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Exploring the Role of Contiguous Farmland Cultivation and Adoption of No-Tillage Technology in Improving Transferees' Income Structure: Evidence from China

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Abstract: Seasonal alternations of extreme weather such as continuous drought and rare rainstorms significantly influence farmers' adoption of agricultural technologies. Compared with traditional tillage, no-tillage technology has more advantages to cope with extreme weather. It is hypothesized that the cultivation of contiguous farmland is still minimal in spite of the transference of farmland on a large scale in China, which ultimately halts the adoption of no-tillage technology and influences the income of households. The current study used 793 farmland transferees' data from Shaanxi, Gansu, and Ningxia provinces of China to explore this phenomenon empirically. By employing the endogenous switching regression model, the study revealed that contiguous farmland significantly promotes the adoption of no-tillage technology and positively influences households' agricultural and non-agricultural income. Meanwhile, the moderating effect of the stability of farmland rental contracts is explored. Further, it was also found that education level, organizational participation, relationship networks, and information acquisition channels influence the income of transferees who opt for no-tillage technology. The study further revealed that if a transferee who opts for no-tillage technology switches to traditional technology, their agricultural and non-agricultural income will decrease by 0.2893 and 1.6979 ten thousand yuan (RMB), respectively. In contrast, if a transferee who opts for traditional technology then switches to adopt no-tillage technology, their agricultural and non-agricultural income will increase by 0.1919 and 1.3044 ten thousand yuan (RMB), respectively. Conclusively, the current study's empirical findings offer policymakers possible guidelines to devise strategies and encourage transferees to opt for no-tillage applications to increase their families' income.

Keywords: contiguous farmland cultivation; no-tillage; traditional tillage; farmland rental contract; family income structure

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1. Introduction

In 2021, the floods in Europe and China and the rising temperature of California confirmed the evolution of "extreme events" as "regular trends" [1]. The rising trend of extreme events coupled with greenhouse gases and global warming intensified the frequency and intensity of damage and even unduly distressed the countries with poor resource settings [2–4]. The developing countries in the monsoon season are more susceptible to extreme weather events such as drought and flood, etc. [5–8]. Researchers argue that poor infrastructure, extensive agricultural farming, and less adoption of new agricultural technologies are the major factors that hinder developing countries from dealing with extreme weather patterns [6,9–11]. In turn, extreme weather also influences agricultural production patterns and technology innovation [12–15]. In this regard, no-tillage technology is found helpful to deal with the seasonal fluctuations of continuous drought and rainstorms [16–18]. No-tillage technology refers to farming that does not require plowing the soil except for sowing and fertilization and uses only drillers for sowing. The amount of soil plowed under no-tillage technology does not exceed the cultivated area by more than 25% [19–21]. Since the soil is less plowed and rotated, and seeds are directly deposited into untilled soil that retains the previous crop residues, the soil's organic matter increases. Many prior studies affirmed that no-tillage technology is helpful to maintain soil's moisture and water content and improves crop resistance towards soil erosion [22–26]. Thus, no-tillage technology is found to be an effective and innovative technology to deal with extreme weather damage sustainably.

Further, during the era of COVID-19, food security issues worldwide have attracted the attention of the government, institutions, and researchers, particularly due to economic recession and downturn, regional conflicts and instability, and broken food supply chains in developing countries [27–33]. The recent report of the United Nations Food and Agriculture Organization documented alarmingly that the number of hungry people in the world increased sharply by 161 million in 2020, and if developing countries progress at the same pace, it will be impossible to achieve the goal of "zero hunger" by 2030 [34]. Though many factors at the national and regional levels lead to food shortages, the most crucial factor is the decline in the quality of farmland caused by long-term over-farming, which adversely influences food production globally [35–38]. Thus, it is recommended to promote conservational tillage technology such as no-tillage technology to improve the quality of farmland and intensify food production sustainably [20,26].

It is noteworthy that farmers in developing countries are reluctant to adopt no-tillage technology [39,40], but recently, certain factors have led them to adopt no-tillage technology [41,42]. For instance, the lower production efficiency of small farmers using the conservational method of farming on fragmented farmland results in lower income [43–45], which creates difficulty in sustaining daily life expenditures and children's education etc. [46–51]. Moreover, it is believed that rural−urban migration and non-agricultural employment shape the rational economic behavior of individuals [52–54]. Thus, reduced farming and abandoning of farmland in rural areas has lessened the food production and supply [46,55–57], which in turn, has promoted the farmland transfer and rental markets in developing countries [58,59]. It is believed that the farmland rental market has encouraged farmland transferees to adopt no-tillage technology more widely.

As mechanized sowing methods mainly implement no-tillage technology, the scale effect significantly affects the adoption of no-tillage technology [60]. However, this phenomenon, which links farmland transfer with scale operation and farmers' technology adoption, is controversial. Some scholars hold that farmland transfer helps in improving the efficiency of farmers to adopt mechanized and labor-saving technology, reducing the cost of production, etc. [61–68], while others believe that farmland transfer does not necessarily foster adoption of technology due to scale operation [69]. Scale operation depends on farmland resources, socioeconomic characteristics, technical equipment, and political and historical conditions [42,70]. In this vein, it is pertinent to say that farmland transfer does not improve farmers' efficiency in adopting agricultural technology [65]. The fundamental reason for the disputes mentioned above is that the existing research ignores the quality of scale operation, which is mainly characterized by the degree of contiguous farmland cultivation. In developing countries, the development of the farmland rental market has only increased the number of transferees' land holdings, but some transferees still implement fragmented agricultural production, and in this way, their family income and welfare are not raised [36,65,71–74]. Moreover, it is proposed that farmland rental contracts should be stable for contiguous farmland cultivation because the transferee can only adopt new agricultural technology and enable inter-period gains within a longer rental term [60,75–77].

So, based on the above discussion, the current study explores the role of contiguous farmland cultivation and the adoption of no-tillage technology in improving the income structure of transferees. In the prevailing literature, many studies have explored the factors affecting farmers' adoption of no-tillage technology, including farmers' characteristics, such as gender, age, education level, and political status [78–80]; family characteristics, such as the number of laborers, the area of arable land, the number of pieces of machinery, and the family income [81,82]; the operating characteristics, such as the degree of specialization and the degree of non-agricultural work [83,84]; cognitive characteristics, such as risk perception, risk preference, risk aversion, environmental literacy, environmental protection awareness, farmland protection awareness [85,86]; and policy measures, such as technical training and government subsidies [87,88], but these studies found inconclusive results. Moreover, farmers' adoption of new agricultural technology is mainly determined by agricultural production costs and benefits from land economics and management. Unfortunately, the existing research has not explored the relationship between the farmland transferees' adoption of no-tillage technology and their agricultural income.

So to explore the phenomenon empirically, the current study used data of 793 farmland transferees from Shaanxi, Gansu, and Ningxia provinces of China. Compared with the previous research, the current study contributes to the literature in the following ways. For example, firstly, the research gathered data from farmland transferees who have been adopting no-tillage technology rather than common farmers. Secondly, our study used the ratio of the largest acre of contiguous farmland to the total farmland area to measure the degree of contiguous farmland cultivation, unlike the studies of Wang and Yang [89] and Xu et al. [90], which used discrete binary variables to assess farmland as contiguous or fragmented. Thirdly, previous research mainly explored the family income or farmers' welfare [91–93], but the present research categorized the transferees' income into agricultural income and non-agricultural income. Moreover, considering the endogenous issue caused by sample selection bias in the adoption of no-tillage technology, this study employed the endogenous switching regression (ESR) model to construct a counterfactual assumption to deal with the possible endogenous issue and further explore the role of contiguous farmland cultivation and adoption of no-tillage technology in improving transferees' income structure. Finally, due to the separation of farmland owners and users, we further analyzed the moderating effect of the stability of farmland rental contracts and the influence of contiguous farmland cultivation on transferees' no-tillage technology adoption and their income structure.

