tag{1.2}$$

which indicate that land endowment influences the decision on education period. Obviously, in Eq. (1.2) the denominator is negative. As for the numerator, the sign of $b_{eL}$ is uncertain. On the one hand, when the scale of managed land is large, the labor force factor is released from the agricultural sector and can opt to move into cities based on their comparative advantage in order to achieve higher income, and thus, $b_{eL} > 0$. However, the opposing mechanism implies that when the scale of managed land is less that the most economic level and agricultural efficiency relatively low, a slight increase in land endowment will reduce most agricultural workers' investment in education, but encourage them to stay at home and farm; hence, $b_{eL} < 0$. The second part of the numerator, $c_{eL}$, is always greater than 0 because an increase in agricultural income leads to an increased opportunity cost from education. All these mean that the sign of the numerator is uncertain. To further explain, Fig. 1 plots the relation between marginal cost and marginal benefit from education.

In Fig. 1, the horizontal axis indicates education while the vertical axis indicates household income at a certain time. The dashed line represents initial equilibrium. The initial marginal cost of education is $c(e, L)$ while the initial marginal benefit is $b(e, L)$.

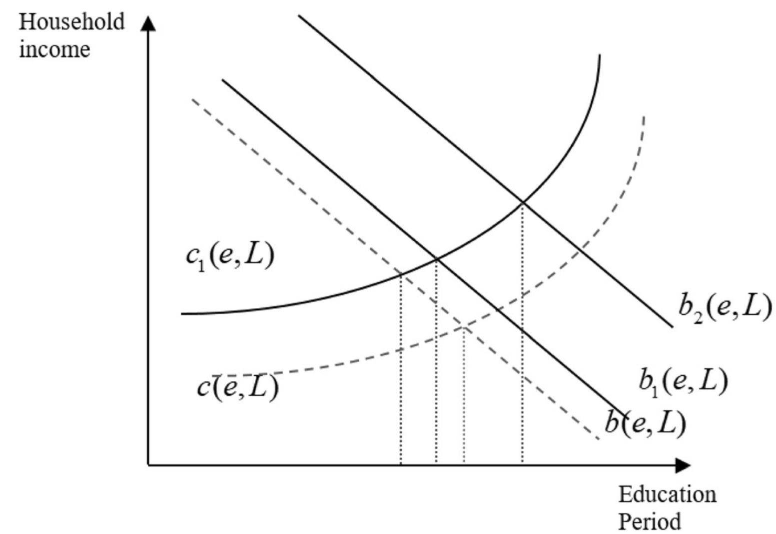


**Fig. 1** Relation between marginal cost and marginal benefit from education

The curves representing marginal cost and benefit move as the scale of managed land changes. When the scale increases, the marginal cost of education goes up and $c(e, L)$ moves to $c_1(e, L)$. However, considering the sign of $b_{eL}$, the change of $b(e, L)$ could lead to two different results. First, if $b_{eL} < 0$, $b(e, L)$ moves right to $b_1(e, L)$. For the households that possess more land, the marginal benefit from unit investment in education could not offset the marginal cost that mainly includes the opportunity cost of farming activities, which lowers the optimal education investment for the household, comparing to the initial equilibrium. Second, if $b_{eL} > 0$, the scale of managed land is large enough and $b(e, L)$ moves to $b_2(e, L)$—i.e., more investment in education leads to a higher net present value of lifetime income. Then, compared with the initial equivalence, the optimal educational investment for this household increases.

According to Eq. (1.2), with static comparative analyses, we propose the hypotheses as follows:

#### Hypothesis 1: Land has dual impact from substitution effect and income effect on education

Consider the impact of land on decision about the education period, $de^*/dL$. As to the denominator, the sign of ($b_{eL}$-$c_{eL}$) could be either negative or positive. Thus, land endowment might have either substitution or income effect on education.

#### Hypothesis 2: If the scale of managed land is large enough, the labor factor is released and the income effect of land on education increases

When the land size grows to a certain extent, the process of agricultural industrialization accelerates and advanced technologies replace labor. Hence, the household is more likely to invest in education in order to transfer labor away from agriculture. At this time, the curve of $b(e, L)$ moves upwards and its intersection with $c(e, L)$ also moves. Thus, the income effect of land on education increases.

