frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 04 February 2026
DOI 10.3389/fsufs.2025.1608136

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OPEN ACCESS

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RECEIVED 08 April 2025
ACCEPTED 25 August 2025
PUBLISHED 04 February 2026

CITATION
Wang J, Liang J, Zhou H, Sun L and Hu X (2026) Income increasing effect of agricultural socialized services on grain farmers: based on cost-benefit perspective.
Front. Sustain. Food Syst. 9:1608136.
doi: 10.3389/fsufs.2025.1608136

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Income increasing effect of agricultural socialized services on grain farmers: based on cost-benefit perspective

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Introduction: This paper explores the growth effect and role decomposition of agricultural socialized service on farmers' agricultural income, and makes comparative analysis on farmers' self-cultivation model and agricultural socialized service model from the perspectives of agricultural production income, production cost and net income. Agricultural socialized service realizes the increase of grain output through the introduction of modern elements, thus promoting the growth of agricultural income and net income.
Methods: Empirically, based on the survey data of grain farmers, multiple linear regression model and propensity score matching method are used to test, and heterogeneity analysis is performed according to grain varieties.
Results and discussion: The results show that agricultural socialized service can significantly increase the agricultural income of grain farmers. Compared with the farmers' self-cultivation model, the production cost of the agricultural socialized service model is significantly higher. The analysis shows that the input of modern factors is higher than the cost of farmers' traditional factors, but the resulting increase in output makes up for it. The comprehensive realization of farmers' adoption of agricultural socialized service brings significant improvement in agricultural production income and net income.

KEYWORDS

agricultural socialized services, income increasing effect, propensity score matching, cost-benefit, grain farmers

1 Introduction

Small-scale production is still the main form of China's agricultural operation, which increases the difficulty for the agricultural sector to make use of modern elements in urban areas. Under the condition of insufficient power for land scale operation, expanding the agricultural division of labor, and developing service scale operation characterized by agricultural productive services can solve the problem without changing the land management rights (Wang and Li, 2019; Gao and Wang, 2022). Cities have gathered a large number of modern factors of production and material means of production necessary for agricultural modernization, including information, science and technology, capital, talents, etc. These modern factors have entered the agricultural field in the form of socialized services, enabling rural areas to enjoy the fruits of urban resources, information technology, etc., and providing funds, advanced production technology and machinery and equipment, etc. to make up for the resource constraints of small farmers (Zhao et al., 2022). Small-scale farmers are constantly confronted with uncertain challenges, and they require support to get through these difficulties in every part of the agricultural production

chain (Alpízar et al., 2020). Developing agricultural socialized services is an effective way to promote the steady increase of farmers' income and drive the high-quality development of rural areas (Chen and Zhao, 2024). The establishment of a new type of socialized agricultural service system is an inevitable requirement for small farmers to connect with large markets, improve agricultural competitiveness and develop modern agriculture (Gao and Kong, 2013). Its impact is mainly reflected in three aspects: enhancing farmers' enthusiasm for producing marketable products, providing farmers with opportunities for direct contact with high-capital buyers, and improving farmers' ability to participate in the market (Ma et al., 2025). It is a policy imperative and a realistic demand to explore a service-oriented agricultural modernization path and provide socialized agricultural services based on small farmers (Huang, 2023). As a new form of socialized agricultural service, agricultural production trust can help farmers to increase their production and income (Li et al., 2022). Based on this, the analysis of the impact of agricultural socialized services on agricultural income is of great theoretical significance and practical need for the development model, focus and management model of agricultural socialized services.