The rest of the paper is organized as follows. Section two highlights the research background, and theoretical and conceptual frameworks are presented in section three. Section four describes the data and methodology. Section five reports and discusses our empirical results. In the final section, conclusions are drawn, and some policy implications are proposed. Finally, the limitation of the study is also presented in the last section.

2. Research Background

As a typical monsoon-affected zone of the Northwest Pacific, China is deeply affected by greenhouse gas emissions and global warming. In 2015, China's Extreme Climate Events, Disaster Risk Management, and Adaptation Assessment Report showed that extreme weather events have significantly altered over the past 60 years with a steep rise in temperature and rainfall [94]. The rural areas of China, with huge poverty levels, were more at risk due to natural disasters from 1978 to 2015 [95]. Agriculture is the most vulnerable sector, being susceptible to extreme weather, and in this instance, traditional small-scale food production cannot meet rural households' growing consumption and expenditure requirements [53,96]. Consequently, non-agricultural employment and large-scale rural−urban labor migration have become the most typical labor spatial characteristics in China in the 21st century [97–99]. In 2019, the total number of migrant peasant workers in China reached 290.77 million, with 116.52 million local migrant workers (within township areas) and 174.25 million migrant workers (outside township areas). Meanwhile, labor mobility also promoted the agricultural rental land market by reducing farmers' dependence on farmland and achieving optimal family labor allocation [100]. By the end of 2020, farmland transferred in China reached 37 million hectares. Thus, it became essential to adopt agricultural technological innovation to cope with the unexpected damage of extreme weather and win the battle against poverty.

In this regard, the no-tillage technology has emerged as an environment-friendly phenomenon that developed in the 1940s, when the United States suffered from severe soil erosion, and is now globally adopted [19]. Since 1978, the Chinese government has been promoting no-tillage technology in the monsoon climate zones where drought and flood occur. As of 2017, the mechanized no-tillage area accounted for 10.48% of the total arable farmland [101]. Nevertheless, compared with other countries, the proportion of mechanized no-tillage technology adopted is relatively low. In this study, we focused on Shaanxi, Gansu, and Ningxia provinces of China due to the following notable aspects: firstly, the three provinces are located in the Loess Plateau region, China, and October to May of each year are dry months and June to September mostly experience concentrated rainfall [102]. Moreover, soil erosion and water shortage severely affect the agricultural production of these regions, which encourages farmers to adopt no-tillage technology. Secondly, since 2001, these provinces have successfully implemented subsidies and training programs to promote no-tillage technology continuously. In 2019, the mechanized no-tillage technology area in Shaanxi, Gansu, and Ningxia provinces accounted for 24.52, 27.20 and 17.85% of the conservation tillage area, respectively. Thirdly, these areas are relatively poor regions in western China, and in 2019, the number of migrant peasant workers was relatively large with 6.0 million, 1.7 million, and 0.8 million people, respectively [103]. Moreover, farmland transference increasingly occurred, with a transfer rate exceeding 20% of the farmland area. Additionally, due to the vertical and horizontal ravines of farmland, the degree of farmland fragmentation is severe. Therefore, these aspects make these provinces a better research area.

3. Theoretical and Conceptual Framework

3.1. Influence of Contiguous Farmland Cultivation on Transferees' Income Structure

Many previous studies revealed that contiguous farmland cultivation is necessary for large-scale agricultural practices [43,48,104]. Contiguous farmland cultivation allocates land use rights and facilitates mechanized farming [104,105]. Contiguous farmland cultivation may have a subtle impact on transferees' income structure. Firstly, contiguous farmland cultivation is good for forming economies of scale as compared to fragmented farmland because fragmented lands are scattered and require huge costs in operating machinery on small-scale plots [69,106–108]. Studies have confirmed that when a small harvester works on a field of 1.35 mu, the time it takes accounts for 15% of the entire 13.15 mu plot area. If the number of plots increases by one plot, the cost of mechanical operations will increase by 1.01% [109]. These cumbersome practices lead to the loss of economies of scale [110]. Secondly, contiguous farmland cultivation is conducive to transferee's unified decision-making, instead of the multi-agent decision-making caused by farmland fragmentation. Moreover, it can also help implement crop specialization production methods, form the brand effect of agricultural products, to the competitiveness of the products in the market [111,112]. Qin and Zhang [113] stated that although diversified planting can spread farmers' production and market risks, specialized production is in line with the mainstream trend of modern agricultural development. Thus, contiguous farmland cultivation is beneficial to increase the transferee's agricultural income. Thirdly, contiguous farmland cultivation helps to reallocate family labor resources. Mechanized farming saves the transferee family's surplus labor and encourages them to engage in non-agricultural employment, thereby increasing the family's non-agricultural income [114]. Consequently, keeping in view the above aspects, this research hypothesizes the first assumptions:

Hypothesis 1. *Contiguous farmland cultivation can increase the farmland transferee's agricultural and non-agricultural income.*

3.2. Influence of Contiguous Farmland Cultivation on Transferee's Adoption of No-Tillage Technology

Previous studies have rarely explored the causal relationship between contiguous farmland cultivation and the transferee's adoption of no-tillage technology. No-tillage is not like abandoned tillage [20]. It mainly reduces cultivated land's plowing and rotary tillage and adopts an effective sowing mechanism for agricultural production [115–117]. In some developing countries, the infrastructure in rural areas is relatively weak [118–120]. If the cultivated land is highly fragmented, the planter will only access the farmland adjacent to the road. Hence, farmers are reluctant to adopt no-tillage technology. Accordingly, contiguous farmland cultivation encourages farmers to adopt no-tillage technology. Besides, no-tillage technology is one of the conservational tillage technologies. Still, some unfavorable views concerning the causal relationship between contiguous farmland cultivation and transferees' adoption of conservation tillage technologies exist. Some scholars believe that the transferee usually pays attention to higher yield and neglects farmland investment, especially in the context of unstable farmland rental contracts [60]. The positive externalities of conservational tillage technology usually have inter-temporal attributes [121–123]. Suppose the rental time of farmland is short. In that case, the transferee is less likely to adopt conservational tillage technology. Within the lease term, the transferee's adoption of conservation tillage technology cannot obtain the technology benefits as expected [124,125]. Thus, the effect of contiguous farmland cultivation on the transferee's adoption of no-tillage technology is uncertain, which usually depends on the stability of the farmland rental contract. Therefore, this research proposes the second assumption as follows:

Hypothesis 2. *The impact of contiguous farmland cultivation on the transferee's adoption of no-tillage technology is uncertain.*

3.3. Influence of Transferee's Adoption of No-Tillage Technology on Their Family Income Structure

Residents' family income includes salary, wages, rent, and transfer income [126,127]. However, in rural areas, these incomes are not evenly distributed among the sample households. In the study, we used agricultural income and non-agricultural income to describe farmers' income structure. In the context of farmland transfer, previous studies have rarely explored the relationship between the adoption of no-tillage technology and the transferees' income structure. Some scholars believe that no-tillage technology improves the land quality and crop yield with time, which endorses the law of marginal benefits of adopting green technology [128–130]. Other scholars hold that no-tillage technology stabilizes agricultural income by reducing the losses due to climate and natural disasters, such as drought and soil erosion, and effectively improves crop yields [16,21,26]. Additionally, according to the previous discussion, no-tillage technology is a capital-intensive rather than labor-intensive technology. Compared with traditional technology, the adoption of no-tillage technology encourages rural laborers to engage in non-agricultural employment opportunities and eventually improves transferees' family welfare. The increase in non-agricultural income may also increase transferees' investment in no-tillage technology [91]. Hence, this research proposes the following assumptions.