#### Proposition: The allocation of land and education will be optimized and household income will increase only if the scale of managed land is large enough

This proposition is derived from the two previous hypotheses. Although land has a positive effect on household income, this effect is relatively weak when the scale of the managed land is not large enough. The substitution effect of land on education restrains the increase of income from migrant work and non-agricultural jobs. Thus, the allocation of land and education is efficient only if the scale of the managed land reaches a certain degree, and this promotes household income.

## Data and methods

### Data and variables

#### *Data*

The data used in this paper are from the 2011 Thousand-Village Survey conducted by Shanghai University of Finance and Economics. The survey strives to describe the political, economic, and cultural status quo in rural China and study on education and income in-depth. The survey project covered 887 villages in 31 provinces, municipalities, and autonomous regions of China, with 506 villages in the eastern region, 176 villages in the central region, and 205 villages in the western region. Questionnaires and in-depth interviews were conducted in these villages; 11,520 questionnaires were distributed and 9540 were collected; the response rate is 82.8%. We analyze each variable of the original data. For those obviously unreasonable values, we either treated them as missing values or did group analysis. It should be noted that since the samples of rural children include all age groups under 25 years old, the household income of the previous 12 months may not reflect the economic status of school age rural children. Therefore, we assume that rural children start primary education and secondary education at the age of 6 and 12, respectively, and complete their high school (or technical school) education and college education at the age of 18 and 22, respectively. We subtracted the child's age of completing education from the age in the survey and obtained the duration of the period he has not been in school. This paper selects samples of children who were not currently attending school and had finished education for no more than 3 years. We believe that rural families' per capita household income for the previous 12 months still has continuity and relevance to the economic situation of the household for the period of time when their children were last enrolled in school. In addition, in each sample household, we retain information of only one child and delete information for other siblings. These basic principles of data processing provide us with useful information for our further test of hypotheses.

#### *Variables*

The educational level of rural children is the explained variable for this paper. We set the levels of education as hierarchical variables: *1* for education level of primary school; *2* for junior secondary education; *3* for high schools, technical schools, and technical secondary school; and *4* for university, college, and higher education. According to the survey, about 20.4% of rural households believe that higher income comes from higher education, and 48.7% believe that it is from technology. Thus, it can be seen that the link between education and income is recognized by most of the surveyed rural households.

This paper uses household land area and income as the main explanatory variables. According to the above theoretical analysis, the impact of household land area on children's years of education may be either positive or negative, while the impact of household income should be positive. In addition to land area and household income, years of education for rural children are also affected by other factors. For example, Walters and Briggs (1993) find that household structure greatly influences children's education. Su and Ding (2007) believe that physical health of household members can affect children's education. Lloyd et al. 2005) analyze the characteristics of school enrollment of Pakistani children and find that the education level of parents and the gender of children can affect the school enrollment ratio. In the model of this paper, we also add proxy variables that reflect household background, in order to control unobserved variables that may affect household income and educational investment, thereby reducing the possible errors of missing variables. These proxies include mainly the years of education and occupational characteristics of parents.

In this paper, the control variables are set up as follows. Variables for child characteristics include gender and age, variables of household characteristics include household size, and proportion of population over the age of 60. The provincial dummy variable indicates eastern, middle, and western regions, where the western region is set as the control group. In this study, we divided the occupational status into three categories following the practice in the existing literature: first, management and professional score, the highest; second, commercial and business services score, the second; third, manual workers, farmers, and others' score, the lowest, as the control group. We take the higher score of occupation when parents are in different categories.

Table 1 lists the descriptive statistics for the data.

