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# Farmer participation in cooperatives enhances productive services in village collectives: a subjective evaluation approach

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**Introduction:** Provision of agricultural productive services to farmers is crucial for integrating them into the modern agricultural system. However, small-scale farmers often face difficulties in accessing these services. One internationally recognized approach to addressing this issue is the government-led provision of productive services to small-scale farmers. In China, production services are provided through village collectives, which are economic organizations established in townships and villages to manage collective assets, develop resources and economy, and provide services to members. Farmer participation in these services can enhance inclusive service dynamics, improving access to services and promoting rural equity.

**Methods:** Farmers' subjective evaluations directly reflect their access to collective agricultural productive services. This study utilized a binary logit model to analyze the impact and mechanism of farmer participation in cooperatives on the collective supply of agricultural productive services. The study involved 3,900 farmers from 29 provinces (autonomous regions and municipalities) in China.

**Results and discussion:** This study proposes for the first time a "cooperative+collective" model for the provision of productive services. In China, safeguarding social equity is one of the important objectives of the Government, and safeguarding and supporting the interests of small-scale farmers is crucial to safeguarding social equity. Participation in cooperatives increased farmers' access to agricultural productive services. The analysis revealed that farmers have significantly increased their level of access to agricultural production services through participation in the "cooperative+collective" model of productive services. Farmers have participation in cooperatives helped integrate and expand farmers' demand, leading to the continuous operation and expansion of business scale, thereby enhancing the collective supply of agricultural productive services. Furthermore, those income low-income, older farmers derived more benefits from participating in cooperatives in terms of accessing these services. This study offers empirical evidence supporting the effectiveness of collective agricultural services.

## KEYWORDS

food safety, cooperative, productive service, collective, demand

## 1 Introduction

The long-term domination of agricultural business entities by small-scale farmers is a fundamental national condition in China. According to the third agricultural census data in China, small-scale farmers account for more than 98% of agricultural management entities, and small-scale farmer employees account for 90% of agricultural employees. Cultivated land operated by small-scale farmers accounts for 70% of the total cultivated land area. An important method to modernize China's agriculture is to incorporate small-scale farmers into the development track of modern agriculture through agricultural productive services, allowing them to share the benefits of modern agricultural development.

However, the reality is different from what was expected. Small-scale farmers struggle to access cost-effective agricultural productive services due to their small and scattered plots (Shen et al., 2021). The supply entities for agricultural productive services in China include market-oriented service entities that provide services related to agricultural production to farmers through market behavior; new agricultural management entities with larger scale of operation, more production inputs, advanced business methods, and higher management level; and collectives, also known as village collectives, which are rural economic organizations established in villagers' groups, administrative villages, townships, and other communities under the jurisdiction of the people's governments of townships and villages. Collectives manage collective assets, develop collective resources and economy, provide services to members, and undertake certain collective public and social functions. China had 890,000 social agricultural service organizations of various types in 2020 (Zhang and Hu, 2021). Market-oriented service entities mainly target those engaged in large-scale operations rather than small farmers (Jiang, 2018). Because their behavior is based on profitability. This results in small and dispersed farmers facing challenges in accessing agricultural productive services. Developed countries like those in Europe and North America enhance the accessibility of agricultural productive services by offering public welfare to farmers. Thus, when addressing market failures in agricultural productive services, China has focused on the collective supply of agricultural productive services with public welfare attributes.

Collectives also known as farmers' cooperatives, they are mutual economic organizations that are voluntarily united and democratically managed by operators of agricultural products of the same type, or by providers and users of agricultural production and management services of the same type. Have long been important providers of agricultural services in China. Between 1953 and 1977, collectives were both landowners and operators responsible for providing unified production services, such as means of production. Agriculture is based on production teams and strictly follows national production plans. All means of production, labor, and production technology are centrally managed and distributed by the collective. All production and construction, such as industry, agriculture, forestry, animal husbandry, and fishing, are operated collectively. After the reform and opening up, a dual-level management system was established based on family management, combining centralized and decentralized management. The collective, as a unified party, was responsible for agricultural production and operation and compensated for the limitations of household management, providing

public welfare and inclusive services for farmers. The collective has long been a natural supplier of agricultural productive services for farmers and first channel for seeking help when facing difficulties. Collective service capacity has been driven by external factors from the government. However, due to the adjustment of national strategies and implementation of the household contract responsibility system, the government's support for the collective in terms of personnel and financing has significantly decreased, resulting in the weakening of collective capacity and various problems, such as insufficient public products in rural areas. In this context, collectives that lost both external and internal driving forces have caused a dilemma in the supply of agricultural productive services. To solve this dilemma, collectives' endogenous motivation must be stimulated.

Supply creates demand, which drives supply. From the perspective of economic activities, the supply of agricultural productive services is essential for meeting farmers' needs. Matching the supply and demand can significantly improve the efficiency of agricultural production. Moreover, farmers' needs are an important source of stimulating collective endogenous motivation. Farmers, particularly in the unique institutional context of China, can be participants and supervisors in collective decision-making and can play a role in meeting their needs. However, farmers have long been passive recipients in the supply system of agricultural productive services. The reasons for this phenomenon are multifaceted, ranging from concerns about the high transaction costs of dispersed farmer participation to the paradox of collective action among small farmers. The main problem for farmer participation is the lack of appropriate organizational support. An important way of improving farmers' organization is through professional farmer cooperatives (hereinafter referred to as cooperatives). Farmers' participation in cooperatives can reduce the transaction costs for farmer participation and help alleviate the collective action dilemma. Previous studies have focused on the role of cooperatives in providing agricultural productive services (Pan, 2021). However, existing research has not considered cooperatives as organizations on the demand side of agricultural production services and their role in collectively providing agricultural productive services. Consequently, the following questions remain unanswered: Since the collective provision of appropriate agricultural services to farmers is essential to helping them in their agricultural production, how should the impetus for the collective provision of agricultural services to farmers be activated? Is it feasible to activate the driving force of farmers' demand on collective supply through appropriate forms of organization? Addressing the above questions can provide useful insights for improving farmers' access to agricultural services and promoting the efficiency of agricultural production.

