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The Impact of Socialized Agricultural Machinery Services on the Labor Transfer of Maize Growers

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Abstract: Socialized agricultural machinery services, effectively cracking the "who to plant, how to plant" dilemma, are an important grasp of the development of modern agriculture. Based on the specialization division of labor theory, using the 2019 national survey data of maize growers in 13 provinces, the instrumental variable method and systematic generalized moment estimation (GMM) were used to overcome the endogeneity problem of mutual causality between socialized agricultural machinery services and labor transfer, analyze the impact of socialized agricultural machinery services on the labor transfer of maize growers and its link to heterogeneity, and explore the impact effect in different terrain conditions, part-time. We also explored the cohort differences in the effect in different terrain conditions and degree of part-time work. The endogenous switching regression model (ESR) was also applied to construct a counterfactual framework to further analyze the impact effect of socialized agricultural machinery services on labor transfer. The results showed that socialized agricultural machinery services could effectively promote labor transfer among maize farmers. Compared with maize farmers in other terrain conditions and part-time degree, the impact effect of agricultural machinery socialization services on labor transfer of flatland and pure farming households was more significant. Socialized agricultural machinery services play an important role in driving traditional farming households to labor transfer and realizing their organic connection with modern agriculture.

Keywords: socialized agricultural machinery services; maize growers; labor transfer; farm household differentiation

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1. Introduction

Against the background of accelerated urbanization, China's agricultural transformation faces difficulties with inconsistent decline in the share of agricultural employment and value-added, low agricultural returns and lower agricultural labor productivity than in other countries [1]. China's agricultural industrial structure is too homogeneous, agricultural production lacks integration of different industries, and the cost of agricultural products continues to rise. Relatedly, the root cause lies in the restricted restructuring and upgrading of production factors. Zhang Peigang first proposed the industrialization of agriculture, the core of which is the dynamic combination and continuous upgrading of production factors. The continuous promotion of urbanization and industrialization has induced a gradual "merit-based transfer" of rural labor [2], which has led to a decrease in the proportion of agricultural labor among Chinese maize-producing farmers and has promoted the adoption of socialized agricultural machinery services by farmers after considering the rational allocation of labor and capital factors. World maize production in major producing countries is shown in Table A1.

Accelerating rural labor force transfer is an important way to improve agricultural labor productivity in China, which is conducive to rural economic development, farmers' income growth, and promoting the upgrading and adjustment of industrial structures. China's rural labor force transfer increased from 19.12 million in 1978 to 288.36 million in 2018 [3], an increase of 15.08 times. At the same time, various socialized service organizations, including agricultural mechanized operations, have developed rapidly, filling the gap of labor shortage and increasing the level of agricultural mechanization [4]. The socialized service of agricultural machinery evolved from the "socialized service" proposed in the First Document of the Central Government in 1983 for the first time, emphasizing the need for a social division of labor that is difficult for farm families to provide to achieve the needs of agricultural production development [5–7].

In the past, farmers would obtain agricultural technology by buying agricultural machinery. However, things have changed in China since 2000. The cost of agricultural labor has gone up, and most people working in rural areas are older or women. Plus, farming households are small-scale. Even though subsidies have made buying machinery cheaper, it is still too expensive for small-scale farmers who do not make much money. As a result, farmers are choosing to use shared farm machinery services instead of buying their own machinery.

Agricultural services are becoming increasingly popular in various countries, including China, Indonesia in Asia, and Africa. In Indonesia, more and more farmers are renting land and using agricultural services to expand their farming operations [8], leading to the replacement of labor with machinery. Similarly, in Africa, farmers are adopting agricultural services due to rising labor costs and the inability to afford agricultural machinery [9]. Subsidized agricultural services have been implemented in Ghana and Nigeria, with Ghana focusing on land preparation and farming services [10], and Nigeria investing in machinery to reduce costs and promote the adoption of agricultural services by small-scale farmers [11].

Starting in 2004, the state issued ten consecutive "No. 1 documents" to actively develop the socialization of agricultural machinery services. The 19th Party Congress report even pointed out: "improve the socialized agricultural service system, to achieve organic linkage between small farmers and modern agricultural development". In 2019, China's agricultural socialized service area reached 13.33 million hm^2, the future market size can reach trillions of yuan (CNY) or even trillions of yuan. The most direct effect of socialized agricultural machinery services is to reduce labor intensity, improve labor productivity, form a direct alternative to agricultural labor, and have a certain impact on the transfer of farm labor. So, does the socialized agricultural machinery service promote the transfer of farm labor by improving the mechanization level of farm households? This is a question worth exploring and has very important practical significance.

Agricultural mechanization is the way to modernize agriculture while achieving agricultural modernization requires a continuous increase in agricultural labor productivity, so that agricultural labor productivity and non-agricultural labor productivity are equal at a high level. The increase in agricultural labor productivity comes from two sources [12]: first, the increase in land productivity, i.e., the increase in yields; and second, the expansion of arable land per capita. The increase in land yields depends more on factor inputs and total factor productivity, while the expansion of arable land area per capita needs to be achieved by expanding the scale of operation or reducing the number of laborers per unit area. China has many people and little land, and there is little room for agricultural labor productivity growth by expanding land size. It measured that the moderate operation size of farm households is about 8–13.3 hm^2 [13,14]. Therefore, expanding the arable land area per capita needs to rely more on the transfer of agricultural labor. The current official statistics of the share of agricultural labor in China is 28% [15], and if the share of agricultural labor is calculated at 15% when agricultural modernization is achieved, 12% of agricultural labor still needs to be transferred to the non-agricultural sector, which shows the necessity of promoting the transfer of farm labor.

The accelerated transfer of China's rural labor force to the non-farm sector has been accompanied by rapid growth in agricultural mechanization during the same period. Many domestic scholars have analyzed and confirmed the existence of a significant relationship between agricultural mechanization and farm labor transfer [16–18], and in fact, the driving effect of agricultural mechanization on farm labor transfer is widely taken for granted [19–21]. Along with the massive outflow of agricultural labor in China, the opportunity cost of agricultural labor continues to increase, and under the constraint of small-scale farming based on family contracting [22], Chinese agriculture, under the condition that neither the per capita nor the scale of individual farming households' arable land has been substantially expanded, has adopted socialized agricultural machinery services to ensure national food security and come out with a distinctive road of agricultural mechanization to make up for the serious deficiency of operation fragmentation [23,24], which facilitates the realization of a higher level of mechanization for small-scale farmers [25]. To address the high demand for agricultural machinery and the low purchasing power of small-scale farmers at the current stage in China, land transfer can be used in the long term to change the status quo of small-scale farming; however, a large number of farmers will be separated from agriculture after the land transfer, and it may be difficult for the secondary and tertiary industries in China to provide sufficient employment opportunities in the short term. Therefore, in the short term, agricultural labor can be released from the land through socialized services of agricultural machinery under the social division of labor, which can promote the transfer of farm labor to a certain extent and introduce small-scale farmers into the development track of modern agriculture and share the division of labor economy [26].