On the economic effect of agricultural socialized service, scholars have explored it from different research perspectives: one is the impact on household income and income structure of farmers. Some scholars show that agricultural socialized services can promote the growth of total household income and wage income, including agricultural income and non-agricultural income (Qu and Zhao, 2021; Zhan and Yan, 2024). Further, when farmers obtain agricultural productive services through organizational means, the effect of improving household income and non-agricultural income is particularly obvious; On the contrary, decentralized service access focuses more on promoting the growth of agricultural income (Xu et al., 2023). The second is the differential impact of different service links on farmers' income. Studies have found that pesticide application service can increase the income of rice farmers by 48%, but the farming and harvesting segments will reduce the income of farmers, while the planting segment has no significant impact on the income (Zhou and Gao, 2023). Some scholars have studied the agricultural productive services in Chifeng, Inner Mongolia, and found that agricultural materials, water conservancy and processing services have a significant role in promoting farmers' production of operational income. Among them, water conservancy services can promote land circulation, thus increasing farmers' production of operational income (Yao and Yu, 2022). In addition, the effective supply of agricultural machinery services and land transfer services can significantly increase the income of farmers, and the diversification of service access channels further enhances this effect of income increase (Li and Li, 2019). The third is the impact on the income gap between urban and rural areas. Agricultural productive services not only help to improve the relative income level of rural residents, but also can narrow the income gap between urban and rural residents, which has a significant spatial spillover effect on the surrounding areas (Zhang and Gao, 2019). There is also a negative correlation between the development of agricultural producer services and the income gap between urban and rural areas. The improvement of service levels, such as agricultural distribution services, agricultural extension services, agricultural information services, agricultural products marketing services, rural financial insurance, and other services, is conducive to narrowing the income gap between urban and rural areas (Lu, 2013).

The existing literature has carried on the rich research and the discussion to the agricultural socialization service economic effect, but still has certain insufficiency. Previous studies have mostly focused on exploring whether agricultural socialized services can bring income to farmers, but lack of in-depth research on the realization mechanism of farmers' income increase, and the cost-benefit comparison between agricultural socialized services model and farmers' self-cultivation model. In addition, most of the existing researches only focus on a certain region or province, or focus on a certain crop for analysis, and the research conclusions are limited. Based on the above analysis, this paper uses the micro-survey data of farmers, uses multiple linear regression model and propensity score matching method to conduct empirical test, explores the income-increasing effect of agricultural socialized service on farmers from agricultural production income, production cost and net income, and conducts heterogeneity analysis according to the classification of food crops.

2 Material and methods

2.1 Data

The data used in this paper are derived from the Agricultural Microeconomic Survey Database of the Institute of Agricultural Economics and Development, Chinese Academy of Agricultural Sciences. Based on the economic development level, rank the provinces in each region according to the average per capita net income of farmers, and select the provinces with the middle average from each region. A stratified random sampling method was adopted to select three counties (cities or districts) in each province, three towns in each county (city or district), three villages in each town, and about 20 households in each village for questionnaire survey. Data are collected by filling out a questionnaire on the spot.

This paper selects the micro-survey data of grain farmers in 2019 and 2020, including Heilongjiang Province, Hebei Province, Henan Province, Fujian Province, Jilin Province, Sichuan Province, Anhui Province, Hunan Province, Shaanxi Province, Yunnan Province, Shandong Province, and Xinjiang Autonomous Region. In 2020, Guangdong Province and Zhejiang Province were added, involving 42 cities and counties and 126 administrative villages. After removing samples with outliers and missing values, the valid samples are 3,927. The questionnaire mainly includes basic household information, production status, income and expenses, and adoption of agricultural socialized services, involving 344 data indicators. Select the survey data of grain farmers, mainly including farmers planting wheat, rice, and corn. The selection of grain farmers as the research object is mainly based on the following three reasons: first, food security is the important content and basis of the overall national security. As wheat, rice and corn are the three major grain crops, it is of great significance to study the impact of agricultural socialized services on food production; Second, food crops belong to field crops, and agricultural socialized service is the

most widely used, representative and typical. Third, we can better explore and summarize the promotion experience and model from food crops, and promote the introduction of successful experience into other crop varieties.

