

## Article

# Impact of New Rural Pension Insurance on Farmers' Agricultural Mechanization Service Inputs

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**Abstract:** The rural social security system is a crucial guarantee for the purpose of transforming agricultural production methods. This research assesses how the new rural pension insurance (NRPI) alters the farmers' agricultural mechanization service (AMS) inputs. Using the 2016 and 2018 waves of the China Family Panel Studies (CFPS), the study observed that NRPI significantly increased farmers' AMS inputs. Participation in the NRPI could increase AMS inputs by 18.6% and 13.2% for households with and without elderly farmers, respectively. Both grandchild care and labor off-farm transfer were significant in mediating the relationship between NRPI and AMS inputs with elderly farmers, accounting for 13.72% and 9.13% of inputs, respectively. Furthermore, for families without elderly farmers, the mechanism tests suggest that the crowding-out effect of labor off-farm transfer was a fundamental transmission mechanism for the NRPI to contribute to the increase in AMS inputs, with a proportion value of 15.41%. Additionally, the heterogeneity analysis demonstrated that for households with elderly farmers, the NRPI had a more evident effect on the AMS inputs of the farmers with grandchild care, as well as a low proportion of non-agricultural labor transfer and a high level of agricultural income. For households without elderly farmers, the NRPI's promotion effect on the investment in AMS inputs was more significant when there was a low proportion of non-agricultural labor transfer and for farmers with low levels of agricultural income. The conclusion provides references for improving NRPI and promoting the promotion of AMS and sustainable agricultural development.



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## 1. Introduction

Developing an agricultural mechanization service (AMS) is recognized as a major step toward the modernization of smallholder farmers in China [1]. Since 2004, AMS has undergone rapid development in rural China [2]. This service combines the provision of professional labor and the service of large harvesters. Given that small farmers represent the greater proportion of poor people in developing countries [3], outsourcing several labor-intensive aspects of agricultural production has reduced the sunk costs of machinery that small farmers find difficult to manage [4]. The investment in mechanization is generally expensive, so the provision of professional services is considered to be the best way forward [5]. With accelerated urbanization, the majority of the agricultural labor force has shifted to non-agricultural sectors [6]. The aging phenomenon in the rural population has become increasingly serious, and the price of labor relative to capital has persistently increased. As a result, both factors have led to the rapid development of AMS in China [2,7]. Coupled with government subsidies and a broad spectrum of services, AMS has become more conventional and affordable among smallholder farmers in China [5]. During recent years, the Chinese government has introduced a series of policies to actively promote the development of AMS. More specifically, China unveiled its "No. 1 Central Document" for 2017–2022, successively proposing the cultivation of new agricultural business entities,



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providing mechanization services for the entire process of agricultural production, and integrating small farmers into the modern agricultural industry chain.

As one of the main social security systems in China's rural areas, NRPI delivers long-term stable income security for farm households and theoretically impacts farm household behaviors (e.g., farmers' labor supply and land resource allocation) [8]. Numerous studies dedicated their efforts to discussing NRPI's effect on the labor supply of farm households, with the majority discovering that NRPI aims to reduce the labor supply of older rural farm households [9–12]. Additionally, NRPI was found to promote an increase in the probability of off-farm transfer and entrepreneurship among young laborers in the household [13–16]. The reason lies in how NRPI differs in terms of its institutional arrangement, which predominantly affects the income of older farmers, while essentially having an indirect substitution effect on young and middle-aged laborers by promoting human capital investment and migration to employment [17]. With the in-depth research on the labor supply of farm households by NRPI, the impact of NRPI on the land-resource allocation behavior of farm households, such as land transfer, has gradually received attention. In terms of land-resource allocation, academics currently focus on the promotion effect of NRPI on land transfer. Few scholars have focused on the impact of NRPI on Chinese rural households' expenditure on AMS. In this context, it is of great theoretical value and policy implications to explore whether, to what extent, and how NRPI, a stable source of income, affects the AMS inputs of Chinese rural households.

The existing literature has provided a critical foundation for this paper, but it can still be expanded from the specific aspects discussed in the subsequent discussion. On the one hand, scholars have investigated how household endowment and the subsidy system affect farm mechanization service inputs but neglected NRPI's impact, a major social security system factor in rural areas, on farm mechanization service inputs. On the other hand, studies on systematic and in-depth analysis on the impact and mechanism of NRPI on AMS inputs of farm households are limited, specifically regarding whether any difference exists in NRPI's impact on AMS inputs of households depending on whether they have elderly farmers (aged 60 or above).

In view of this, the potential innovations of this paper are threefold. First, the study encompassing the impact of rural social security system factors on AMS inputs of farm households will be expanded, with systematic discussion and testing of NRPI's impact on such inputs from the standpoint of whether there are elderly farmers involved or not. The Heckman two-stage model, PSM-DID model, and the technique of replacing the explained variables are employed for the robustness test to enhance the accuracy and reliability of the research conclusions. Second, based on a theoretical analysis that examines the difference of NRPI on labor allocation between households with and without elderly farmers, this paper empirically evaluates the different mechanisms of NRPI's effects on the AMS inputs of both types of households. Third, the use of large sample panel data in two phases will aid in improving the representativeness and external validity of the research conclusions. Accordingly, based on this theoretical analysis, this study probes into NRPI's impact on the AMS inputs of households with and without elderly farmers. This approach was based on a panel Tobit random effects model using the panel data of the China Family Panel Studies (CFPS) corresponding to two periods in 2016 and 2018. It also aimed to test the mechanism of action using a panel-mediated effects model with stepwise regression. Additionally, heterogeneity will be addressed in more detail to acquire an objective and comprehensive understanding of NRPI's effect on household AMS inputs with and without elderly farmers.

## 2. Theoretical Analysis and Research Hypothesis

Theoretically, promoting NRPI will affect labor resource allocation within farm households and then affect the AMS inputs. In line with the research on NRPI's effect on the allocation of household labor resources, this paper explores the impact of such an insurance

system on the AMS inputs of the two specific types of households (the elderly and the non-elderly) from the perspective of family population structure.