The role played by socialized agricultural machinery services has always been the focus of academic circles, one of which is the promotion of labor transfer for farmers. On the one hand, the socialized services of agricultural machinery emerged from the deepening of the professional division of labor, the strengthening of technological innovation, and the increasing shortage of agricultural labor [27]. Due to the constraints of farmers' own time, technology, and machinery, outsourcing the links of food production to socialized service organizations through the socialized services of agricultural machinery replaces the own labor and promotes the continuous deepening of farmers' labor transfer. On the other hand, the adoption of socialized agricultural machinery services by farmers facilitates the reallocation of resources (labor, land, and capital) and can weaken the constraints on labor.

In this study, the instrumental variables approach, systematic generalized moments estimation (GMM), and endogenous switching regression model were used to assess the impact effect of socialized agricultural machinery services on labor migration.

2. Materials and Methods

2.1. Data

The data used in this study were obtained from a rural survey conducted by the China Agricultural University in 2019 among maize growers. Data were collected by a combination of stratified and random sampling, and the main maize-producing provinces in the country, namely Hebei Province, Shandong Province, Anhui Province, Hunan Province, Hubei Province, Henan Province, Jiangsu Province, Sichuan Province, Gansu Province, Jilin Province, Liaoning Province, Heilongjiang Province, and Inner Mongolia Autonomous Region, were selected based on the principles of high production and many farmers involved. The research team consisted of teachers and undergraduate, master, and doctoral students from China Agricultural University and took the form of one-on-one interviews with farmers. The questionnaires were filled out by the researchers, and their contents were reviewed by experts after the questionnaires were collected. Researchers who completed the questionnaires with high quality were given certain rewards, and those who completed them with poor quality were eliminated to fully ensure the authenticity of each questionnaire. After removing invalid questionnaires, such as logical errors, lack of key information, and missing variables, a total of 1048 valid maize grower questionnaires were collected.

2.2. Empirical Model Setting

2.2.1. IV-Tobit Model

The study examined how socialized agricultural machinery services impact labor transfer among maize growers. This study focused on the core explanatory variable of socialized agricultural machinery services. To measure labor transfer, the group used the percentage of farm households with members working outside of the home as a proxy indicator. The labor shift of maize farmers is a restricted variable, ranging from 0 to 1 with a right-handed truncated distribution. The study utilized an IV-Tobit model with a restricted dependent variable to test the effect of socialized agricultural machinery services on labor shift. The estimated model is as follows:

$$\begin{aligned}\text{Migrantratio}_i = \alpha + \beta_1 \text{service}_i + \beta_2 Ln(age_i) + \beta_3 edu_i + \beta_4 health_i + \beta_5 train_i + \beta_6 staff_i + \beta_7 Ln(asset_i) \\ + \beta_8 Ln(area_i) + \beta_9 quality_i + \beta_{10} Ln(block_i) + \varepsilon_i\end{aligned} \tag{1}$$

The subscript i denotes the ith farm household, the Migrantratio is the labor transfer of the maize grower, and service is whether or not socialized agricultural machinery services are used. In order to ensure the accuracy and reliability of the estimation results, and also confined to the availability of data, this study used per capita maize sown area (AREA), land quality (QUALITY), land fineness (BLOCK), age of household head (AGE), education of household head (EDU), health of household head (HEALTH), household agricultural training (TRAIN), household cadre status (staff), and average agricultural machinery assets per mu (asset) as control variables. The constant term was α, and β was the parameter to be estimated, where β_2 was the parameter of interest for this study, and was the random disturbance term. In order to attenuate the heteroskedasticity problem of the model, the variables were scaled down by taking the natural logarithm of the age of the household head, the average agricultural machinery asset per mu, the degree of land fragmentation, and the maize sown area per capita. In addition, to control for factors that cannot be observed and measured in different survey areas, such as differences in crop production characteristics, natural environment, and different agricultural industrial policies, this study also controlled for regional differences in the model.

The development of socialized agricultural machinery services and labor shifts of maize farmers may have a causal endogeneity problem, in that the development of socialized agricultural machinery services promotes labor shifts, and in turn, the shifts of rural labor promote the development of socialized agricultural machinery services. In addition, farmers' labor shifts decisions may be influenced by observable (e.g., age of household head, education level, sowing area, etc.) and unobservable factors (e.g., farmers' innate ability, motivation, risk preference, etc.), thus causing bias due to omitted variables.

In order to minimize the impact of the endogeneity problem on the model, the instrumental variable method was used for estimation in this study. Referring to the discussion of the endogeneity problem by Xinyan Hu et al. [28], the average level of adoption of agricultural machinery socialized services in the village was chosen as the instrumental variable, i.e., the percentage of farmers in the village who adopted agricultural machinery socialized services other than that farmer [29].

$$\text{service}_i = \theta_0 + \delta_i V_i + \sum \omega_i Z_i + \mu_i \tag{2}$$

In the above equation, V is the instrumental variable for this study, Z is the control variable, service is the endogenous variable, μ_i is the random error term, and the instrumental variable is selected as the average level of adoption of socialized agricultural machinery services in villages. Obtaining instrumental variables from aggregated data at the district level to deal with endogeneity has been widely accepted and its validity has been verified in many pieces of the literature [30].

2.2.2. GMM Model

Generalized moment estimation (GMM) model is a semi-parametric estimation method under loose assumptions, and Hansen won the 2013 Nobel Prize in Economics for inventing this method. It allows for the presence of serial correlation and heteroskedasticity in the random error term when the exact distribution of the random error term is not yet clear, and its estimated parameters are accurate and valid compared to other methods.

For the IV estimator in a linear or nonlinear regression model, the equation is as follows:

$$E[\overline{m_n}(\beta)] = E\{\frac{1}{n}\sum_{i=1}^{n} z_i[y_i - h(x_i, \beta)]\} = 0 \quad (3)$$

where there are L instrumental variables in Z_i and K parameters in β.

2.2.3. Endogenous Switching Regression Model

While the PSM method is usually applied to deal with situations where selectivity bias exists, the PSM method suffers from the drawback of controlling only the heterogeneity of the observable variables, when the endogenous switching regression model is applied. Unlike the Heckman two-step method that focuses only on the observable equation, the endogenous switching regression model (ESR) proposed by Maddala (1983) can treat the unobservable variables as missing values by first estimating the decision selection equation followed by the outcome decision equation.

The specific steps are shown below:

Behavioral equation (adoption of socialized agricultural machinery services or not):

$$A_i = \delta' Z_i + k' I_i + \mu_i \quad (4)$$

Resulting in Equation (1) (treatment group, i.e., labor transfer equation for the socialized agricultural machinery service adopter group):

$$Y_{ia} = \beta_a' X_{ia} + \varepsilon_{ia} \quad (5)$$

Resulting in Equation (2) (control group, i.e., labor transfer equation for the group of non-adopting households of socialized agricultural machinery services):

$$Y_{in} = \beta_n' X_{in} + \varepsilon_{in} \quad (6)$$

A is a binary choice variable indicating whether farmers adopt socialized agricultural machinery services; Z is the influencing factor of whether farmers adopt socialized agricultural machinery services; μ_i is the error term; and I is the instrumental variable. It was incorporated into the decision model of agricultural machinery socialization services of farm households. Y_{ia} and Y_{in} denote the labor transfer of the two sample groups of agricultural machinery socialization service adopter households and agricultural machinery socialization service non-adopter households, respectively; X_{ia} and X_{in} are the factors influencing the labor transfer of farm households; and ε_{ia} and ε_{in} are the corresponding error terms.