2.2 Methods

The benchmark regression analysis uses ordinary least squares (OLS) to construct the benchmark regression model.

$$Y_i + \beta_1 Service_i + \beta_2 Controls + \varepsilon_i \quad (1)$$

In Equation 1, the dependent variable Y_i is the farmers' economic income, the core independent variable $Service_i$ is the farmers' adoption of agricultural socialized services, *Controls* is the control variable, β is the coefficient to be estimated, β_0 is the constant term, and ε_i is a random disturbance term.

Whether farmers choose to use agricultural socialized services is affected by their own resource endowments, and there is a sample selectivity bias problem. The propensity score matching method (PSM) can well deal with the sample self-selection problem, and eliminate the effect of selectivity bias by matching individuals with the same endowment conditions. It is divided into the following steps:

The sample farmers were divided into two groups according to whether to adopt agricultural socialized service, in which the farmers who adopted agricultural socialized service were the treatment group and the farmers who did not adopt agricultural socialized service were the control group.

First, a tendency score PS_i is calculated, and the tendency score can be estimated using a Logit model or a Probit model,

$$PS_i = p(X_i) = \Pr[D_i = 1|X_i] \quad (2)$$

In Equation 2, it indicates that farmers use agricultural socialized services, while it indicates that farmers do not use agricultural socialized services, which is a covariate, indicating the probability that farmers use agricultural socialized services.

Use the Logit model to estimate the propensity score:

$$Logit\ (D = 1) = \beta_0 + \beta_j X_i + \delta_i \quad (3)$$

Secondly, matching is performed. The observable variables are controlled by matching samples with the same covariate characteristics, so that the result variables are only affected by the process variables. The selected matching methods are K-nearest neighbor matching, radius matching and kernel matching. Different matching methods are selected to verify the robustness of the results.

The average processing effect (ATT) is then estimated:

$$\begin{aligned} ATT &= E[Y_{1i} - Y_{0i} \mid D_i = 1] = E[Y_{1i} - Y_{0i} \mid D_i = 1,\ p(X_i)] \quad (4) \\ &= E\{E[Y_{1i} \mid D_i = 1,\ p(X_i)] - E[Y_{0i} \mid D_i = 1,\ p(X_i)] \mid D_i = 1\} \end{aligned}$$

In Equation 4, Y_{1i} and Y_{0i} represent the income of farmers who use agricultural socialized services and those who do not, respectively, $p(X_i)$ representing the probability that farmers will use agricultural socialized services, calculated by the logit model. $E[Y_{0i} \mid D_i = 1,\ p(X_i)]$ indicates the economic income of the farmers who use agricultural socialized services when they do not use agricultural socialized services. However, this cannot be known from the observation. This is a counterfactual estimate. Therefore, suppose:

$$E[Y_{0i} \mid D_i = 0,\ p(X_i)] = E[Y_{0i} \mid D_i = 1,\ p(X_i)] \quad (5)$$

2.3 Variable settings

(1) Dependent variables

The explained variable is the economic effect brought by farmers' adoption of agricultural socialized service, which is measured by farmers' agricultural operational income, operating cost, and net operating income. Net operating income is obtained by calculating the difference between farmers' agricultural operational income and operating costs. Amounts are logarithmic to eliminate numerical effects, however, net gains is not logarithmic when they have negative values.

(2) Core independent variable

The core explanatory variable is the adoption of agricultural socialized services, which is assigned to 1 if farmers adopt agricultural socialized services in any production link and 0 if they do not adopt agricultural socialized services in any link.

(3) Control variables

Referring to the related researches, the control variables selected in Li and Li (2019), Tang et al. (2021) and Yang et al. (2022) include the characteristics of farmers and families. The characteristics of farmers include gender, age, education level, health status, technical training, and whether they are party member of the Communist Party of China. The characteristics of families include the number of labor force in the family, whether farming is the main income, whether to join cooperatives, and whether to purchase agricultural insurance.

