The effect and mechanism of farmland transfer on the multidimensional relative poverty of rural women

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Introduction: Over the past 40 years of reform and opening up, China has made significant progress in poverty reduction in rural areas. China's land system is different from that of other countries in the world because of its special national conditions and the influence of small farmers in large countries. The rural female labor force is the key force to reduce rural poverty and realize rural revitalization.

Methods: This paper attempts to construct a multidimensional relative poverty measurement index system for rural women and estimates the multidimensional relative poverty of the rural female labor force using the data of China Family Panel Studies in 2018. This paper also uses propensity score matching to estimate the correlation between rural land transfer and rural female poverty.

Results and discussion: Based on the aforementioned conclusions, this paper puts forward relevant policy suggestions from two aspects: encouraging the rational and effective transfer of agricultural land and breaking the inherent gender order 1) to encourage the rational and effective circulation of agricultural land, so as to reduce the degree of fragmentation and promote the appropriate scale management of contiguous plots; 2) to break the inherent gender order, so as to achieve the improvement of women's economic income, and the alleviation of multidimensional relative poverty, so as to alleviate the poverty of families.

KEYWORDS

agricultural land transfer, female labor force, multidimensional relative, non-agricultural employment, poverty

1 Introduction

1.1 Current situation of international female poverty

Since Peirce put forward the concept of "poverty feminization" in 1978, the proportion of women engaged in agricultural production has increased, and the term "agricultural feminization" has gradually been discussed more frequently by researchers (Chant, 2006; Bieri, 2014; Gaddis and Klasen, 2014). With the transition from a traditional agricultural society to modern industrial society, the feminization of agriculture is a significant feature in the development. Currently, this feminization has become a global phenomenon (Bieri, 2014). At present, this phenomenon is particularly prevalent in developing countries, such as

China, Nepal, India, Bangladesh, most of Latin America, and those still predominantly agricultural countries in Africa.

Women play an important role in agricultural production and management. Aggregated data show that, globally, women make up approximately 43% of the agricultural labor force (Terri et al., 2011). In most developing countries, women produce 60–80% of the food, accounting for half of the world's food production (Onyalo, 2019). In short, women play an important role in agricultural labor supply, land distribution, food production, and other areas (Onyalo, 2019; World Bank, 2014; Ngomane and Sebola, 2019). However, despite playing an important role in agriculture, women still lack opportunities to participate in cooperative organizations in many developing countries (FAO, 2011). In addition, in some developed countries, agricultural feminization has become a trend. For example, in 2001, the proportion of women as full-time workers in the German agricultural sector increased from 36 to 44%, and the proportion of women in part-time agricultural work increased from 60 to 65% (Inhetveen and Schmitt, 2017), which clearly indicates the trend of feminization in Germany.

1.2 China's agricultural management system

1) In 1978, the household contract responsibility system was officially established. The people's commune system of "more than two Gong" was abolished, and the agricultural management system completed the transformation of the two-tier management mode from contract production to contract work to the household. 2) The 1993 Amendment to the Constitution of the People's Republic of China stipulates that "the responsibility system based on a household contract in rural areas is a socialist economy under collective ownership by the working people." 3) Since the 1990s, agricultural industrialization has become the basic feature of modern agriculture, market-oriented, production, supply, marketing, agriculture, industry, and trade closely combined with the management system.

1.3 Labor mobility

1) With the reform of the economic system structure, the rural labor force has gradually transferred to the city. The degree of differentiation of farmers has gradually deepened, and the behavior of farmers leaving towns and villages for work has gradually become normal (Zhu Dongliang, 2020). 2) Due to the outflow of the rural labor force, China's existing institutional arrangements do not fully match the direction of agricultural development.

1.4 Land ownership confirmation

1) China's land property rights system originated in the period of planned economy, and the legal definition of farmers' right to transfer contracted land was not clear. Before the land ownership is confirmed, the area and registration of contracted land by farmers are relatively vague, and farmers do not have the right to freely transfer contracted land. 2) Land ownership confirmation realizes the implementation of land contracts and certificates to farmers,

enhances the actual control of farmers over contracted land, and provides protection for farmers to increase their income. 3) The Central Rural Work Conference in 2013 pointed out that "farmers' rural land contract management rights should be divided into contract and management rights, and the separation of contract and management rights should be realized in parallel" so that the reform of the separation of three rights was formally established as an institutional arrangement.

In the 40 years of reform and opening-up, China has made remarkable achievements in poverty alleviation 2020, which had been a decisive year in China's fight against poverty, and the rural poor women under the current standard have been lifted out of poverty, which indicates that China has historically eliminated absolute poverty (Ye and Yin, 2019). The Fourth Plenary Session of the 19th Central Committee of the Communist Party of China (CPC) proposed "Winning the battle against poverty and establishing a long-term mechanism to solve relative poverty," which means that after the elimination of absolute poverty in 2020, the focus of poverty alleviation will shift to relative poverty (Xing and Li, 2019). This also means setting new poverty standards, identifying the poor population, identifying the targets of poverty alleviation, and formulating poverty alleviation measures. In the past, the poverty measurement was usually based on the family unit, but in reality, there may be differences in poverty statuses among different family members due to their close relationships, different resources, and ownership of decision-making power. In the past, the family was regarded as "homogeneous," in which resources within the family were regarded as equally shared by family members. However, in reality, there are gender differences in rural households' resource input tendency, division of labor decision making, and social and economic statuses, which may also lead to the feminization of rural poverty (Lott et al., 2002). The rural female labor force is the key to achieving rural revitalization of rural poverty reduction and power, and the attention to their poverty problem is not only of great significance to their own development but also has a great effect on the alleviation of their family poverty.