The expectation of labor transfer of households adopting socialized agricultural machinery services (treatment group) is as follows:

$$E[Y_{ia}|A_i = 1] = \beta_a' X_{ia} + \sigma_{\mu a}\lambda_{ia} \quad (7)$$

Labor transfer expectations of non-adopting households of socialized agricultural machinery services (control group) are expressed as follows:

$$E[Y_{in}|A_i = 0] = \beta_n' X_{in} + \sigma_{\mu n}\lambda_{in} \quad (8)$$

The expectation of labor transfer in the case of non-adoption of services by adoptive households of socialized agricultural machinery services is expressed as follows:

$$E[Y_{in}|A_i = 1] = \beta_n' X_{ia} + \sigma_{\mu n}\lambda_{ia} \quad (9)$$

The expectation of labor transfer in the case of non-adopted household adoption of socialized agricultural machinery services is expressed as follows:

$$E[Y_{ia}|A_i = 0] = \beta_a' X_{in} + \sigma_{\mu a}\lambda_{in} \quad (10)$$

$$ATT_i = E[Y_{ia}|A_i = 1] - E[Y_{in}|A_i = 1] = (\beta'_a - \beta'_n)X_{ia} + (\sigma_{\mu a} - \sigma_{\mu n})\lambda_{ia} \quad (11)$$

$$ATU_i = E[Y_{in}|A_i = 0] - E[Y_{ia}|A_i = 0] = (\beta'_n - \beta'_a)X_{in} + (\sigma_{\mu n} - \sigma_{\mu a})\lambda_{in} \quad (12)$$

In summary, this paper will examine the average treatment effect of socialized agricultural machinery services on labor transfer of farm households using the average values of ATT_i and ATU_i.

2.3. Variable Selection

1. Explanatory variables. The proportion of labor shifted by maize farmers as the explanatory variable was based on the method defined by Mullan [31], the proportion of labor shifted by maize farmers = number of workers outside the household/(number of agricultural laborers in the household + number of workers outside the household).

2. Core explanatory variables. As the core explanatory variables, most previous studies used "whether or not to adopt socialized agricultural machinery services" or "whether or not to adopt socialized agricultural machinery services in a production chain" to define the socialized agricultural machinery services variable [32,33]. In this study, we first defined the variables based on whether the farmers adopted the socialized agricultural machinery services and conducted the baseline regression. Then, in order to further improve the accuracy of the measure of the socialized agricultural machinery service variables, we referred to the construction of the socialized agricultural machinery service indicators by Hu Xinyan [28] and used the data information of farmers' adoption of socialized agricultural machinery services (mu) and maize sowing area in the five segments of maize planting in the questionnaire to construct the following measures:

$$service = \frac{\sum_{i=1}^{n} w_i}{m},\ n = 5$$

where service is the degree of adoption of socialized agricultural machinery services by farmers; w_i (i = 1, 2, 3, . . . , 5) denotes the area of socialized agricultural machinery services in tillage, seeding, plant protection, irrigation and drainage, and harvesting, respectively; and m denotes the area of maize sown. That is, the degree of adoption of socialized agricultural machinery services is defined as the ratio of the area of adopted socialized agricultural machinery services in each segment of maize production to the sown area, and a substitution indicator is used for robustness testing.

In addition, the control variables of this study were based on three levels: farm household, land, and region. At the farm household level, the age and health status of the household head were selected to control for the household life cycle effect acting on the labor transfer behavior of farm households; the education level of the household head, the agricultural training status of the household, and the cadre status of the household were selected to control for the differences in household resource endowment; and the average agricultural machinery assets per mu of the household were selected to control for the stock of agricultural machinery in the household and the possible opportunity cost of abandoning agricultural production. At the level of the land situation, per capita maize sowing area, land quality, and land fragmentation were selected and introduced into the model to control for differences in farm households' land endowment.

At the regional level, this study divided China into four major regions—eastern (Shandong Province, Jiangsu Province, and Hebei Province), western (Sichuan Province, Gansu Province, and Inner Mongolia Autonomous Region), central (Anhui Province, Hunan Province, Hubei Province, and Henan Province), and northeastern (Liaoning Province, Jilin Province, and Heilongjiang Province)—to control for unobserved fixed effects. Similarity, it was divided to control for differences in unobservable factors, such as geographic location, hydrological conditions, climatic factors, and agricultural production habits in different regions, and to eliminate the influence of regional factors on the labor transfer of farmers (Table 1).

Table 1. Definition of variables and descriptive statistics.

Type	Variables and Codes	Variable Code	Variable Definition	Mean	Standard Deviation
Explained variable	Maize Growers Labor Transfer	Migrantratio	The proportion of the number of people working outside the household to the number of people in the household labor force	0.218	0.209
Core explanatory variables	socialized agricultural machinery service	Service	Used in any of the 5 segments of maize production = 1, not used = 0	0.569	0.495
	The degree of adoption of socialized agricultural machinery services	Service degree	Ratio of the area of socialized agricultural machinery services to the sown area adopted in each segment of maize production	1.151	1.629
	Tillage link socialized service of agricultural machinery	Service1	Adopted = 1, not adopted = 0	0.324	0.468
	Sowing link socialized service of agricultural machinery	Service2	Adopted = 1, not adopted = 0	0.309	0.462
	Plant protection link agricultural machinery socialized service	Service3	Adopted = 1, not adopted = 0	0.094	0.292
	Irrigation and drainage link agricultural machinery socialization service	Service4	Adopted = 1, not adopted = 0	0.135	0.342
	Harvesting link agricultural machinery socialized service	Service5	Adopted = 1, not adopted = 0	0.421	0.494
The land situation	Maize sown per capita	Area	Maize sown area/(number of family agricultural laborers + number of family workers outside the home)	3.507	5.216
	Land Quality	Quality	Poor land = 1, land of moderate to low quality = 2, land of moderate quality = 3, land of moderate to high quality = 4, very fertile land = 5	2.963	0.853
	Degree of land fragmentation	Block	Number of plots of arable land (blocks)	4.702	4.648
Household situation of farmers	Age of household head	Age	Actual age of head of household (years)	51.838	10.272
	Education level of household head	Edu	Illiterate = 1, elementary school = 2, middle school = 3, high school = 4, college = 5, college or above = 6	2.776	0.929
	Health status of the head of household	Health	Good = 1, fair = 2, poor = 3, incapable of work = 4	1.416	0.628
	Training in family farming	Train	No training in agricultural production and management = 0, training in agricultural production and management = 1	0.180	0.384
	Family Cadre Status	Staff	No = 0, village cadres = 1, township cadres = 2, county-level or above cadres = 3	0.149	0.414
Instrumental variable	Average acreage of agricultural machinery assets	Asset	Present value of agricultural machinery assets per acre for farm households	285.226	649.815
	Village agricultural machinery service adoption level	Average service	The average adoption rate of socialized agricultural machinery services among farmers in the village other than this farmer	1.068	1.507
Region dummy variable	Eastern Region	Prov1	Is it located in the eastern region? Yes = 1; No = 0	0.395	0.489
	Central Region	Prov2	Is it located in the central region? Yes = 1; No = 0	0.223	0.417
	Western Region	Prov3	Is it located in the western region? Yes = 1; No = 0	0.222	0.415
	Northeast Region	Prov4	Is it located in the northeast region? Yes = 1; No = 0	0.160	0.366

The sample farmers showed varying degrees of adoption of socialized agricultural machinery services, including those for tillage, sowing, plant protection, irrigation and drainage, and harvesting. The mean values for the adoption of these services were 0.569, 0.324, 0.309, 0.094, 0.135, and 0.421, respectively. Household heads had an average age of 52 years and tended to have received education at primary or junior high schools. The majority of household heads were in good health, and the farming households had relatively low ownership of agricultural machinery. After this part of this paper, the socialized agricultural machinery service is replaced by service.

