The impact of free farmland transfer on the adoption of conservation tillage technology -- empirical evidence from rural China

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ABSTRACT

At present, there are a large number of free farmland transfer without monetary or physical rents in rural China. It is relatively worthwhile to verify whether the transferees who transfer in farmland for free, the actual operators of farmland, would adopt the conservation tillage technology (CTT), which is crucial in protecting farmland quality and improving agricultural production efficiency. Based on the data of 527 plots surveyed by China Land Economic Survey (CLES) in Jiangsu Province in 2020, this paper employs Negative Binomial Regression (NBR), Poisson Regression with Endogenous Treatment Effects (ETPR) and Endogenous Switching Regression (ESR). Results show that: (1) Compared with the transferees who transfer into farmland with compensation, the free transfer is not conducive to the transferees' adoption of CTTs such as straw mechanical returning, soil testing and formulated fertilization. Specifically, the total number of technology adoptions by transferees who transfer in farmland without compensation is decreased by 39.54%. The result is still robust after replacing the dependent variable. (2) Further heterogeneity analysis results of different types of technologies show that the number of labor-saving CTTs such as straw mechanical returning adopted by the transferees of free transfer decreases by 11.55%, and the number of labor-intensive tillage technologies such as soil testing and formulated fertilization decreases by 83.20%. Thus, free transfer has a stronger inhibitory effect on the transferees' adoption of labor-intensive CTTs. Therefore, for the most developing countries including China, the governments should continue to improve the farmland factor market oriented by price mechanism and implement targeted conservation tillage technology according to the different degree of transfer marketization in different places.

1. Introduction

According to the general principle of market allocation of resources, farmland can theoretically flow to more efficient transferees through the price signal of rent. So the formation of rent is an important representation of the development of farmland factor market. However, there are a host of free transfer phenomena in China's farmland transfer market, which suggests that the price formation mechanism of rent is not perfect. According to the data of the rural fixed observation points of the Ministry of Agriculture and Rural Affairs from 2003 to 2013, the zero rent transfer rate of land in China exceeds 50%. The survey data of China Household Finance Survey (CHFS) in 2015 show that the proportion of free farmland transfer is about 42.5%. In addition, the investigation of farmers in three counties of Chongqing surveyed by Wang et al. (2019) also find that up to 74.0% of the plots do not charge rent when they are transferred.

Free transaction is often regarded as the lack of marketization and standardization of farmland transfer (Tang et al., 2019). In practice, the free circulation generally occurs between relatives and friends, and often replaces the written contract with oral agreement, with less agreed period, which is the concrete embodiment of relationship governance in acquaintance society on rent arrangement. Most of the existing studies have discussed the realistic causes of free transfer from the perspective of the transferrors, including reducing transaction costs (Wang et al., 2015a, b), reciprocity of human relations (Chen, 2018; Huy et al., 2016), property security or control preference (Wang et al., 2015a,b; Qian and Hong, 2018). However, it is more important that the transferees, the actual operators of farmland, are directly related to specific agricultural production. The role of free transfer on the production behavior of the transferees is also the key to excavating the realistic impact of free transfer of farmland. Reality, the development of modern agriculture...
we lay out the settings for the empirical analyses in which we describe the data and the variable selections, the empirical model and estimation methods. The estimated results are presented in Section 4. And the concluding remarks and policy suggestions are put forward in the final section.

2. Theoretical analysis

Indeed, cost-benefit analysis is the basis of decision-making for the transferees to adopt CTTs. Compared with the traditional agricultural production technology, CTTs such as straw mechanical returning generally need higher input, and its benefit from the current investment is divided into multiple periods, which indicates that the intertemporal attributes of current and future earnings need to be considered simultaneously by the transferees (Xu et al., 2018).