## Model and method

### *Baseline model*

This paper follows the educational transfer equation of Mare (1980), which introduces the household background variable as an influencing factor. Education level, as the dependent variable in Mare's model, is an ordered discrete variable. Thus, this paper uses an ordered logit model. The following Eq. (2.1) is the ordered logit regression model that analyzes the influencing factors on the education level of rural children.

$$\begin{aligned}\text{Prob}\ (\text{education}_\text{i} = \text{j}) &= \text{Prob}\left(\text{v}_{\text{j-1}} < \ \text{education}_\text{i}{}^{*}\overset{\acute{\text{A}}}{\text{E}}\text{v}_\text{j}\right) \\ &= \frac{1}{1+e^{-\nu_j+\beta\text{land}_i+\gamma\text{income}_i+\lambda Z_i}} - \frac{1}{1+e^{-\nu_{j-1}+\beta\text{land}_i+\gamma\text{income}_i+\lambda Z_i}} \quad (j=0,1,2,3,4)\end{aligned} \tag{2.1}$$

In the model, subscript $i$ represents the individual; *land* represents household land acreage; *income* represents household income per capita; $Z_i$ represents personal characteristics (gender, age), rural household status (seven variables for household size, male population ratio, etc.), and provincial dummy variables; $\beta$, $\gamma$, and $\lambda$ are the regression coefficients; $\nu_j$ is the threshold value; and $\varepsilon_i$ is the stochastic disturbance.

### *Generalized propensity score (GPS) matching*

In the regression model shown in Eq. (2.1), the correlation coefficient between household land acreage and the years of rural children's education was interpreted as the

**Table 1** Variable definition and descriptive statistics

| Variable | Definition | Mean | Standard error |
|---|---|---|---|
| Acreage of land endowment (logarithm) | Acreage of land possessed by the household (Chinese mu) | 1.42 | 1.04 |
| Education of child | Decision on child's education, hierarchical variable | 2.19 | 1.20 |
| Income per capita (logarithm) | Arithmetic mean value of income per capita in the previous 12 months (RMB) | 8.40 | .83 |
| Demographic variables of child | | | |
| Gender | Dummy, 1 indicates male | 49.93% | |
| Age | Age of the child | 21.40 | 3.15 |
| Demographic variables of household | | | |
| Male proportion | Proportion of male members in the household | .52 | .23 |
| Household size | Numbers of household members | 4.34 | 1.20 |
| Over-60 proportion | Proportion of senior members over 60 years old in the household | .11 | .15 |
| Under-18 proportion | Proportion of young members under 18 years old in the household | .13 | .15 |
| Migrant proportion | Proportion of migrant workers in the household | .46 | .30 |
| Medicare insurance | Dummy, 1 indicates the household has insurance through the new rural cooperative medical system (NCMS) | 91.37% | |
| Region | | | |
| Eastern provinces | Sample from eastern province | 47.49% | |
| Central provinces | Sample from central province | 26.60% | |
| Western provinces | Sample from western province | 25.90% | |
| Household background variables | | | |
| Parents' average education | Arithmetic mean value of parents' education period (year) | 6.77 | 3.75 |
| Management and professional | Dummy, 1 indicates at least one of the parents works a as manager or professional | 21.40% | |
| Commercial and business service | Dummy, 1 indicates at least one of the parents works in commercial or business service while neither of the parents holds a position as a manager or professional | 32.57% | |
| Manual workers, farmers, and others | Dummy, 1 indicates both parents works as manual laborers, farmers, or others | 46.03% | |

overall effect intensity of the following two aspects. First, when rural households have an adequate supply of land, it may reduce their willingness to have their children emigrate for work. Second, agricultural income from land production and land management reduces budget constraints that reduce the likelihood that rural children will receive an education. However, the size of the household's land is subject to various factors that impact land circulation, such as diversification of farmland systems in different regions and for different periods (Yao, 2000). Differences in farmland systems are the product of differences in local natural, economic, and social environment. Currently, highly diversified farmland systems widely exist in China's rural areas, such as the mode of land management with "stable and minor adjustment," the "dual-function farmland" mode initiated by Pingdu County in Shandong Province, and the mode of mechanized collective farming in southern Jiangsu Province (Yao, 2000). Covariance in farmland systems also affects decisions about non-agricultural employment as well as children's education, which creases endogeneity. However, the diversity of the farmland system is not the focus of this paper. Additionally, it is difficult to collect and to classify the specific farmland systems for different regions and different periods using information from questionnaires or interviews. Therefore, despite the heterogeneous characteristic control variables of rural households, variable $\alpha$ representing the farmland system is omitted in the error item $\varepsilon_i$. Thus, $\mathrm{cov}(a_i, \mathrm{income}_i) \neq 0$ may lead to endogeneity.