Farmers' subjective evaluation of the collective supply of productive services directly reflects the situation in which they obtain a collective supply of productive services. Therefore, this study theoretically and empirically examines the impact and mechanism of farmers' participation in cooperatives on the collective supply of agricultural productive services based on farmers' subjective evaluations. This study aims to provide a foundation for improving the accessibility of agricultural productive services for small farmers and promoting organic connections between small farmers and modern agriculture.

## 2 Literature review

### 2.1 Supply of agricultural productive services

Agricultural productive services refer to high-quality, efficient, comprehensive, and supportive public welfare and operational services for agriculture before, during, and after production. Adoption of new technologies can improve the efficiency of agricultural production and increase the profitability of farmers. In China, suppliers of agricultural productive services include production service providers, new agricultural operators, and collectives. New agricultural management entities are not only recipients of agricultural production services but also have certain service capabilities due to their large scale, with some becoming suppliers (Li et al., 2021). New agricultural management entities include enterprises and cooperatives. A production linkage mechanism has been established between new agricultural management entities and farmers. The “enterprises+farmers” model integrates the dispersed needs of farmers through the order between enterprises and farmers. The “cooperative+farmer” model integrates dispersed farmers through cooperatives and provides services to them. Providing services to farmers is not the main business project of new business entities. These entities establish various models of interest linkages between new agricultural business entities and farmers, and the beneficiaries are mainly the new entities rather than farmers. In this type of model, new agricultural operators mainly provide services to participating farmers. Low-income and small-scale farmers struggle to obtain services from new agricultural management entities (Huang, 2012). Moreover, issues of alienation exist in productive service systems. Entities engaged in scale operations collude with scale service organizations to capture public resources and obtain financial subsidies. Family farms use government subsidies to pay production custody costs. Hosting service organizations are limited by high service search and transaction costs associated with connecting with small farmers and are unwilling to provide productive services to dispersed small farmers (Shen et al., 2021).

The service targets of productive agricultural service providers are mainly large-scale operating entities, such as large households, family farms, and leading enterprises (Jiang, 2018). Small-scale farmers find it difficult to connect with large-scale socialized service entities (Cai and Liu, 2018). Most farmers purchase services from individual agricultural machinery operators (Kong et al., 2009). Individual operators have weak service capabilities, poor risk resistance, and limited services. These difficulties cause farmers with lower education levels and income and those farther away from the township governments to face significant difficulties in accessing socialized (market-oriented) and agricultural productive services (Li and Jiang, 2015).

To address the failure of the productive agricultural service market, some scholars advocate strengthening government functions, such as the construction of public welfare entities, including agricultural technology and input service stations. However, these organizations lack capacity due to various issues, such as funding, workforce, and governance (He, 2012). Some scholars believe that agricultural productive services should be provided by collectives, which have the discourse power and overall planning ability that small farmers lack (Zhang et al., 2019), can compensate for the limitations

of family management (Sun, 2017), and are a bridge between small farmers and modern agriculture (Chen and Feng, 2019). These scholars advocate innovating the connotation of the basic management system (Wang and Cao, 2022), thereby allowing the collective to effectively serve farmers with the help of socialized entities (Guan, 2020). Nevertheless, some scholars note the limitations of collective supply. Since the reform and opening up, the function of collective transportation of agricultural surplus to industry has gradually been stripped away, and financial and organizational capabilities of collectives have declined, resulting in decreased abilities of unified collective management in the dual-tier management system (Tu and Li, 2003). The significant weakening of collective functions without external support causes a series of problems, such as insufficient rural public goods and a lack of inclusive agricultural productive services. Collectively restoring these functions requires strengthening service capabilities and improving governance systems, which necessitates long-term efforts. Improving the accessibility of agricultural productive services for small-scale farmers requires new ideas.

### 2.2 Agricultural productive service demand of farmers and cooperative organization

Farmers require agricultural productive services to improve the efficiency of household operations or reduce production costs. Utilizing agricultural productive services promotes the transfer of household resource factors to non-agricultural fields, liberates the household labor force (Xu et al., 2022), optimizes the allocation of the labor force in rural households, and helps improve household management efficiency. The adoption of high-quality seeds, fertilizers, and new technologies can also help improve farmers' production efficiency. Due to the rapid urbanization and industrialization in China, many young and middle-aged laborers have relocated to urban areas for work, resulting in an aging and part-time rural labor force and an increase in agricultural labor costs. This also increases the demand for machinery to replace labor and service outsourcing (Li and Zhong, 2020). Consequently, weak agricultural labor requires external forces, namely agricultural productive services, in agricultural operations (Hu and Zhong, 2012). Valuing the intrinsic needs of farmers is also a key focus in the construction of productive agricultural service systems (Pang, 2006).