Land, as the direct object of agricultural production activity, is the basic source of livelihood of farmers, is also an important supplement of the rural social security system and has a certain effect on poverty reduction (Kimura et al., 2011a; Peng et al., 2019). With the implementation of policies such as land ownership confirmation and separation of three rights, the circulation speed of rural land elements has accelerated, and the promulgation and revision of documents, such as the Rural Land Contract Law, have greatly promoted farmers' interest and enthusiasm in land transfer. If land is used by farmers with a higher utilization rate of land resources, the overall agricultural production and productivity will be improved to a certain extent so as to achieve a reasonable allocation of resources. The rational allocation of land resources is an important factor in the rational allocation of agricultural resources (Restuccia, 2016). The work of land ownership confirmation has basically come to an end, the facts have proved that land ownership confirmation has important practical significances, and the result of land ownership confirmation is also worth discussing. Some scholars believe that by clarifying the ownership of property rights, land right confirmation can reduce transaction costs, reduce conflicts between farmers caused by unclear right confirmation, promote land transfer, and improve

land utilization (Chernina et al., 2014). However, some other scholars believe that land ownership confirmation can not only promote land transfer but also inhibit land transfer. Existing studies mainly focus on whether land ownership confirmation can promote land transfer and realize the mortgage guarantee function. However, there is still no complete conclusion on whether the effect of land ownership confirmation can promote the income growth of farmers. Land has a basic security function and plays a very important role in rural poverty. The impact of a land policy on it is directly related to whether farmers can stabilize the achievements of poverty alleviation (Delinking, 2015). At present, land fragmentation and the aging of the labor force seriously restrict national food security, with the increase in farmers' income and the process of China's agricultural modernization, the imperative of land transfer.

Zhang and Wan (2009) found that land transfer can guarantee a part of the rental income of the low-income group and narrow the income gap between farmers of agricultural income and non-agricultural income. Jin and Deinincer (2009) believed that land transfer can promote a part of the surplus rural labor force to transfer to cities and towns, thereby increasing the rural household income. Kimura et al. (2011a) found that through the model of determinants of land lease transactions that land transfer could not only partially reduce agricultural production costs but also transfer part of rural young and middle-aged labor to non-agricultural sectors, thereby increasing the household income of farmers, thereby achieving the effect of poverty reduction. Land is farmers' important livelihood capital, and its flow inevitably leads to a change in farmers' livelihood strategy, which may impact the farmers' poverty (Peng et al., 2019). At present, scholars are studying the impact of farmland changing on poverty in a series of research, but the existing studies mostly consider the effect on poverty at the farmer level and rarely explore the impact of farmland transfer on a certain group of farmers or a specific population (Kimura et al., 2011b; Hu et al., 2016; Kimura et al., 2011b). The influence of rural land transfer on family members does not have "homogeneity." The outflow of rural male young and middle-aged labor force makes the rural population present the characteristics of "38, 61, and 99," left-behind population. The responsibility of farmland care, the place of farmland transfer and the place of performance are all located in rural areas. Therefore, the poverty impact of rural land transfer on women, children, and the elderly left behind in rural areas may be more intuitive, and the poverty impact of rural land transfer on different members of the family, such as women, children, and old people, may also be different. At present, the agricultural labor force is generally for old people and women, the comparative benefit of agricultural income is low, and rural youths are reluctant to engage in agricultural production activities. The outflow of young and middle-aged people in the countryside has led to the increase in aging of the agricultural labor force (Mullan et al., 2011). The traditional "male plowing and female weaving" has gradually changed into a new model of "male workers and female plowing," which has also led to the rising share of women in agricultural labor. There are few studies on the influence of aging and feminization of family demographics on family poverty (De Brauw and Mueler, 2012; De Brauw et al., 2014; Wang et al., 2007). Although land transfer can improve farmers' income and improve the land utilization rate, China's land transfer level is not very ideal, which may be due to the imperfect development of medical and old-age security undertakings in rural areas, and the standard of security needs to be improved. Farmland has become an informal form of security for farmers, who rely heavily on land for agricultural production, resulting in a security function far greater than the value of land as a condition for agricultural production.

The rural female labor force is an important force in promoting rural poverty reduction and realizing rural revitalization. As an important part of the family labor force, the alleviation of the rural female labor force is conducive not only to the improvement of the family's economic level but also to the investment in children's health education. With the continuous acceleration of China's urbanization process, a large number of rural households are transferred to non-agricultural production sectors, and the transfer of a high-quality labor force in rural families ensures that women replace men as the main labor force in agricultural production, indicating the increase of female agricultural labor supply (De Brauw et al., 2008). Throughout the feminine literature about the agricultural labor force, rarely any attention was given to the change in the exterior market environment's impact on farmers' production and life behavior. Land transfer can help improve factor productivity and increase the income of farmers' families, thus alleviating the impact of the feminization of the agricultural labor force on agricultural production. Therefore, it is particularly important to study the effect of farmland transfer on rural female labor poverty. This paper is based on the Multidimensional Poverty Index (MPI) and Human Development Index (HDI) to build a multidimensional relative poverty system adapted to rural women, using the 2018 China Family Panel Studies (CFPS) data, measure the multidimensional relative poverty of rural women, and investigate the effect and mechanism of farmland transfer on it.

2 Theoretical analysis and research hypothesis

Gender differences extend from physiological aspects to various fields, such as social culture, politics, and economy (Xia and Kuang, 2017; Li and Zhang, 2020). Because of this, the rural female labor force is considered to have weak ability (low human capital stock) and the advantages of taking care of the family and discriminated, thus forming the "men take care of the outside and women take care of the inside" division of the family tradition, where women in agricultural production have to take care of the family (Xu, 2019). Rural women are the main source of labor in the "38, 61, and 99" troops and the main undertakers of agricultural production and family care; the transfer of agricultural land will inevitably reduce their production burden and promote the change toward their livelihood strategies, which will have an impact on their personal and even family poverty (Guan and Dong, 2018). Because of farmland transfer, the rural female labor force of agricultural production is responsible. Due to the consideration of economic benefits, the gathering of couples, and other aspects, the rural female labor force may decide on the livelihood strategy of migrant work and, thus, play a role in alleviating their poverty situation.