### *2.1. The Impact of NRPI on AMS Inputs of Households with Elderly Farmers*

According to the time allocation theory, assuming economic rationality, individuals or households will pursue utility maximization under specific resource constraints and then realize the optimal allocation of labor supply and leisure time.

For households with elderly farmers, the NRPI facilitates an increase in the AMS input of farmers through two methods. The first is grounded in the crowding-in effect of grandchild caregiving. In China, most elderly people live with their children or with those who are nearby [18], ensuring frequent interactions with them. They provide assistance by taking care of their grandchildren and farming on their children's land when the latter leaves for work. Concerning intergenerational care, the proportion of Chinese grandparents that take part in caring for their grandchildren has been increasing at a significant rate. A survey showed that in South Korea, the proportion of grandparents participating in intergenerational care was 6%. Meanwhile, in China, it was as high as 58% [19]. Elderly parents take on the burden of looking after their grandchildren [20]. It is also worth noting that the participation of elderly farmers over 60 years old in NRPI significantly increases their time spent caring for their grandchildren [21]. While participation in NRPI can increase the grandchild care time, it reduces the agricultural labor time of elderly farmers. As a result, the rational choice for farmers is opting for AMS to compensate for the lack of family agricultural labor supply and reduce labor costs [22]. Farmers' AMS inputs will increase correspondingly. The second aspect is through the crowding-out effect of non-farm labor transfer. Some papers highlighted that the elderly will increase their tendency to look after their grandchildren when they receive a substantial amount of unexpected pension income. As a result, this will increase the employment of young and middle-aged workers in the family [15]. By alleviating the elderly farmers' pension risks and the care constraints involving children [22], the NRPI effectively promotes the off-farm transfer of the young and middle-aged labor force within the household. Moreover, the off-farm transfer of young and middle-aged labor will result in a decrease in the quantity and quality of household agricultural labor supply, which will then cause an increase in AMS inputs for households with older farmers. According to the above analysis, the following hypotheses are proposed:

**Hypothesis 1:** *For households with elderly farmers, NRPI participation can significantly increase farm mechanization service inputs.*

**Hypothesis 2:** *For households with elderly farmers, the NRPI will prompt farmers to increase farm mechanization service inputs through the crowding-in effect of grandchild care and the crowding-out effect of labor off-farm transfer.*

### *2.2. The Impact of NRPI on the AMS of Households without Elderly Farmers*

For non-elderly farming households, despite having not received pension income from NRPI in the current period, they have improved their expectations with respect to the participating farmers' pension security. This also affects the allocation of farming households' labor resources and promotes the off-farm transfer of labor, thereby positively influencing their AMS inputs, which is equally important.

For non-elderly farm households, the NRPI primarily contributes to the increase in farm mechanization service inputs through the crowding-out effect of the labor off-farm transfer. Younger grandparents in non-elderly farm households who are still able to work are more likely to work than to care for their grandchildren [23]. In such households, young grandparents who remain capable of working are more likely to work than look after their grandchildren [24]. Hence, the crowding-out effect of NRPI through grandchild caregiving has a limited impact on AMS input in households without elderly members. Participation

in NRPI drives down uncertainties about future income sources, reduces precautionary savings, and increases investment in employment, which then increases the non-farm labor supply [25]. As the amount of non-farm employment increases, farm household AMS inputs increase significantly [26]. Then, for non-elderly farm households, NRPI stimulates the off-farm transfer of farm household labor, thus reducing the agricultural labor input per unit of arable land area. Consequently, this has a catalytic effect on their AMS inputs. Accordingly, the following research hypotheses are proposed:

**Hypothesis 3:** *For non-elderly farm households, participation in NRPI can significantly increase farm mechanization service inputs.*

**Hypothesis 4:** *For non-elderly farm households, the NRPI will prompt farmers to increase their AMS inputs through the crowding-out effect of labor off-farm transfer.*

### 3. Study Design

#### 3.1. Data

The empirical analysis utilizes microdata from Peking University's China Household Panel Studies (CFPS). It aims to reflect the social, economic, and demographic changes in China by tracking and collecting data at the individual, household, and community levels. The analysis intends to establish a database for academic and policy research. Since 2010, CFPS has performed a follow-up survey every two years, which has been updated to 2018. The CFPS sample covers the data of 16,000 households across 25 provinces (autonomous regions and municipalities) (excluding Beijing, Xinjiang, Tibet, Qinghai, Ningxia, Hainan, Hong Kong, Macao, and Taiwan) in China. Employing the three-stage unequal probability overall sampling method, the population of the sample area accounted for approximately 95% of the country's total population, which served as its representative sample. Its content comprised insurance participation, AMS-related expenditure, basic information about the individuals, family economy, and economic information of village residents. Given that CFPS2010-2014 did not inquire about the expenditure data on AMS, this paper used the unbalanced panel data of CFPS2016 and CFPS2018 in the empirical study to observe how the new rural insurance system affects the farmers' investment in AMS.

In the process of data processing, the sample of farmers with rural household registration was initially selected. Then, the main variables were chosen in keeping with the study objectives and CFPS item settings: (a) key variables characterizing NRPI and AMS inputs; and (b) control variables that encompassed household-level farm endowment characteristics variables, village-level economic and social characteristics variables, and regional dummy variables. Since CFPS2016 and CFPS2018 lack data on village-level and crop varieties grown by farmers, we merged the data of CFPS2014 with those of CFPS2016 and CFPS2018. The reasoning behind this was to obtain village-level data and eliminate the sample of farmers who only grew cash crops. Finally, the samples with "unknown" and "inapplicable" contents were handled as missing values and eventually removed. The farming ability and willingness to farm of only elderly farming households over 60 years old have significantly decreased. On top of that, the NRPI fundamentally plays the function of old-age security and stimulates the increase in daily household consumption expenditure, which is less relevant to this paper's topic. As a result, the sample of only elderly farming households was excluded from this study.

To prevent the interference of other insurance on the farmers' AMS inputs, we omitted households with members participating in other insurance schemes. After the above treatment, a total of 6637 valid samples of grain farmers were acquired, including 2563 samples of households with elderly farmers and 4074 without elderly farmers. Overall, the study sample covered 25 provinces (districts and cities), 138 counties, and 340 villages in China. Compared with the existing literature, the data in this paper are relatively new and correspond to a large sample size with sufficient regional representation.