3. Results

3.1. Overall Estimation

Services and labor transfer have an endogenous relationship of mutual cause and effect. Rural labor can be transferred to cities and towns for non-agricultural employment because of the availability of services to replace labor on farmland. Conversely, rural labor transfer can also provide conditions for services. Relatedly, it is impossible for the study to capture all individual characteristic variables such as labor employment, income, and risk preferences of production and business decision makers and other members of farm households, and the above-omitted variables may affect the decision set of farm households to choose agricultural machinery socialization services, which in turn leads to farm households' agricultural machinery socialization services choice to be related to the disturbance term. The unidirectional effect of agricultural machinery socialization services on labor transfer needs to be separated in the econometric model. Therefore, the one-way effect of agricultural machinery socialization services on labor transfer needs to be separated in the econometric model.

Considering that there may be mutual causality as well as omitted variable problems between services and farm labor shifts, thus creating endogeneity problems, the IV-Tobit model and GMM model were used to analyze the effect of services on farm labor shifts. The results of the first stage estimation are not presented due to space limitations. The regression results based on the IV-Tobit model and GMM model to analyze the effect of services on labor shifts of farm households are presented in columns (1) and (3) in Table 2. The prerequisite for applying the instrumental variables approach is the existence of endogenous explanatory variables, for which a Hausman test is required, with the original hypothesis that all explanatory variables are exogenous. The Hausman test value for this model is 10.94 and rejects the original hypothesis of the non-existence of endogenous variables at a 5% level of significance, indicating that the introduction of this instrumental variable is necessary. The Wald test value is 176.03, showing that the hypothesis of the non-existence of endogeneity is rejected at a 1% level of significance, again proving the problem of the endogeneity of variables. The weak instrumental variables test was determined by the presence of a positive effect of instrumental variables on services at the 1% significance level in the first stage regression in the instrumental variables method, and the F value of the joint significance test = 266.4 ***, referring to the rule of thumb proposed by Stock and Yogo (2005), which states if the F statistic of this test is greater than 10, then the original hypothesis of the variable corroborates that there is no weak instrumental variable problem.

The second-stage results of the instrumental variables regression illustrate that: after excluding the endogeneity problem between variables, there is a positive effect of services on farm household labor transfer, which passes the significance test at the 1% statistical level; it verifies the research hypothesis of this study, indicates that services have a facilitating effect on farm household labor transfer, and further elucidates that services are a significant factor in promoting farm household labor transfer. It further explains that services are a significant factor in promoting labor transfer of farmers. The service is conducive to integrating farmers into the agricultural production division-of-labor system, promoting the modernization of farmers' maize production and guiding farmers into the development track of modern agriculture, so that farmers' willingness to transfer labor will be enhanced.

In terms of control variables, the age of the household head has a significant negative effect on the labor transfer of farm households, probably due to the fact that older farm households have certain labor constraints, and their physical condition is not suitable for heavy labor. In contrast, the non-farm employment of rural laborers in China is mainly manual labor, and older farmers are less inclined to move to urban areas for non-farm employment. Conway et al. [34] also showed that young farmers at the early stage of the life cycle are more likely to obtain non-farm employment. Moreover, the age of the household head also indicates his or her experience in maize farming, and older farmers with more experience in maize farming, traditional dependence on maize production, and expected uncertainty about obtaining income from non-farm employment are reluctant to shift their labor force.

Table 2. Impact of services on labor transfer of farm households.

Variable	IV-Tobit Model		GMM Model	
Service	0.103 *** (0.029)		0.116 *** (0.033)	
Service degree		0.068 *** (0.016)		0.070 *** (0.015)
Age(log)	−0.152 *** (0.051)	−0.094 *** (0.030)	−0.099 *** (0.032)	−0.095 *** (0.034)
Edu	−0.017 (0.012)	0.006 (0.011)	−0.011 (0.008)	0.005 (0.007)
Health	−0.017 (0.017)	−0.010 (0.015)	−0.008 (0.009)	−0.008 (0.011)
Train	−0.009 (0.025)	−0.018 (0.023)	−0.001 (0.001)	−0.016 (0.015)
Staff	0.022 (0.024)	0.011 (0.021)	0.014 (0.015)	0.008 (0.017)
Quality	0.004 (0.011)	0.014 (0.010)	0.001 (0.006)	0.007 (0.007)
Area(log)	−0.112 *** (0.015)	−0.095 *** (0.031)	−0.055 *** (0.009)	−0.042 *** (0.008)
Block(log)	0.002 ** (0.001)	0.002 ** (0.001)	0.002 ** (0.001)	0.001 ** (0.000)
Asset(log)	−0.004 ** (0.002)	−0.006 ** (0.003)	0.001 (0.002)	−0.006 *** (0.002)
Region dummy variable	Controlled	Controlled	Controlled	Controlled
Constant	0.787 *** (0.226)	0.434 *** (0.106)	0.614 *** (0.135)	0.429 *** (0.139)
Sample size	1048	1048	1048	1048
R^2			0.252	0.170
Wald test	176.03 ***	204.83 ***	270.87 ***	236.85 ***

Note: *** and ** are significant at the levels of 1% and 5%, respectively; the values in parentheses are standard errors. The same follows for below.

Maize sowing area per capita has a significant negative effect on farm labor shifting. Maize production has a certain seasonality, and each production step needs to be operated at the appropriate time [35]. When the per capita area of maize sown by farmers is large, it requires both agricultural machinery and manual work supervision with the cooperation of farm household labor during the limited suitable operation time, thus inhibiting the transfer of farm household labor. The per capita maize sowing area also reflects the human–land relationship of farm households; when the per capita maize sowing area of farm households is small, their labor will be shifted from agricultural production to non-agricultural industries, which confirms the study of Sun Dingqiang and Feng Zixi [36].

The degree of land fragmentation has a significant positive effect on farm labor shifts. Land fragmentation consumes the travel time of laborers between various non-contiguous plots, and these additional consumptions require more agricultural labor inputs if a certain level of output is to be guaranteed [37]. At the same time, land fragmentation can also be detrimental to the replacement of labor by agricultural machinery operations, which can increase the supply of agricultural labor and inhibit the transfer of farm labor.

The average agricultural machinery assets per mu has a significant negative impact on the transfer of farm labor. The average agricultural machinery assets per mu owned by farmers implies that they have certain a sunk cost of agricultural operation and investment lock, and the transfer cost of farm labor is higher, which hinders the transfer of farm labor. The number of agricultural machinery assets per mu owned by farmers also affects the adoption intensity of services. Farmers with less average agricultural machinery assets per mu have weaker ability to self-serve food production and tend to adopt services, which in turn promotes the transfer of farm labor.