See Table 1 for the specific variable definition and descriptive statistics.

3 Results

3.1 Regression analysis of benchmark model

After the benchmark regression, the question of whether there is multicollinearity among variables is tested. The results show that the distribution interval of VIF values of variables is [1.01, 1.24],

TABLE 1 Variable definition and descriptive statistics.

Variable	Definition	Average value	Standard deviation
Dependent variables			
Agricultural operational income	Grain income/yuan, logarithmic	11,692.180 (9.122)	17,635.010 (1.313)
Operating cost	Production input cost/yuan, logarithm	2,901.552 (7.149)	4,920.541 (1.202)
Net operating income	The difference between agricultural operational income and operating costs/yuan	2,835.610	15,201.980
Core independent variable			
Agricultural socialized service adoption	1 = adopted, 0 = not adopted	0.816	0.387
Control variables			
Gender	1 = male; 0 = female	0.947	0.224
Age	Actual age/year of head of household	53.965	9.781
Education years	Actual years of schooling of head of household/year	7.501	2.918
Is it party member	1 = party member; 0 = non-party member	0.257	0.437
Health condition	1 = health; 2 = weak and sickly; 3 = chronic diseases; 4 = suffering from serious illness; 5 = disability	1.271	0.773
Agricultural training	1 = receiving technical training; 0 = No technical training	0.312	0.463
Number of workers	Number/Person of household workforce	2.890	2.285
Major source of income	1 = farming as the main source of income; 0 = other	0.798	0.402
Whether to join a cooperative	1 = joining a cooperative; 0 = Not joined in cooperatives	0.476	0.499
Agricultural insurance	1 = purchase of agricultural insurance; 0 = No agricultural insurance purchased	0.557	0.497

The calculation results after taking logarithm are shown in brackets.

and the average VIF value is 1.11, all <10, indicating that there is no multicollinearity among variables.

As shown in the benchmark regression results in Table 2, on the whole, agricultural socialized service has a significant positive impact on farmers' agricultural production operational income, operating costs and net income at the level of 1%, indicating that agricultural service has positive economic benefits for agricultural production and can promote farmers' income.

From the regression results of model (1), agricultural socialized service has a significant positive impact on farmers' agricultural production operational income at the level of 1%, indicating that farmers' adoption of agricultural socialized service can bring about an increase in agricultural production income. Among the control variables, gender has a significant positive impact, indicating that men can obtain higher agricultural income than women, because women are significantly weaker than men in physical strength and labor intensity, and have disadvantages in mechanical work and social communication ability. Age has a significant negative impact on agricultural income, indicating that with the growth of age, the decline in technical level and physical ability affects agricultural production. Agricultural technology, labor force, major sources of income, joining cooperatives, and purchasing agricultural insurance all have significant positive effects on farmers' agricultural income. Farmers trained in agricultural technology can master advanced technology and apply it to agricultural production, thus promoting the improvement of production level. The larger the number of household labor force, the more labor force is put into agricultural production, and the more refined production can be realized. If the family's main source of income is farming, the higher the level of specialization in agricultural production, the more experienced and skilled the farmers will be in agricultural production in order to obtain agricultural income. Farmers joining the cooperatives can obtain economies of scale in the process of purchasing agricultural materials and selling agricultural products, thus achieving the effect of saving money and increasing income. The purchase of agricultural insurance can increase the risk of farmers to resist natural disasters and reduce the economic losses caused by production reduction.

From the regression results of model (2), agricultural socialized service has a significant positive impact on agricultural production and operation costs at 1%, indicating that farmers' adoption of agricultural socialized service will increase production costs. Among the control variables, gender, party member, household labor force, joining cooperatives, taking farming as the main source of income and purchasing agricultural insurance variables will significantly increase the production cost of farmers, while age, length of education, and health status have significant negative impact on operating cost.