### 3.2. Variable Settings and Descriptions

#### 3.2.1. Explanatory Variables

In this research, the explanatory variable was the AMS inputs measured by the ratio of total agricultural mechanization operation service inputs to the number of working-age household laborers. Moreover, the definition of the variable AMS inputs was relatively uniform in previous studies and essentially refers to the total cost of renting others' machinery and equipment. It seeks to provide farm machinery operation services such as plowing, sowing, and harvesting for the household. In this paper, the total input of AMS was characterized based on the questionnaire of the CFPS: "How much does it cost to rent machinery"?

#### 3.2.2. Core Explanatory Variables

The binary dummy variable of "NRPI" was utilized as this paper's core explanatory variable. For households with elderly farmers, the value was one when elderly farmers received NRPI pensions and children paid premiums, and zero when elderly farmers did not receive NRPI pensions and children did not pay premiums. For households without elderly farmers, the value was one when household members paid NRPI and zero when no household members paid NRPI.

#### 3.2.3. Mediating Variables

The grandchild care and the proportion of non-farm labor transfer served as the mediating variables of NRPI influencing farm households' AMS inputs. According to Haiyi Wang [27], in conjunction with the CFPS database for children, the sample of children who predominantly received daytime care from someone other than their parents and evening care from their elderly parents were set as having grandchild care. Otherwise, no grandchild care was noted. The ratio of the amount of non-farm employment of the labor force in the household to the total number of household members was utilized to measure the proportion of non-farm labor transfer.

#### 3.2.4. Other Control Variables

Together with the key variables mentioned above, this paper also controlled for variables, namely the main labor force characteristics, farm household characteristics, village characteristics, and regional characteristics with reference to existing studies. More specifically, there were four main variables:

- The variables of key labor force characteristics (features of non-elderly farming households aged 25–59 and elderly farming households aged 60–80) were the proportion of males, average age, average education level, and average health status.
- The household characteristics variables comprised the household size, proportion of labor force, value of agricultural machinery, borrowing constraints, remittances of migrant workers, agricultural income level, household net income per capita, and government subsidies (whether they received various government income transfers).
- The village characteristics variables included the distance from the county, proportion of village agricultural labor, number of village children, and number of village elderly.
- Concerning the regional characteristic variables in this study, those were the main grain-producing areas, and regional dummy variables were designated as regional characteristic variables. Additionally, given the lack of arable land area data in the CFPS data used and the high correlation between the arable land area and agricultural income of food growers, agricultural income level served as an approximate proxy for arable land area and input into the model as a control variable. The specific approach was dividing the agriculture income level of farm households into low, medium, and high agricultural income levels. Table 1 itemizes the descriptions and descriptive statistics of each of the above variables.

**Table 1.** Variable definitions and descriptive statistics.

Variable Name	Definition and Assignment	Households with Elderly Farmers		Households without Elderly Farmers	
		Mean	Std. Dev.	Mean	Std. Dev.
AMS inputs	Rental cost of agricultural machinery/number of working-age household laborers (yuan, logarithm)	2.353	2.684	2.578	2.817
NRPI	Are any members of the household enrolled in the NRPI? Yes = 1; No = 0	0.661	0.474	0.713	0.452
Grandchild care	Is there grandchild care? Yes = 1; No = 0	0.546	0.498	0.394	0.489
Proportion of non-farm transfer of labor force	Number of outworking laborers/total household size (%)	0.652	0.418	0.675	0.445
Proportion of males	Number of male non-elderly farming households/number of household non-elderly farming households (%)	0.489	0.312	0.500	0.226
Age	Average age of non-elderly farm households (years)	40.256	10.565	44.712	7.578
Education level	Average number of years of education for non-elderly farm households (years)	5.854	3.922	5.759	3.350
Health level	Average health of non-elderly farm households (rating 1 to 5)	4.371	3.258	4.267	2.791
Household size	Total number of household members (person)	4.532	2.026	3.720	1.758
Proportion of labor force	Number of working-age household laborers/total household size (%)	0.518	0.568	0.633	0.622
Agricultural machinery value	Total value of household agricultural machinery (yuan, taken as logarithm)	4.019	4.115	4.047	4.195
Lending constraints	Total amount of outstanding loans to the household (yuan, cc)	0.123	0.265	0.132	0.272
Remittance of migrant workers	Remittance amount of migrant workers (yuan, taken as logarithm)	4.690	4.823	4.851	4.813
Agricultural income level	Total agricultural income level: low agricultural income = 1; medium agricultural income = 2; high agricultural income = 3	1.965	0.839	2.073	0.828
Household net income per capita	Household net income per capita (yuan, take logarithm)	8.645	1.591	8.764	1.778
Government subsidies	Do you receive government subsidies? Yes = 1; No = 0	0.707	0.455	0.679	0.467
Distance from the county	Distance from the village council to the county seat of the county (km)	0.955	0.921	0.922	0.853
Proportion of agricultural labor in villages	Number of village agricultural laborers/total village population (%)	0.478	0.260	0.507	0.263
Number of children in the village	Number of people under 15 years old in the village (persons, taken as logarithm)	4.975	2.040	5.100	1.931
Number of elderly people in villages	Number of people over 60 years old in the village (persons, taken as logarithm)	5.198	1.585	5.230	1.537
Major grain-producing areas	Is it a major grain producing area? Yes = 1; No = 0	0.528	0.499	0.532	0.499
Eastern region	Is it located in the eastern region? Yes = 1; No = 0	0.287	0.452	0.326	0.469
Central region (control)	Is it located in the central region? Yes = 1; No = 0	0.373	0.499	0.487	0.500
Western region	Is it located in the western region? Yes = 1; No = 0	0.340	0.487	0.351	0.477

Note: Calculated based on CFPS data in 2016 and 2018.