Although the needs of farmers have been valued in productive agricultural service systems, the problem of supply–demand imbalance remains. Some scholars believe that this problem is created by government management. Due to the diversification of interests caused by the supply of multiple entities in the productive service system, government role and functions are unclear, and a contradiction exists between government leadership and farmer-centeredness (Li et al., 2013). Furthermore, some scholars believe that this is a problem with the operational mechanism, in which complementary and interconnected service resources are hindered. Diversified service providers have poor coordination among different departments, and their respective service systems have been established, which is not conducive to the supply of agricultural productive services (Li, 2011). Some scholars believe that acquaintance societies in rural areas have formed relatively closed and exclusive regional service markets, creating structural barriers to the supply of external services (Li and Zhong, 2020). The differentiation of farmers and diversification of

agricultural formats and service providers have increased the difficulty of supplying agricultural productive services, resulting in a supply and demand imbalance (Liu and Cheng, 2021). Scholars believe that the decentralization of small farmers has made it difficult for the service supply to meet fragmented and scattered service needs (Sun, 2017), lacking appropriate supporting organizations. Small farmers must choose different service providers for different production processes and face high transaction costs. Scholars propose that organized small-scale farmer demand can improve the technical efficiency of accessing agricultural productive services (Xu et al., 2022) and achieve de-departmentalization through farmer organization and cooperation (Tong, 2016). This breaks down barriers to coordination between productive agricultural service entities. Among them, cooperatives are the main carriers of farmer organizations (Mu and Kong, 2019).

Thus, studies have examined the supply and demand of agricultural productive services. However, existing research has limitations. First, while previous studies on the supply of productive services have demonstrated the role of collectives in providing productive services, they have overlooked the limitations of collectives in subjective willingness and motivation. A supply system that relies solely on policy support is unsustainable; thus, the collective supply of agricultural productive services driven by demand must be explored. Second, previous studies have revealed the role of farmer demand in productive agricultural service systems. Farmers are the main recipients of productive services and have a traction effect on the supply of productive services. However, existing research on collective and socialized supply considers farmers passive recipients of services, ignoring their subjectivity in the supply of agricultural productive services. Third, research on farmers' participation in the supply of agricultural productive services is lacking. Although previous studies have discussed the possibility of using cooperatives as providers of productive services, most existing cooperatives have relatively single functions and low service levels, making it difficult to meet the production needs of farmers. Cooperatives are voluntary organizations for small farmers and can become effective support organizations for farmers to participate in the supply system of agricultural productive services, integrating their fragmented service needs. Combined with the collective supply of productive services, obtaining agricultural productive services is beneficial for farmers, especially weak farmers excluded from the market. Therefore, this study analyzes farmers' subjective evaluations of collective services, explores the impact of farmer participation in cooperatives on the collective supply of agricultural productive services, and investigates its mechanism of action.

## 3 Theoretical analyses

### 3.1 Advantages of the collective supply of agricultural productive services

A proportion of small-scale, family-run farmers have difficulty accessing services related to agricultural production, which constitutes a market failure. Utilizing collectives to provide agricultural productive services to small-scale farmers is an important method to compensate for the market failure of productive services. Developed countries such as Europe and America have government-led or participatory public welfare agricultural service systems that provide

corresponding services for agriculture (Lu and Han, 2023). In China, the suppliers of public welfare agricultural service systems are primarily collectives. In the basic rural management system, collectives compensate for market failures, ensure the status of family operations, and help farmers resolve public affairs that cannot be handled by individual households, including providing agricultural productive services for farmers. Collectives have the dual agent status of government and farmers and have certain advantages in coordinating service subjects and organizing farmers. The social characteristics of acquaintances in rural areas may lead to soft barriers from regions, languages, and other aspects of non-local productive agricultural service providers (Li and Zhong, 2020). Collectives are internal organizations in rural communities and likely to gain recognition and acceptance from farmers in the community.

China's reform and opening up refers to a series of policies of internal reform and opening up to the outside world that have been implemented in China since 1978, leading to a great increase in the welfare of the Chinese people. However, in the early stages of the reform and opening up, with the adjustment of the national strategy, collective financial and organizational capacity sharply declined. Thus, the collective supply of agricultural productive services was restricted and insufficient. The collective supply of agricultural productive services, which has lost the support of external forces, is difficult to sustain. Demand drives supply, which creates demand. The collective supply of agricultural productive services based on government wishes, driven by the demand of farmers, lacks long-term sustainability.

### 3.2 Cooperatives and the collective supply of productive services

Farmers play an important role in the modernization of agriculture and rural areas. Farmers have a dual identity in the productive agricultural service system, which provides them with the opportunity to participate in the supply of agricultural productive services. On one hand, farmers with collective membership can participate in collective decision-making. The collective's wishes are determined jointly by its members. In matters such as land contracting and land adjustment, collective members are required to make joint decisions, and the collective is subject to the supervision of its members. On the other hand, farmers demand agricultural productive services. Demand induces supply, and supply creates demand, which is the basic law of economic operations. From the perspective of supply and demand, farmers demand productive services. The expansion of demand is the main driving force for the development of agricultural productive services (Lu and Han, 2023) and leading force for matching supply and demand.

Although farmers' main role is important, their participation faces multiple challenges. First, collectives face high transaction costs and must consider the needs of different farmers in a coordinated manner, which reduces their efficiency. Second, farmers' demand for agricultural productive services is small and fragmented, and differences in planting structures and methods result in significant differences in the time and type of demand for agricultural productive services. This undoubtedly increases supply costs. Third, based on the production and transaction characteristics of agriculture, generating economies of scale under small-scale decentralized management is difficult. The long agricultural production cycle and difference in the



required labor force at different stages hinder the division of the labor economy, which is not conducive to the development of productive agricultural service markets. Even if farmers play a leading role in the productive service industry, they face many difficulties. Public welfare government service departments and operational market service entities face difficulties in connecting with small and scattered farmers. Although dispersed farmers may spontaneously integrate, connecting with service providers hinders achieving large-scale services. Moreover, due to their low negotiating status, they are easily overlooked by public service departments and exploited by operational service providers.