First of all, from the perspective of cost input of technology adoption, the transferees make the transfer decision according to the marginal cost and output of farmland input before transferring in farmland with compensation. When the marginal output of farmland input is higher than the transfer rent, the transferees will choose to transfer into farmland, and vice versa. Therefore, the sum of their own and transferred farmland area will not exceed the optimal operation scale. At this point, they have the ability and willingness to seek improvements in production technology through the realignment of capital, labor and other factors on the land transferred. However, the transferees of free circulation can obtain farmland without paying rent, and their transfer-in area is not determined by the balance of rent, which often exceeds its optimal operation scale. Therefore, it is difficult to fully match farmland with other production factors such as labor. Due to the law of diminishing marginal returns in scale expansion (Wu, 2011), the transferees of free circulation may still invest in production following previous experience, as measured by cost-benefits. The operation itself is extensive, which limits the transferees’ ability to invest in CTT on plots. Even if the transferees who transfer farmland without compensation have certain investment capacity, they are more inclined to adopt technology on their own plots rather than on the transfer-in plots due to different guarantee effects of property rights (Holden et al., 2011).

Secondly, from the perspective of current income, in the paid circulation, the transferees need to bear the transfer rent and face the possible fluctuation of the rent, and thereby transferees have the motivation to seek production improvement through technological progress to cover the rent cost and ensure the current income. However, in the free circulation, the transferees can easily be assured of their current earnings and expected profits by virtue of the depressed rental cost, so they may lack the willingness to improve production. More importantly, since the current income is easier to be obtained, the real price of farmland is underestimated for the transferees who obtain farmland for free, resulting in that the relative price of farmland and other factors such as labor cannot reflect its scarcity (Wei et al., 2021). The theory of induced technological change holds that the relative price among factors is an important signal to reflect the resource endowment and then guide the technological progress and choice. In other words, the absence of rent in free circulation weakens the price signal function of rent, thereby reducing the willingness of the transferees to choose CTT for production improvement.

Finally, from the perspective of expected earnings, property rights theory demonstrates that property rights determine the distribution of future multi-period income of land (Taylor and Featherstone, 2018). Stable property rights contribute to the formation of long-term expectations, thereby promoting farmers’ soil conservation investment (Besley, 1995). Due to the intertemporal nature of CTT, whether the transferees can obtain all future benefits will directly affect their willingness to adopt technology. It can be seen that clearer rights boundary and longer transfer period can effectively encourage the transferees to adopt CTT.

A large number of literatures believe that the purpose of the transferees not
charging rent in the free circulation is to reduce the risk that the farmland cannot be recovered (Qian and Hong, 2018; Wang et al., 2015a, b), or to achieve more flexible control of farmland afterwards (Qian and Hong, 2018). That is to say, the free transfer can be regarded as the game between the two transferring parties on the terms, control rights and rents. In most cases, no written contract or specific period will be signed in the free circulation (Chen et al., 2019; Wang et al., 2015a, b), and the transferors may request to recover farmland at any time. This will directly cause the transferees unconvinced of obtaining the future income. Meanwhile, the difference of discount rate $^1$ of different transferees will also lead to different expected profits (Liebenemh and Waibel, 2014), which reflects the difference of adoption behavior of CTT. Compared with the paid transfer, the discount rate of the transferees in the free circulation is higher due to the uncertainty of future income caused by the unstable management right. The transferees who transfer for free have a low present value of discounting the future income of adopting CTT to the current period because of the high discount rate. And the net present value is lower after deducting the investment cost of potential technology adoption, so the willingness to adopt technology is impeded.

Accordingly, hypothesis 1 is proposed: Compared with the transferees in the paid transfer, the transferees in the free transfer is less willing to adopt the CTTs after comprehensively considering the cost input, current and expected benefit of technology adoption.

Further, among the many types of CTTs available, farmers will make choices in order to maximize the benefits of adopting decisions based on their own factor endowment constraints. CTTs can be divided into labor-saving and labor-intensive technologies in light of the difference of labor input (Cao and Zhao, 2019). For example, farmers who adopt straw mechanical returning technology only need to invest in the purchase of corresponding services without additional labor time. However, if farmers adopt soil testing and formulated fertilization technology, they need to increase the number of fertilization and invest additional labor time. According to the theory of factor-induced technological innovation, the scarcity of land, labor, capital and other resources available to farmers is the driving force for their cognitive demand for agricultural technology (Hayami and Ruttan, 1985), according to which they will choose technologies with different labor attributes.