With the proposal and development of Amartya Sen's feasibility, poverty research has increased from a single economic indicator to a multidimensional perspective, and

research on female poverty has also adopted a Gender-related Development Index (GDI), Capacity Poverty Measure (CPM), and other multidimensional considerations (Sen, 1999). Farmland transfer can promote non-agricultural employment of the female labor force, and this change of livelihood strategy may affect not only the poverty of economic income dimensions but also the poverty of other dimensions, such as health and quality of life. Therefore, the discussion on the impact of rural land transfer on rural women's poverty should also be considered from multiple dimensions, such as economy, health, and quality of life, and a composite poverty measurement index adapted to the post-2020 poverty standard should be selected to investigate the impact and comprehensive impact of rural land transfer on rural women's poverty in various dimensions. Multilayered relative poverty is not only a multilayered poverty but also a reality that China will shift from absolute poverty to relative poverty after 2020. Based on the aforementioned strategies, this article is from the perspective of multidimensional relative to explore the influence on rural land transfer of rural poor women. Based on the Sustainable Livelihood Framework (SLF) analysis, this paper constructs the rural land transfer path diagram of the impact of poor rural women, and according to the previous analysis and the research purpose of this paper, the research hypothesis is proposed.

Hypothesis 1. (H1). Rural land transfer of rural women in multidimensional relative poverty has a significant negative impact; that is, the transfer of rural land can effectively alleviate the occurrence of multidimensional relative poverty of rural women.

Hypothesis 2. (H2). Rural female off-farm employment plays a mediating role in the impact effect of farmland transfer on rural female poverty.

On the basis of measuring the multidimensional relative poverty of rural women, this paper uses the logit model to estimate the impact of rural land transfer on rural women's multidimensional relative poverty and uses propensity score matching (PSM) to test the robustness of rural land transfer and female multidimensional relative poverty. On the aforementioned basis, this paper uses the mediation effect model to investigate the mechanism of rural land transfer on the multidimensional relative poverty of rural women, verifies the research hypothesis, and draws policy implications based on the relevant research conclusions.

3 Materials and methods

3.1 Data sources

The data used in this paper are the data of CFPS, which has been organized and implemented by the China Social Science Survey Center of Peking University since 2010, covering 25 provinces, municipalities, and autonomous regions. According to the research purpose, this article selects the personal and family survey released in 2018 with new data. To investigate the mediating effect of non-agricultural employment, the sample age of rural women is divided into the working age that ranges from 16 to 60 years old, and invalid and missing samples are excluded according to the characteristics of the

household registration type, gender, and age range. Finally, 6,201 rural female data samples were obtained, including rural women's family conditions, economic conditions, living conditions, health conditions, and social welfare levels.

3.2 Methods of research

3.2.1 Multidimensional poverty measurement methods

According to Alkire and Foster's (2007) multidimensional poverty index measurement method based on the poverty deprivation count, each individual rural female labor force surveyed was set as y_{ij}. y_{ij} represents the value of an individual i in dimension j, $i = 1,2,3, \cdots n$; and $j = 1,2,3, \cdots d$, forming a dimensional matrix $n \times d$ as follows:

$$Y = \begin{pmatrix} y_{11} & \cdots & y_{1d} \\ \vdots & \ddots & \vdots \\ y_{n1} & \cdots & y_{nd} \end{pmatrix}. \tag{1}$$

We define a deprivation critical value z_j ($z_j > 0$) for each dimension of poverty identification, representing the poverty line on the j dimension. For matrix Y, the deprivation matrix can be obtained as follows:

$$g_{ij} = \begin{cases} 1, x_{ij} < z_j \\ 0, others, \end{cases} \tag{2}$$

where $[g_{ij}]$ represents the poverty status of individual i in the j dimension. Furthermore, we define a column vector $c_i = [g_{ij}]$ that represents the total number of deprived dimensions undertaken by the i female individual.

The weight of each dimension needs to be considered for dimensional summing. This paper adopts the equal weight method that is commonly used in the academic community (Alkire and Foster, 2007; Song et al., 2019; Wang and Sabina, 2009). In particular, we define W to represent the d dimension's weight row vector, whose element $W_j (W_j \in W$ is the j dimension's weight, and the sum of the dimensions' weights is equal to d.

Then, each dimension of the individual is identified, k represents the critical value of the dimension, $\sum c_i$ represents the sum of the weight of the dimension of the i individual deprived, and compared with the value k, the number P_k matrix of impoverished deprived individuals is obtained, when $c_i \geq k$, $P_k(y_i; z) = 1$ and when $ci < k$, $P_k(y_i; z) = 0$.

Based on the revised multidimensional poverty measurement method of FGT proposed by Alkire and Foster in 2007 (Sen, 1999), Multidimensional Poverty Index $M_0 = \mu(g(k)) = HA$, where the new matrix in the formula $g(k)$ is obtained after replacing all the row elements of all non-poor individuals in the deprivation matrix with 0 and μ is the average of each element in matrix $g(k)$. Finally, M_0 can be expressed as two components H (incidence of poverty) and A (average share of deprivation).

3.2.2 Regression estimation

In order to analyze the influence of rural land transfer of poor rural women, this paper took control of the women's individual

characteristics and characteristics of the family. The model settings are as follows:

$$Poverty_i = \beta_0 + \beta_1 Transfer_i + \delta X_i + \varepsilon_i, \tag{3}$$

where i indicates the survey object, $Poverty_i$ as an interpreted variable, i indicates whether the rural female labor force of the survey object is in poverty. In order to explain the variable, $Transfer_i$ indicates whether the rural female labor family of the survey object i has farmland transfer; X_i is a series of individual characteristics and characteristics of the family from the investigation object of control variables; ε_i is a random error term.