Hypothesis 3. *Adoption of the no-tillage technology can increase transferee's agricultural income and non-agricultural income and finally exerts an influence on family income structure.*

The theoretical and conceptual framework discussed above is exhibited in Figure 1.

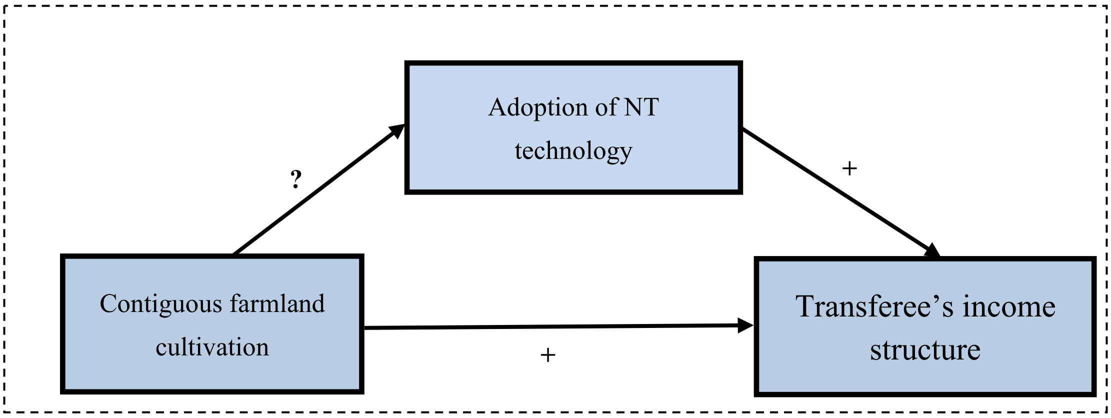

Figure 1. Theoretical framework used in the current study.

4. Data and Methodology

4.1. Study Sites

Three provinces of China, namely, Shaanxi, Gansu, and Ningxia, were selected as the study area, located at 92°13′−111°15′ east longitude and 31°42′−42°57′ north latitude, with a total area of 697,800 square kilometers (see Figure 2). The areas are the most monsoon-affected area in China. Moreover, the alternating seasonal patterns of drought and soil erosion also create challenges for these regions to enhance agricultural production. Additionally, these provinces have set the trend for adopting no-tillage technology firstly compared to other areas, with the help of experienced and well-trained staff. Compared with other parts of China, no-tillage technology has been most widely adopted in these areas.

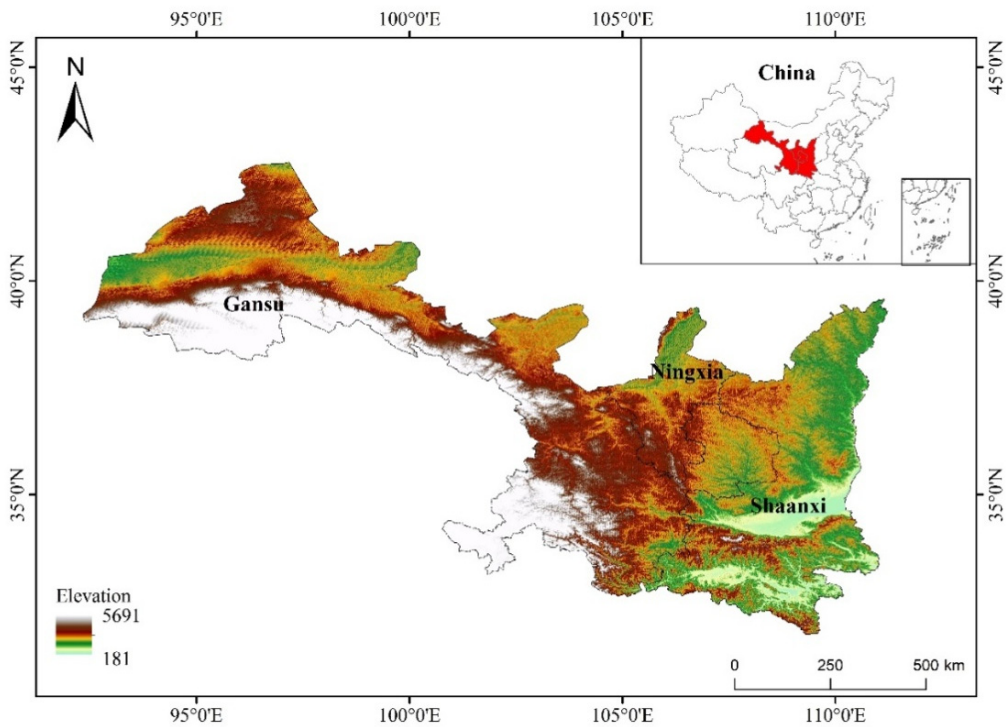

Figure 2. Map of study area (Source: Arc GIS 10).

4.2. Sample Selection

The data for the current study were collected from Shaanxi, Gansu, and Ningxia provinces by distributing a questionnaire from 2 January to 16 January 2019. The questionnaire survey group consisted of 3 associate professors and 7 graduate students who had undergone professional training before the formal investigation. Meanwhile, the questionnaire survey obtained information support from the agricultural departments of the sampled counties. The survey adopted a combination of stratified and simple random sampling. First, 4 sample counties in each province were randomly selected, then 5–8 towns from the sampled counties were randomly selected. Finally, 40–50 households from each town were randomly selected. The specific questionnaire survey area is about 41,800 square kilometers, including Shenmu, Zizhou, Yanchang, and Huanglong counties in Shaanxi Province; Jingchuan, Jingning, Guazhou, and Zhengning counties in Gansu Province; and Yongning, Tongxin, Yanchi, and Haiyuan counties in Ningxia. The survey gathered data from 1585 respondents; after removing blank and contradictory questionnaires, 1496 valid samples were retained, including 703 farmland transferors and 793 transferees, which comprised 472, 525, and 499 households, respectively, from Shaanxi, Gansu, and Ningxia provinces. The effective rate of the questionnaire was about 94.39%.

The sampled data for empirical analysis comprised 793 farmland transferees, including 267 households from Shaanxi, 251 households from Gansu, and 275 households from Ningxia. Before the formal survey, the research team conducted a pre-survey in Zhangye, Gansu province and accordingly modified research content such as households' characteristics, family characteristics, operating conditions, social capital, adoption of no-tillage technology, organizational participation, government incentives, etc. Besides, in-depth interviews with farmland transferees were also conducted during the survey. These interviews provided good evidence for interpreting the quantitative findings.

4.3. Variable Selection

4.3.1. Outcome Variables

A variety of crops, such as wheat, corn, potatoes, etc., were planted by the transferees in the sampled areas. The planting patterns were highly heterogeneous, such as specialized or multiple planting. Hence, this study did not analyze yield differences between no-tillage and traditional tillage, but directly converted crop yield into agricultural income. The main outcome variable in the current study was farmland transferees' income structure. The income structure can reflect the main source of household income and serve as the main channel for assessing farmers' future income [131–133]. In traditional economics, the income structure includes wages and operating, property, and transfer incomes. The wage income comes from non-agricultural employment; the operating income comes from agricultural planting; property income is from renting houses and vehicles; transfer income mainly refers to government subsidies for households adopting no-tillage technology. However, suppose the statistical analysis is performed according to these income classifications on the sampled data. In that case, some data might drop as most farmland transferees do not have property income or wage income. Against this backdrop, the current study categorized the income structure into agricultural income and non-agricultural income by following the study of Danso-Abbeam et al. [91], Amfo and Ali [134], and Pang et al. [135].