### 3.3. Statistical Description of Key Variables

From the statistical results in Figure 1, the AMS inputs of farmers in the insured group are higher than those in the uninsured group, both for households with and without elderly farmers. It can be seen that the NRPI shows a boosting effect on the AMS inputs of both households with and without elderly farmers. As can be seen from Figure 2, for households with elderly farmers, the proportion of grandchild care and off-farm labor transfer were higher in the insured group than in its non-insured counterpart. Figure 3 details that for households without elderly farmers, the proportion of non-farm labor transfer was higher in the insured group than in the non-insured group.

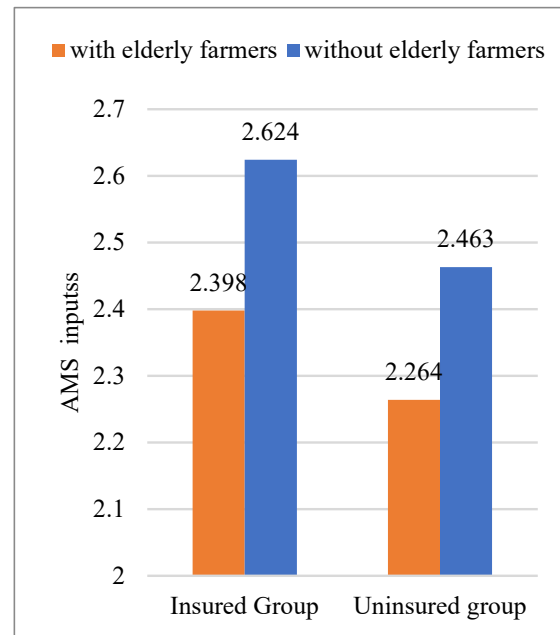


Figure 1. NRPI and AMS inputs.

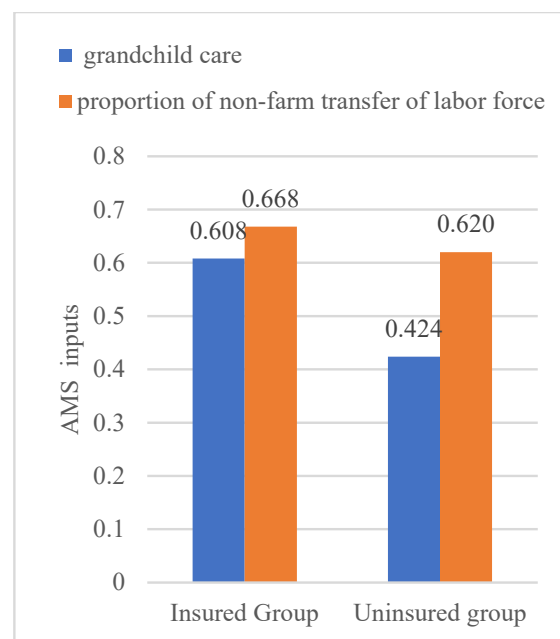
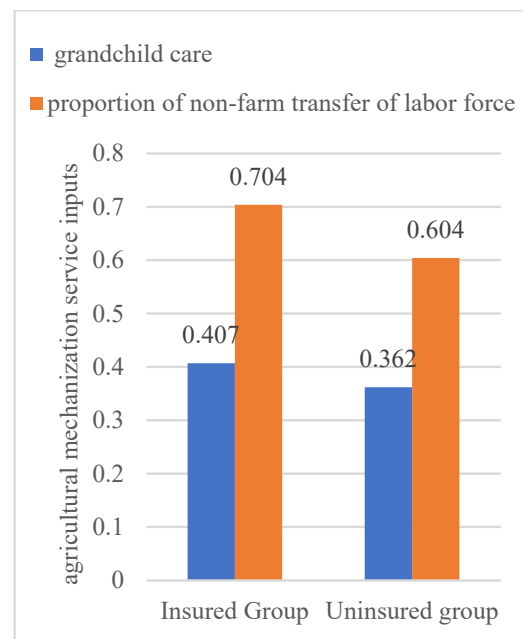


Figure 2. Households with elderly farmers.



**Figure 3.** Households without elderly farmers.

### 3.4. Model Setting

For the empirical analysis of NRPI's impact on farm households' AMS inputs, we constructed the following panel Tobit model, which is given by:

$$Ln\_AMS_{it} = \begin{cases} C + \alpha_1 NRPI_t + \alpha_2 Control + \mu_i + \varepsilon_{it}, & \text{if } AMS > 0 \\ 0, & \text{if } AMS_{it} = 0 \end{cases}$$

where  $AMS_{it}$  denotes the AMS inputs per farmer's labor or the explained variable, and  $NRPI_t$  represents whether any member of a household is insured and is the core explanatory variable. Since "control" signifies a series of control variables, for households with elderly farmers over 60 years old, the control variables mostly included the characteristics variables of elderly farmers, non-elderly farmers, farmers' households, and the village, as well as regional dummy variables. Meanwhile, for households without elderly farmers who were over 60 years of age, the control variables were missing elderly farmers' characteristics variables.  $\alpha_1$  and  $\alpha_2$  are the coefficients to be estimated,  $\varepsilon_{it}$  is the random disturbance terms, and  $\mu_i$  covers the individual effects.

Given that many farmers' AMS inputs were zero, demonstrating the accumulation of zero points, it was impossible to obtain consistent estimators using the OLS estimation. In this case, a panel Tobit model was adopted for analysis. Since an adequate statistic for individual heterogeneity could not be detected, we could not use the panel Tobit fixed effects model to perform conditional maximum likelihood estimation. Moreover, the obtained fixed effects estimates were inconsistent, so the panel Tobit fixed effects model was not taken into account. For panel data, the mixed panel Tobit model and the panel Tobit random effects model are more widely used. In light of this, we selected the panel Tobit random effects model for estimation based on the likelihood ratio test (LR) results.

## 4. Results and Analysis

### 4.1. Baseline Regression Results

Table 2 reports the estimation results of the panel Tobit random effects model for NRPI's effect on farm households' AMS inputs, with the marginal effects presented. The regression results underscore that the LR test results strongly reject the hypothesis that there was no individual effect, leading us to select the panel Tobit random effects model as a more valid regression than the mixed Tobit model.



**Table 2.** Regression results of the panel Tobit random effects model for the effect of NRPI on AMS inputs of farm households.