3.2.3 Intermediate effect model

Compared with regression analysis, intermediary effect analysis can not only explain the direct interaction between variables but also reveal the indirect interaction mechanism between variables. In order to clarify whether rural land transfer affects its multidimensional relative poverty through the non-agricultural employment of female labor, this paper will build the following intermediary effect model:

$$Poverty_i = a_0 + a_1 Transfer_i + a_2 X_i + \varepsilon_1, \tag{4}$$

$$Employment_i = b_0 + b_1 Transfer_i + b_2 X_i + \varepsilon_2\ Employment_i, \tag{5}$$

$$Poverty_i = c_0 + c_1 Transfer_i + c_2 Employment_i + c_3 X_i + \varepsilon_3. \tag{6}$$

In Formula 4–6, $Poverty_i$ represents the multidimensional relative poverty of the rural female labor force. $Transfer_i$ indicates whether the agricultural land is transferred out. The intermediate variable $Employment_i$ represents the i non-agricultural employment status of rural female labor force. X_i is a series of control variables from the individual characteristics and family characteristics of the survey subjects. In Formula 4, a_1 shows the overall impact of rural land transfer of rural women on multidimensional relative poverty. In Formula 5, b_1 is the impact of farmland transfer on rural women's non-agricultural employment. In Formula 6, c_1 and c_2 are the direct effects of rural land transfer and rural women's non-agricultural employment, respectively, on the i multidimensional relative poverty of rural women. By substituting Formula 2 into Formula 3, we can obtain the intermediary effect of rural land transfer $b_1 c_2$, that is, the indirect impact of rural female labor force's non-agricultural employment on its multidimensional relative poverty through the intermediary variable. In this paper, the Bootstrap test method will be used to test the significance of the mediation effect.

3.3 Index system construction

The multidimensional relative poverty indicator system in this paper is constructed on the basis of the multidimensional poverty indicator system. In terms of the selection of multidimensional poverty dimensions, based on the HDI, Human Poverty Index (HPI), and MPI, and on the basis of existing research, three dimensions of economic level, quality of life, and health status are selected to measure multidimensional relative poverty (Song et al., 2019; Wang and Sabina, 2009; Wang and Ye, 2014). These three dimensions correspond to economic poverty, welfare poverty, and ability poverty. The economic level corresponds to economic poverty, quality of life corresponds to welfare poverty, and health status corresponds to ability

poverty. According to the 2018 CFPS data characteristics, each dimension selection and index assignment are as follows.

Economic level: In this paper, 50% of the *per capita* disposable income of the sample households and 50% of the median female labor income were selected for relative poverty. In the study of existing multidimensional poverty, the poor economic level is usually calculated by the critical value with the annual *per capita* net income (poverty) compared. With the elimination of absolute poverty in China, the economic dimension of poverty also needs to be determined from absolute poverty to relative poverty, and the relative poverty standard is usually set as a proportion of the average income or the median income. Because the median is more robust than the average, it is used in most cases (Wang et al., 2020). From the definition of absolute poverty from the past economic level to the cognizance of relative poverty, combined with China's current poor situation and individual characteristics of rural female labor, the *per capita* disposable income of 50% is considered the relative poverty line (Epstein, 1969; Van Vliet and Wang, 2015; Song et al., 2022). At the same time, in order to more comprehensively reflect the relative poverty of rural women, this paper selects two indicators of *per capita* net household income and female labor income from the economic dimension and assigns a value of 1%–50% below the median of the whole sample and 0 to the other half.

Health status: Due to physiological characteristics, fertility effects, and other reasons, the particularity of the female labor force requires us to consider their health status when studying female labor poverty. The commonly used quality of life index (QWB) in China has high data requirements. In view of this, many researchers use health variables that are easy to self-report (Ren and Tang, 2014; Wang and Lv, 2013). In this paper, self-rated health variables are also selected, including physical health and psychological loneliness degree. The physical health status was based on the self-rated health status compared with that of peers, and the general value of self-rated physical health was 1; that is, there is relative poverty in health, and the value of relatively healthy, healthy, and very healthy is 0, and there is no relative poverty in health; for mental loneliness, the frequency of "I feel lonely" is mainly selected. If the number of times of I feel poor is more than once in a week, the value is 1; that is, there is spiritual poverty, and the value is 0.

Quality of life: In this paper, two indexes of domestic fuel and drinking water are selected; particularly the use of natural gas, gas, induction stove, solar energy, and other clean fuels commonly used by ordinary families is as an indicator to determine whether the living fuel is poor, and drinking water poverty is measured by access to clean water sources. Dimension and index weight: this paper uses the equal weight method which is commonly used in academia. The dimension and index selection, critical value, and weight of multidimensional poverty measurement are shown in Table 1.

4 Variable selection and descriptive analysis

4.1 Multidimensional relative poverty measurement

Based on the data of CFPS in 2018 and the multidimensional relative index system shown in Table 1, this paper calculates the multidimensional relative poverty index of the rural female labor force

TABLE 1 Dimension, index, critical value, and weight setting.

Dimension	Index	Critical value	Weight setting
Economic level	eco1: Relative poverty in the *per capita* household income	A value of 1 is assigned to 50% of households with the *per capita* net income below the median of the full sample, and 0 is assigned to households with a net income below 50%	1/2
	eco2: Relative poverty of the female labor income	A value of 1 is assigned to women whose labor income is less than 50% of the median female individual in the full sample, and 0 is assigned to women whose labor income is less than 50%	1/2
Health status	hel1: Self-assessment of physical health	Self-rated health as poor or very poor compared with peers is 1, and the opposite is assigned a value of 0	1/2
	hel2: Mental loneliness	Feeling lonely sometimes, often, or always is a 1, and the opposite is assigned a 0	1/2
Quality of life	lif1: Fuel usage	The use of no electricity, gas, natural gas, and solar energy is assigned a value of 1, and the opposite is assigned a value of 0	1/2
	lif2: Drinking water condition	The main drinking water is not tap water (including pure water) is 1, and on the contrary, it is assigned a value of 0	1/2

TABLE 2 Multidimensional relative poverty index of the rural female labor force.

Value K	Multidimensional poverty number	Total deprivation of poverty	H (the incidence of poverty) (%)	A (average poverty deprivation value)	M (multidimensional poverty index)
K = 1	5316	1988.67	85.73	0.1247	0.1069
K = 2	3668	1714.00	59.15	0.1558	0.0921
K = 3	744	535.17	12.00	0.2398	0.0288

using the A–F multidimensional poverty measurement method introduced previously (Table 2), and rural women with two or more poverty dimensions are defined as multidimensional relative poverty. No or only a single level of poverty of rural poor women is defined as no multidimensional relative poverty of rural women. It can be seen from Table 2 that the incidence of multidimensional relative poverty among sample rural women is 59.15%.