4.3.2. Explanatory Variables

Some previous research has usually equated farmland transfer with large-scale operation and regarded transferees' farmland area as contiguous farmland cultivation [136–138], while other scholars considered the product of the area of transferred farmland and the number of plots as the index of contiguous farmland cultivation [68,69]. It is believed that these studies have neglected the spatial location of cultivated land resources; that is, cultivated land after farmland transfer may also present a fragmented block distribution instead of a flaky distribution. So, unlike the previous studies, the current study used the ratio of the largest acre of contiguous farmland to the total farmland as the degree of transferee's contiguous farmland cultivation. Hence, the transferee's contiguous farmland cultivation is a continuous variable that lies between 0–1. Additionally, there is sample self-selection behavior when the transferee adopts no-tillage technology. If the transferee adopts the no-tillage technology, the value assigned is 1; if the transferee does not opt for the no-tillage technology and continually implements traditional tillage, the value is 0. The sampled data showed that around 335 farmland transferees adopted no-tillage technology, and 458 transferees continuously used the traditional-tillage method.

4.3.3. Control Variables

The study also included other variables in the model that were expected to impact the farmland transferees' income structure. Following previous studies such as Si et al. [139] and Su et al. [140], the study used transferees' gender, age, education level, number of laborers, family loan, organization participation, relationship network, information acquisition channels, and government skill training in the model as control variables for empirical analysis. The study additionally included farmland rental contract stability and it was measured by the term of the farmland rental contract [60]. Moreover, Ningxia province was added as the control group, while two dummy variables were created for the other two regions, Gansu and Shaanxi.

4.3.4. Empirical Estimation

To explore the influence of contiguous farmland cultivation and adoption of no-tillage technology on farmland transferees' income structure, the following model was structured:

$$Y_i = X_i\gamma + D_i\xi + Z_i'\tau + \varepsilon_i \tag{1}$$

where Y_i represents the transferee's income structure, X_i is the contiguous farmland cultivation, D_i denotes whether the transferee adopts no-tillage technology, Z_i' is control variables. γ, ξ, and τ are coefficients to be estimated, and ε_i is the random error term. According to the utility theory in economics, it is assumed that the utility of the farmland transferee adopting no-tillage technology is D_{i1}^*, and the utility of adopting traditional technology is D_{i0}^*. Thus, if $D_i^* = D_{i1}^* - D_{i0}^* > 0$, it means transferees will adopt no-tillage technology. D_i signifies an unobservable latent variable, but it can be regarded as a linear function of the contiguous farmland cultivation and control variables, which is as follows:

$$\begin{aligned} D_i^* &= X_i\alpha + Z_i'\beta + \mu_i \\ D_i &= \left\{ \begin{array}{l} 1,\ if\ X_i\alpha + Z_i'\beta + \mu_i > 0 \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ 0,\ if\ X_i\alpha + Z_i'\beta + \mu_i \le 0 \end{array} \right\} \end{aligned} \tag{2}$$

where D_i, X_i, and Z_i' have the same meaning as Equation (1). α and β are coefficients to be estimated, μ_i is a random error term. D_i is an endogenous variable because it is both the explained Equation (2) and the explanatory variable of Equation (1). If it is estimated by the OLS method and logit model, the regression results will be biased. Besides, there are unobservable factors that might affect transferees' no-tillage technology adoption and family income structure simultaneously, which in turn influence the random error terms of (1) and (2), bringing about a possible correlation between the two error terms and are further likely to affect the model estimation results. Consequently, the endogenous transformation regression (ESR) model proposed by Maddala [141] is employed in the current study to explore the influence of contiguous farmland cultivation and adoption of no-tillage technology on transferees' income structure. The ESR model is superior to other traditional models due to the following features: firstly, it can solve the self-selection issue of transferees adopting no-tillage technology and the endogeneity caused by other unobservable factors impacting family income structure; secondly, it can analyze the influencing factors of transferees' income structure with no-tillage technology adoption and traditional tillage adoption, respectively; finally, it can realize counterfactual analysis to avoid missing related information [142,143].

Moreover, the shortest distance between the contiguous farmland and field road is chosen as the identification variable introduced into the transferees' no-tillage decision model. The main basis for selecting the identification variable is that the accessibility of field roads affects the planting operation, which is also a key element that drives a transferee's decision to adopt no-tillage technology. The shortest distance between the contiguous farmland and the field road does not influence a farmland transferee's income structure. Accordingly, the transferees' no-tillage adoption decision model is constructed as follows:

$$D_i{}^* = X_i\alpha + W_i\kappa + Z_i'\beta + \mu_i$$
$$D_i = \begin{cases} 1,\ if\ X_i\alpha + W_i\kappa + Z_i'\beta + \mu_i > 0 \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ 0,\ if\ X_i\alpha + W_i\kappa + Z_i'\beta + \mu_i \leq 0 \end{cases} \tag{3}$$

where W_i denotes the shortest distance between the contiguous farmland and field road, and κ is the coefficients to be estimated. The family income structure model of farmland transferee can be built as:

$$\begin{aligned} Y_{i1} &= X_{i1}\gamma_1 + Z_{i1}'\tau_1 + \varepsilon_{i1},\ if\ D_i = 1 \\ Y_{i0} &= X_{i0}\gamma_0 + Z_{i0}'\tau_0 + \varepsilon_{i0},\ if\ D_i = 0 \end{aligned} \tag{4}$$

where Y_{i1} and Y_{i0} represent the income structure of transferee when adopting no-tillage and traditional tillage, respectively. X_{i1} and X_{i0} are the degree of the contiguous farmland cultivation of transferee with no-tillage and traditional tillage. Z_{i1}' and Z_{i0}' are other control variables, and γ_1, γ_0, τ_1, τ_0 are the coefficients to be estimated, ε_{i1} and ε_{i0} are random error term. We cannot detect the same transferee's income structure Y_{i1} and Y_{i0} simultaneously. To eliminate the inconsistency of estimation results caused by sample selection bias, the inverse Mills ratio λ_{i1} and λ_{i0} are introduced, and the covariance $\sigma_{\mu 1}$ and $\sigma_{\mu 0}$ to modify the model. Suppose $Var(\mu_i) = 1$, and the random error terms ε_{i1}, ε_{i0} and μ_i obey the multivariate normal distribution with the mean vector as a zero vector, and the covariance matrix is:

$$\Omega = \begin{bmatrix} \sigma_1^2\ \sigma_{10}\ \sigma_{1\mu} \\ \cdots\cdots\cdots \\ \sigma_0^2\ \sigma_{0\mu} \\ \cdots\cdots\cdots \\ 1 \end{bmatrix} \tag{5}$$

Therefore, the model of a farmland transferee adopting no-tillage is:

$$\begin{aligned} E(Y_{i1}|D_i = 1) &= X_{i1}\gamma_1 + Z_{i1}'\tau_1 + E(\varepsilon_{i1}|\mu_i > -X_i\alpha - W_i\kappa - Z_i'\beta) \\ &= X_{i1}\gamma_1 + Z_{i0}'\tau_1 + \lambda_{i1}\sigma_{\mu 1} \end{aligned} \tag{6}$$

The model for a farmland transferee adopting traditional tillage is:

$$\begin{aligned} E(Y_{i1}|D_i = 1) &= X_{i1}\gamma_1 + Z_{i1}'\tau_1 + E(\varepsilon_{i1}|\mu_i > -X_i\alpha - W_i\kappa - Z_i'\beta) \\ &= X_{i1}\gamma_1 + Z_{i0}'\tau_1 + \lambda_{i1}\sigma_{\mu 1} \end{aligned} \tag{7}$$

The ESR model can also estimate the average treatment effect of transferees adopting no-tillage technology and traditional technology.