Cooperatives provide solutions to high transaction costs and difficulties in meeting diversified demands in the supply of productive services for farmers (Pan, 2021). Cooperatives are formed through voluntary connections among farmers and are one of the main forms of farmer organization. They are used to solve the economic and social problems that socialized large-scale production causes for small farmers, such as bankruptcy, career, and poverty. Cooperatives can reduce information asymmetry and lower transaction and supervision costs, thereby improving agricultural management efficiency and profits. Cooperatives coordinate and organize dispersed small farmers, reduce transaction costs for farmers to participate in the supply of productive services, and improve their market position. Moreover, through large-scale and contiguous management, cooperatives concentrate the fragmented and scattered demand for agricultural productive services, reduce the spatiotemporal gap in productive agricultural service demand caused by planting structure and technology, and decrease the difficulty and cost of the collective supply of productive services. This is an effective organizational form to leverage the traction role of farmer demand in the supply of productive services.

### 3.3 Mechanism analysis: farmer participation in cooperatives, contiguous management, and collective supply of agricultural productive services

Continuous management can coordinate the planting structure in a region, alleviate fragmented service demands caused by differences in crop production times and processes under household management models, and form a sufficient service market with a unified service time and the same service type. This promotes the healthy development of agricultural productive services (Luo, 2017). Contiguous management can unify the planting structure between adjacent plots and time of provision of agricultural machinery and materials, thereby improving the efficiency of machinery use. Furthermore, continuous operations can expand the market capacity within the region and lay the foundation for the development of productive agricultural service markets. Contiguous management can organize and coordinate farmers' productive agricultural service needs and reduce the difficulty and cost of the collective supply of agricultural productive services. With the unification of crop cultivation, collectives must provide professional and targeted agricultural productive services. The types of services and difficulty of supply decrease, effectively alleviating the problem of insufficiently diversified service capabilities provided by collectives. Moreover, the traction effect of demand endows collectives with endogenous power

to supply agricultural productive services. Accurately matching the needs of farmers improves supply efficiency, enabling collectives to continuously and effectively supply agricultural productive services.

Cooperatives promote the continuous operation of agriculture, and cooperative societies choose appropriate crop management based on the market and local conditions. They prompt farmers to make changes through services and technical training in various aspects, such as pre-, mid-, and post-production, thereby achieving large-scale operations and regional agglomeration of the agricultural industry. The characteristic operations of cooperatives and establishment of geographical brands for agricultural products have prompted farmers to plant similar crops. The implementation of integrated management facilitates the coordinated supply of agricultural productive services in time and space, reducing costs and increasing efficiency of agricultural productive services.

### 3.4 Mechanism analysis: cooperative participation, business scale, and collective supply of agricultural productive services

China's agricultural practices are primarily based on family management, farmers cultivating small plots of land. With land scale expansion and inability of family labor to meet the needs of agricultural production, demand for hired labor management arises. In other words, under market economy conditions, demand for agricultural productive services arises when farmers shift from self-sufficient small-scale farming to commercialized production. In the process of transitioning to commercialized production, farmers expand their production and operation scale, and the seasonal nature of agricultural production causes a structural contradiction between surplus and shortage of agricultural labor time. This contradiction endogenously leads to the employment and operation of farmers and development of the agricultural labor factor market (Luo, 2017). The expansion of business scale significantly increases the demand for agricultural productive services among farmers (Peng and Wu, 2019). The expansion of land management scale formed by the transfer of land from farmers promotes demand for socialized agricultural services. The expansion of business scale indicates that the production purpose of farmers has shifted from self-sufficiency to profitability. From the perspective of reducing labor costs, considering significant rural labor outflow and a rapid increase in labor prices, replacing labor with machinery is undoubtedly suitable for reducing labor costs. From the perspective of improving production efficiency, adopting modern science and technology, improving the level of facilities and equipment, and introducing industrialized production methods for standardized production can reduce production costs and achieve higher production efficiency (Han et al., 2019). Demand for new technologies and agricultural machinery to improve production efficiency has increased. The effective demand of farmers endows them with endogenous motivation to participate in the collective supply of agricultural productive services, thereby unleashing the traction effect of demand on the collective supply of agricultural productive services.

Cooperatives are an important operating entity in the process of agricultural transformation and can lead farmers to adopt new agricultural technologies, transform production methods, promote land circulation, expand business scale, and improve

income and efficiency through stable sales channels, saving production costs, and providing credit support (Abate et al., 2014; Li and Lu, 2022; Ma and Abdulai, 2019; Zhou et al., 2019). The participation of farmers in cooperatives can significantly promote land transfer and expand their production and operational scales (Li and Lu, 2022). Farmers expand their production scales by participating in cooperatives, thereby increasing endogenous demand and driving a collective supply of agricultural productive services.

## 4 Methodology

### 4.1 Data sources

This study uses 2021 survey data on inclusive finance, agriculture, and farmers in rural areas collected by South China Agricultural University and Southwestern University of Finance and Economics and data from the China Household Finance Survey South China Agriculture University (CHFS-SCAU) collected by Southwestern University of Finance and Economics. Data are sampled using a three-stage stratified PPS sampling method. In the first stage, the stratified population scale proportional probability (PPS) method is used to randomly select districts and counties. In the second stage, communities are selected in selected districts and counties. In the third stage, households are randomly selected in communities. The survey samples for 2021 cover 29 provinces (autonomous regions and municipalities directly under the Central Government) nationwide, and the samples are nationally representative. The sample size is 22,027 households, including 8,154 households. After processing the missing variable values, 4,181 households are included in the final analysis.