4.2 Variable selection

This paper mainly investigates the effect and mechanism of rural land transfer on the multidimensional relative poverty of rural women. The dependent variable for rural women's multidimensional relative poverty: poverty more than one dimension of the rural female labor force is defined as a multidimensional relative poverty. The core explanatory variable of this paper is whether or not rural land transfer occurs. The choice of the control variable is mainly from three aspects: individual characteristics, family characteristics, and social welfare characteristics of the rural female labor force, including age, gender, education level, marital status, number of children, intergenerational support, neighborhood relationship, pension insurance, and medical insurance. The calculation method and the analysis of descriptive statistics are shown in Table 3.

4.3 Data analysis procedure

Data from CFPS (2018) were processed using stata15.0 to retain a sample of 6,201 eligible rural women aged 16–60 years.

The explained variable, whether there is multidimensional relative poverty: According to the multidimensional poverty measurement method introduced previously, rural women with two or more dimensions of poverty are defined as being in a multidimensional relative poverty state, and rural women with no poverty or only a single dimension of poverty are defined as not being in a multidimensional relative poverty state.

The core variable, whether to transfer off the farm: If the land owned by rural women is transferred out, they can obtain a certain amount of financial support by means of transfer payment to better maintain their family life. Therefore, the core variable of this paper is whether the agricultural land is transferred out, and the value of agricultural land transferred out is 1 and the value of no farmland transferred out is 0.

Control variables, individual characteristics: It is mainly manifested by the characteristics of rural women themselves, such as age, gender, and education. Family characteristics: Rural women's family conditions will also determine whether they have multidimensional poverty, such as marital status, population burden coefficient, and family size as the control variables of this study. Welfare characteristics: Rural medical insurance as a measure of rural women's welfare characteristics is a control variable in this study.

A mediator variable, rural women's non-agricultural employment: Rural women's non-agricultural employment can generate income for their families, thereby alleviating their own or their family's poverty. The proportion of rural women engaged in non-agricultural employment was 1, and that of non-rural women was 0.

TABLE 3 Main variables and calculation methods.

Variables	Meaning	Calculation method	Mean value	Variance
Explained variable	Whether there is multidimensional relative poverty	More than one dimension of poverty exists = 1; there is no poverty or only a single dimension of poverty = 0	0.5915	0.4916
Core variable	Whether to transfer off the farm	Roll-out = 1; and no roll-out = 0	0.1793	0.3837
Control variable	Age	Actual age of the female labor force	41.6246	11.1294
	Educational level	Illiterate = 1; primary school = 2; junior high school = 3; high school/technical school/technical school = 4; college = 5; and bachelor degree or above = 6	2.4440	1.2388
	Marital status	Having a spouse (married) = 1; unmarried, divorced, or widowed = 0	0.9021	0.2972
	Coefficient of population burden	Non-working age population/working age population	0.0722	0.1985
	Family size	Household size	4.7246	2.0144
	Neighborhood relationship	Trust rating for neighbors (self-rating 10-point scale)	6.5656	2.1546
	Medical insurance	Having health insurance = 1; none = 0	0.9389	0.2396
Intermediate variable	Rural women non-agricultural employment	Rural women's engaged in non-agricultural employment = 1; not engaged = 0	0.3709	0.4831

5 Results and discussion

5.1 Baseline regression of the impact of farmland transfer on the multidimensional relative poverty of the female labor force

In order to verify hypothesis H1, this paper examines the impact of rural land transfer on the multidimensional relative poverty of the rural women based on the construction of the index system and the measurement of multidimensional relative poverty mentioned previously and uses the variable "whether multidimensional relative poverty exists" in Table 3 as the explained variable in Formula 3 for logit regression estimation. Before model estimation, considering the possible collinearity problem between variables, the variance expansion factor method was used to perform multiple collinearity tests on all independent variables in this paper. The results show that the VIF value of all variables is less than 10, and there is no collinearity problem.

Table 4 mainly examines the impact of farmland transfer on the multidimensional relative poverty of rural women (Eq. 1). Control variables of rural women's individual characteristics, family characteristics and social welfare characteristics were introduced to further test the impact of rural land transfer on multidimensional relative poverty of rural women (Formula 2). The estimated results of Eq. 1 in Table 4 show that farmland transfer is significant at the statistical level of 1% and the estimated coefficient is negative; type 2 shows that the control variables are introduced to farmland transfer in 1% of the statistical level negative influence on multidimensional relatively poor rural women, determining the land transfer of rural women multidimensional relative poverty relief. At the same time, the education level, marital status, and neighborhood relationship of the female labor force have a significant negative impact on their multidimensional relative poverty, and age and family size have a significant positive impact on their multidimensional relative poverty.

The education level of the female labor force has a significant negative impact on its multidimensional relative poverty. The education level represents human capital, and the higher the education level of women, the stronger the human capital and the stronger the family management ability, thus increasing the operational income that the family can obtain and, thus, alleviating the phenomenon of family poverty. At the same time, the stronger the human capital, the greater the non-farm employment opportunities for women and the less dependent they are on land, thus resulting in higher income for the family. Table 4 shows that the higher the female education level, the lower the probability of multidimensional relative poverty.

Women's marital status has a significant negative impact on their multidimensional relative poverty. In rural households, married women have an alleviating effect on multidimensional relative poverty. This may be because there will be a male labor force in the family of married women, and the male labor force is more competitive than the female labor force in terms of social status and workability, and it is easier to obtain higher income in the family. Table 4 shows that the married female labor force has a negative impact on its multidimensional relative poverty.

The larger the family size, the higher the household expenses. In the case of a certain number of labor force, the larger the family size, the more likely the women are to have multidimensional relative poverty. Table 4 shows that the larger the number of rural family members, that is, the larger the number of non-working people, such as the elderly and children, the higher the living expenses, education expenses, and medical expenses and the more likely it is to fall into multidimensional poverty.