$$E(Y_{i0}|D_i = 1) = X_{i1}\gamma_0 + Z_{i1}{}'\tau_0 + \lambda_{i1}\sigma_{\mu 0} \tag{8}$$

$$E(Y_{i1}|D_i = 0) = X_{i0}\gamma_0 + Z_{i0}{}'\tau_0 + \lambda_{i0}\sigma_{\mu 1} \tag{9}$$

Equations (10) and (11) are the calculation equations for the average family income structure of farmland transferees adopting no-tillage technology and traditional technology. Equations (8) and (9) are the average income structure of transferees adopting no-tillage technology then changing to adopt traditional technology, and transferees using traditional technology switching to adopt no-tillage technology, respectively. Consequently, the average treatment effect (ATT) of income structure of transferee adopting no-tillage technology can be expressed as the difference between (6) and (8):

$$ATT = E(Y_{i1}|D_i = 1) - E(Y_{i0}|D_i = 1) = X_{i1}(\gamma_1 - \gamma_0) + Z'_{i1}(\tau_1 - \tau_0) + \lambda_{i1}(\sigma_{\mu 1} - \sigma_{\mu 0}) \quad (10)$$

The average treatment effect (ATT) of income structure of a transferee adopting traditional technology can be expressed as the difference between (7) and (9):

$$ATT = E(Y_{i1}|D_i = 0) - E(Y_{i0}|D_i = 0) = X_{i0}(\gamma_1 - \gamma_0) + Z'_{i0}(\tau_1 - \tau_0) + \lambda_{i0}(\sigma_{\mu 1} - \sigma_{\mu 0}) \quad (11)$$

5. Results and Discussion

5.1. Descriptive Statistics

The descriptive statistics of all variables with their measurement are shown in Table 1. From Table 1, it can be seen that the main source of farmland transferees' income was from non-agricultural sources, and agricultural income only accounted for 32.17%. The farmland transfer did not significantly improve the fragmentation of cultivated land, and the degree of contiguous farmland cultivation was less than 50%. The terms of the farmland rental contracts were relatively short, with an average value of 2.7201. Moreover, the heads of farmland transferees were mainly males, and the proportion of females participating in family decision-making was relatively low. The transferees had a relatively low level of education, and most of them were middle-aged and older adults, accounting for 73.84%. The family labor resources in the sample area were not highly sufficient, with an average value of only 3.1677 people. Additionally, 34.05% of households faced loan pressure from banks, and 46.53% of the transferees actively participated in agricultural cooperative organizations to increase their family income. Regarding no-tillage technology, only 42.25% of the transferees adopted this technology, and the technology adoption rate was still relatively low. In information sources, only 9.08% of transferees obtained technology adoption information through modern communication modes. Meanwhile, less than 50% of the transferees received no-tillage training provided by the government free of cost.

Table 1. Descriptive statistics of variables.

Variables	Measurement	Percentage	Mean	S.D.	Relevant Literature
Transferee's income structure	Agricultural income (ten thousand yuan RMB)	32.17%	1.5065	1.7537	Pang et al. [135]
	Non-agricultural income (ten thousand yuan RMB)	67.83%	3.1603	4.9320	
Contiguous farmland cultivation	The ratio of the largest acre of contiguous farmland to the total farmland area		0.4602	0.2497	Qu and Zhao [69]
Adoption of no-tillage technology	No-tillage adoption = 1 Traditional tillage adoption = 0	42.25% 57.75%	0.4225	0.4943	Chaudhary et al. [16]
Farmland rental contract stability	Terms of farmland rental contract (year)		2.7201	3.1486	Si et al. [60]
Gender	Male = 1 Female = 0	96.97% 3.03%	0.9697	0.1714	Tan et al. [144]
Age	<40 year 40–60 year >60 year	26.16% 40.35% 33.49%	52.3228	10.4571	Cao et al. [145]

Table 1. *Cont.*

Variables	Measurement	Percentage	Mean	S.D.	Relevant Literature
Education level	<7 year (primary school) 7–9 year (middle school) 10–12 year (high school) >12 year (university)	30.25% 46.79% 20.08% 2.88%	5.7755	3.6615	Danso-Abbeam et al. [91]
Number of laborers	<4 people 4–6 people >6 people	62.15% 30.07% 7.78%	3.1677	1.4358	Deichmann et al. [54]
Family loan	Loan = 1 Non-loan = 0	34.05% 65.95%	0.3405	0.4742	Zhang [98]
Organization participation	Participation = 1 Non-participation = 0	46.53% 53.47%	0.4653	0.4991	Zhu and Li [136]
Relationship network	Contacts stored in the phone(people)		73.2283	87.7937	Xu et al. [146]
Information acquisition channels	Modern communication equipment such as mobile phones or the internet = 1 Non = 0	9.08% 90.92%	0.0908	0.2875	Zhan and Li [126]
Government skill training	Training = 1 Non-training = 0	46.15% 53.85%	0.4615	0.4988	Tran and Vu [71]
Gansu	Gansu = 1 non-Gansu = 0		0.3594	0.4801	Sheng et al. [133]
Shaanxi	Shaanxi = 1 non-Shaanxi = 0		0.2358	0.4248	

Source: field survey (2019).

5.2. Statistical Inference

According to the recent study of Abdelhafez et al. [147], it is stated that correlation is a non-deterministic interdependence relationship; that is, for each value of the independent variable, the dependent variable is affected by random factors, and its corresponding value is non-deterministic. We further drew the nuclear density curve to infer the correlation relationships between the contiguous farmland cultivation and transferees' adoption of no-tillage technology (see Figure 3), the contiguous farmland cultivation and transferees' income structure (see Figure 4), as well as transferees' adoption of no-tillage technology and family income structure (see Figure 5). It is apparent from Figure 3 that as the degree of contiguous farmland cultivation increased, the nuclear density curve of the farmland transferees' adoption of no-tillage technology shifted to the right, indicating that contiguous farmland cultivation and the adoption of no-tillage technology have a positive relationship. Figures 4 and 5 also show that the higher the degree of contiguous farmland cultivation, the more the transferees adopted no-tillage technology and increased their agricultural incomes to be greater than the income obtained by traditional technology. Meanwhile, the non-agricultural income obtained by the transferees adopting no-tillage technology was also greater than the non-agricultural income obtained by the transferees adopting traditional technology.

5.3. Results of Endogenous Switching Regression (ESR) Model

The ESR mode l is used to explore the influence of contiguous farmland cultivation and the adoption of no-tillage technology by transferees on their agricultural income (Model 1) and non-agricultural income (Model 2), respectively. The regression results of the models are shown in Table 2 and reveal that the Wald values of Models (1) and (2) are 161.55 and 162.07, respectively, which are significant at a 1% level, while the LR values are 9.22 and 9.25, respectively, which are significant at 5% levels, indicating that the two models have a relatively good fitting effect. Moreover, Equation (1) indicates the transferees' decision regarding the adoption of no-tillage technology. In contrast, Equations (2) and (4) represent the agricultural and non-agricultural income equations of the transferees' adopting no-tillage technology. Equations (3) and (5) are the agricultural income and non-agricultural income equations of the transferees adopting traditional tillage technology. Additionally, to explore the moderating effect of contract stability in the influence of contiguous farmland cultivation on the transferees adopting no-tillage technology and their income structure, the interaction terms of contiguous farmland cultivation and the stability of the farmland rental contracts (contract stability) were incorporated, and it was found that the main effect of contiguous farmland cultivation and contract stability remains significant. Hence, Table 3 also shows the ESR results with the interaction term added.