### 4.2 Variable selection

#### 4.2.1 Dependent variable and core explanatory variables

Subjective evaluations of the farmers participating in the collective provision of productive agricultural service constitute the dependent variable. This variable uses a single measurement question item. The respondents were asked whether village collectives effectively provide agricultural services, such as purchasing agricultural materials, technical advice, selling agricultural products, and financing. This indicator reflects village collectives' performance in providing agricultural productive services. Objective indicators may not be able to measure the collective services received by farm households. The types of services provided to farmers in the same collective are fixed; however, differences exist in the services received by farmers according to their needs and availability. As consumers of agricultural production services, evaluating the production services provided by a collective directly reflects farmers' opinions and collectives' provision of services (Zhu et al., 2011). Traditional village-level data reflect only supply and cannot accurately reflect demand. Therefore, this study examines the collective supply of productive services based on a subjective evaluation of farmers' demand.

The core explanatory variable is farmers' participation in cooperatives, assigned a value of "1" for "yes," and "0" for "no".

#### 4.2.2 Mediating variables

The mediating variables are fragmentation and business scale. Serialized management, which cannot be directly measured, is regarded as the opposite of fragmentation. Degree of fragmentation is measured as the number of plots divided by cultivated land area; thus, this study measures serialized management as cultivated land area/number of plots.

#### 4.2.3 Control variables

The control variables are village, farm business, and farm household characteristics. These indicate whether or not a farmer participates in a cooperative.

##### 4.2.3.1 Village characteristics

The cultivated area of the village reflects village size. Farmers in larger villages are more difficult to coordinate. Financial services and stability of agricultural land rights are also measured. Stable property rights facilitate land transfer (Qiu et al., 2020).

##### 4.2.3.2 Characteristics of farmers' operations

Types of crops grown are examined, as crop types have different demands for productive services, which may affect the collective supply of agricultural productive services.

##### 4.2.3.3 Characteristics of farm households

Individual characteristics of farm households include the household head's gender, physical condition, and education.

### 4.3 Econometric model

The binary dependent variable is the collective supply of agricultural productive services. Therefore, this study uses the binary logit model as the benchmark for the empirical analysis. The regression equation is as Equation 1:

$$P(Y = 1 | X) = \Lambda(\beta_1 X_1 + \beta_2 \text{controls} + \varepsilon) \quad (1)$$

where Y is the dependent variable; X is the core independent variable; controls are the control variables, such as village and farmers' characteristics;  $\varepsilon$  is a random error term; P is the probability of Y = 1;  $\Lambda(\cdot)$  is the cumulative distribution function that obeys the logistic distribution; and  $\hat{\beta}_1$  and  $\hat{\beta}_2$  denote the parameters of the model to be estimated.

This model tests the relationship between farmers' participation in cooperatives and agricultural productive services. To determine the mechanism of action, this study constructs the following equation. The intermediary variable M represents the scale of the integrated operation or business, which is a continuous variable; therefore, this study chooses the ordinary least squares (OLS) model estimator in Equation 2. As the dependent variable is binary, this study uses the binary logit model estimator in Equation 3 as the benchmark regression model. The mediating effect test model is as follows:

$$M = \gamma_0 + \gamma_1 X + \gamma_2 \text{controls} + \varepsilon_M \tag{2}$$

$$Y = \alpha_0 + \alpha_1 M + \alpha_2 \text{controls} + \varepsilon_Y \tag{3}$$

where Y is the dependent variable; X is the core independent variable; M is the mediating variable; controls is the control variable;  $\hat{\alpha}_M$ ,  $\hat{\alpha}_Y$ , and  $\hat{\alpha}_Y$  are model error terms; and  $\hat{\alpha}$ ,  $\hat{\alpha}$ , and  $\hat{\alpha}$  are the proxy estimation parameters.

## 5 Results

### 5.1 Baseline model

This study uses Stata 16.0 in its empirical analysis. As shown in Table 1, farmers’ participation in cooperatives has a significant positive impact on the collective supply of agricultural productive services ( $p < 0.01$ ). The probability of farmers in cooperatives achieving a better collective supply of agricultural productive services is 14% higher than the baseline. This result indicates that farmers’ participation in cooperatives effectively promotes the collective supply of agricultural productive services.

### 5.2 Robustness tests

To test the robustness of the measurement results, this study switches the measurement model from binary logit regression to OLS and increase the number of control variables. As shown in Table 1, 27 virtual variables of the provinces are set; however, the results are not reported due to space constraints. The binary logit method is used to estimate the models controlling for the impact of regions and provinces. As shown in Table 1, after replacing the econometric

model, farmers’ participation in cooperatives still has a significant positive impact on the collective supply of agricultural productive services ( $p < 0.05$ ). After controlling for provincial dummy variables, the positive significant impact and significance level of farmers’ cooperatives did not significantly change. Thus, the results are robust.

### 5.3 Endogenous treatment

The more agricultural productive services provided by a collective to farmers, the better the quality of the services provided, the better the basis for the development of cooperatives within the same collective, and the greater the likelihood that the demonstration effect will lead to an increase in the number of farmers joining the cooperatives. Therefore, there may be a reverse causality endogeneity problem between farmers’ participation in cooperatives and productive agricultural services. Since the collective provision of agricultural productive services to farmers is a complex economic issue that is subject to data constraints, there are limited variables that can be included in the empirical model. Thus, there may also be an estimation bias caused by omitted variables.