To solve the endogeneity problem, this paper employs the generalized propensity score (GPS) matching method developed by Hirano and Imbens (2004). The GPS matching method has two benefits: first, it addresses the difficulty of the orthogonality assumption of the instrumental variable, and second, the conditional independence assumption of binary processing variable in PSM method is applied to continuous processing variable with GPS matching method.

When using the abovementioned GPS method to estimate the influence of land endowment on decisions about children's education, the conditional independence assumption needs to be satisfied. Thus, the factors associated with land endowment need to be controlled. Combining the existing literature and the data used in this study, we select the following three types of variables as matching variables: (1) characteristic variables of rural households, including proportion of males, household size, proportion of people over age 60, proportion of people under age 18, proportion of migrant worker, and proportion receiving neo farmers' co-op; (2) household background variables, including parents' average education and occupation; and (3) provincial dummy variables.

#### *Estimation and method of testing threshold effect*

We argue that agricultural labor productivity gradually improves when the scale of the managed land exceeds the "threshold value," thereby releasing the great potential of agricultural labor to continuously optimize household income, revealing a nonlinear relationship between variables. Therefore, we use a nonlinear threshold regression model with a household land area as the threshold variable, based on the method proposed by Hansen (2000), which not only estimates the threshold using panel data, but also derives the approximate distribution of the least squares estimator of the threshold value of the cross-sectional data.

$$\mathrm{Income}_i = \theta_1 x_i I_i(\mathrm{land}_i \leq \gamma) + \theta_2 x_i I_i(\mathrm{land}_i > \gamma) + e_i \tag{2.3}$$

In Eq. (2.3), acreage of land endowment is the threshold variable; the household income per capita is a dependent variable, $x_i$ is a series of explanatory variables, $\gamma$ is threshold value, and $e_i$ is the residual. There is a dummy variable $I_i(\gamma) = \{\mathrm{land}_i \leq \gamma\}$, where $I_i\,(\bullet)$ is the indicator function. The real threshold value that we seek is the estimated threshold value for minimizing the residual. Based on the estimation of the threshold value, we further obtain other regression parameter estimates.

After obtaining the parameter estimate of threshold regression, it is necessary to verify the significance of the threshold effect and the existence of the threshold. The null hypothesis of the significance test of threshold effect is $H_0$: $\theta_1 = \theta_2$, and the alternative hypothesis is $H_1$: $\theta_1 \neq \theta_2$. We apply the constraint $\theta_1 = \theta_2$ to the regression model of the threshold value and use the LM test. Then, we employ the self-sampling method to obtain the asymptotic distribution of the parameter and obtain and test the $P$ value.

## Empirical results

### The overall impact of land on decisions regarding rural children's education

#### *Results of baseline regression*

First, this paper examines the total effect intensity of land endowments on the education level of rural children. In this part of study, the explained variable of the model is an ordinal discrete variable. Thus, we adopt the ordered logit model as in Eq. (2.1). As for the explanatory variables, we control for the demographics of rural children and household in model 1 and gradually add household background variables and the province dummy variables in model 2 and model 3 to reduce the possible missing variables and to verify the robustness of the model. Comparing all three models, the coefficients and significance levels of most variables have not fundamentally changed. In the following part, we describe the regression results of model 3 for the convenience of explanation.

Models 1–3 show the regression results of the ordered logit model with education level of rural children as the dependent variable. For the acreage of land endowment, its coefficient is significantly negative at the 0.01 level. We focus on the estimated marginal effects of model 3. It shows that every 1% of the increase in land endowment acreage changes the probability of increasing education level to 0.940 times of its initial value, or in other words, a decrease of 6%. This is consistent with the conclusion from Chen and Yuan (2012). From the perspective of control variables, the coefficient of gender is 0.175, which means that a boy is 1.191 times more likely than a girl to achieve more years of schooling. Household size has a positive effect on increasing the education level of rural children; i.e., an additional person in a household population leads to a 10.9% increase in the probability that the children's education level increases. When we look at the proportion under age 18, every unit increase in the proportion of family members aged under 18 in the household reduces the probability of an increase in the education level of rural children to 0.377 times of its initial value. Compare two rural households of four people: one with two children and two adults and the other with one child and three adults. The former is 62.3% less likely than the latter to improve their children's education level. Moreover, when the proportion of migrant workers in a household increases by one unit, the probability of increasing the child's education level will be 1.691 times its initial value. This is consistent with findings from Li et al. (2002). From the province dummy variable, under the same condition, the probability of increasing child's education level in the eastern region is 1.338 times of that in the western region. We can also see that rural household background has a significant impact on the education level of the children: when the average years of parents' education increases by one, the probability of increasing children's education level will be 1.032 times of the initial value. Comparing to household with parents working as farmers or manual workers, those with parents working as managers or professional staff are 1.377 times more likely to support their children to achieve more years of schooling, whereas children whose parents work in business or commercial services are 1.327 times more likely to achieve more years of schooling. This indicates that household resources are important in promoting children's education, as is consistent with empirical findings.