From the regression results of model (3), the agricultural socialized service has a significant positive impact on the net income of agricultural production at the level of 1%, indicating that the adoption of agricultural socialized service by farmers can bring about the improvement of agricultural benefits. Among the control variables, age and health status have significant negative

TABLE 2 Benchmark regression results.

Variable	(1) Operational income[a]	(2) Operating costs[a]	(3) Net operating income
Agricultural socialized service adoption	0.520*** (0.108)	0.524*** (0.066)	2,660.996*** (565.371)
Gender	0.448* (0.231)	0.492*** (0.102)	−1,578.294 (3,187.258)
Age	−0.016*** (0.004)	−0.007* (0.004)	−96.721** (40.386)
Education years	0.011 (0.0126)	−0.035*** (0.011)	−126.981 (145.753)
Is it party member	−0.037 (0.085)	0.203*** (0.075)	3,871.410** (1,750.031)
Health condition	−0.084 (0.0511)	−0.062* (0.031)	−669.898*** (208.401)
Agricultural training	0.304*** (0.095)	0.129 (0.087)	1,246.376 (1,261.677)
Number of workers	0.046** (0.022)	0.125*** (0.023)	358.932 (286.054)
Major source of income	0.689*** (0.072)	0.311*** (0.059)	2,470.9487*** (858.551)
Join the cooperative	0.552*** (0.121)	0.279*** (0.104)	1,110.615 (1,354.853)
Agricultural insurance	0.474*** (0.075)	0.404*** (0.06)	−245.676 (803.707)
_cons	7.917*** (0.379)	6.207*** (0.291)	5,693.575 (4,021.831)
Number of obs	1,152	1,410	1,365
Pseudo R^2	0.225	0.155	0.028

*, * *, and * * * are significant at the levels of 10%, 5%, and 1%, respectively, with robust standard errors in parentheses and a in logarithmic form.

TABLE 3 Logit model regression results.

Variable	Coefficient	Robust standard error
Gender	−0.376	0.305
Age	0.012*	0.007
Education years	0.005	0.020
Is it party member	−0.082	0.142
Health condition	−0.240***	0.060
Agricultural training	0.478***	0.172
Number of workers	0.042	0.040
Major source of income	0.412***	0.115
Join the cooperative	0.381*	0.203
Agricultural insurance	0.468***	0.120
_cons	0.870	0.553
Pseudo R^2	0.0379	

*, * *, and * * * are significant at 10%, 5%, and 1%, respectively.

effects, while farmers as party member and families with farming as the main source of income have significant positive effects.

3.2 Propensity score matching

(1) Logistic model estimation results

The Logit model is used to estimate the probability of farmers adopting agricultural socialized services, and the tendency score is obtained. The estimation results of Logit model are shown in Table 3. Age, agricultural technology training, joining cooperatives, and agricultural insurance have significant positive effects on farmers' adoption of agricultural socialized services, while health status has significant negative effects.

(2) Common support domain and balance test

In order to ensure the validity of the PSM estimation, the common support hypothesis test was performed. Taking K-nearest neighbor matching as an example, as shown in Figure 1, the tendency scores of the control group and the processing group overlap in a large range, the sample size outside the common support domain is small, and the vast majority of samples are in the common support domain, indicating that the matching effect is good and the common support hypothesis is satisfied.

The covariates are checked for balance to check whether the matching results better balance the data. The standard deviations of the variables after matching are all reduced to <10%. Comparing the results before matching, the standardized deviations of the variables are all significantly reduced, indicating that the matching effect is good. After matching, the difference of covariates between the control group and the treatment group is eliminated.

In order to test whether the balance of PSM regression results is satisfied, K-nearest neighbor matching is taken as an example to compare the normalized deviation, B-value and R-value before and after variable matching. From Table 4, it can be found that after matching, Pseudo R^2 is significantly reduced to below 0.005, the mean deviation and median deviation are both reduced from above 10% to below 5%, the B-value is also significantly reduced from above 38% to below 17%, and the range of R-value is [0.86, 1.27]. The above index changes indicate that the matching result is good. After matching, the difference of covariates between the processing group and the control group is eliminated, and the data is well balanced.