The instrumental variable method and extended regression model (ERM) are chosen to deal with the possible endogeneity problems and ensure the robustness of the results. The instrumental variables approach can address a wide range of possible endogeneity problems, and the ERM can handle multiple endogeneity problems concurrently and is applicable to continuous, restricted, binary and ordered dependent variables. Since the peer effect results in the economic behavior of individuals being influenced by the characteristics of the group they belong to Liu and Yuan (2020), the participation rate of cooperatives in the village is selected as an instrumental variable for whether farmers join cooperatives or not.

Given that the dependent variable “collective agricultural productive service supply” is a dichotomous choice variable, it is

TABLE 1 Estimated results of cooperative participation in the evaluation of agricultural productive services of farmers’ village collectives.

Variables	Results of the estimation of the baseline model			Robustness tests	
	Estimated coefficients	Marginal effects	Odds ratio ( $\exp(\hat{\beta}_j)$ )	Replacement of estimation methods	Controlling for provincial variables
	(1)	(2)	(3)	(4)	(5)
Farmers’ participation in cooperatives	0.650*** (0.116)	0.131***	1.140	0.148*** (0.028)	0.601*** (0.119)
Type of crop grown	-0.033 (0.103)	-0.007	0.993	-0.007 (0.022)	-0.044 (0.110)
Area of cultivated land in villages	-0.157* (0.087)	-0.032*	0.969	-0.031* (0.017)	0.105 (0.113)
Number of village financial service outlets	0.134*** (0.038)	0.027***	1.027	0.028*** (0.008)	0.091** (0.041)
Whether or not the right is established	0.037 (0.153)	0.008	1.008	0.007 (0.030)	0.147 (0.161)
Gender	0.098 (0.096)	0.020	1.020	0.016 (0.018)	0.064 (0.097)
Physical condition	-0.124*** (0.034)	-0.025***	0.975	-0.025*** (0.007)	-0.124*** (0.034)
Educational level	0.211*** (0.036)	0.043***	1.044	0.044*** (0.008)	0.218*** (0.037)
Province dummy variables	-	-	-	-	Controlled
CONS	-1.140*** (0.256)	-	-	-0.215*** (0.045)	-1.496*** (0.575)
R <sup>2</sup>	0.024	-	-	0.030	0.034
N	4,181	-	-	4,181	4,180

\* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ . Numbers in parentheses indicate standard errors.

assigned a value of 1 if the collective performs better at “providing services for farming (such as the purchase of agricultural materials, technical advice, sales of agricultural products, financing, etc.)” Therefore, this study chooses the endogenous probit model (Eprobit) for empirical analysis. The constructed model is as follows:

$$Probit(P_i) = \ln \frac{P(Y_i = 1)}{1 - P(Y_i = 1)} = \alpha_0 + \alpha_1 Cooperative_i + \alpha_{2n} Controls_i \tag{4}$$

$P_i$  denotes the probability of collective agricultural productive service supply enhancement;  $Y_i$  represents the dependent variable collective agricultural productive service supply;  $Cooperative_i$  denotes the core independent variable (farmers’ participation in cooperatives); and  $Controls_i$  denotes the control variables such as village characteristics and farmers’ characteristics.  $\alpha_0$  is a constant term;  $\alpha_1$  and  $\alpha_{2n}$  both denote the parameters of the model to be estimated.

The estimation results of the ERM model are shown in columns (1) and (2) of Table 2. Column (1) presents the estimation results with the inclusion of only the core explanatory variable (farmer participation in cooperatives), while column (2) presents the estimation results with the addition of other control variables. The correlation coefficients of the error terms in columns (1) and (2) in Table 2 indicate endogeneity in the baseline model ( $p < 0.01$ ). The endogenous variable regression results, which are only reported for the error correlation coefficients due to space constraints, show that there is a significant correlation between the instrumental variables and the endogenous variables ( $p < 0.01$ ). This suggests that the instrumental variables do not suffer from a weak instrumental variable problem. Based on the estimation results, farmers’ participation in cooperatives significantly contributes to the collective supply of agricultural productive services.

Column (3) of Table 2 shows the estimation results of the instrumental variable method. The result of Wald test for the original hypothesis of exogeneity shows  $p = 0.082$ , indicating that farmers’

participation in cooperatives is an endogenous variable. Based on the results in Table 2, the effect of farmers’ participation in cooperatives on the supply of collective agricultural productive services is still positive and significant ( $p < 0.01$ ) when endogeneity is addressed.

Table 2 confirms that the participation of farmers in cooperatives has a significant positive effect on the supply of collective agricultural productive services ( $p < 0.01$ ). This suggests that after dealing with possible endogeneity problems, farm households are able to significantly contribute to the provision of collective agricultural productive services when organized through cooperatives.

### 5.4 Mechanism testing

As shown in Table 3, farmers’ participation in cooperatives significantly promotes the collective supply of agricultural productive services and integrated management, improving the collective supply of agricultural productive services. Furthermore, the Sobel test shows that the Z-statistic is 1.719, which is significant ( $p < 0.1$ ). This indicates that farmers’ participation in cooperatives promotes the collective supply of agricultural productive services through integrated management. Continuous operations due to cooperative participation facilitate the collective supply of agricultural productive services and reduce temporal and spatial differences and cost of agricultural productive services.

Cooperative participation significantly improves the scale of farmers’ businesses, which is significant ( $p < 0.01$ ). The business scale has a significant positive impact on the collective supply of agricultural productive services. Furthermore, the Sobel test shows that the Z-statistic is 1.983, which is significant ( $p < 0.05$ ). Thus, cooperative participation significantly increases the scale of operations, increasing collective supply of agricultural productive services. Business scale expansion generates demand for agricultural productive services, creating endogenous power for farmers to participate in the collective supply of agricultural productive services and playing the role of demand traction.