Generally speaking, the transferees in the free circulation prefer to adopt labor-saving technology rather than labor-intensive technology. The possible reasons are that, on one hand, the transfer-in area of the transferees in the free circulation is not regulated by rent, so it may exceed its optimal operating scale, which will lead to a decrease in the allocation of family labor force on the farmland per unit area. The shortage of labor force makes the transferees only maintain the basic labor time of agricultural production. On the other hand, free transfer is generally accompanied by labor exchange. It is often necessary for the transferees to provide care for the transferors in daily life after obtaining farmland for free (Chen et al., 2019), which indicates that the free transfer will actually disperse part of the transferees’ working time in the form of human exchange and further lead to the tension of the working time of the transferees’ family. At the same time, considering that the current agricultural opportunity cost increases year by year, the labor factor of the transferees in the free circulation is relatively scarce. Therefore, the transferees who transfer in farmland for free are more reluctant to adopt labor-intensive technologies.

Accordingly, hypothesis 2 is proposed: Compared with labor-saving CTT, the transferees in the free transfer are less willing to adopt labor-intensive CTT.

$^1$ When studying farmers’ behavior, the discount rate refers to the degree of time preference expressed in the form of interest rate in intertemporal decision-making (Xu et al., 2018). If the marginal utility of farmers to current income is higher, the discount rate is higher.
estimation bias (Qiu et al., 2020; Qian et al., 2021). The characteristics of family decision-making managers include demographic characteristics such as education level and age. In general, young adults with higher education level have a better understanding of the role of CTT. Moreover, the young labor force has a longer time to benefit from technology under the same learning cost (Yang, 2018), so it's expected that young people are relatively more willing to adopt CTT. In the characteristics of family level, the higher the family agricultural population and agricultural machinery value, the greater the family's dependence on agriculture, which increases the possibility of adopting conservation tillage techniques to improve agricultural income. The characteristics of plots are the important control variables introduced in this paper. The use change passed, the PR should be used; otherwise, the NBR should be employed.

3.4.1. Poisson Regression and Negative Binomial Regression

Actually, the adoption quantity of CTT belongs to the counting data. If the traditional linear regression model is adopted, it will lead to biased estimation. Considering that the five CTT adoptions concerned in this paper have strong independence and no inevitable connection with each other, this paper employs the counting model. The commonly used counting models include Poisson Regression (PR) and Negative Binomial Regression (NBR). The difference between the two is to assume whether the variance is equal to the expectation or over dispersion. If they are equal, PR should be adopted. Eq. (1) is set as follows:

\[ P(y_i|\text{Price}_i, C_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!} \quad (y_i = 0, 1, 2, \ldots) \]  

where whether the CTT is adopted on the plot is denoted by \( y_i \), whether the plot is transferred for free is denoted by \( \text{Price}_i \), and control variables that affect the adoption of CTT is denoted by \( C_i \). The Poisson arrival rate is represented by \( \lambda_i \), which refers to the number of events determined by each explanatory variable.

If the variance is greater than the expectation, it is excessive dispersion, and the NBR should be used at this time. Specifically, \( \epsilon_i \) is added to model 1 to control the unobservable variables and individual heterogeneity in Eq. (2), which is set as follows:

\[ P(y_i|\text{Price}_i, C_i, \epsilon_i) = \frac{e^{-\lambda_i} \lambda_i^{y_i}}{y_i!} \quad (y_i = 0, 1, 2, \ldots) \]  

As for the choice of the two models, it can be judged by the LR test after the NBR, the original assumption of which is “there is no excessive dispersion, so the PR should be used”. If the original assumption is passed, the PR should be used; otherwise, the NBR should be employed.