The neighborhood relationship represents the variable of social capital. The better the neighborhood relationship is handled, the stronger its social capital is and the more the relationship networks the family can have when it is in trouble, thus reducing the occurrence of multidimensional relative poverty of women. Table 4 shows that better neighborhood relations have a significant easing effect on the multidimensional relative poverty of the female labor force.

TABLE 4 Empirical estimation of the multidimensional relative poverty of rural female labor force caused by farmland transfer.

Variable	Equation 1		Equation 2	
	Coef.	Std. err.	Coef.	Std. err.
Whether to transfer off the farm	−0.5157***	0.0665	−0.4326***	0.0690
Age	—	—	0.0086***	0.0029
Educational level	—	—	−0.3422***	0.0258
Marital status	—	—	−0.6196***	0.0989
Coefficient of population burden	—	—	0.2106	0.1405
Family size	—	—	0.0790***	0.0143
Neighborhood relationship	—	—	−0.2960***	0.0557
Medical insurance	—	—	−0.0619	0.1134
Constant term	0.1793***	0.0288	1.3637***	0.2175
R-squared	0.0045		0.0507	
Observations	6201		6201	

Values in brackets are robust standard errors; ***, **, and * indicate that the explanatory variable coefficients are significant at the level of 1%, 5%, and 10%, respectively, the same as follows.

5.2 Propensity matching estimation analysis

The effect of rural land transfer on the multidimensional relative poverty of the rural female labor force is discussed above, and variables such as female individual characteristics, family characteristics, and social welfare characteristics are introduced to control for it. (Elkhan et al., 2023). However, by ignoring other variables related to rural land transfer, the aforementioned model may overestimate or underestimate the impact of rural land transfer on the multidimensional relative poverty of the female labor force. In order to test the robustness of the model estimation results, this paper uses PSM to pair samples and then perform measurement estimation. The key to the use of PSM is the need to establish a comparable group with high confidence to eliminate the problems associated with selection bias. Before using PSM for estimation, sample matching needs to be checked if it is reasonably valid. In this paper, the more commonly used propensity score kernel density function distribution was used to examine the match between the treatment group and the control group before and after matching, respectively. Figure 2A and Figure 1 (B) represent the distribution of kernel density before and after the matching of agricultural land transfer. Figure 2 shows that using the nearest neighbor matching method, this paper also attempts to use the effect of other similar matching methods; the treatment group tends to the score matching value that significantly decreased, and the probability distributions of differences tend to the score interval that had a considerable overlap. Moreover, most of the observed values were within the common value range, indicating that the matching method can effectively reduce the differences in individual characteristics, family characteristics, and social welfare characteristics between the treatment group and the control group, indicating that the matching effect of the nearest neighbor matching method is better.

In the estimation of PSM, the probabilistic regression method was used to calculate the propensity score, the multidimensional poverty of rural women was taken as the result, and the variable considered to

be farmland transfer was taken as the explanatory variable. In general, the variables associated with multidimensional poverty among rural women are also highly likely to be associated with the transfer of agricultural land. In contrast, this study does not include variables that are only associated with rural land transfer and not with multidimensional poverty among rural women.

After checking the sample match, PSM estimation is performed, shown as follows: first, according to the observable individual and family characteristics (this paper mainly selected rural women's age, education level, marital status, number of children, population burden coefficient, family size, neighborhood relationship, and medical insurance), we estimated the probability of women falling into multidimensional relative poverty and calculated the tendency score, which can be expressed as follows:

$$P(X_i) = \Pr(F_i = 1 \mid X_i) = \frac{\exp(\beta X_i)}{1 + \exp(\beta X_i)} + \varepsilon. \qquad (7)$$

In Eq. 7, the binary virtual variable F represents the characteristics of agricultural land transfer, X_i represents the relevant influencing factors, β is the coefficient of the model, and ε is the random error. Then, we searched for rural women who have the closest scores with the propensity to move out of rural land without moving out of their families as a counterfact, compared the differences between the two groups trapped in multidimensional relative poverty, and took an average of the calculated differences; thus, the average impact of rural land outmigration on rural women falling into multidimensional relative poverty is obtained, which can be expressed as follows:

$$ATT = E(Y_{i,1} | T_i = 1) - E(Y_{i,0} | T_i = 1). \qquad (8)$$

In this paper, three matching methods, namely, neighbor matching, radius, and secondary Kernel matching, were selected to process propensity value matching. The changes of characteristic variables of samples obtained before and after secondary kernel
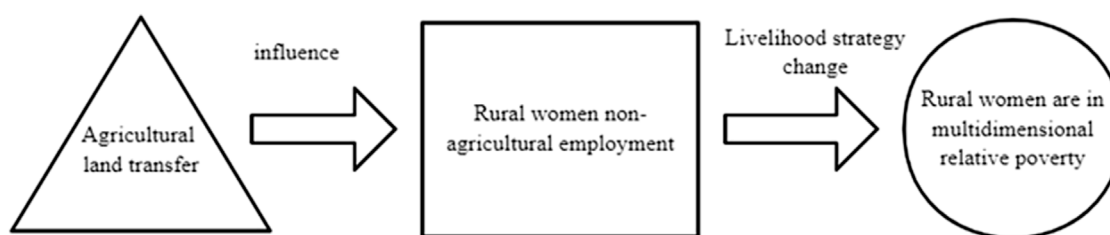
FIGURE 1
Influence of farmland transfer on the multidimensional relative poverty of rural women.
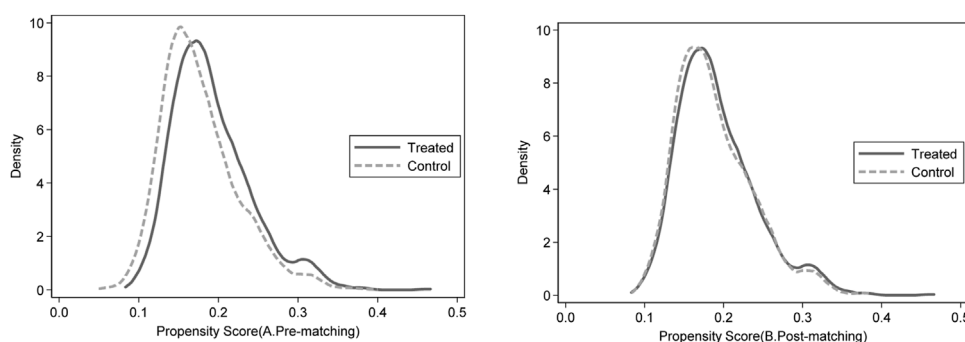
FIGURE 2
Probability distribution of propensity score nuclei before and after matching.