TABLE 2 Endogenous treatment results of cooperative participation in the evaluation of agricultural productive services of farmers’ village collectives.

Variables	ERM model estimate result		Instrumental variable estimate result
	(1)	(2)	(3)
Farmers’ participation in cooperatives	1.266*** (0.174)	1.159*** (0.206)	3.558*** (0.270)
Type of crop grown	-	-0.022 (0.061)	0.003 (0.012)
Area of cultivated land in villages	-	-0.103** (0.051)	-0.002** (0.001)
Number of village financial service outlets	-	0.064*** (0.023)	-0.001 (0.001)
Whether or not the right is established	-	0.051 (0.091)	0.041 (0.063)
Gender	-	0.058 (0.056)	-0.283*** (0.096)
Physical condition	-	-0.071*** (0.019)	0.193*** (0.059)
Educational level	-	0.127*** (0.021)	0.001 (0.002)
Instrumental variable	0.012*** (0.001)	0.010*** (0.001)	-0.034 (0.234)
Error correlation coefficient	-0.229***	-0.223***	-
CONS	-0.648*** (0.021)	-0.848*** (0.136)	Chi2 (1) = 3.01 Prob>Chi2 = 0.082
N	4,181	4,181	4,181

\* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ . Numbers in parentheses indicate standard errors.



## 5.5 Heterogeneity analysis

Small-scale farmers, especially older and low-income ones, are excluded from the agricultural productive services market (Li and Jiang, 2015). Agricultural productive services provided by collectives realize the function of collective ownership to ensure social equity (Mi and Luo, 2021), which helps meet the demand of low-income, older, and other small-scale farmers and compensates for market failure. The demand of low-income and older farmers for agricultural productive services is difficult to monitor. Therefore, low-income and older farmers may benefit from participating in cooperatives. Therefore, this study further analyzes the differences in the impact of farmers' participation in cooperatives on the collective supply of agricultural productive services based on households' annual income and age.

The farmers are divided into five groups according to the quantile of their annual household income. As shown in Table 4, cooperative participation among farmers in the lowest-, high-, and highest-income groups has a significant positive effect on the collective supply of agricultural productive services. The lowest-income group, that is, farmers whose income level is below 20% of the total, is more sensitive to the joint role of cooperatives than the low- and average-income groups. This may be because farmers in low-income groups are excluded from the market and obtain agricultural productive services mainly from collectives. Unifying demands among farmers in low-income groups reduces the difficulty of the collective supply of

agricultural productive services. The higher- and the highest-income groups—that is, farmers whose income level is more than 60% of the total—also played a significant role.

Based on a previous study (Hu and Zhong, 2012), 60 years of age has been selected as the standard for dividing the aging labor force. Farmers aged 60 years and above are classified as the older group and assigned a value of “1,” and farmers under 60 years of age are classified as the young group and assigned a value of “0.” Fisher's combination test reveals a significant difference between the groups ( $p = 0.07$ ). As shown in Table 5, cooperative participation has a significant positive impact on the collective supply of agricultural productive services ( $p < 0.01$ ), with a greater effect among older farmers. This confirms the hypothesis that older farmers require cooperatives more than younger ones due to their weakness.

## 6 Discussion

In China, small-scale farmers comprise the main body of agricultural production and operations, a situation that is expected to persist for a long time. Therefore, China's agricultural development should connect small farmers with modern agriculture through agricultural productive services and enable them to share the benefits of agricultural modernization. The special position of collectives in rural areas has unique advantages in organizing and providing

TABLE 3 Mediating effects test.

Variables	Serialization	Agricultural productive Services	Scale of operations	Agricultural productive Services
	(1)	(2)	(3)	(4)
Farmers' participation in cooperatives	1.785** (0.823)	-	0.159*** (0.056)	-
Serialization	-	0.010** (0.004)	-	-
Scale of operations	-	-	-	0.102** (0.040)
Control variables	-	Controlled	Controlled	Controlled
The constant term	2.939*** (0.137)	-1.172*** (0.242)	1.911*** (0.014)	-1.329*** (0.244)

\* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ . Numbers in parentheses indicate standard errors.

TABLE 4 Estimates of heterogeneity analysis based on income.

Variables	Low-income groups	Lower income groups	General income group	Higher income groups	High-income groups
	(1)	(2)	(3)	(4)	(5)
Participation of farmers in cooperatives	0.450*(0.171)	0.099 (0.204)	0.230 (0.160)	0.390**(0.166)	0.618*** (0.136)
Type of crop grown	-0.150 (0.158)	-0.218 (0.154)	-0.058 (0.140)	0.422*** (0.154)	-0.029 (0.116)
village size	-0.151 (0.144)	-0.185 (0.130)	-0.173 (0.106)	0.021 (0.116)	-0.080 (0.103)
Number of village Financial service outlets	0.047 (0.050)	0.076 (0.060)	0.086* (0.051)	0.094* (0.049)	0.103* (0.053)
Whether or not the right is established	-0.124 (0.205)	-0.037 (0.224)	0.276 (0.233)	-0.193 (0.196)	0.021 (0.194)
Gender	0.091 (0.125)	-0.052 (0.130)	-0.042 (0.120)	0.096 (0.136)	0.165 (0.139)
Educational level	0.138*** (0.057)	0.202*** (0.060)	0.213*** (0.058)	0.121** (0.059)	0.099* (0.056)
CONS	-0.811*** (0.268)	-0.885*** (0.303)	-1.256*** (0.296)	-1.198*** (0.300)	-1.078*** (0.291)
R2	0.020	0.018	0.023	0.026	0.030
Sample size	853	826	860	797	842

\* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ . Numbers in parentheses indicate standard errors.