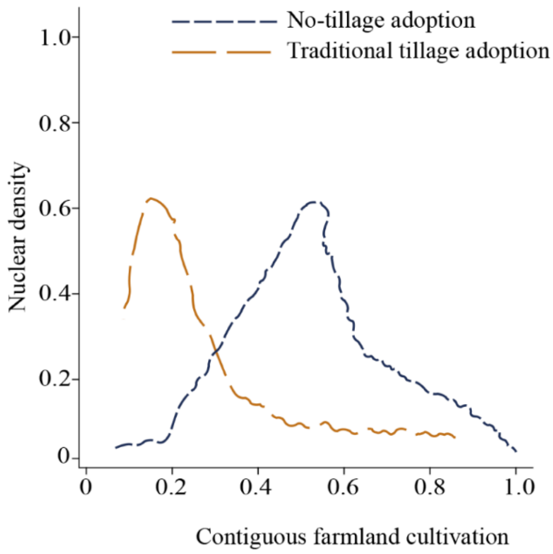

Figure 3. Nuclear density curve between the contiguous farmland cultivation and transferees' adoption of no-tillage technology (Source: field survey 2019).

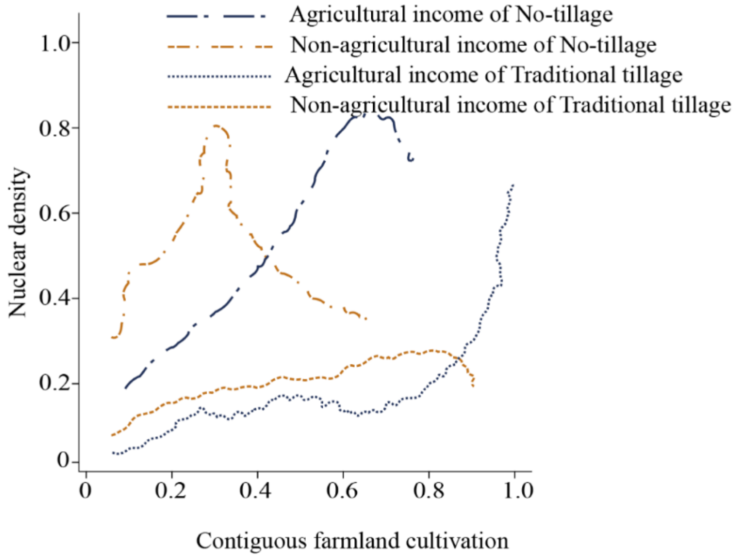

Figure 4. Nuclear density curve between the contiguous farmland cultivation and transferees' income structure (Source: field survey 2019).

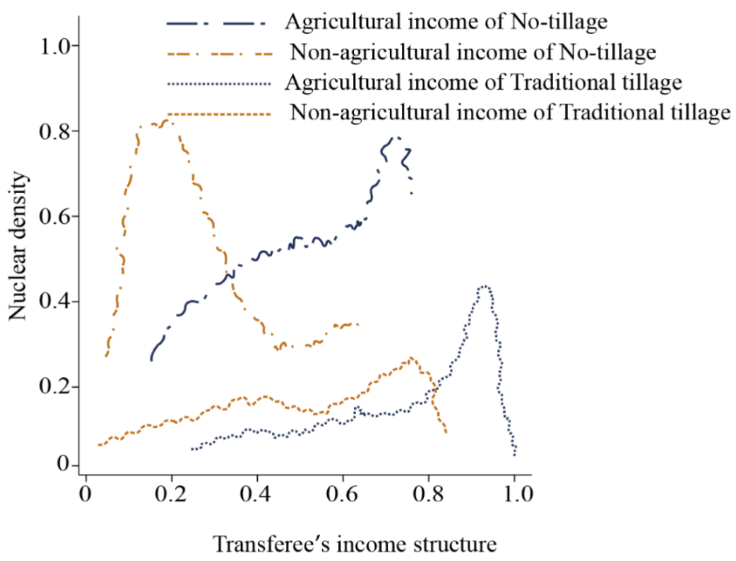

Figure 5. Nuclear density curve between transferees' NT technology adoption and family income structure (Source: field survey 2019).

Table 2. Regression results of ESR model.

Variables	Model 1			Model 2	
		Agricultural Income		Non-Agricultural Income	
	No-Tillage Decision (Equation (1))	No-Tillage Adoption (Equation (2))	Traditional Tillage Adoption (Equation (3))	No-Tillage Adoption (Equation (4))	Traditional Tillage Adoption (Equation (5))
Contiguous farmland cultivation	0.1725 *	0.2035 ***	0.0922 *	0.3109 ***	0.1604 *
	(0.0958)	(0.0636)	(0.0512)	(0.1110)	(0.0844)
Contract stability	0.2036 **	0.0821 **	0.305	0.0079 *	0.1045
	(0.0969)	(0.0373)	(0.2102)	(0.0045)	(0.0746)
Contiguous farmland cultivation*contract stability	0.0982 ***	0.1265 ***	0.0179 **	0.1136 **	0.0428 *
	(0.0327)	(0.3833)	(0.0077)	(0.0490)	(0.0231)
Distance between farmland and field road	0.3070 ***				
	−0.1023				
Gender	0.0701	0.0425	0.0368	0.0721	0.042
	(0.0519)	(0.0502)	(0.0407)	(0.0826)	(0.0328)
Age	−0.2003	−0.1714	−0.1207	−0.1129	−0.1065
	(0.1406)	(0.1302)	(0.0903)	(0.0828)	(0.0750)
Education level	0.4075 ***	0.3901 **	0.3082 *	0.4041 ***	0.4408 *
	(0.1405)	(0.1773)	(0.1751)	(0.1412)	(0.2395)
Number of laborers	0.0109	0.0602	0.0701	0.0225 ***	0.02721 *
	(0.0225)	(0.0471)	(0.0520)	(0.0056)	(0.0151)
Family loan	−0.3002 **	−0.288	−0.2705	−0.3037	−0.388
	(0.1443)	(0.2028)	(0.2004)	(0.2510)	(0.2425)
Organizational participation	0.0605	0.0235 ***	0.0182 *	0.0895 *	0.0601 *
	(0.0437)	(0.0075)	(0.0102)	(0.0514)	(0.0323)
Relationship network	0.5011 ***	0.4020 **	0.4128 **	0.6021 ***	0.6288 ***
	(0.1566)	(0.1896)	(0.1929)	(0.2020)	(0.2082)
Government skill training	0.6012 **	0.7022	0.6023	0.7625	0.613
	(0.2613)	(0.5302)	(0.5475)	(0.5389)	(0.4442)

Table 2. *Cont.*

Variables	Model 1			Model 2	
		Agricultural Income		Non-Agricultural Income	
	No-Tillage Decision (Equation (1))	No-Tillage Adoption (Equation (2))	Traditional Tillage Adoption (Equation (3))	No-Tillage Adoption (Equation (4))	Traditional Tillage Adoption (Equation (5))
Information acquisition channels	0.1306 (0.0921)	0.1709 * (0.0988)	0.1045 ** (0.0486)	0.1828 *** (0.0630)	0.1402 * (0.0779)
Regional variables Gansu	0.0602 * (0.0316)	0.0435 * (0.0250)	0.032 (0.0221)	0.0561 * (0.0346)	0.0396 ** (0.0171)
Shaanxi	0.0686 (0.0429)	0.0711 (0.0467)	0.0602 (0.0376)	0.0452 (0.0295)	0.0685 (0.0462)
Constant term	0.2022 ** (0.0944)	0.1780 *** (0.0524)	0.1605 ** (0.0674)	0.2121 *** (0.0652)	0.2032 ** (0.0840)
σ_1		0.1603 *** (0.0577)		0.2705 ** (0.1218)	
σ_0			0.1402 *** (0.0523)		0.1803 ** (0.0831)
$\rho_{\mu 1}$		0.1529 ** (0.0632)		0.2321 * (0.1349)	
$\rho_{\mu 0}$			0.1211 ** (0.0507)		0.1614 * (0.0887)
Wald chi2(10)		161.55 ***		162.07 ***	
LR chi2(1)		9.22 **		9.25 **	
Log-likelihood		−728.259		−730.612	

Notes: Coefficients are reported in the table, and standard errors are presented in parentheses. The significance level at 1%, 5%, and 10% are represented by asterisk ***, **, and *, respectively. Source: Authors' computation.