matching (this paper also attempts to adopt other matching methods with similar changes) are shown in Table 5. According to existing research, the absolute value of the standard deviation after matching is usually equal to 10, which is used as the criterion to judge the matching effect. The match is better if the absolute value of the standard deviation after matching is less than 10. Table 5 shows that the standard deviation of the characteristic variable of the two groups of samples is significantly reduced, and the absolute value of the standard deviation is less than 10, indicating that the mean difference of each characteristic variable is very small, the characteristic difference between the samples is eliminated to a certain extent, and the matching effect is good.

In this paper, neighborhood matching, caliper matching (radius), and kernel function are used to study the average treatment effect of rural land transfer on the multidimensional relative poverty of the rural female labor force, so as to ensure the robustness of the estimation results. The results of the average treatment effect estimation in Table 6 show that before matching, farmland transfer can reduce the incidence of the rural female labor poverty by 12.69% at the significance level of 1%. A matching method is adopted to eliminate the difference between samples in the control group and treatment group, the net effect ATT average ranges from 8.73% to 10.89%, namely, the rural female labor force for farmland transfer actually reduced the multidimensional relative poverty, in which approximately 10% of the regression coefficient is not matching before slight convergence. This indicates that the use of ordinary logit regression will

overestimate the impact of rural land transfer on the multidimensional relative poverty of rural women, and the use of PSM estimation further proves research hypothesis H1, that is, rural land transfer will indeed reduce the probability of rural women labor falling into poverty.

5.3 Mediating effect of rural land transfer on the multidimensional relative poverty of rural women

In order to further explore the rural land transfer of rural women's multidimensional relative poverty impact mechanism, this paper examines the intermediary effect of rural women's non-agricultural employment. The influence mechanism shown in Figure 3 can be obtained by combining the measurement observed in Eqs 4–6. The result shows that the total effect of rural land transfer on the multidimensional relative poverty of rural women is −0.1008, the direct effect of which is −0.0847 and the indirect effect is −0.0161, which can be interpreted as rural land transfer actually reduces the multidimensional relative poverty of rural women by 10.08%. Among them, the mediating effect through female non-agricultural employment accounted for 15.97% of the total effect; that is, the probability of rural women falling into multidimensional relative poverty will be reduced by 1.61% through the path of rural women's non-agricultural employment.

TABLE 5 Changes of feature variables before and after sample matching (kernel).

Variable	Sample	Mean value		Standard deviation (%)	Deviation reduction (%)	t-test	
		Interactive group	Control group			T value	p-value
Whether to transfer off the farm	Before matchmaking	41.87	41.57	2.7	47.9	0.81	0.418
	After matchmaking	41.86	42.02	−1.4		−0.33	0.743
Age	Before matchmaking	2.6996	2.3881	25.3	92.3	7.63	0.000
	After matchmaking	2.6967	2.6727	1.9		0.45	0.652
Educational level	Before matchmaking	0.8831	0.9063	−7.6	84.0	−2.36	0.018
	After matchmaking	0.8839	0.8876	−1.2		−0.27	0.784
Marital status	Before matchmaking	0.0690	0.0690	0.0	−803.0	−0.01	0.994
	After matchmaking	0.0690	0.0686	0.2		0.06	0.956
Coefficient of population burden	Before matchmaking	4.4874	4.7764	−14.8	82.8	−4.34	0.000
	After matchmaking	4.4905	4.4408	2.6		0.64	0.523
Family size	Before matchmaking	6.5333	6.5726	−1.8	99.1	−0.55	0.581
	After matchmaking	6.5329	6.5325	0.0		0.00	0.997
Neighborhood relationship	Before matchmaking	0.9335	0.9401	−2.7	80.9	−0.83	0.404
	After matchmaking	0.9334	0.9350	−0.5		−0.12	0.904

TABLE 6 Average treatment effect estimation results.

Matching method	Treated	Controls	Difference	S.E.	T value
Unmatched	0.4874	0.6143	−0.1269	0.0162	−7.83***
Neighbor	0.4878	0.5752	−0.0873	0.0185	−4.72***
Radius	0.4878	0.5907	−0.1029	0.0166	−6.17***
Kernel	0.4878	0.5968	−0.1089	0.0166	−6.57***

In order to more accurately judge the mediating effect of female non-agricultural employment, a bootstrap test was conducted. Table 7 shows that the aforementioned direct and indirect effects were both significant at the level of 1%, and the 95% confidence interval showed that the confidence interval of both direct and indirect effects did not contain 0, no matter before or after bias correction. The mediation effect was tested using the bootstrap test. This verifies hypothesis H2, that is, the probability of rural women falling into multidimensional relative poverty will be reduced by 2.31% through the path of rural women's non-agricultural employment.