Model 4 of Table 2 examines the impact of household income on the education level of rural children. Comparing model 4 and model 3, the absolute value of the coefficient of the land variable decreases after controlling for income, indicating that the influence of land endowment on education is partly via the effect on the current income. Of course, this does not mean that land endowment has only one impact on education. In fact, after controlling the income variable, the coefficient of land is significantly negative, indicating

**Table 2** Land and education level of rural children

| | Model 1 with income uncontrolled | | Model 2 with household background | | Model 3 with dummy variable of province | | Model 4 with income controlled | |
|---|---|---|---|---|---|---|---|---|
| | *B* | Exp(B) | *B* | Exp(B) | *B* | Exp(B) | *B* | Exp(B) |
| Acreage of land endowment (logarithm) | − .081*** (.027) | .922 | − .0835*** (.026) | .920 | − .062** (.027) | .940 | − .057** (.027) | .944 |
| Demographic variables of child | | | | | | | | |
| Gender | .175*** (.064) | 1.191 | .177*** (.064) | 1.194 | .175*** (.064) | 1.191 | .177*** (.064) | 1.193 |
| Age | .003 (.009) | 1.003 | .003 (.009) | 1.003 | .001 (.009) | 1.001 | − .002(.009) | − .033 |
| Demographic variables of household | | | | | | | | |
| Income per capita (logarithm) | | | | | | | .104** (.040) | 1.110 |
| Male proportion | − .077 (.147) | .926 | − .049 (.148) | .952 | − .014 (.148) | .986 | − .011 (.150) | .989 |
| Household size | .110*** (.025) | 1.116 | .083*** (.025) | 1.087 | .103*** (.025) | 1.109 | .113*** (.026) | 1.120 |
| Over-60 proportion | − .176 (.185) | .839 | − .194 (.185) | 0.824 | − .287 (.186) | .751 | − .343* (.188) | .710 |
| Under-18 proportion | − 1.067*** (.195) | .344 | − .997*** (.196) | 0.369 | − .975*** (.196) | .377 | − .974*** (.199) | .378 |
| Migrant proportion | .912*** (.102) | 2.489 | .588*** (.117) | 1.800 | .525*** (.118) | 1.691 | .474*** (.120) | 1.606 |
| Medicare insurance | − .145 (.118) | .865 | − .180 (.118) | 0.835 | − .161 (.118) | − .851 | −.155 (.118) | .856 |
| Household background variables | | | | | | | | |
| Parents' average education | | | .035*** (.007) | 1.036 | .031*** (.007) | 1.032 | .031*** (.007) | 1.031 |
| Managers and professionals | | | .355*** (.083) | 1.426 | .320*** (.083) | 1.377 | .314*** (.084) | 1.369 |
| Commercial and business services | | | .313*** (.071) | 1.368 | .283*** (.071) | 1.327 | .279*** (.072) | 1.321 |
| Province | | | | | | | | |
| Eastern | | | | | .291*** (.070) | 1.338 | .220*** (.075) | 1.246 |
| Central | | | | | − .047 (.071) | .954 | .068 (.072) | 1.070 |
| Obs | 4198 | | 4198 | | 4198 | | 4099 | |
| Pseudo $R^2$ | .012 | | .016 | | .018 | | .019 | |
| LM | 155.64 | | 205.84 | | 233.33 | | 230.68 | |
| LM logarithm | − 6303.367 | | − 6278.270 | | − 6264.522 | | − 6115.884 | |

*Note:* The figures in parentheses are standard errors. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

that an increase in land has some other negative effects on education. Therefore, hypothesis 1 is supported.