3.4.2. Poisson Regression with Endogenous Treatment Effects (ETPR)

Compared with the panel data, the cross-sectional data is faced with a serious problem of missing variables. In this paper, there may also be the problem of sample self-selection, which means that whether the transferors can transfer the plot for free is not entirely determined by the transferrees themselves, and it may also be selected by the transferors for reasons such as property rights protection or human exchange (Wang et al., 2015a,b; Chen et al., 2019). The instrumental variable method is a good solution to this problem. Since the traditional IV-Poisson method is only applicable to the case where the endogenous variable is a continuous variable, and the endogenous variable in this paper is a binary variable, the ETPR is introduced to solve this problem. The ETPR model includes two-stage equations, and the specific settings of the equations are as follows:

\[ \text{Price}_i = \varphi C_i + \mu_i, \text{Price} = \begin{cases} 1 & \text{if } \text{Price}_i > 0 \\ 0 & \text{otherwise} \end{cases} \]  

\[ f(y_i) = \exp\{ -\exp(\text{Price}_i, \beta y_i + \epsilon_i) \} \cdot \{ \exp(\text{Price}_i, \gamma y_i + \epsilon_i) \}^y \]  

where equation (3) and equation (4) are the first-stage and the second-stage regression of the ETPR model, respectively. The latent variable for the adoption of CTT is denoted by \( \text{Price}_i' \). When \( \text{Price}_i' > 0 \), \( \text{Price}_i = 1 \), otherwise \( \text{Price}_i = 0 \). The control variables affecting the free transfer and affecting the adoption of CTT are separately represented by \( C_i \) and \( Z_i \). It should be noted that there may be overlapping variables in \( C_i \) and \( Z_i \), but at least one variable in \( C_i \) is not in \( Z_i \), in order to play the role of an instrumental variable. \( \varphi, \beta \) and \( \gamma \) are parameters to be estimated, \( \mu_i \) and \( \epsilon_i \) are random interference terms.

### Table 1. The definitions and descriptive statistics of variables.

| Category          | Variable                     | Definition                                      | Mean    | SD   |
|-------------------|------------------------------|-------------------------------------------------|---------|------|
| Dependent variable| Adoption of CTT              | Number of technologies actually adopted         | 1.169   | 1.296|
| Independent variable| Free transfer               | Yes = 1; No = 0                                 | 0.148   | 0.355|
| Control variable  | Age of family decision maker | Actual age                                      | 56.069  | 9.111|
|                   | Education level of family decision maker | Years of schooling | 7.308   | 3.497|
|                   | Household’s agricultural population | Number of households engaged in agricultural work | 1.932   | 0.873|
|                   | Value of household agricultural machinery | Value of agricultural machinery family owned (10,000 yuan) | 4.935   | 17.309|
|                   | Household non-agricultural income | Annual household nonfarm income (10,000 yuan) | 8.513   | 4.753|
|                   | Plot area                    | The actual area of the plot transferred in (mu) | 16.495  | 23.564|
|                   | Distance from plot to hardened road | Distance from the plot to the nearest hardened cement road (mile) | 0.625   | 1.426|
|                   | Is the plot near the expressway? | There is an expressway within 1000 m | 0.088   | 0.283|
|                   | Can the plot be irrigated?    | Yes = 1; No = 0                                 | 0.040   | 0.196|
|                   | Plot fertility                | Poor = 1; Medium = 2; Good = 3                  | 2.329   | 0.621|
|                   | Was the plot hit?             | The plot was hit in 2019 = 1; otherwise = 0    | 0.161   | 0.368|
|                   | Is there an agreed period for transfer? | Yes = 1; No = 0                                | 0.631   | 0.483|
|                   | Policy support                | Number of family members with agricultural skills or training | 0.349   | 0.687|


In addition, the ETPR model can also measure whether there are endogenous problems such as selective bias caused by unobservable factors and mutual causality by calculating ATT. Specifically, the $y_{i1}$ of the treatment group (the adoption level of CTT by the transferees in free transfer) is shown in Eq. (5), and the $y_{i0}$ of the control group (the adoption level of CTT of the transferees in paid transfer) is shown in Eq. (6):

$$E(y_{i1} | Price_i = 1) = \exp(\beta_i Price_i + \gamma_i Z_{i} + \epsilon_{i1})$$  

$$E(y_{i0} | Price_i = 0) = \exp(\beta_i Price_i + \gamma_i Z_{i} + \epsilon_{i0})$$