Variable Name	Households with Elderly Farmers		Households without Elderly Farmers	
	Coefficients	Marginal Effects	Coefficients	Marginal Effects
NRPI	0.509 ** (0.243)	0.186 ** (0.089)	0.346 *(0.199)	0.132 * (0.076)
Characteristics of non-elderly farming households				
Proportion of males	−1.901 ** (0.39)	−0.697 ** (0.142)	0.127 *** (0.037)	0.048 *** (0.014)
age (years)	0.018 (0.011)	0.007 (0.004)	−0.004 (0.010)	−0.001 (0.004)
Education level	0.029 (0.044)	0.011 (0.016)	0.143 *** (0.039)	0.055 *** (0.015)
Health Level	0.052 (0.052)	0.019 (0.019)	−0.149 (0.122)	−0.057 (0.046)
Characteristics of elderly farmers				
Proportion of males	−0.705 *(0.338)	−0.258 ** (0.124)	−	−
Age (years)	0.007 (0.008)	0.003 (0.003)	−	−
Education level	0.038 (0.034)	0.014 (0.013)	−	−
Health level	−0.132 (0.094)	−0.048 (0.035)	−	−
Family characteristics				
Household size	−0.276 *(0.065)	−0.101 ** (0.024)	−0.238 ** (0.060)	−0.091 ** (0.023)
Proportion of labor force	−0.141 (0.232)	−0.052 (0.085)	−0.024 (0.180)	−0.009 (0.069)
Agricultural machinery value				
Lending constraints	0.559 (0.415)	0.205 (0.152)	0.958 *** (0.320)	0.365 *** (0.122)
Remittance of migrant workers	0.067 ** (0.025)	0.024 *** (0.009)	0.052 *** (0.020)	0.020 *** (0.008)
Agricultural income level	0.785 *** (0.160)	0.288 *** (0.058)	0.634 *** (0.140)	0.242 *** (0.053)
Household net income per capita	0.136 *(0.075)	0.050 *(0.028)	0.106 *(0.055)	0.041 *(0.021)
Government subsidies	0.644 ** (0.253)	0.236 ** (0.093)	−0.000 (0.000)	−0.000 (0.000)
Village characteristics				
Distance from the county	−0.068 (0.122)	−0.025 (0.045)	−0.206 ** (0.105)	−0.078 ** (0.040)
Proportion of agricultural labor in villages				
Number of children in the village	0.404 *** (0.082)	0.148 *** (0.030)	0.248 *** (0.068)	0.095 *** (0.026)
Number of elderly people in villages	−0.495 ** (0.103)	−0.181 ** (0.038)	−0.307 ** (0.085)	−0.117 ** (0.032)
Regional characteristics				
Major grain-producing areas	1.050 *** (0.262)	0.385 *** (0.096)	1.061 *** (0.210)	0.404 *** (0.080)
Regional dummy variables				
Controlled	Controlled	Controlled	Controlled	Controlled
Constant	−1.463 (1.101)	−	−0.791 (0.731)	−
LR test	4.921 *** (0.119)	−	4.990 *** (0.093)	−
Wald chi2	258.160	−	436.240	−
Prob > chi2	0.000	−	0.000	−
Log-likelihood	4415.662	−	7284.137	−
Sample size	2563	2563	4074	4074

Note: \*\*\*, \*\*, \* indicate significant at the 1%, 5%, and 10% levels, respectively; standard errors are in parentheses.

The regression results in column (1) of Table 2 indicate that for households with elderly farmers, participation in NRPI significantly contributed to the increase in AMS inputs at the 5% confidence level. Based on the findings of marginal effects in column (2), households with elderly farmers participating in NRPI could increase their AMS inputs by 18.6% (significant at the 5% confidence level). As established by the outcomes, NRPI significantly contributed to the increase in AMS inputs for households with elderly farmers. The reasoning behind this was that because the insured households with elderly farmers were in the stage of receiving the new rural insurance pension, the NRPI increased the disposable income of farmers in the current period and altered the allocation of household labor resources. In turn, agricultural labor inputs per unit area were reduced, thereby contributing to the increase in their AMS inputs. Overall, this verified Hypothesis 1.

The results of estimation in column (3) of Table 2 depict that NRPI experienced a significant increase in AMS inputs for households without elderly farmers, and the regression results were significant at the 10% confidence level. Subsequently, the results of marginal

effects in column (4) indicate that for farming households without elderly members, participating in NRPI led to a 13.2% increase in AMS inputs, which was statistically significant at the 10% confidence level. Compared with non-insured households, although there was no current pension income for insured households without elderly farmers, NRPI exerted an income expectancy effect [28] that influenced the allocation of their household labor resources. As a result, this promoted an increase in farm households' AMS inputs, which then verified Hypothesis 3.

#### 4.2. Robustness Test

##### 4.2.1. Replacement Model

###### 1. Heckman Two-stage Model

In the study sample, taking into account that some farmers had zero AMS inputs, selection bias could have occurred if the missing data in the sample were not random [29]. To solve this, the Heckman two-stage model was used as much as possible. The Heckman two-stage regression model consists of a selection equation and an outcome equation. Applying it to our analysis, first, the selection equation was put to use to estimate how farm households participate in the NRPI. Next, the inverse Mills ratio (calculated using the selection equation) was incorporated into the outcome equation.

Table 3 enumerates the second-stage regression results of the Heckman two-stage model. The inverse Mills ratio in the model was all significant at the 1% confidence level, indicating the existence of sample selectivity bias and that the use of the Heckman two-stage model was reasonable. Based on the marginal effects, it turned out that after correcting for the selectivity bias, NRPI could increase the AMS inputs by 18.1% and 12.6% for households with and without elderly farmers, respectively. Table 3 presents the comparison of the regression results, which exhibited similarities, denoting that the baseline regression results presented in this paper remained robust even after fully considering the problem of possible selectivity bias.