Table 3. The average treatment effect of ESR model.

	Agricultural Income				Non-Agricultural Income			
	No-Tillage Technology Adoption	Traditional Technology Adoption	ATT	ATU	No-Tillage Technology Adoption	Traditional Technology Adoption	ATT	ATU
Transferee adopting no-tillage technology	(a) 1.5021	(c) 1.2128	0.2893 ** (0.1315)	-	(e) 3.1004	(g) 1.4025	1.6979 ** (0.7382)	-
Transferee adopting traditional tillage technology	(d) 1.0025	(b) 0.8106	-	0.1919 * (0.1066)	(h) 2.6108	(f) 1.3136	-	1.3044 * (0.6865)

Notes: Coefficients are reported in the table, and standard errors are presented in parentheses. The significance level at 1%, 5%, and 10% are represented by asterisk **, and *, respectively. Source: Authors' computation.

5.3.1. Impact of the Contiguous Farmland Cultivation on Transferees' Adoption of No-Tillage Technology

Table 2, Equation (1) shows that contiguous farmland cultivation has a positive and significant effects on a transferee's adopting no-tillage technology at a 10% significance level. The results suggest that the higher the degree of contiguous farmland cultivation, the greater the probability that the transferee adopts no-tillage technology; hence hypothesis H2 is confirmed. The results suggest that large-scale mechanized farming and reduced production costs lead to the diffusion of no-tillage technology. Further, the economies of scale formed by no-tillage technology reduce the input cost of low-skilled labor in agriculture and increase capital-intensive technologies' adsorption effect on farmland. Many previous studies also explored the phenomenon and had the same outcome [19,20,52,118,143]. Further, the interaction term of contiguous farmland cultivation and contract stability also positively influences transferees' adoption of no-tillage technology at a 1% significance level, indicating that the farmland rental contract stability plays a moderating role in effecting contiguous farmland cultivation and transferees' adoption of no-tillage technology. The findings further reveal that the longer the farmland lease contract term, the more obvious effect of contiguous farmland cultivation on scale economy. The findings correspond well with the previous research [64,122,123].

It is also revealed that no-tillage technology has inter-temporal benefits and has higher marginal effects of technology adoption; the short-term direct effects of no-tillage technology also exist, which suggests that more farmland transferees should be encouraged adopt no-tillage technology actively. These results contradict the previous researchers who did not find short-term effects such as the increase of food production as a result of the adoption of green technology [131,148]. In terms of identification variables, the findings reveal that the shortest distance between the contiguous farmland and field road positively and significantly influences a transferee's adoption of no-tillage technology at a 1% significance level. The results are analogous with the findings of Adnan et al. [148], Teruel and Kuroda [149], and Urquía-Grandeand Rubio-Alcocer [150]. The findings affirm that improving agricultural infrastructure such as field roads is essential for the development of large-scale and mechanized farming and an important source for the innovation and promotion of agricultural technology. In terms of control variables, the findings reveal that educational level promotes transferee adoption of no-tillage technology at 1% statistical level. The results suggest that if a transferee's educational level is higher, they are more inclined to adopt no-tillage technology to control the risks of extreme weather shocks. Gerdes et al. [151] and Sharifzadeh and Abdollahzadeh [152] also stated that education level influences an individual's ability to obtain information, awareness of adopting technology, and management capability of farming risk. Moreover, family loans showed a negative and significant impact on transferees' adoption of no-tillage technology at the 5% statistical level. The results are expected as no-tillage technology is capital-intensive and requires investment in a planter for seeding. If the transferee is under great financial pressure, it is not easy to adopt no-tillage technology. Jia and Qian [153] also had the same verdict and held that credit constraints negatively affect farmers' investment in production and technology adoption activities.

Besides, relationship networks were found to be positively significant in influencing a transferee's adoption of no-tillage technology at a statistical level of 1%. The outcome reveals that a relationship network is likely to promote farmers' adoption of green agricultural technologies through information sharing, risk sharing, mutual learning, and the peer effect. Likewise, government skill training was found positively significant at a 5% significance level and suggests that the major bottleneck in developing countries is farmers' lack of skills. Thus, the government skills training is likely to alleviate the information asymmetry between farmers and the technology supply market, reduce the costs of farmers' technology acquisition and use, improve farmers' ability to adapt to climate and market risks and eventually promote transferees' adoption of no-tillage technology. Many earlier studies also revealed the same findings [154–159]. Additionally, the regional dummy variables were also found to be significant, indicating the great regional disparity in the adoption of no-tillage technology; the possible reason is that the income effect of technology adoption varies from region to region, which is consistent with the research conclusion of Xu et al. [160].

5.3.2. Impact of the Contiguous Farmland Cultivation on Transferees' Income Structure

According to Equations (2)–(5) in Table 2, it is apparent that contiguous farmland cultivation positively and significantly influences the agricultural income and non-agricultural income of transferees adopting no-tillage at a 1% significance level. Hence, assumption H1 is also confirmed. Meanwhile, according to group regression, it was found that there was a big difference between the income structure of the transferees adopting no-tillage technology and traditional tillage technology, indicating that the adoption of no-tillage technology positively and significantly influences transferees' income structure and endorses the H3 assumption. During the field survey, it was found that the higher the degree of contiguous farmland cultivation, the higher the proportion of adoption of no-tillage and resultantly, the farming skills of the transferees also improved. Consistent with the research of Bernard de Raymond [111], Xu et al. [160], and Ntihinyurwa and de Vries [108], our findings show that the contiguous farmland cultivation can increase family agricultural income by improving the level of specialized production, enhancing the brand effect and market competitiveness of agricultural products, and continuously improving the efficiency of agricultural production. Accordingly, the adoption of no-tillage technology also helps in improving agricultural production efficiency. The findings further reveal that the scale and mechanized farming enabled on contiguous farmland, coupled with no-tillage technology adoption, promoted the planting area of cash crops such as peanuts and vegetables larger than other grain crops such as wheat and rice. These are contrary to the findings of Li and Liu [161], Liu and Zhou [35], and Muraoka et al. [162].

In the context of global food security, the findings provide a realistic basis for the rising risk of food crop plantings in the development of the farmland rental market. The fundamental reason is that cash crops' prices and income are far higher than those of food crops [163]. Moreover, contiguous farmland cultivation promotes the rural−urban migration of rural labor and also enhances non-agricultural income, which results in the development of labor-intensive urban industries and enables developing countries to reduce poverty [164–168]. Further, the stability of farmland rental contracts also exerts a positive and moderating effect in the influence of continuous farmland farming on the agricultural income and non-agricultural income of transferees adopting no-tillage at 1% and 5% significance levels, respectively. The stability of farmland rental contract not only increases a transferee's agricultural production, adoption of no-tillage technology, capital investment, agricultural operational risks reduction, but also effectively leads to the implementation of all agricultural technologies with inter-periodical attributes represented by no-tillage technology [58,59,106].