Furthermore, the ATT of ETPR model can be expressed as Eq. (7):

$$E(y_{i1} - y_{i0} | Price_i = 1) = E\left[ \frac{\exp(\beta_i Price_i + \gamma_i Z_{i} + \epsilon_{i1}) - \exp(\beta_i Price_i + \gamma_i Z_{i} + \epsilon_{i0})}{\Phi(\Phi^{-1}(\text{Pr}(\text{CTT})))} \right]$$

In order to ensure that the ETPR model can be identified, it is necessary to find an effective instrumental variable, which should not only correlate with endogenous variables, but also meet the exogenous conditions. In the research on micro-individual level of farmers, it is a common method to use the data at the county level and village level as instrumental variables. In Wei et al. (2021), indicating that free transfer can reduce the land in-principle hypothesis of the null hypothesis of the 95% confidence interval of alpha is (0.02, 0.52). Corresponding to PR, whose result presents the null hypothesis of “alpha = 0” can be rejected at 5% level, the results of NBR are relatively more reliable. From the perspective of the marginal effect reported by the NBR, compared with the paid farmland transfer, the free transfer reduces the number of 2.65 CTT adoptions of the transferees when selecting the number of technology adoptions to measure the adoption level of CTT. Thus Hypothesis 1 is preliminarily tested, which is consistent with the findings of Wei et al. (2021), indicating that free transfer can reduce the land investment willingness and behavior of the transferees.

As for the control variables, the number of farmers in the transferee’s family promotes the adoption of CTT, which is in line with the general common sense judgment. The more agricultural population in the transferee’s family indicates that agricultural production plays an important role in family management. So family members can better recognize the role and benefits of CTT in future production, and the transferee’s family will have more labor force to invest in learning and adopting CTT. The value of household agricultural machinery also significantly promotes the adoption of CTT by the transferees, which also aligns with the theoretical expectation. The higher the value of household agricultural machinery, the stronger the agricultural production capacity of the transferees, the stronger the risk resistance function of technology adoption. Accordingly, the transferees have stronger willingness and ability of technology adoption. In terms of plot characteristics, the ability of plot irrigation has a significant positive impact on the adoption of CTT. The possible explanation is that the transferees have higher expected returns on plots with better quality, stimulating the stronger willingness to adopt new technology. It should be noted that if the plot has suffered natural disasters in the year before the survey, the