**Table 3.** Estimation results of the Heckman two-stage model of the impact of NRPI on AMS inputs of farm households.

Variable Name	Households with Elderly Farmers		Households without Elderly Farmers	
	Coefficients	Marginal Effects	Coefficients	Marginal Effects
NRPI	0.514 * (0.258)	0.181 * (0.094)	0.331 * (0.199)	0.126 * (0.076)
Control variables	Controlled			
Inverse Mills ratio	0.571 *** (0.207)	–	–5.488 ** (1.129)	–
Wald chi2	115.59	–	436.90	–
Prob > chi2	0.0000	–	0.0000	–
Sample size	2563	2563	4074	4074

Note: \*\*\*, \*\*, \* indicate significant at the 1%, 5%, and 10% levels, respectively; standard errors are in parentheses; Due to space limitations, only the second-stage regression results are reported.

###### 2. PSM-DID Model

Since participating in NRPI resulted from the voluntary selection of households, the study of NRPI's effect on AMS inputs of farm households encountered the endogeneity problem caused by the self-selection of samples. Moreover, the PSM-DID model possessed the advantages of using two methods: (a) the PSM approach to eliminate the endogeneity problem caused by self-selection and (b) the DID approach to remove the issue involving unobservable variables that remained the same over time. Balanced panel data were constructed, and farmers who were uninsured in 2016 and then insured in 2018 were set as the treatment group. Additionally, uninsured farmers in both 2016 and 2018 were fixed as the control group. The model results emphasize (Table 4) that NRPI significantly contributed to an increase in AMS inputs for farmer households with and without elderly members

by 18.7% and 12.9%, respectively, compared with non-insured farmers. This highlights that the findings are, to a great extent, consistent with the baseline regression results after addressing the potential endogeneity issues, further demonstrating the robustness of the estimation results.

**Table 4.** Estimation results of PSM-DID model for the impact of NRPI on AMS inputs of farm households.

Variable Name	Households with Elderly Farmers		Households without Elderly Farmers	
	Coefficients	Marginal Effects	Coefficients	Marginal Effects
NRPI	0.510 ** (0.243)	0.187 ** (0.089)	0.338 * (0.198)	0.129 * (0.075)
Control variables			Controlled	
Wald chi2	257.63	–	475.00	–
Prob > chi2	0.0000	–	0.0000	–
Sample size	1473	1473	2675	2675

Note: \*\*, \* indicate significant at the 5% and 10% levels, respectively; standard errors are in parentheses.

#### 4.2.2. Replacement of Interpreted Variables

To substantiate the robustness of the previous benchmark regression results above, the explanatory variable was replaced with the level of AMS of farm households, i.e., the proportion of AMS inputs to total agricultural production inputs. Table 5 shows the estimation results, illustrating that NRPI significantly contributed to the increase in AMS inputs of farm households with and without elderly farmers. At the 10% confidence level, the estimated coefficients were both significant, further portraying the robustness of the benchmark regression results.

**Table 5.** Panel Tobit random effects model estimation results of NRPI on the level of AMS of farm households.

Variable Name	Households with Elderly Farmers		Households without Elderly Farmers	
	Coefficients	Marginal Effects	Coefficients	Marginal Effects
NRPI	0.022 * (0.013)	0.008 * (0.004)	0.018 * (0.010)	0.007 * (0.003)
Control variables			Controlled	
Wald chi2	222.58	–	401.27	–
Prob > chi2	0.0000	–	0.0000	–
Sample size	2563	2563	4074	4074

Note: \* indicate significant at the 10% levels; standard errors are in parentheses.

## 5. Mechanism Test and Heterogeneity Analysis

### 5.1. Mechanism Test

The baseline regression results above point out that NRPI can significantly and positively contribute to the increase in AMS inputs for households with and without elderly farmers. Combined with the previous theoretical analysis, a panel-mediated effects model with stepwise regression was introduced for additional investigation of the mechanism of NRPI's effect on AMS inputs of households with and without elderly farmers.

Table 6 itemizes the results of the regression analysis of the stepwise regression panel-mediated effects model. The results in columns (1) and (3) indicate that for households with elderly farmers, NRPI promoted the increase in the proportion of grandchild care and labor off-farm transfer of elderly farmers at the 1% confidence level. The results in columns (2) and (4) show that when the mediating variables (proportion of grandchild care and labor off-farm transfer) were introduced into the model, the marginal effects of NRPI

on farm households' AMS inputs decreased from 0.186 (column (2) of Table 2) to 0.104 and 0.167, respectively, and both were significant at the 10% confidence level.

**Table 6.** Validation of the impact mechanism of NRPI on farm mechanization service inputs of farm households.

Variable Name	Panel Tobit Random Effects Model (Conditional Marginal Effects)					
	Households with Elderly Farmers			Households without Elderly Farmers		
	(1) Grandchild Care	(2) AMS Inputs	(3) Proportion of Non-Farm Transfer of Labor Force	(4) AMS Inputs	(5) Proportion of Non-Farm Transfer of Labor Force	(6) AMS Inputs
NRPI	0.125 *** (0.016)	0.104 * (0.061)	0.071 *** (0.013)	0.167 * (0.089)	0.090 *** (0.010)	0.114 ** (0.100)
Grandchild care	–	0.203 ** (0.092)	–	–	–	–
Proportion of non-farm transfer of labor force	–	–	–	0.238 ** (0.121)	–	0.226 ** (0.076)
Control variables	Controlled					
Sobel test	Coefficient significant without Sobel test					
Intermediary effect as a percentage	13.72%		9.13%		15.41%	
Sample size	2563		2563		4074	

Note: The mediating effect proportion is the mediating effect/total effect, where the total effect is the coefficient of the core explanatory variables "NRPI" in columns (2) and (4) in Table 2. \*\*, \*, \* indicate significant at the 1%, 5%, and 10% levels, respectively; standard errors are in parentheses.

In terms of the share of mediating effects, for households with older farmers, about 13.72% of NRPI's effect on farm mechanization service inputs was realized through the indirect channel of grandchild care and 9.13% was realized through the indirect channel of labor off-farm transfer. This attests that for households with elderly farmers, the proportion of grandchild care and labor non-farm transfer plays a partially mediating role in the relationship between NRPI and farmers' AMS inputs, i.e., the influence mechanism that NRPI promotes is the increase in the farmers' AMS inputs through the crowding-in effect of grandchild care and the crowding-out effect of non-farm labor transfer exists. This verifies Hypothesis 2.