Robustness tests were conducted using replacement indicators, as shown in columns (2) and (4) in Table 2. The agricultural machinery socialization service variable in the baseline regression was whether agricultural machinery socialization services were used in any of the five segments of farmers' maize production. Further, to improve the measurement accuracy of the agricultural machinery socialization service variable, the ratio of the scale of agricultural machinery socialization services purchased by farmers in maize production to the maize sown area was used to characterize the agricultural machinery socialization service variable. The results illustrate that neither the application of different measures (whether farmers adopt the service or the ratio of adoption) nor the application of different estimation methods (IV-Tobit model or GMM model) significantly changed the results of the model. The socialized services of agricultural machinery still have a positive effect on the labor transfer of farm households and pass the significance test at 1% statistical level, which proves the robustness of the estimation results in columns (1) and (3) in Table 2.

3.2. Impacts of Services on Labor Transfer of Farm Households in Different Segments

In fact, the degree of specialization of services in different segments differs in the way they allocate labor and other factors, and their effects on the labor transfer of farm households are different. The IV-Tobit model and GMM model were used for estimation, and the core explanatory variables were whether to adopt the services in tillage, seeding, plant protection, irrigation and drainage, and harvesting, and the average adoption level of services in tillage, seeding, plant protection, irrigation and drainage, and harvesting of other farmers in the village besides this farmer was taken as the variable of services in tillage, seeding, plant protection, irrigation and drainage, and harvesting, respectively. The instrumental variables in the first-stage estimation and the estimated coefficients of the average adoption levels of agricultural machinery socialization services in tillage, seeding, plant protection, irrigation, drainage, and harvesting in the village were all highly significant for the corresponding agricultural machinery socialization services variables.

The estimation results in Table 3 show that services in tillage, seeding, irrigation, drainage, and harvesting have significant positive effects on farmers' labor shifts, indicating that farmers' adoption of services in tillage, seeding, irrigation, drainage, and harvesting is beneficial to farmers' labor shifts. Among them, the services in tillage had the highest influence on the labor transfer of farmers, followed by sowing and harvesting, and the services in irrigation and drainage had a low influence on the labor transfer of farmers. This result is consistent with the actual situation because the concentration of labor demand in the tillage, sowing, and harvesting segments is higher and the intensity of demand is higher [38], and the mechanization level of the tillage, sowing, and harvesting segments is an important indicator for the Ministry of Agriculture and Rural Development to measure the overall mechanization level in China.

However, the socialized service of agricultural machinery in plant protection links does not have a significant impact effect on the labor transfer of farmers. As the application technology of agricultural machinery in plant protection link is yet to be developed, the combination of agricultural machinery and agronomy is not enough, resulting in serious pesticide drift loss in the spraying process of plant protection machinery. Only 30% of the pesticide deposited to the maize crop [39], and many places need to repeat pesticide spraying manually, making it difficult for farmers to be completely liberated from the heavy maize plant protection operation.

Table 3. Impacts of services on labor transfer of farm households in different segments.

Variable	IV-Tobit Model	GMM Model
Service1	0.119 *** (0.047)	0.114 *** (0.042)
Service2	0.101 *** (0.038)	0.095 *** (0.032)
Service3	0.037 (0.029)	0.034 (0.030)
Service4	0.071 *** (0.029)	0.062 *** (0.024)
Service5	0.086 *** (0.029)	0.081 ** (0.040)
Age(log)	−0.089 ** (0.043)	−0.073 ** (0.034)
Edu	0.009 (0.010)	0.006 (0.007)
Health	0.013 (0.014)	0.013 (0.012)
Train	0.001 (0.001)	0.001 (0.001)
Staff	0.005 (0.019)	0.004 (0.015)
Quality	0.017 * (0.009)	0.009 (0.007)
Area(log)	−0.066 *** (0.012)	−0.047 *** (0.009)
Block(log)	0.005 ** (0.002)	0.003 (0.002)
Asset(log)	0.003 (0.003)	0.003 (0.002)
Region dummy variable	Controlled	Controlled
Controlled	0.677 *** (0.182)	0.625 *** (0.141)
Sample size	1048	1048
R^2		0.193
Wald test	237.86 ***	269.65 ***

Note: ***, **, and * are significant at the levels of 1%, 5%, and 10%, respectively; the values in parentheses are standard errors. The same follows for below.

3.3. Robustness Analysis

Farmers' decision of whether to adopt services is not randomly given, but is influenced by a variety of factors, which may also affect farmers' labor transfer decisions, thus generating a sample selectivity bias [40]. There is a mutual causal endogeneity problem between services and farmers' labor transfer, so in this section, in order to overcome both the sample selectivity bias and endogeneity problems, the endogenous switching regression model (ESR) constructed by Maddala (1983) is used to conduct a robustness analysis of the impact of services on the labor shifts of farm households. The model was chosen for the following reasons: first, to solve the self-selection problem of farmers' decision to adopt services; second, to effectively identify the factors influencing labor transfer between farmers in the adoption group and those in the non-adoption group, and to conduct differential analysis; and third, to use counterfactual analysis to evaluate the effect of services on farmers' labor transfer. For the agricultural machinery socialization service variable, to satisfy the matching mechanism of the endogenous switching regression model, the dependent variable of the estimating equation must be a binary dummy variable, and most of the existing literature also uses a binary dummy variable to measure the adoption of agricultural machinery socialization service behavior by farmers [41,42]. In this section, the agricultural machinery socialization service variable is set as whether farmers adopt agricultural machinery socialization services, i.e., if farmers adopt agricultural machinery socialization services in any of the five segments of maize production, the agricultural machinery socialization service variable is one, otherwise, it is zero. The estimation results of the agricultural machinery socialization service adoption decision model and the farm labor transfer effect model are shown in Table 4, and the inter-equation independence test (LR test) rejects the decision model at the original hypothesis, which argues the decision model and the farm labor transfer effect model are independent of each other at the 5% statistical level. The Wald test of the model is significant at the 1% statistical level, indicating that it fits well and there is a problem of sample selectivity bias caused by unobservable variables, and the application of the endogenous switching regression model is reasonable and reliable.]ρ_{u0} and ρ_{u1} are the correlation coefficients between the decision model and the error terms of the labor transfer effect model for farmers who adopt services and farmers who do not adopt services, where the ρ_{u0} is estimated to be negative and significant at the 1% statistical level, indicating that the labor transfer of non-adopted agricultural machinery socialization service farmers is lower than the labor transfer level of general farmers in the sample. This result is consistent with the reality because the most fundamental role of agricultural machinery socialization services is its substitution of agricultural labor, and since the comparative returns of the agricultural sector have been lower than those of the non-agricultural sector for a long time, farmers as a rational group of economic people are "profit-oriented" and will tend to adopt services to replace manual labor and then shift to non-agricultural industries.