### Table 2. Benchmark regression results.

|                      | (1) PR      |         | (2) NBR      |         |
|----------------------|-------------|---------|-------------|---------|
|                      | Estimation coefficient | marginal effect | Estimation coefficient | marginal effect |
| Free transfer        | -2.340***   | -2.633*** | -2.348***   | -2.650*** |
|                      | (0.051)     | (0.059) | (0.051)     | (0.058) |
| Age of family decision maker | 0.006       | 0.007   | 0.006       | 0.007   |
|                      | (0.005)     | (0.006) | (0.005)     | (0.006) |
| Education level of family decision maker | -0.005      | -0.005  | -0.005      | -0.005  |
|                      | (0.014)     | (0.016) | (0.015)     | (0.017) |
| Household's agricultural population | 0.078*      | 0.088*  | 0.082*      | 0.093*  |
|                      | (0.041)     | (0.046) | (0.042)     | (0.048) |
| Value of household agricultural machinery | 0.005**     | 0.005** | 0.005*      | 0.006*  |
|                      | (0.002)     | (0.002) | (0.003)     | (0.003) |
| Household non-agricultural income | -0.005      | -0.005  | -0.004      | -0.005  |
|                      | (0.009)     | (0.010) | (0.009)     | (0.010) |
| Plot area            | -0.000      | -0.000  | -0.000      | -0.000  |
|                      | (0.001)     | (0.001) | (0.001)     | (0.001) |
| Distance from plot to hardened road | -0.011      | -0.013  | -0.010      | -0.011  |
|                      | (0.033)     | (0.038) | (0.034)     | (0.038) |
| Is the plot near the expressway? | 0.230       | 0.259   | 0.245       | 0.277   |
|                      | (0.148)     | (0.168) | (0.150)     | (0.170) |
| Can the plot be irrigated? | 0.634***    | 0.713***| 0.631***    | 0.712***|
|                      | (0.187)     | (0.209) | (0.187)     | (0.210) |
| Plot fertility       | 0.036       | 0.041   | 0.036       | 0.041   |
|                      | (0.073)     | (0.082) | (0.074)     | (0.084) |
| Was the plot hit?    | 0.707***    | 0.795***| 0.722***    | 0.815***|
|                      | (0.079)     | (0.081) | (0.084)     | (0.086) |
| Is there an agreed period for transfer? | 0.128       | 0.144   | 0.110       | 0.125   |
|                      | (0.114)     | (0.127) | (0.118)     | (0.133) |
| Policy support       | 0.104*      | 0.117*  | 0.109*      | 0.123*  |
|                      | (0.061)     | (0.069) | (0.062)     | (0.071) |
| Village fixed effect | Yes         | Yes     | Yes         | Yes     |
| Wald chi²            | 165.77***   | 160.43*** |            |
| Pseudo R²            | 0.16        | 0.13    |            |
| N                    | 527         | 527     | 527         | 527     |
support significantly promotes the adoption of CTT of the transferees. The more times the transferees receive technical training, the more comprehensive their understanding of technology and the stronger their ability and willingness to adopt new technologies, which is also consistent with the conclusions of Mao and Cao (2020).

4.2. Endogenous discussion

Generally speaking, it is difficult to control individual effect and endogenous problems in the model with cross-sectional data. Taking the above benchmark regression as a reference, Table 3 shows the regression results of the ETPR model. In order to facilitate comparison, the regression results assuming that the dependent variable is a continuous variable are also presented in Table 3. The Eregress under the framework of the extended regression model (ERM) is employed to estimate. This model and ETPR model can simultaneously solve the endogenous problem and the selective bias caused by unobservable factors.

The estimation coefficient of the first stage shows that the average human expenditure of the sample village will have a significant impact on the free farmland transfer. The endogenous parameters reported by the two models have passed the significance test, indicating that there are endogenous problems in the models, and the instrumental variable method is more appropriate. In the second stage of regression, the variable of free transfer significantly inhibits the transferees from adopting CTT at the level of 1% after eliminating endogeneity. In general, when investigating the economic meaning of regression, the average treatment effect (ATT) of the treatment group should be paid attention. After calculation, the ATT reported by Eregress model is about -2.207, and that by Etpoisson model is about -1.977. There is no difference in significance and influence direction between the two, but the absolute value of the estimation coefficient of Etpoisson model is smaller, which demonstrates that the assuming the dependent variable is regarded as a continuous variable will lead to biased estimation, which enlarges the inhibitory effect of free transfer on the adoption of CTT by the transferees. In short, after eliminating the endogeneity of the model, the free transfer significantly reduces the number of 1.977 CTTs adopted by the transferees, and hypothesis 1 is confirmed.

4.3. Correcting selective bias: ESR model

The endogenous treatment effect model assumes that the covariate is independent of the treatment variable to affect the dependent variable. At this time, the treatment effect is only the up and down movement of the regression curve, and the free transfer and the adoption of CTT may be affected by common unobservable factors. The separate estimation of the transfer model and CTT adoption model may lead to inaccurate conclusions due to endogenous problems. Therefore, the Endogenous Switching Regression (ESR) model is introduced in this paper, which assumes that the treatment effect is transmitted by covariates and will change the slope of the regression curve. Compared with ETPR model, ESR model has the following advantages: (1) It can simultaneously deal with the selectivity deviation caused by observable and unobservable factors; (2) The estimated coefficient is allowed to change between paid transfer and free transfer, so as to estimate the influence of free transfer on the adoption of CTT in heterogeneous samples.