(3) Estimated average treatment effect (ATT)

In order to eliminate the interference of other relevant characteristics of farmers on the research results, the propensity score matching method (PSM) was used to further verify the robustness of the impact of agricultural socialized services on farmers' income. When estimating the average processing effect (ATT) of agricultural socialized services, three matching methods, namely, K-nearest neighbor matching method, caliper matching

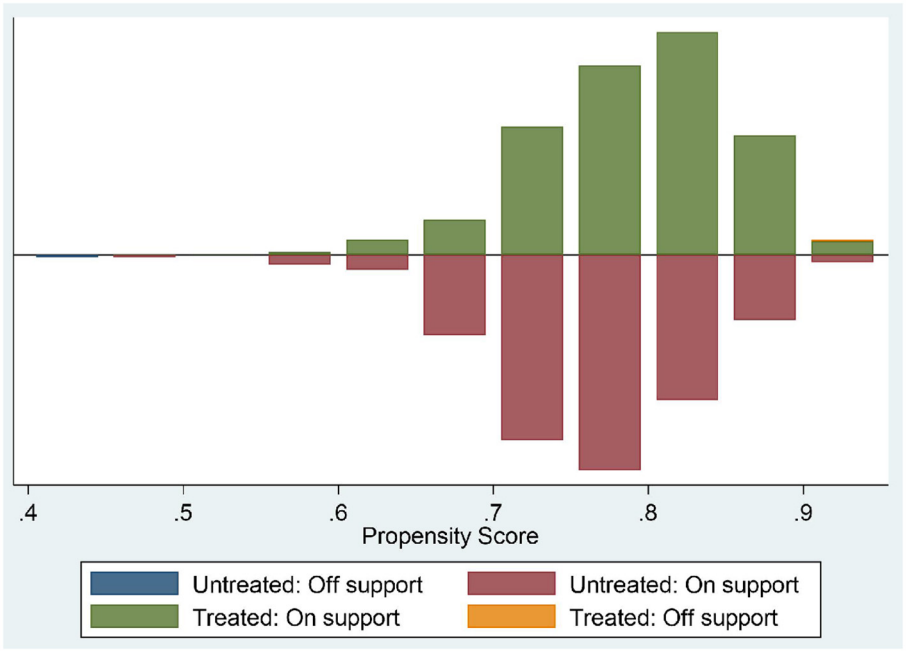

FIGURE 1
Common support domain.

TABLE 4 Test results of covariate balance after matching.

Variable name	Match status	Pseudo R2	LR statistics	*P-value*	Mean deviation	Median deviation	*B-value*	*R-value*
Operational income	Before matching	0.063	46.48	0.000	20.8	18.9	71.0*	1.42
	After matching	0.004	10.9	0.366	Four	2.9	15.6	1.03
Operating cost	Before matching	0.025	36.79	0.000	10.5	12.2	39.5*	1.11
	After matching	0.001	2.03	0.996	1.3	One	6.1	1.27
Net operating income	Before matching	0.025	35.25	0.000	10.3	11.4	39.6*	1.03
	After matching	0.005	14.68	0.144	4.5	3.5	16.6	0.86

*, * *, and * * * are significant at 10%, 5%, and 1%, respectively.

method and kernel matching method, were used to perform regression to test the robustness of the model estimation results. As shown in Table 5, the estimation results of the three matching methods are consistent, the average processing effect is significant at the level of 1%, and the ATT values and significance levels of the corresponding variables in PSM regression are consistent, indicating that the model results have certain reliability. The average level of operational income, operating cost and net income of the farmers group using agricultural socialized services are significantly higher than the average level of the farmers group not using agricultural socialized services.