To improve model identification, the variable "average level of adoption of services in villages" was introduced as an instrumental variable in the decision model of farm households' adoption of services. The factors related to human capital (education of household head and agricultural training of household) and agricultural operation (land quality and per capita maize sowing area) and the instrumental variable (average level of adoption of agricultural machinery socialization services in villages) had a significant positive effect on farm households' adoption of agricultural machinery socialization services; agricultural machinery assets had a significant negative effect on farm households' adoption of agricultural machinery socialization services. Comparing the estimation results of the labor transfer effect model between farmers in the adopted group and those in the non-adopted group, we can see that the age of the household head had a significant negative effect on the labor transfer of farmers in the non-adopted group, probably due to the physical constraints of older farmers and the fact that they did not adopt services, which affects their labor transfer. The age of the household head had a significant positive effect on the labor transfer of farmers in the adoption group. The degree of land fragmentation of farmers and their adoption of services showed a significant negative relationship. The degree of land fragmentation had a greater impact on the adoption of the service group because the services are mainly based on the scale of machinery and the fragmentation of farming plots is not conducive to the use of mechanical equipment and farmland infrastructure. The increase in land fragmentation will stimulate farmers to reallocate agricultural production factor inputs among different scattered plots, such as reducing modern service inputs and increasing inputs to labor capital, which will inhibit the transfer of farm labor. The higher education level of the household head, better land quality, and smaller maize sowing areas promoted the labor transfer of farmers who adopted services compared with those who did not. In addition, the lower education level of the household head, the presence of cadres in the family, and the smaller agricultural machinery assets promoted labor transfer among farmers who did not adopt services.

Table 4. Estimation results of the endogenous switching regression model.

Rural Household	Decision Model (Whether to Adopt the Service)		Rural Household Labor Transfer Effect Model Adoption Services		Service Not Adopted	
Variables	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**	**Coefficient**	**Standard Error**
Age(log)	0.236	0.345	0.094 *	0.050	−0.205 ***	0.047
Edu	0.116 **	0.052	0.032 ***	0.012	−0.023 **	0.010
Health	0.016	0.071	0.003	0.014	0.005	0.016
Train	0.073 **	0.035	−0.010	0.024	0.006	0.024
Staff	−0.083	0.163	−0.010	0.021	0.052 **	0.023
Quality	0.039 ***	0.010	0.027 ***	0.010	−0.017	0.011
Area(log)	0.084 ***	0.026	−0.038 ***	0.012	−0.026	0.017
Block(log)	−0.045 ***	0.012	−0.006 **	0.003	−0.002 **	0.001
Asset(log)	−0.075 ***	0.015	−0.002	0.003	−0.006 **	0.003
Average service	0.627 ***	0.109	-	-	-	-
Region dummy variable	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Constant	−2.622 ***	0.955	−1.277 ***	0.208	1.184 ***	0.205
$\ln\sigma_{u0}$	-		-		−1.598 ***	0.034
ρ_{u0}	-		-		−0.259 ***	0.098
$\ln\sigma_{u1}$	-		−1.962 ***	0.031	-	
ρ_{u1}	-		−0.016	0.134	-	
Log likelihood value			−106.994			
LR test			6.13 **			
Wald test			15.66 **			

Note: ***, **, and * are significant at the levels of 1%, 5%, and 10%, respectively; the values in parentheses are standard errors. The same follows for below.

Based on the above empirical estimation results of the endogenous switching model for services, the average treatment effect was derived by excluding the effect of other factors by measuring the farm labor transfer expectation under the counterfactual condition assuming non-adoption, assuming adoption, and the actual condition of adoption and non-adoption for a total of four scenarios (Table 5).

Table 5. Average treatment effect of socialized services of agricultural machinery on labor transfer of farm households.

Farmers Category	Decision-Making Stage Adoption Services	Service Not Adopted	Treatment Effect ATT	ATU
Service adopter	0.330	0.235	0.095 ***	-
Not service adopter	0.375	0.188	-	0.186 ***

Note: ATT and ATU represent the average treatment effect of households that adopt agricultural machinery socialization services and households that do not adopt agricultural machinery socialization services, respectively. *** is significant at the levels of 1%, respectively; the values in parentheses are standard errors. The same follows for below.

Overall, the average treatment effect of farmers' adoption of services on their labor transfer was statistically significant and positive at the 1% level. Based on the counterfactual hypothesis, when farmers who adopted services did not implement corresponding service adoption behavior, their farm labor transfer level would decrease by 0.095; when farmers who did not adopt services applied services, their farm labor transfer level would increase by 0.186. The above indicates that the adoption of services by farmers can significantly promote their labor transfer.

3.4. Heterogeneity Analysis

The impact of services on the labor transfer of farm households is analyzed above, but the regression results only represent the overall average effect of the impact and cannot reflect the possible heterogeneous effect of its effect. On the one hand, the differentiation of farm households has gradually become a common phenomenon in rural China [43], and the differentiation allows farming households to differ in their farming behavior, changing from homogeneous farming households to pure farming households and part-time farming households. The number of family laborers and the time spent on agricultural labor are different for farmers with different part-time jobs, while services are essentially hired labor, and inadequate labor supervision is likely to lead to inefficient agricultural machinery operations, thus causing different effects of adopting services on the labor transfer of farmers. Referring to the international classification of farming households, the studied farming households were classified as purely farming households if their non-agricultural income did not exceed 10% of their total income, and those whose non-agricultural income exceeded 10% of their total income were classified as part-time farming households. Group regressions were conducted, and the empirical results are shown in Table 6.

Table 6. Impacts of socialized services of agricultural machinery on labor transfer of farm households under different concurrent business conditions.

Variables	Pure Agricultural Households		Multiple Occupations Farmers	
	IV-Tobit Model	GMM Model	IV-Tobit Model	GMM Model
Service	0.211 ***	0.187 ***	0.067 ***	0.059 ***
	(0.070)	(0.062)	(0.014)	(0.016)
Age(log)	−0.173 ***	−0.124 **	−0.159 ***	−0.121 ***
	(0.028)	(0.056)	(0.047)	(0.036)
Edu	0.006	0.006	−0.024 **	−0.018 **
	(0.038)	(0.012)	(0.011)	(0.008)
Health	−0.128 **	−0.103 ***	0.001	0.001
	(0.057)	(0.037)	(0.015)	(0.013)
Train	0.081	0.072	0.013	0.017
	(0.083)	(0.069)	(0.024)	(0.025)
Staff	0.019	0.007	0.030	0.023
	(0.071)	(0.028)	(0.024)	(0.017)
Quality	0.090 **	0.020	0.021	0.018
	(0.041)	(0.013)	(0.017)	(0.015)
Area(log)	−0.203 ***	−0.196 ***	−0.073 ***	−0.068 ***
	(0.048)	(0.062)	(0.022)	(0.019)
Block(log)	0.011 **	0.002	0.001	0.001
	(0.005)	(0.002)	(0.001)	(0.001)
Asset(log)	0.003	0.001	0.003	0.003
	(0.011)	(0.003)	(0.003)	(0.002)
Region dummy variable	Controlled	Controlled	Controlled	Controlled
Constant	2.933 ***	1.498 ***	0.876 ***	0.724 ***
	(0.941)	(0.521)	(0.206)	(0.153)
Sample size	304	304	744	744
R^2		0.397		0.137
Wald test	54.89 ***	66.98 ***	51.76 ***	86.59 ***

Note: *** and ** are significant at the levels of 1% and 5%, respectively; the values in parentheses are standard errors. The same follows for below.

From column (1) of Table 6, it can be seen that based on the IV-Tobit model, services significantly increased the labor transfer of purely agricultural households by 0.211 on average. While replacing the estimation method, it was found that services still showed a significant positive effect on the labor transfer of purely agricultural households, and the estimation results were largely consistent, further confirming the existence of services on the labor transfer of purely agricultural households. Based on the IV-Tobit model, it was found that the services significantly increased the labor transfer of part-time farming households by 0.067 on average, and the estimated coefficients were also generally consistent when the GMM model was used for robustness testing.