The outcomes in column (5) of Table 6 validate that for households without elderly farmers, NRPI significantly contributed to the increase in the proportion of labor off-farm transfers and was significant at the 1% confidence level. Meanwhile, the estimation results in column (6) portray that the marginal effect of NRPI on farm mechanization service inputs of farm households was found to decrease from 0.132 (column (4) in Table 3) to 0.114 and was significant at the 5% confidence level by introducing the mediating variable (proportion of labor off-farm transfer) into the model.

With respect to the share of mediating effects, for households without elderly farmers, 15.41% of the NRPI's effect on farm mechanization service inputs was realized through the indirect channel of promoting labor non-farm transfer. The above findings emphasize that for those without elderly farmers, the proportion of labor non-farm transfer had a partially mediating role in the relationship between NRPI and farmers' AMS inputs, i.e., the influence mechanism of NRPI promoting the increase of farmers' AMS inputs through the crowding-out effect of labor non-farm transfer exists. This verifies Hypothesis 4.

## 5.2. Heterogeneity Analysis

Considering the possible heterogeneity of NRPI's impact on the AMS of farmers with varied resource endowments, based on the household demographic perspective, this paper further divided the subsamples according to the presence of grandchild care, the proportion of labor non-farm transfer, and agricultural income level. The objective behind this approach was to explore the potential heterogeneous impact of NRPI. Table 7 enumerates the empirical results.

**Table 7.** Estimation results of the panel Tobit random effects model for the impact of NRPI on AMS inputs for farmers with different endowments.

Sample Grouping		Households with Elderly Farmers		Households without Elderly Farmers		Sample Size	Wald chi2
		Coefficients	Marginal Effects	Coefficients	Marginal Effects		
Grandchild care	With grandchild care	0.786 ** (0.349)	0.281 ** (0.125)	0.465 (0.364)	0.176 (0.138)	1397	78.10 ***
	No grandchild care	0.243 (0.349)	0.092 (0.132)	−0.040 (0.245)	−0.015 (0.096)	2472	326.14 ***
Proportion of non-farm transfer of labor force	Above average	0.487 (0.392)	0.180 (0.145)	−0.011 (0.340)	−0.004 (0.118)	1946	271.41 ***
	Below average	0.512 * (0.309)	0.186 * (0.112)	0.462 * (0.253)	0.176 * (0.096)	2128	278.65 ***
Agricultural income level	Above average	0.647 ** (0.329)	0.258 ** (0.131)	0.347 (0.274)	0.138 (0.109)	1987	189.79 ***
	Below average	0.258 (0.355)	0.087 (0.120)	0.579 ** (0.286)	0.211 ** (0.104)	2087	229.56 ***

Note: \*\*\*, \*\*, \* indicate significant at the 1%, 5%, and 10% levels, respectively; standard errors are in parentheses.

The estimation results of the grandchild care subgroup exhibited that for households with elderly farmers, NRPI increased the mechanized agricultural service inputs of farmers with grandchild care by 28.1%. Contrastingly, the effect on farmers without grandchild care was not statistically significant. The grounds for this were that compared with households without grandchild care, those with grandchild care will consume more of the time and energy of elderly farmers. For this reason, there was less agricultural labor time per unit area of arable land, and the promotion effect of NRPI on AMS inputs of farmers was more significant. The above results validate that NRPI promotes AMS inputs of households with elderly farmers through grandchild care. For non-elderly households, NRPI did not significantly affect the mechanized agricultural service inputs of both non-grandchild and grandchild care households. More specifically, this was because grandparents in households without elderly farmers were younger and in relatively good health and income status, on top of having a stronger inclination to work than to take care of their grandchildren [23]. This makes it challenging to play the role of NRPI in facilitating the increase in intergenerational care, resulting in the absence of NRPI's impact on the AMS expenditures of farmers in the intergenerational care group.

The empirical results grouped based on the proportion of labor non-farm transfer revealed that NRPI increased AMS inputs by 18.6% and 17.6% for farm households with and without elderly farmers, respectively, for farm households with low labor transfer ratios. The conceivable reason is that, compared with farmers with a high labor off-farm transfer ratio, those with a low ratio had the potential to further transfer labor. Additionally, participation in NRPI increased the labor off-farm transfer of farmers. The increase in labor transfer probability will reduce labor input per unit cultivated land area, thus stimulating the increase in farmers' AMS inputs.

This result again specifies that NRPI can increase farm mechanization service inputs by promoting the labor off-farm transfer of farmers. The effect of NRPI on AMS expenditures of farm households in the high labor force non-farm transfer group was not statistically significant. That outcome was in response to the possibility that the proportion of surplus labor in farm households in the high labor force non-farm transfer group was low, and it was more complex for this group of farm households to complete a non-farm transfer. Despite participating in the NRPI, there were difficulties in increasing the proportion of

non-farm transfer of farm households, thereby inhibiting the promotion effect of the new agricultural insurance on AMS expenditures.

The results of the agricultural income level subgroup estimation brought to light that for households with elderly farmers, NRPI increased the AMS inputs of farmers with high agricultural income levels by 25.8%. At the same time, the effect on households with low agricultural income levels was not statistically significant. This is because, generally, in contrast with households with low agricultural income, those with high agricultural income have larger farmland operations and encounter greater labor constraints in agricultural production, which makes NRPI's promotion effect on AMS inputs more significant.

For households without elderly farmers, NRPI increased AMS inputs by 21.1% for farmers with low agricultural income levels. Contrastingly, the effect on those with high agricultural income levels was not statistically significant. The impact of NRPI on the AMS expenditures of farm households in the high labor force non-farm transfer group was not statistically significant. The logic behind this could be that the proportion of surplus labor in farm households in the high labor force non-farm transfer group was low, and it was more complex for this group of farm households to complete a non-farm transfer. Despite participating in the new agricultural insurance, increasing the proportion of non-farm transfer of farm households was not a straightforward task, which inhibited the promotion effect of the NRPI on AMS inputs.