5.4 Discussion and recommendations

Based on the aforementioned research and discussion, we can see that rural land transfer has an alleviating effect on the poverty of rural women. Land systems vary from country to country. For example, the United States mainly privatizes land and implements large family farms. Japan learned from the West at an early stage and introduced advanced agricultural machinery, agricultural policies, and other methods. Japan first forcibly purchased land and then distributed it to small farmers for production, thus realizing the redistribution of land
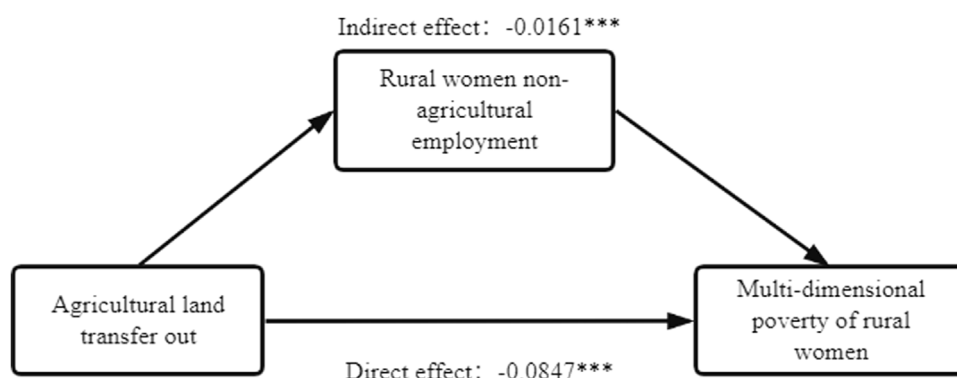
FIGURE 3
Mediating effect relationship diagram.

TABLE 7 Mediation effect and 95% confidence interval tested using the bootstrap test.

Influence mechanism	Effect estimation	Std. err.	95% confidence interval		95% confidence interval after correction for bias	
			Floor	Upper limit	Floor	Upper limit
Indirect effect	−0.0161***	0.0028	−0.0223	−0.0113	−0.0219	−0.0112
Direct effect	−0.0847***	0.0162	−0.1171	−0.0535	−0.1159	−0.0509

ownership. By adjusting land-related laws and policies, Japan has gradually attempted to reduce the *status quo* of land scale management in Japan. The fact that other countries in the world do not implement land ownership is also related to the national conditions of each country. China, as a traditional agricultural country, originated from the period of a planned economy, and finally, the separation of three rights was officially established in 2013. China's special national conditions mean that it is impossible to make a simple comparison with the land-related systems of other countries in the world, so this study focuses on the specific situation of China.

This study includes the policy background of China's land ownership confirmation and land management system. China's current agricultural production is changing from traditional agriculture to modern agriculture. Can rural women change their disadvantageous position in agricultural production through the combination of the new division of labor and new production factors in the process of agricultural modernization? The contribution of rural women to the household is more visible through land transfer, which allows them to have extra time for non-farm employment. Land ownership confirmation strengthens farmers' actual control over contracted land and provides a certain guarantee for farmers' income increase. In 1987, for the first time, it was clearly proposed to take different forms to promote the appropriate scale management of agriculture. Decentralized management can only maintain food and clothing; particularly, under the trend that a large number of surplus rural labor flows to cities and farmers are engaged in part-time work, the development of moderate-scale management has become an effective path for agricultural transformation and modernization. China's moderate scale of operation can enable rural

women to switch from agricultural to non-agricultural operations, thereby raising the family income level, thus achieving the purpose of alleviating poverty. Therefore, exploring the process, characteristics, problems, and challenges of rural women engaged in family farming under the background of land transfer and moderate-scale management in China will help better understand the dynamic role of rural women in agricultural development and rural revitalization.

The innovation of this study is to construct a multidimensional poverty index system for rural women, which included the concept of relative poverty and investigated the effect and mechanism of rural land transfer on it. The limitation of this paper is that due to the availability of data and the lack of relevant theories, the relative attributes of non-economic poverty indicators are not highlighted.

The rural female labor force is an important force in promoting rural poverty reduction and realizing rural revitalization. Based on agricultural modernization development and comprehensive poverty alleviation in 2020, under the background of reality, based on the 2018 CFPS data, this paper analyzes the impact of rural land transfer on rural female poverty from a multidimensional relative perspective by using PSM. The research results show that 1) at present, the poverty situation of rural women is relatively severe. In total, 85.73% of rural women have a single dimension of poverty, and most of the rural women are in a multidimensional state of relative poverty. 2) Farmland transfer of rural women's multidimensional relative poverty has significant negative effects, and farmland transfer actually reduces rural women's multidimensional relative poverty by approximately 10%. It can be considered that the comprehensive rural land transfer has a significant easing effect on rural women's poverty. 3) The influence of non-agricultural employment of female labor will play an intermediary role in the multidimensional relative poverty of rural

women in rural land transfer mechanism, and the intermediary effect accounts for 15.97% of the total effect; that is, rural land transfer will reduce the probability of rural women falling into multidimensional relative poverty by 1.61% through the non-agricultural employment of rural women.

The aforementioned conclusions are of great significance to the transfer of agricultural land and the alleviation of rural female poverty, particularly the alleviation of female labor poverty. Combining the full text and the aforementioned conclusions, corresponding policy implications can be drawn, including the following two aspects: first, the rational and effective transfer of agricultural land was advocated. With the convincing village organization as the link, the rational and effective transfer of rural land was promoted, so as to reduce the degree of fragmentation and promote the moderate-scale management of contiguity. However, in the process of agricultural land transfer, we should insist on the reversibility of land transfer, ensure a reasonable level of land rent, and ensure a high commitment capacity. Second is breaking the inherent gender order. The rural female labor force is an important force in promoting rural poverty reduction and realizing rural revitalization. At present, the poverty problem of rural women in China remains very serious. We need to not only adjust and balance the distribution of male and female resources through the top-level design of the system and the implementation of grass-root policies but also break the inherent gender order and work together to create reasonable family and job market status of rural women, so as to achieve the increase of women's economic income. Multidimensional relative poverty alleviation was promoted to carry out accurate and effective poverty alleviation measures and let farmers solve the problem from the root, thus reducing family poverty.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material; further inquiries can be directed to the corresponding authors.

Author contributions

ML: methodology, resources, validation, and writing–original draft. ZZ: data curation, validation, and writing–review and editing.

JZ: project administration, supervision, writing–original draft, and writing–review and editing. DY: conceptualization, validation, investigation, visualization, and writing–original draft. TW: conceptualization, formal analysis, funding acquisition, software, and writing–original draft.

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Conflict of interest

Author DY was employed by Strategic Development Department of China RongTong Agricultural Development Group Co., Ltd.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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