It can be seen that the coefficients of the impact of services on labor transfer of farm households, analyzed in terms of farm households' part-time employment, were greater in the pure farm household group than in the part-time farm household group, and the impact coefficients all passed the significance test. Since services are still essentially hired labor, it is difficult for farm households to adopt services to avoid the loss of maize production efficiency due to information asymmetry and opportunistic motives of service providers [44–46].

The topographic conditions of farmland owned by farmers were also considered to be an important factor affecting the labor transfer of farmers, as the topographic conditions of farmland affect the ease of farming and the willingness of farmers to engage in agricultural business. Farmers have different household land resource endowments, different degrees of dependence on the land, and different quantities and qualities of labor devoted to maize production, resulting in the heterogeneity of labor transfer from services to farmers in different terrain conditions. Based on the group regression of the effect of services on the labor transfer of farm households under different terrain conditions, the empirical results are shown in Table 7.

Table 7. Effects of services on labor transfer of farmers under different terrain conditions.

Variables	Flatland Plains		Sloping Hill	
	IV-Tobit Model	GMM Model	IV-Tobit Model	GMM Model
Service	0.199 ***	0.167 ***	0.207	0.143
	(0.053)	(0.036)	(0.135)	(0.107)
Age(log)	−0.179 ***	−0.126 ***	−0.029	−0.036
	(0.054)	(0.035)	(0.109)	(0.063)
Edu	0.021 *	−0.013	−0.005	−0.005
	(0.012)	(0.008)	(0.023)	(0.015)
Health	−0.029	−0.016	0.034	0.022
	(0.019)	(0.011)	(0.029)	(0.019)
Train	0.001	−0.001	0.001	−0.001
	(0.002)	(0.001)	(0.003)	(0.004)
Staff	0.028	0.020	−0.095 *	−0.046 *
	(0.026)	(0.016)	(0.055)	(0.027)
	0.004	0.002	0.043	0.033
Quality	(0.012)	(0.007)	(0.029)	(0.027)
Area(log)	−0.091 ***	−0.044 ***	−0.195 ***	−0.093 ***
	(0.017)	(0.010)	(0.031)	(0.015)
Block(log)	0.006 ***	0.004 **	−0.002	0.002
	(0.002)	(0.002)	(0.005)	(0.002)
Asset(log)	0.001	0.001	0.010	0.009
	(0.003)	(0.002)	(0.007)	(0.007)
Region dummy variable	Controlled	Controlled	Controlled	Controlled
Constant	0.882 ***	0.676 ***	0.436 ***	0.419 ***
	(0.229)	(0.147)	(0.153)	(0.121)
Sample size	879	879	169	169
R^2		0.273		0.289
Wald test	104.34 ***	188.77 ***	93.22 ***	327.26 ***

Note: ***, **, and * are significant at the levels of 1%, 5%, and 10%, respectively; the values in parentheses are standard errors. The same follows for below.

On average, the services significantly increased the labor transfer of flatland farmers by 0.199. Plain areas are suitable for agricultural machinery operations, and the application of services significantly reduced the labor time of flatland farmers engaged in maize production, allowing labor to devote time to non-agricultural industries, resulting in a part-time labor transfer. The development of services provided sufficient motivation for the labor transfer of flatland farmers and optimized the conditions for labor transfer.

Services do not yet have a significant impact effect on the labor transfer of sloping mountain farmers. As a factor to replace agricultural labor, services are also relatively difficult to replace factors in areas with a high proportion of sloping lands. Faced with the complex topography of sloping mountainous areas, where it is desirable to have a high mechanization and finishing effect, making it difficult to promote agricultural machinery operations, the operational efficiency of agricultural machinery, especially large agricultural machinery, in sloping mountainous areas is restricted to a greater extent [47], which is not conducive to the development of services. The role of services in sloping mountainous areas is weakened for both large-scale and small-scale farmers so that it does not have a significant impact on the labor transfer of farmers. In general, the services mainly promoted the labor transfer of flatland farmers, and did not promote the labor transfer of sloping mountain farmers, or promoted it less, and all of them did not pass the significance test.

4. Discussion

In economies with limited land resources, the use of agricultural machinery has resulted in the displacement of tenant farmers. Conversely, in economies with abundant land resources, the adoption of agricultural machinery has affected traditional land tenure. The employment impact of mechanization on agriculture is often perceived as negative [48]. However, in Asia, small farms can benefit from using farm machinery services instead of investing in expensive farm machinery, which could save them a lot of money [49,50]. According to Otsuka [51], mechanization of large farm machinery is more likely to be adopted by larger farms, without altering the family contract responsibility system and farmers' land property rights. Service scale operation compensates for the issue of land fragmentation of farmers' family operations, providing a new approach to moderate agricultural-scale operation beyond land-scale operation. Thus, small-scale land has the potential for scale efficiency. Several empirical studies conducted by scholars show that agricultural machinery is suitable for small-scale farming, and it can be used for services as well, breaking the constraints of "ridge" [52].

As stated by the Chinese Ministry of Agriculture and Rural Affairs, by late 2016, approximately 97% of China's farm families (around 260 million households) had land operations not exceeding 50 mu. In China, where the mean farm size is a mere 0.5 ha, services have both engaged farm families in labor division tasks and enabled swift agricultural mechanization. Under the restrictions of the family joint production responsibility system and limited farming operations, China's agriculture has forged a unique path of mechanization through services, without considerable enlargement of the per capita land operation scale, thereby guaranteeing national food security. Notably, without altering the fundamental management system's premise, the specialized labor division in agricultural production stages and the advancement of services have liberated labor from the land to facilitate the seamless integration of small-scale farmers with modern agriculture [27].

Based on the neoclassical theory of farmers' behaviors, it is assumed that farmers' behavioral decisions are based on economic rationality. Considering the constraints imposed by a farming household's resource endowment, an expanding price gap between labor in the agricultural and non-agricultural sectors leads to a growing opportunity cost for agricultural production. Consequently, to maximize profit, farmers will autonomously choose to shift their labor into the non-agricultural domain. Concurrently, advancements in social services and the proliferation of agricultural mechanization not only facilitate the substitution of labor moving towards the non-agricultural sector, but also elevate the opportunity cost of labor as opposed to machinery within the agricultural sector. This, in turn, spurs decisions that further encourage the transition of labor towards non-agricultural pursuits.

Classical economics acknowledges the theory of specialized division of labor as a crucial driver for enhancing labor efficiency and fostering economic growth. This phenomenon, encompassing specialization and service provision, arises from technological advancements and the evolving dynamics of social labor distribution. Under the condition of the limited endowment of farmers' own time, equipment, and technology level, farmers trust or outsource the maize production process to service organizations that have mechanical equipment, labor, and technology. It changes the scarcity of agricultural machinery for farmers (especially small-scale farmers), making it a more affluent element than labor and, further, playing the role of agricultural machinery as a substitute for farmers' labor. That is, the more agricultural machinery that is invested, the less the number of labor required, given the same level of production technology. When agricultural machinery is invested in grain production in a limited way, the economic cost of replacing labor with machinery is high in the case of the insufficient transfer of farm labor, and the cost of labor is lower than the cost of machinery, making grain production in a labor-intensive way more economically efficient. With technological progress, the cost of agricultural machinery manufacturing is massively reduced, and the cost of labor is increased by non-farm employment opportunities. At this time, under the role of the service market, socialized services help to realize the "division" of agricultural machinery. This can effectively increase the machinery input per unit area of land for all kinds of farmers, so that the machinery cost is lower than the labor cost, which will help to replace labor with machinery, thus forming more surplus agricultural labor and promoting the transfer of labor of farmers.