## 6. Discussion and Conclusion

### 6.1. Discussion

Throughout the last several years, public transfer programs such as universal pensions have emerged as a vital strategy for social protection and poverty alleviation in several developing countries. Simultaneously, extensive research has covered the impact evaluation of such programs or policies on beneficiaries and their households [10,30,31]. Additionally, the analysis of the effects of the new rural social pension insurance system in China has been a hot topic since its implementation [32]. The poverty reduction and income increase effects of various pension projects have been verified across many developing countries, including Brazil, Mexico, South Africa, and India, among several others [33,34]. However, the impacts of pension programs on household economic welfare differ in every country, sometimes significantly, due to the variations in system design, benefit conditions, and treatment levels [35].

The primary focus of policymakers on the effectiveness of NRPI is its influence on the economic welfare of rural households and the individual welfare of residents. However, some researchers have identified the policy effects of NRPI to have gone beyond this and caused spillover effects at the household, community, and even broader scales [32]. By way of illustration, the effects of NRPI extend to the residents' retirement patterns [36–38], rural land transfer [8,20,39], human capital accumulation, and long-term development involving other household members (especially children) [40] capital and labor market performance and level of the income distribution [15,30], child care and health [32], and political trust [41].

These spillovers are of academic interest and hold pronounced policy implications. In this context, this paper revolves around NRPI's spillover effects on Chinese rural households' AMS expenditures and the direction of such spillover effects. The reason for selecting this research question is that Chinese agricultural operators are principally small-scale, middle-aged, and elderly farmers. It is equally important to mention that NRPI's implementation further reduced the number and labor supply of this group of farmers, which could significantly impact the development pattern, scale of operation, and utilization of AMS in Chinese agriculture [42].

This paper also contributes to our general knowledge of public pension programs in developing countries. China's rural pension system is only a few years old and is yet to be studied exhaustively. These findings have significant implications for in-depth research on AMS promotion and sustainable agricultural development. In the path of



AMS promotion, pension security policies such as the NRPI implicitly influence farmers' adoption of AMS by influencing the labor resource allocation of farm households. In the long run, the new agricultural insurance, as a means of pension security, will aid in promoting sustainable agricultural development and will hold a pivotal role in the process of agricultural modernization. In the process of AMS promotion, the new agricultural insurance pension can change the farmers' traditional agricultural production and operation mode, to a certain extent, by modifying the allocation of family labor resources. It provides inspiration in the current times.

Ultimately, it is worth noting that our findings were based on relatively small NRPI benefits in rural China compared with the pensions in South Africa, which were twice the median per capita income in rural areas. It can be anticipated that the spillover effect of NRPI on AMS expenditures will continue to expand as pension benefits increase in the future, contributing to the transformation of the country's agricultural operations and sustainable agricultural development.

## 6.2. Conclusions

Based on the panel data of farm households in CFPS2016 and CFPS2018, this paper focused on the impact and mechanism of NRPI on the AMS inputs of farm households with and without elderly people from the perspective of household population structure using a panel Tobit random effects model. The findings are threefold:

Firstly, NRPI significantly positively contributes to the AMS inputs of farm households. The results of marginal effects revealed that participation in NRPI could increase the AMS inputs of households with and without elderly farmers by 18.6% and 13.2%, respectively. In particular, to ensure the robustness of the findings, we conducted robustness tests and obtained consistent regression results. Secondly, for households with elderly farmers, NRPI primarily promoted the AMS inputs through the crowding-in effect of grandchild care and the crowding-out effect of labor off-farm transfer. For households without older farmers, NRPI promotes AMS inputs mainly by facilitating off-farm labor transfers. Thirdly, heterogeneity analysis found that for households with elderly farmers, the effect of NRPI on AMS inputs was more significant for households with grandchild care, a low proportion of labor off-farm transfer, and a high agricultural income level. Subsequently, for households without elderly farmers, NRPI's positive effect on AMS inputs was more significant for those with a low proportion of labor off-farm transfer and low levels of agricultural income.

The rural social security system is a crucial guarantee to attain the transformation of agricultural production methods and the sustainable development of agriculture. For the government and academics, its impact on the agricultural production and operation behavior of farm households is a common concern. Synthesizing the above research findings, this paper obtained three insights:

Firstly, the subsidy amount of new agricultural insurance pensions should be reasonably increased. Alongside this, the old-age security function of land has continued to weaken, and a family's old age causes increasing pressure. Against that backdrop, we give full credit to the role of NRPI in alleviating old-age risks, which can help guide the re-optimization of the labor resources of various farm households while providing favorable conditions for the development of AMS. By establishing and improving the new agricultural insurance system that adapts to the changes in China's agricultural production methods, the income security function of the new agricultural insurance ascertains that labor transfer is free of worries. Additionally, it could guide farm households in adopting AMS to boost agricultural productivity and guarantee national food security.

Secondly, NRPI can effectively play a positive role in AMS inputs by fortifying the publicity and education of the old-age protection function of NRPI, improving farmers' knowledge of risk prevention, and encouraging them to actively participate in the insurance plans. At the same time, actively promoting the stability of the local non-farm employment environment, executing employment training, and promoting the transfer of surplus rural labor can advance the development of China's AMS industry.

Thirdly, focusing on the group of households with elderly farmers and facilitating the improvement of the social security level of rural elderly farm households can alleviate the negative impact of the aging agricultural labor force on agricultural production and the welfare loss of elderly farmers caused by grandchild care. Unambiguously, for groups with grandchild care, a low proportion of labor non-farm transfers, and a high level of agricultural income, increasing the level of old-age security for households with elderly farmers can contribute to mobilizing their incentive to invest in agricultural production and foster the development of the AMS market.

The literature on the spillover effect of the new rural insurance and household AMS expenditure in this paper has augmented our understanding of the performance of the new rural insurance policy to a certain extent. We also deemed this specific experience as valuable inspiration for the sustainable development of agriculture. Internationally, a considerable number of studies, based on survey data from various countries, have substantiated that old-age security will reduce the labor supply of the elderly and increase the non-agricultural labor supply of young and middle-aged labor. In addition, the change in household labor supply will transform the agricultural production mode. Therefore, efforts should be devoted to improving the national pension security system, enhancing the pension and welfare level of the rural elderly, and advocating for the optimal allocation of rural land resources.

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