Farmers who use agricultural socialized services have higher agricultural production operational income than those who do not use agricultural socialized services, while farmers who use agricultural socialized services have higher production costs, indicating that farmers need to pay for agricultural socialized services and spend more on mechanized fuel costs. Compared with farmers who did not use agricultural socialized services, although the use of agricultural socialized services increased production costs, but the net income did not decrease. It is worth noting that the average net income of farmers who do not use agricultural socialized services is negative. After removing various production costs, the income from selling agricultural products is difficult to sustain agricultural production.

3.3 Heterogeneity analysis

According to the difference of the varieties planted by the farmers, the varieties of grain planted by the farmers are paddy, wheat and corn. The regression is carried out according to the kinds of crops to test the income-increasing effect of socialized agricultural services on the farmers' production. The regression results are shown in Table 6. The results showed that from the significance of the regression coefficient, rice farmers and corn farmers increased the farmers' agricultural income after using

TABLE 5 Estimation results of average processing effect.

Variable	Matching method	Processing group average/mean value	Control group average/mean value	ATT	Standard error	T value	Sample size
Operational income	*K-nearest neighbor matching*	8.883	8.338	0.545***	0.141	3.86	1,152
	Radius matching	8.883	8.214	0.668***	0.118	5.67	
	Kernel matching	8.883	8.378	0.505***	0.126	3.99	
Operating cost	*K-nearest neighbor matching*	7.235	6.566	0.669***	0.0734	9.12	1,410
	Radius matching	7.235	6.649	0.587***	0.065	9.03	
	Kernel matching	7.235	6.648	0.587***	0.0676	8.68	
Net operating income	*K-nearest neighbor matching*	2,762.875	−225.965	2,988.840***	553.052	5.40	1,365
	Radius matching	2,762.875	−207.394	2,970.268***	543.094	5.47	
	Kernel matching	2,762.875	−201.132	2,964.007***	545.690	5.43	

*, * *, and * * * are significant at 10%, 5%, and 1%, respectively.

agricultural socialized services, while wheat farmers did not have a significant increase in income after using agricultural socialized services. Judging from the size of the regression coefficient, agricultural socialized service has a greater effect on increasing the income of farmers who plant corn than those who plant rice. From the perspective of the crops' own characteristics, the production process of rice involves multiple complex links such as seedling raising, transplanting, irrigation, and pest control, with each link having high requirements for technology and management, which is difficult for individual farmers to complete efficiently on their own. Corn planting, on the other hand, is highly dependent on large machinery in links like sowing and harvesting, and large-scale operations can significantly reduce costs. Therefore, rice and corn growers have a more urgent demand for agricultural socialized services. When they adopt these services, such as professional seedling raising services and mechanized harvesting services, they can effectively improve production efficiency, thereby bringing about significant income growth. However, the production process of wheat is relatively standardized. Farmers have formed a relatively mature traditional planting model through long-term practice in all links from sowing to harvesting, resulting in a low elasticity of demand for external socialized services. This makes the effect of income increase after adopting the services less significant.

4 Conclusions and policy implications

Based on the micro-survey data of grain farmers, this paper studies the effect of agricultural socialized services on the agricultural income of grain farmers by constructing a benchmark regression model and matching the tendency scores, and compares the group differences among different crops. The research results show that agricultural socialized service can effectively increase farmers' income from agricultural production and operation. However, compared with those farmers who do not use socialized service in agricultural production, the production cost will increase, but the net operating income of farmers who use agricultural service will not decrease. It is worth noting that the average net income of farmers who do not use agricultural socialized services is negative. After removing various production costs, the income from selling agricultural products is difficult to sustain agricultural production. However, this study has certain data limitations, which to some extent constrain the depth and breadth of the empirical analysis. Future research could further refine the analysis by expanding data sources and introducing more rigorous processing methods.