Controlling for the heterogeneity of rural households, we find that land does have a substitution effect on rural children's education as well as an indirect influence through the income channel. However, the abovementioned ordered logit method may still omit other variables that affect agricultural land circulation and labor factor allocation, such as the specific farmland systems. Hereinafter, we use the generalized propensity score (GPS) matching method to again test our hypotheses of the substitution effect and the income effect of land on education.

#### *GPS testing of the impact of land on education*

The most critical explanatory variable in this study is land endowment. We eliminate the differences in control variables between treatment and control groups and then examine the response of different land endowments on the education level of rural children. The first step of the GPS test employs the maximum likelihood method to estimate the conditional probability distribution that the logarithm of acreage is at a certain level. The regression results show that the overall model is significant, and the sign of each variable is broadly consistent with empirical findings.

In the following two stages, we estimate the conditional expectation of the logarithm of the household land area based on the former propensity matching value *G* and study the influence of the land endowment on rural children's education for different quantiles. The results show that the intervention variable $T$ and its quadratic term $T^2$ are significant at the 1% level. The influence of rural household land endowment on children's education presents a U-shaped trend, which means that land promotes rural children's education only after acreage reaches a certain level.

The mean value of the acreage (logarithm) in the sample is 1.42. Therefore, at the current stage, the influence of land on rural children's education is mainly in the descending part of the U shape; i.e., the effect is negative. Only when land endowment exceeds a certain threshold can an increase in land promote rural children's education. Thus, after solving the endogeneity problem, the substitution effect is still significant. The results of the generalized propensity value are not presented in the paper due to space limits.[2]

### Decomposition of income and substitution effect

We argue that rural children's education is directly affected by household land endowment. Meanwhile, it also influenced by household income level, which is related to household land endowment. Therefore, we employ a method to estimate cross-generational income that was proposed by Sun et al. (2012). We analyze the correlation coefficient of land on education (represented by $r_{\text{edu}\bullet\text{land}}$) and calculate the contribution of the income effect and substitution effect.

The regression equation of rural children's education is as follows:

$$y_{\text{edu}} = \beta_{\text{edugland}} x +^{\text{land}} \beta_{\text{edugincome}} x_{\text{income}} + \varepsilon \tag{3.1}$$

In Eq. (3.1), $\beta_{\text{edu} \times \text{income}}$ is the coefficient of household income and the education level of rural children, while $\beta_{\text{edu} \times \text{land}}$ is the coefficient of land endowment and the education level of rural children.

Then, we have decomposition as follows:

$$r_{\mathrm{edu}\times\mathrm{land}} = \beta_{\mathrm{edu}\times\mathrm{land}} + \beta_{\mathrm{edu}\times\mathrm{income}} \cdot r_{\mathrm{land}\times\mathrm{income}} \tag{3.2}$$

Using the correlation coefficient decomposition method from Eq. (3.2), we use $\beta_{\mathrm{edu}\ \times\ \mathrm{income}}$ (the regression coefficient of the education level of rural children to the household income), $r_{\mathrm{land}\ \times\ \mathrm{income}}$ (the correlation coefficient of rural household income and land endowment), and $r_{\mathrm{edu}\ \times\ \mathrm{land}}$ (the correlation coefficient of land endowment and the education level of rural children) to assess what extent the income transmission factors related to land endowment contribute to the education of rural children. $\beta_{\mathrm{edu}\ \times\ \mathrm{income}}$ equals 0.095, which suggests that household income is significantly positively correlated with rural children's education level.[3] The correlation coefficient of household income and land endowment, $r_{\mathrm{land}\ \times\ \mathrm{income}}$, equals − 0.114, while the correlation coefficient of household land endowment and rural children's education level, $r_{\mathrm{edu}\ \times\ \mathrm{land}}$, equals − 0.05. After decomposition, $\beta_{\mathrm{edu}\times\mathrm{income}} \cdot r_{\mathrm{land}\times\mathrm{income}}/r_{\mathrm{edu}\times\mathrm{land}} = 21\%$, suggesting that the income factor related to total acreage may explain the 21% correlation between land and education. Accordingly, the contribution rate of the substitution effect is 1–21% = 79% (Table 3). The substitution effect of land on rural children's education is greater than the income effect. This also means that, at the present stage, land has suppressed the positive effect of urban employment on the education investment of rural children.