It can be seen from Table 4 that the average treatment effect of the adopted number of CTTs by the transferees in paid transfer (ATE) is -0.970, and the average treatment effect of the adopted number of CTTs by the transferees in free transfer (ATU) is -1.778. In addition, the average treatment effect of the number of CTTs adopted in the total sample (ATE) is -1.107.

4.4. Robustness test

In order to further verify the reliability of the previous regression results, this paper replaces the dependent variable for robustness test. The excessive application of chemical fertilizers has led to serious farmland quality problems such as soil acidification and water eutrophication (Wei, 2017). “The action plan for zero growth of chemical fertilizer by 2020” issued by the Ministry of Agriculture in 2015 specially emphasizes the reduction of chemical fertilizers to protect farmland quality. Without affecting fertility, the use of organic fertilizer and soil testing formula fertilizer is a typical conservation tillage behavior, alternative to traditional chemical fertilizer. Thereby, this paper uses the application intensity of organic fertilizer and formula fertilizer as alternative variables for ESR regression respectively, whose regression results are shown in Table 5.

To simplify the analysis, Table 5 only reports the average treatment effect of the treatment group (ATT). It can be seen from Table 5 that the free transfer significantly reduces the application of organic fertilizer by 1.934 kg/mu and the application of formula fertilizer by 0.739 kg/mu. Therefore, the Hypothesis 1 is further verified.

4.5. Further discussion: heterogeneity analysis of different technical types

As shown in the above results, compared with the transferees who transfer in farmland with compensation, the transferees in free circulation are generally less willing to adopt CTT. According to Hypothesis 2 in the theoretical analysis, the influence degree of free transfer on the...
by the marginal cost and output, and the labor force is relatively scarce caused by the free transfer. Therefore, Hypothesis 2 is confirmed. It should be pointed out that this does not prove that the transferees in free circulation are more willing to adopt labor-saving CTT, but only shows that the transferee in free circulation has less relative rejection of adopting labor-saving technology among the two types of technologies.

In order to verify the reliability of the above heterogeneity analysis, this paper further classifies and tests five specific technical types. If the transferees adopt a specific technology, a value of 1 is assigned, otherwise the value equals 0, so five zero-one dummy variables are obtained. In light that the independent variable and dependent variable are both binary variables, the ivprobit model is selected for regression, and “the average human expenditure at the village level” is still used as the instrumental variable of free transfer. The regression results are presented in Table 7, where the regression coefficients reported are the marginal effects. After the classification test of specific technology types, it is found that the free farmland transfer has a significant negative impact on the other four types of CTTs except for pesticide packaging recovery. Through the comparison of the influence coefficients of specific technical types, the negative impact of free transfer on the transferees’ adoption of two types of labor-intensive technologies is greater than that of two types of labor-saving technologies, so the heterogeneity analysis results of technical types are robust.

5. Conclusions

In the current situation that other rural factor markets in China are imperfect, free transfer, as a special form of resource allocation, has certain rationality and practical significance in the farmland market. Under the current realistic background of emphasizing the policy requirements of high-quality agricultural development and the increasingly severe problem of farmland quality, it is equally important to investigate the impact of free transfer on agricultural production, especially the mechanism of protective production behavior of plots, from the micro level of farmland transferees. Motivated by the existing research, this paper investigates whether and how free transfer affect the transferees’ adoption of CTTs, and empirically examine the influence mechanisms and heterogeneous channel of free transfer in this particular farmland transfer market. Through a quantitative analysis, this paper finds that compared with paid transfer, the transferees who transfer in farmland for free are less inclined to adopt CTTs because the operating area may exceed the optimal scale, and the future income can’t be guaranteed. Specifically, the number of CTT adoptions by the transferees in free circulation decreases by 1.977. This result is still robust after replacing the dependent variable. Further, the heterogeneity analysis results of different types of CTTs indicates that the number of labor-saving CTTs such as straw mechanical returning adopted by the transferees in free transfer decreases by 0.231, and the number of labor-intensive CTTs such as soil testing and formula fertilization decreases by 2.496, which means the free transfer has a stronger inhibitory effect on the transferees’ adoption of labor-intensive technologies. This result is also robust after testing by specific technical types.