Further, the educational level is also positive in influencing the agricultural and non-agricultural income of the transferee adopting no-tillage at 5% and 1% significance levels, respectively. The higher the education level, the more transferees can utilize no-tillage technology and the more obvious the technological economy and scale effect. Meanwhile, the higher the education level, the more opportunities for non-agricultural employment, and the higher the income, as revealed by the studies of Qi et al. [169] and Li and Wang [170]. The number of laborers positively affects the non-agricultural income of transferee adopted no-tillage at a 1% significance level. Chen et al. [171] also exposed the same verdicts and stated that agricultural technological innovation is essential for allocating rural labor in the marketplace. Moreover, organizational participation also exerts a positive and significant influence on the agricultural and non-agricultural income of transferees adopting no-tillage technology at a 1% and 10% significance level. On the one hand, social organizations such as cooperatives expand their interest level with farmers by providing technical guidance, safe production, and management of crops, etc., to boost the effectiveness of social organizations, and finally realize the continual increase of farmers' agricultural income [172–174]. On the other hand, social organizations are also important channels for absorbing local non-agricultural employment and continuously increasing non-agricultural family income [175,176]. Moreover, farmers can also engage in agricultural production during busy periods to achieve a two-way interactive increase in agricultural income and non-agricultural income [177].

Moving ahead, relationship networks also positively and significantly affect the agricultural income and non-agricultural income of the transferees adopting no-tillage at 5% and 1% levels. The results suggest that most economic activities are closely embedded in the relationship network. A relationship network plays a vital role in developing trust and boosting human relations in promoting no-tillage technology at the government level and increasing agricultural income growth by reducing transferees' cost of technology adoption [178,179]. Meanwhile, relationship networks can also alleviate the information asymmetry between the market labor demand and the non-agricultural employment of rural labor [180]. Information acquisition channels positively impacted the agricultural income and household income of transferees who adopted no-tillage technology at 10% and 1% significance levels. The previous studies of Gao et al. [85], Abdullahi et al. [147], and Sharma et al. [181] also revealed that contemporary communication channels such as mobile phones or the internet have a structural influence on boosting farmers' production behavior by enhancing the production factors and the conditions for obtaining technical information. Modern information acquisition channels reduce the cost of information, accelerate the information exchange, reduce the information asymmetry, bridge the "digital divide," promote farmers to make decisions concerning adoption of no-tillage technology, and increase farmers' non-agricultural employment opportunities [182,183]. Besides, regional differences were also found as expected in the income structure of transferees adopting the no-tillage technology.

5.4. Average Treatment Effect of Contiguous Farmland Cultivation and Adoption of NT Technology on Transferees' Income Structure

The study further analyzed the average treatment effect of the stability of contiguous farmland cultivation and adoption of no-tillage technology on transferees' agricultural income and non-agricultural income in Table 3. The results show that (a) and (b) represent the actual agricultural income of transferees adopting no-tillage and traditional tillage technology, respectively, and (c) and (d) represent counterfactual assumptions. The ATT and ATU are the average treatment effects. The results proved that the average treatment effect (ATT) of the transferee adopting no-tillage technology is positive and significant at 5% level, indicating that the actual agricultural income (a) of the transferees opting conservational tillage was higher than the counterfactual hypothesis (c), i.e., if the transferee opted for no-tillage technology then switched to adopt traditional tillage, the agricultural income would decrease by 0.2893 ten thousand. Likewise, the average treatment effect (ATU) of transferees adopting traditional tillage is also positive and significant at 10% level, indicating that the counterfactual hypothesis (d) is higher than the actual agricultural income of the transferee (b), i.e., if the transferee adopted traditional tillage decides to switch to adopt no-tillage technology, the agricultural income will increase by 0.1919 ten thousand yuan. Similarly, suppose the transferee adopting no-tillage technology switched to adopt traditional tillage. In that case, the non-agricultural income will decrease by 1.6979 ten thousand yuan. If the traditional tillage-opting transferee adopts no-tillage technology, the non-agricultural income would increase by 1.3044 ten thousand yuan. Our findings further show that the income gap between farmland transferees adopting no-tillage and traditional tillage is widened; that is, the family income of transferees adopting no-tillage technology was much greater than that of transferees reliant on traditional tillage practices.

6. Conclusions and Policy Implications

The extreme altered seasonal patterns have posed more grim effects on agricultural production, specifically in the monsoon-affected regions. In this regard, technological innovation is assumed to improve the farmer's adaptability to cope with drastic climate changes. Moreover, the rural−urban migration of labor and the large-scale farmland transfer also influence the farmers' technology adoption in China. The current study employed the ESR model and counterfactual framework to empirically explore the influence of contiguous farmland cultivation and the adoption of no-tillage technology on transferees' income structure. The study also analyzed the moderating effect of the stability of farmland rental contracts.

The overall findings revealed that contiguous farmland cultivation significantly promotes the adoption of no-tillage technology by farmland transferees. The findings further revealed that education, organization participation, relationship networks, and government skill training also stimulate transferees to adopt no-tillage technology actively. However, a family loan inhibits the technology adoption. Moreover, regardless of the intertemporal nature of no-tillage technology, its adoption is likely to increase the transferee's agricultural and non-agricultural income directly. Meanwhile, contiguous farmland cultivation also increases agricultural and non-agricultural income of transferees who adopted no-tillage technology. Education level, organization participation, relationship networks, and information acquisition channels also profoundly impact the income structure of transferees with no-tillage technology. The moderating effect further showed that farmland rental contract stability moderates the relationship between contiguous farmland cultivation, transferees' no-tillage adoption and family income structure. Lastly, addressing selection bias of no-tillage technology adoption and counterfactual assumptions, the results revealed that a transferee could improve their agricultural and non-agricultural income by switching to no-tillage technology. It is noteworthy that the income gap can be further widened between farmland transferees with no-tillage and transferees still practicing traditional tillage technology.

Based on the empirical findings, the study offers valuable implications for policymakers to devise strategies to encourage transferees to opt for no-tillage technology sustainably. In this regard, firstly, the government should establish a farmland transfer information system to effectively link farmland transferors with transferees, reduce the information asymmetry between the supply and demand sides, and encourage the farmland transferees to achieve the greatest degree of concatenation farmland cultivation. Secondly, the government should ensure the stability of formal lease contracts, encourage smooth and orderly farmland transfer, provide employment skills training for farmland transferees, and finally provide a good system guarantee for transferees' long-term adoption of no-tillage technology. Thirdly, the government should reduce the cost of transferees' no-tillage technology adoption and increase the enthusiasm and initiative of transferees to adopt this technology by increasing the subsidy standards and carrying out training guidance. Finally, considering that non-agricultural income is far greater than the agricultural income obtained through no-tillage adoption, the government should extend the agricultural industry chain, increase the value of agricultural products, and continuously increase the agricultural income of transferees adopting no-tillage technology by creating scale and branding effects of agricultural products.

7. Limitation

Of course, our research still has some shortcomings. Firstly, conservation tillage technologies include no-tillage, sub-soiling, and straw being returned to the field. Apart from no-tillage technology, other technologies may also help farmers cope with drought and soil erosion. This study has not yet compared the roles of no-tillage technology with others in agricultural production. Secondly, the adoption of no-tillage technology requires planters for farming. Due to the lack of survey data, our research has not considered the heterogeneity of topography, such as plains and mountains. Thirdly, input costs, such as machinery, pesticide, labor input, etc., may also influence the transferee's no-tillage adoption and family income structure. Limited to the data obtained, we did not explore the effects of cost factors. Finally, this research only addressed the sample selection bias of no-tillage technology adoption. As the transferee's family income increases, it may adversely affect the adoption of no-tillage technology, which is likely to cause severe endogeneity. However, these issues provide adequate directions and ideas for future in-depth research.

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Institutional Review Board Statement: As the study does not involve any personal data and the respondents were well aware that they could opt out any time during the data collection phase, a written institutional review board statement was not required.

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