5. Limitations of the Study

Services play an essential role in helping economic structure transformation, regulating resource allocation, and promoting the labor transfer of farmers. The shortcoming of this study is that, due to the sample limitation, this study cannot introduce more effective control variables. Subsequently, we will design questionnaires based on the development of services combined with various industries to obtain more comprehensive research data and explore the more profound role of services on labor transfer in a broader dimension.

6. Conclusions

The study on the impact of services on the labor transfer of maize farmers can help deepen the understanding of farmers' decision-making behaviors and promote the adoption of services by the majority of farmers. Services can effectively solve the dilemma of "who should grow the land and how to grow the land" and are an important tool for developing modern agriculture. Based on the theory of specialized division of labor, we use the 2019 farm household survey data to overcome the causal endogeneity between services and labor transfer of farm households by using the instrumental variable method and systematic generalized moment estimation (GMM) to analyze the impact of services on labor transfer of farm households and explore the differences in the impact effect in different terrain conditions and part-time degree of cohorts. The endogenous transformation model (ESR) is also applied to construct a counterfactual framework to further analyze the impact effect of services on the labor transfer of farm households.

The results show that the socialized service of agricultural machinery can effectively promote the transfer of peasant household labor forces. In addition, under the counterfactual hypothesis, when the farmers who adopt the socialized service of agricultural machinery do not implement the corresponding socialized service of agricultural machinery, their labor transfer level will decline. However, when farmers do not adopt the socialized service of agricultural machinery, their labor force transfer level will rise. However, the effect of agricultural machinery socialization service has link heterogeneity. The effect intensity of agricultural machinery socialization services on the labor force transfer of rural households is as follows: tillage and preparation link, sowing link, harvesting link, irrigation and drainage link, while the plant protection link has no significant impact on the labor force transfer of rural households. Compared to farmers with other terrain conditions and part-time employment, agricultural machinery socialization services have a more significant effect on the labor force transfer of flat and pure agricultural households.

Therefore, we should focus on supporting the key links and weak links of food production to participate in the socialization of agricultural machinery services, such as agricultural mechanization being an important part of the plowing link, sowing link, harvest link, the development prospect of plant protection link, and so on. Seize the opportunity of high-standard farmland construction, and actively guide farmers in China's plain areas to use agricultural machinery socialization services. For pure agricultural households with abundant labor endowment, labor-intensive agricultural machinery socialization services, such as tillage and sowing, can be considered to release surplus agricultural labor force and transfer it to non-agricultural industries. In the face of the reality that small-scale farmers in China will still exist for a long time, emphasis should be placed on improving the cognition of small-scale farmers to the socialized service of agricultural machinery. More small-scale farmers can safely use the socialized service of agricultural machinery, so as to promote the integration of small-scale farmers into the development track of modern agriculture.

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Appendix A

The principal maize-growing nations are predominantly located in the Americas, East Asia, and South Asia, including the United States, Brazil, Argentina, Mexico, China, and India. From 1990 to 2019, the U.S. led the world in maize production, accounting for 30.22% of the global yield in 2019. Over the past three decades, China's maize output has consistently ranked second, trailing only the United States. It has grown substantially from 0.97 billion tons in 1990 to 261 million tons in 2019, an increase of 169.07%. China has maintained a maize production level of over 200 million tons for eight years in a row since 2012, achieving 261 million tons in 2019.

In particular, China's maize production reached 264 million tons in 2016, compared to 216 million tons in 2014, an increase of 22.22%. The Chinese government reduces the maize-planting area by adjusting the structure, on the one hand, and digests the excess maize stock by increasing the maize consumption capacity on the other hand. Such an increase or decrease adjustment makes China's maize supply-and-demand situation transform from a structural surplus to the current production shortage. From 2017 to 2019, China's maize production fell back to maintain a balanced maize supply-and-demand transition, which is not only related to the maize industry but also to national food security.

Table A1. World maize production in major producing countries, 1990–2019.

Year	World	United States	Brazil	Mexico	India	Argentina	China
1990	48,362.07	20,153.20	2134.78	1463.54	896.17	540.00	9721.39
1991	49,440.76	18,986.78	2362.43	1425.15	806.44	768.48	9914.78
1992	53,378.93	24,071.92	3050.61	1692.93	999.21	1070.05	9577.29
1993	47,722.11	16,098.58	3005.56	1812.53	960.10	1090.10	10,311.00
1994	56,866.35	25,529.50	3248.76	1823.58	888.44	1036.00	9967.41
1995	51,729.90	18,797.00	3626.70	1835.29	953.40	1140.40	11,236.16
1996	58,614.61	23,451.78	2965.28	1802.36	1076.90	1051.83	12,786.54
1997	58,441.19	23,386.43	3294.80	1765.63	1081.60	1553.68	10,464.76
1998	61,508.18	24,788.20	2960.18	1845.47	1114.77	1936.07	13,319.76
1999	60,743.47	23,954.86	3223.95	1770.64	1150.96	1350.41	12,828.72
2000	59,203.87	25,185.39	3232.10	1755.69	1204.32	1678.07	10,617.83
2001	61,515.24	24,137.67	4196.25	2013.43	1316.02	1535.94	11,425.60
2002	60,355.19	22,776.69	3594.08	1929.78	1115.17	1471.21	12,018.89
2003	64,505.52	25,622.90	4832.73	2070.14	1498.43	1504.45	11,599.79
2004	72,951.79	29,987.56	4178.76	2167.02	1417.20	1495.08	13,043.43
2005	71,419.11	28,226.26	3511.33	1933.87	1470.99	2048.26	13,949.85
2006	70,793.72	26,750.29	4266.17	2189.32	1509.70	1444.55	15,173.14
2007	79,353.24	33,117.73	5211.22	2351.28	1895.54	2175.54	15,241.89
2008	82,979.22	30,591.15	5893.33	2432.01	1973.14	2201.69	16,603.21
2009	82,081.98	33,192.11	5071.98	2014.28	1671.95	1312.14	16,410.76
2010	85,216.06	31,561.79	5536.43	2330.19	2172.58	2266.31	17,754.08
2011	88,703.47	31,278.89	5566.02	1763.54	2176.00	2379.98	19,290.42
2012	87,556.32	27,319.24	7107.28	2206.93	2226.00	2119.66	20,571.93
2013	10,1680.26	35,127.19	8027.32	2266.40	2425.95	3211.92	21,862.19
2014	10,3961.97	36,109.11	7988.16	2327.33	2417.00	3308.72	21,581.21
2015	10,5260.87	34,548.63	8528.31	2469.40	2257.00	3381.77	26,515.73
2016	11,2735.13	41,226.22	6418.83	2825.02	2590.00	3979.29	26,377.78
2017	11,3865.40	37,109.60	9791.07	2776.32	2589.99	4947.59	25,925.63
2018	11,2472.19	36,426.22	8236.65	2716.94	2875.29	4346.23	25,734.87
2019	11,4848.73	34,704.76	10,113.86	2722.82	2771.51	5686.07	26,095.77

Note: Data from FAO. Unit: million tons.

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