Based on the above conclusions, the following inspirations are drawn: increase the promotion and support of agricultural socialized services. Agricultural socialized service can effectively increase farmers' income from agricultural production and operation. The government should further strengthen the promotion of socialized agricultural services and encourage more grain farmers to adopt socialized services for agricultural production through policy guidance, financial subsidies, technical support, and other means. At the same time, we should establish and improve the agricultural social service system, improve the service quality and service efficiency, to ensure that farmers can truly benefit. Establish access standards for socialized service

TABLE 6 Impact of adoption of agricultural socialized services on farmers' agricultural income under different crop varieties.

Variable	(1) Operational income[a]	(2) Operating costs[a]	(3) Net operating income
Rice			
Agricultural socialized service	0.383** (0.168)	0.233*** (0.078)	1,472.590*** (472.316)
Control variable	Controlled	Controlled	Controlled
_cons	7.632*** (0.867)	5.908*** (0.372)	2,245.779 (2,961.015)
R^2	0.351	0.136	0.125
Wheat			
Agricultural socialized service	−0.176 (0.175)	0.016 (0.953)	2,382.176 (3,820.491)
Control variable	Controlled	Controlled	Controlled
_cons	8.526*** (0.482)	7.509*** (0.694)	18,540.660 (27,335.320)
R^2	0.166	0.089	0.091
Corn			
Agricultural socialized service	0.854*** (0.220)	0.779*** (0.137)	3,486.302** (1,427.201)
Control variable	Controlled	Controlled	Controlled
_cons	8.172*** (0.772)	5.839*** (0.566)	6,903.582 (5,380.005)
R^2	0.323	0.342	0.046

*, * *, and * * * are significant at the levels of 10%, 5%, and 1% respectively, the figures in brackets are robust standard errors, and a is in logarithmic form.

providers at the county level, mandate service contracts to specify work quality, cost composition and liability for breach of contract, and conduct quarterly evaluation of farmers' satisfaction based on village service stations. Build a provincial agricultural socialized service platform to realize real-time docking of service supply and demand information, and require service organizations to publicize service items, charging standards and performance commitments on the platform. To reduce production costs and improve the competitiveness of grain farmers. Although the net operating income of farmers using agricultural socialized service did not decrease, the production cost of farmers using agricultural socialized service increased compared with that of farmers not using agricultural socialized service. This shows that reducing production costs is the key to improving the competitiveness of grain farmers. The government should provide agricultural technology training and guidance, promote advanced agricultural production technology and equipment, and improve the efficiency of agricultural production; At the same time, strengthen the construction of agricultural products market system, promote the circulation and sale of agricultural products, reduce the cost of sales of agricultural products. Specific measures include conducting "field school" training programs, which offer targeted training on topics such as reducing fertilizer use while enhancing efficiency and water-saving irrigation for users of socialized agricultural services, thereby lowering the per-mu cost of production inputs. Additionally, we will establish agricultural product distribution centers at the township level and promote a contract farming model featuring the collaboration of "service organizations + cooperatives," aiming to reduce sales costs through centralized transportation. In addition, tax relief, and credit support can be considered to reduce the economic burden of grain farmers and improve their production enthusiasm and market competitiveness.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the [patients/ participants OR patients/participants legal guardian/next of kin] was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

JW: Conceptualization, Data curation, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. JL: Project administration, Resources, Funding acquisition, Writing – review & editing. HZ: Conceptualization, Data curation, Project administration, Resources, Visualization, Writing – review & editing. LS: Project administration, Resources, Supervision, Writing – review & editing. XH: Formal analysis, Funding acquisition, Project administration, Resources, Validation, Visualization, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. The project was supported by Major Project of National Social Science Foundation (24ZDA055), the key project of "Basic Research Support Program for Excellent Young Teachers" in provincial universities in Heilongjiang Province (YQJH2025213), and Heilongjiang University of Science and Technology introduced high-level talents to start scientific research fund projects (HKDADJ202541).

Conflict of interest

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

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