### Threshold effect of land and household income

Owing to the different size of land, land has different effects on household income. In order to explore this, we use Hansen's threshold regression model (Hansen, 2000) and take land size as the threshold variable to test whether the interval effect exists in the impact of different size of land endowments on rural households' income. The results show that the LM statistic is 83.85 and the corresponding $p$ value is 0. Thus, the null hypothesis is rejected at the 1% significance level; i.e., the threshold effect exists in the relationship between land size and rural household income. The threshold value of land size, namely the variable of total land acreage, takes a logarithm of $\hat{\gamma} = 2.014$. We further examine the value of threshold. The result shows that when the threshold value of land size is 2.014, it falls within the confidence interval of 95%. Therefore, $\hat{\gamma} = 2.014$ is the real threshold value.

Table 4 includes the control variables identified in Table 2. The results show that only when the total amount of land reaches a certain threshold, land allocation and education can efficiently increase household income. This is also the process through which labor from agricultural economy is released, a process that occurs after the increased agricultural efficiency is brought about by large-scale land management and with a decline in the substitution effect of land on education. Combined with the results of descriptive statistics, the logarithmic mean value of the current household land acreage

**Table 3** Contribution rate of the income and substitution effects

| | Correlation $r$ | | Regression | | Decomposition | |
|---|---|---|---|---|---|---|
| | Acreage | Education | $\beta$ | S.E. | Interaction | Contribution |
| Acreage | 1.000 | − .053 | − .040*** | .015 | – | – |
| Income | − .114 | .122 | .095** | .016 | − .010 | 21% |

**Table 4** OLS regression and threshold effect of land on income

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | | Logarithmic acreage ≤ 2.014 | Logarithmic acreage > 2.014 |
| Independent variable | | | |
| Logarithmic acreage of land | − .017* (.010) | − .044** (.017) | .089** (.025) |
| Control variables | Controlled | Controlled | Controlled |
| Constant | 8.269*** (.093) | 8.312*** (.108) | 7.804*** (.177) |
| Obs | 4099 | 3143 | 956 |
| Adj $R^2$ | .243 | .262 | .189 |

*Note*: The figures in parentheses are standard errors. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

in China is 1.42, which is clearly lower than 2.014. Overall, the effect of land size on farmers' income growth is negative across the country. This means that the current agricultural land transfer in China has not yet reached a modest scale. In our field investigation, we also find that, due to the decrease of labor in agriculture and the difficulty in the concentration of land circulation, there is a trend that crop production degrades to the natural economic mode. It is reasonable that this phenomenon is observed in areas with relatively scarce arable land. However, we detect the same phenomenon exists in the areas of eastern and central China, which are traditional grain-producing areas with abundant land. In other word, crop production's degradation to the natural economic mode is quite significant across China. The interviewed farmers have little interest in increasing productivity and income by using technology. The phenomenon is consistent with the empirical results of this paper.

Nevertheless, we do not believe that after the logarithmic acreage of land exceeds the threshold of 2.014, it would always be better for acreage to continue to increase. There should be a secondary threshold after the first one of 2.014; i.e., an excessively large amount of land will not result in an increase to farmers' income. Because the first threshold is larger than the mean value of the full sample, the observations are insufficient for us to calculate the second threshold.

## Conclusion

The dual economic structure in China's urban and rural areas has continuously been strengthened, and this has raised many challenges for China's urbanization and rural development. Since 2003, a large number of processing and manufacturing enterprises have faced the difficult situation of a shortage of experienced and skilled workers, while the development of agricultural areas has also faced the reality of the "hollowing" of rural areas—specifically, a lack of young and middle-aged labor with higher education. Based on the 2011 Thousand-Village Survey, this paper studies the relationship between land size and education investment of rural households and identifies a mechanism for improving human capital in rural areas and optimizing the allocation of labor factors from the perspective of the farmland system. This paper derives, theoretically and empirically, that land has substitution and income effects on education and tests the hypothesis that only if the scale of managed land is large enough can the allocation of land and education be optimized and household income will increase.