Given that the imperfect farmland market is relatively common in China and other developing countries, it still makes sense to focus on the phenomenon of free transfer and the influence it brings. More importantly, how to protect land quality and prevent soil degradation have become a common concern of countries around the world, indicating the critical role of the CTT adoptions in the agricultural production. Thereby, some policy implications of the above conclusions are in place. Firstly, it is necessary to change the transaction pattern of weak market-oriented transfer. The research conclusion shows that free transfer is not conducive to encouraging the transferees to invest protectively in cultivated land in agricultural production. From the perspective of effective utilization of farmland, “the farmer with the highest price gets the land” should gradually become the main mechanism of farmland resource allocation in the long run, in order to guide more farmland transferring to farmers with

Table 6. Heterogeneity analysis of different technical types.

|                      | Exponential | Free               | Labor-intensive technology | Free               | Labor-saving technology |
|----------------------|-------------|--------------------|---------------------------|--------------------|-------------------------|
|                      | Stage I     | Stage II           | Stage I                   | Stage II           |                         |
| Average human        | 0.894***    | 0.794***           |                           |                    |                         |
| expenditure at the   | (0.218)     | (0.185)            |                           |                    |                         |
| village level         |             |                    |                           |                    |                         |
| Free transfer         | -2.496***   | -0.231***          |                           |                    |                         |
| (0.520)              | (0.042)     |                    |                           |                    |                         |
| Control variables    | Yes         | Yes                | Yes                       | Yes                |                         |
| Village fixed effect  | Yes         | Yes                | Yes                       | Yes                |                         |
| ATT                  | -0.791***   | -0.061***          |                           |                    |                         |
| (0.097)              | (0.012)     |                    |                           |                    |                         |
| Endogenous parameter | 6.041***    | 10.717***          |                           |                    |                         |
| (0.011)              | (0.250)     |                    |                           |                    |                         |
| Wald chi²            | 176.91***   | 1896.88***         |                           |                    |                         |
| N                    | 527         | 527                |                           |                    |                         |

Table 7. Classification test of specific technology types.

|                      | Labor-saving technology | Labor-intensive technology |
|----------------------|-------------------------|----------------------------|
|                       | straw mechanical returning | high-efficiency pesticide | organic fertilizer | soil testing and formulated fertilization | pesticide packaging recovery |
| Free transfer         | -0.209***               | -0.163***                 | -1.113**           | -0.853*                                    | -0.293                         |
| (0.078)              | (0.059)                 | (0.415)                   | (0.438)            | (0.215)                                    |                                |
| Control variables    | YES                     | YES                        | YES                 | YES                                         | YES                            |
| Village fixed effect  | YES                     | YES                        | YES                 | YES                                         | YES                            |
| N                    | 527                     | 527                        | 527                 | 527                                         | 527                            |
stronger management ability. On one hand, governments should continuously promote the new round of rural land tenure to ensure the safety and stability of the contracted rights of transferors, so that transferors are reassured to transfer farmland to external unfamiliar transferees. On the other hand, governments should accelerate the establishment and improvement of the transfer service platform, expand the scope of transactions and reduce the transaction costs of each link of transfer, in order to attract business entities with stronger ability. Secondly, under the realistic background that there are still many free transfers in China at present, the pertinence and accuracy in the promotion of CCTs should be paid high attention, and different technologies should be popularized according to local conditions. In areas where free transfer is common, the government can give priority to promoting suitable labor-saving technologies through developing social services in combination with the characteristics of local agricultural production, assuring farmers adopt technologies more conveniently. In areas with a high degree of marketization of transfer, governments can further strengthen the publicity and training of labor-intensive technologies, provide a certain amount of operating subsidies, and encourage farmers to adopt CCTs in agricultural production by reducing labor input through technical means.

Declarations

Author contribution statement

Jia Chen: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jingwen Xu: Conceived and designed the experiments; Performed the experiments.

Hongxiao Zhang: Conceived and designed the experiments.

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Data availability statement

The authors do not have permission to share data.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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