TABLE 5 Heterogeneity analysis based on age.

Variables	The younger age group	The senior group
	(1)	(2)
Participation of farmers in cooperatives	0.335*** (0.090)	0.572*** (0.118)
Type of crop grown	0.002 (0.077)	-0.076 (0.107)
Village size	-0.118* (0.063)	-0.050 (0.091)
Number of village financial service outlets	0.067** (0.029)	0.104*** (0.038)
Whether or not the right is established	0.093 (0.120)	-0.125 (0.144)
Gender	0.040 (0.071)	0.123 (0.098)
Educational level	0.104*** (0.027)	0.189*** (0.038)
CONS	-0.935*** (0.160)	-1.091*** (0.196)
R2	0.014	0.037
Sample size	2,530	1,653
p value of Fisher combination test	0.070	

\* $p < 0.1$ , \*\* $p < 0.05$ , \*\*\* $p < 0.01$ . Numbers in parentheses indicate standard errors.

agricultural productive services. Existing research has focused on the impact of the supply side, including cooperatives, new agricultural management entities, and collectives, on small farmers' access to agricultural productive services. However, few studies have examined cooperatives' joint role in improving small farmers' access to agricultural productive services. Small farmers, which represent the demand side, play a significant role in driving the collective supply of agricultural productive services. However, the scattered and fragmented demand of small farmers hinders effective supply. Therefore, this study analyzes the impact and mechanism of small farmers in cooperatives on their access to collective agricultural productive services, which serve as organizational support for the demand side of small farmers. The results show that farmers' participation in cooperatives significantly improves the level of productive services that farmers obtain from the collective, and the effect is mediated by the level and scale of continuous operation of farmers, especially low-income, small-scale, and older ones.

Existing research suggests that cooperatives are the main carriers of farmer organizations (Mu and Kong, 2019). By participating in cooperatives, farmers can access the agricultural productive services they provide (Abate et al., 2014; Li and Lu, 2022; Ma and Abdulai, 2019; Zhou et al., 2019). However, the limited variety of services provided by cooperatives has been overlooked, hindering their ability to meet the diversified production needs of farmers. A prior study has confirmed the ability of small-scale farmers to access productive services through an organized approach (Xu et al., 2022). This study considers cooperatives the main form of farmer organization and focuses on their role in organizing farmers, rather than treating them as the main providers of services. Collectives are an important organizational form in rural China, with multiple functions for managing and organizing farmers. However, management difficulties due to the wide spread of farmers cause collectives to overlook the role of small farmers, particularly low-income and vulnerable older farmers. Combining the organizational role of cooperatives for small

farmers and advantages of the collective supply of agricultural productive services can provide new ideas for improving the level of agricultural productive services for small farmers.

The inability of market service providers to provide small-scale farmers with agricultural productive services. Existing research on the supply of productive services to farmers focuses on agricultural socialization services, with the help of market service providers (Lei et al., 2024). However, it is difficult for market service providers to provide socialization services to single farmers with low market status and a small scale. However, small-scale farmers still account for more than 98% of the agricultural production in China, and ignoring the production service needs of this large portion of small-scale farmers is likely to be detrimental to the healthy development of Chinese agriculture. Collectives, as the government's agents in the countryside, take on the function of providing production services. By activating the endogenous motivation of collectives to provide production services to farmers, they can effectively solve this dilemma and help improve the overall level of production services in China's rural areas.

However, this study has some limitations. First, the study uses subjective evaluation by farmers to measure their experience of the agricultural productive services provided by collectives. Therefore futures studies should incorporate objective measures to further support the finding in this study. Second, the data used in the article are cross-sectional. Therefore, follow-up surveys should be conducted collect tracking data for dynamic measurements to better determine the role of cooperatives as a form of organization in improving farmers' access to productive services.

## 7 Conclusion

Agricultural productive services are important for agricultural modernization, promoting agricultural development, and realizing the organic connection between small farmers and modern agriculture. This study proposes for the first time a "cooperative+collective" model for the provision of productive services. In China, safeguarding social equity is one of the important objectives of the Government, and safeguarding and supporting the interests of small-scale farmers is crucial to safeguarding social equity. Cooperatives, as an important form of self-organization for farmers, can improve farmers' access to productive services through the "cooperative+collective" model of agricultural productive service provision. Through the joint role of cooperatives, farmers' needs can be integrated, transaction costs can be reduced, and effective support organizations can be provided for farmers' participation. This study reveals that farmers have significantly increased their level of access to agricultural production services through participation in the "cooperative+collective" model of productive services. The farmers as recipients of productive services, allows them to rely on cooperatives to improve their organization, integrate their fragmented and decentralized demand, and increase agricultural productive services access level. Furthermore, cooperative participation promotes the collective supply of agricultural productive services by increasing demand through continuous operation and expansion of business scale. Moreover, cooperative participation among low-income and older farmers has a stronger positive effect on the collective supply of agricultural productive services. This

demonstrates that collective play ensures social equity by providing agricultural productive services.

## Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: only database licensed personnel can use the data. Requests to access these datasets should be directed to <https://chfser.swufe.edu.cn/datas/>.

## Author contributions

YZ: Conceptualization, Methodology, Software, Writing – original draft, Writing – review & editing. YM: Conceptualization, Funding acquisition, Project administration, Supervision, Visualization, Writing – review & editing. CL: Funding acquisition, Methodology, Supervision, Writing – review & editing.

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## 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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