Our interpretation of the relationship between land size and the education investment behavior of rural households is related not only to the reasons for the inefficient labor allocation during China's urbanization, but also to the appropriate size of agricultural land managed by a household. We find that when the logarithmic acreage of land is below the threshold of 2.014, it is difficult for either land endowment or the education level of labor to have a significant effect on farmers' income. When land size is lower than the threshold value, agricultural efficiency is low and laborers invest more heavily in agriculture, thus leading to a strong constraint on income from migrant and non-agricultural work. Therefore, when rural households whose land size is higher than the threshold are endowed with slightly abundant land, their willingness to allocate resources to education reduces. At this point, land generally has a substitution effect on education, which may distort the allocation of land and labor.

We believe that the transfer of rural labor and changes to the structure of rural household income are problems that agricultural and rural areas will have to face in the next one or two decades. To ensure the sustainable development of agriculture, the rural economy, and the whole society, as well as to raise the income of rural households, it is necessary to accelerate the systematic reform of rural land circulation; to develop rural vocational and technical education; to strengthen the support and protection of agriculture, rural areas, and farmers; and to improve the social security system in rural areas. We propose the following policies.

Firstly, promote moderate land circulation with farmers at the core, speed up the reform of the rural system by centralizing the land circulation system, and boost the development of modern scale agriculture. Instead of prohibiting land management by household, the essence of centralized land circulation is to achieve the proper land circulation with farmers as decision makers. As land circulation and proper land management improve, administrative intervention should be carried out with limitation and caution. Fundamentally, land circulation is not the ultimate goal. However, as shown in the Thousand-Village Survey, the interest of agricultural workers is usually impeded when farmland circulates. A set of nationwide standardized laws and detailed regulations for farmland circulation is required, while still allowing local conditions to be taken into consideration. A stable system of farmland circulation will increase individual income through production of scale as well as through non-agricultural employment.

Secondly, make vocational education accessible for more farmers and start a project to cultivate a "new generation of farmers." The present scarcity of migrant workers occurs because of insufficient supply of better-educated rural laborers. Apart from current students, those who have left school and are working in rural areas are also potential targets of rural education. As shown in the questionnaire, about 90% of interviewees intend to send their unemployed children to receive training if it is available in the village. This percentage indicates the existence of great unemployment due to lack of skill as well as farmers' desire for vocational education. However, 71% of our interviewees have attended no short-term vocational training during the last 5 years. Thus, a vocational education system, including practical skills, agricultural knowledge, basic law, and rural policies, should be developed for rural adults. We expect that, through vocational education, the new generation of farmers with skill can work in either in urban areas or in agriculture to ensure higher productivity and better return. This will help address the scarcity of migrant labor as well as the "hollowing" of rural areas.

Finally, push for the construction of rural social security system based on farmland circulation. The collective economy was widely accepted in rural areas before 1978. In this system, farmers depended on their land as the means of social insurance. Even after the reform of farmland management in 1978, farmland has served as unemployment insurance for rural residents. At the same time, most migrant workers are not included in China's urban social insurance system. As shown in the questionnaire, it is the migrant workers themselves rather than their urban employers who pay for the social insurance. Then, with the centralization of farmland in circulation, how will migrant workers without farmland support themselves in their old age? Thus, the lack of social insurance in rural areas hinders farmland circulation and labor transfer. Therefore, a multi-level social insurance system for rural residents, including health insurance, stipend, and other basic insurance, is a necessary condition for labor to transfer from agriculture to other sectors.

## Endnotes

[1]In China, no individual is entitled to the ownership of the land. The farmers have right to use the land or they can also transfer this ius utendi (right of use) to others. The "property income" refers to the payment that farmers gain through this transfer.

[2]These results are available directly from the author.

[3]Due to space limits, the results from standardized data are not presented.

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#### Authors' contributions
The two authors contribute equally to this paper. YY contributes mainly to the theoretical part while YX contributes mainly to the empirical part. Both authors read and approved the final manuscript.

#### Competing interests
The authors declare that they have no competing interests.

## Publisher's Note


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