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Factors affecting adoption of forestry social services: evidence from major forestry provinces in China

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Abstract: Analyzing the influence mechanism of the transformation of demand willingness and behavior of forestry social services (FSS) of farmers with different operation scales in the production process is crucial for promoting the modernization of the collective FSS system. Based on the survey data of 800 farmers in 3 provinces of China, this study uses the multivariate (Mv-) probit model to quantitatively analyze the mechanism of factor endowments' influence on farmers' deviation of demand willingness and choice behavior on three FSSs in the different scales: fine seed and cultivation technology service (SCTS), forest insect pest prevention and treatment service (IPTS), and timber collection and sale service (TCSS). Our results show that the demand rates of IPTS, SCTS, and TCSS are 80.25%, 68.00%, and 68.38%, respectively. Large-scale farmers are more willing to demand FSS than small and medium-scale farmers. However, their actual adoption behavior is low, and there are significant deviations in farmers' demand willingness and adoption behavior for different types of FSS, i.e., 30.37%,12.62%, and 44.88% for SCTS, IPTS, and TCSS, respectively. Farmers' transformation from demand willingness to adoption behavior is significantly affected by farmers' characteristics. Compared with the farmers' demand willingness model, the inhibitory factors for the transformation behavior for FSS increased significantly, including common factors such as the scale of the managed forest land, the difficulty in applying for logging permits, getting afforestation subsidies, and the proportion of forestry income. In contrast, these factors had the opposite influence on the demand willingness model. The number and degree of positive significant influencing factors decreased, with only the family labor force positively influencing farmers' transformation behavior for SCTS. Based on the results, it is suggested to scientifically guide the orderly flow of rural labor, promoting the moderate scale concentration of forest land flow, accelerating the speed and benefits of inclusiveness in rural finance, and resolving issues related to farmers' loans to improve the adoption behavior of FSS by farmers.

Keywords: Forestry social service; factor endowment; willingness; adoption behavior; scale heterogeneity; Mv-probit

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Introduction

In recent decades, China has seen remarkable growth in forest resources, but the nation's per capita forest area still remains less than one-third of the global value (FAOSTAT 2021). The prevalence of small-scale forestland operations has led to inefficiencies and irrational allocation of production inputs (He et al. 2011). To address these issues, the Chinese government implemented rural land system reforms aimed at increasing productivity through the privatization of forest rights, which in turn allowed for the transfer of forestland for large-scale operations (Tokede et al. 2005, Yin et al. 2013). Additionally, the government has bolstered support for various social services organizations, such as brokerage, law, finance, insurance, certification, consulting, and social cooperation services, each with its own focus (Kong et al. 2017). Social services can significantly improve the external division of labor within the economy, leading to the increased marginal productivity of agricultural labor. Both the rural land system reforms and the support for social service organizations work in tandem to promote the productivity of forest production (Yang & Zhao 2003, Liu et al. 2017).

Forestry social services (FSS) include a range of offerings, such as forestry technical guidance (Zhang & Mehmood 2001, O'Herrin & Shields 2016), pest and disease control (Ji et al. 2011, Bhatia & Yousuf, 2013), forest fire prevention (Stocks & Martell 2016), operational and management support (Boakye-Danquah & Reed 2019), and forest product processing and sales (Munn & Rucker 1994). The provision of these services primarily relies on the collaborative body of four key stakeholders: government agencies, markets, social organizations, and farmers, each with distinct objectives (Szulecka et al. 2016). Although the adoption of FSS by farmers is on the rise (Mattila & Roos 2014), they show a particularly strong preference for production and sales services (Finley 2002, Boakye-Danquah & Reed 2019). The adoption of FSS tends to be lower in underdeveloped regions than the developed counterparts (Kienzle 2013, Emerick et al. 2016). Existing studies on FSS identify three main types of social services in high demand by farmers: SCTS, IPTS, and TCSS, which relate to the production and post-production phases of forest land management.

In order to further enhance forestry productivity and boost farmers' income, China initiated a new wave of collective forest tenure reform in 2003. This reform, a significant milestone in China's forestry land transformation, aimed to enrich and refine China's rural household contract management system (Yin et al. 2013). The forest tenure reform seeks to define the ownership, contract, and management rights for mountains and forests, implementing a three-rights separation. In this system, ownership is held by the collective, contracting rights by the farmers, and management right by the actual operators. This arrangement aims to uphold ownership, stabilize contracting rights and liberalize management rights. The first round of pilot reforms took place in the Fujian, Jiangxi, and Zhejiang provinces of China. These forestry property rights reforms have yielded positive outcomes, including establishing and improving the forestry social services system, advancing the local forestry economies, and increasing motivation for forest farmers to engage in production and management (Liu et al. 2017).

Several global and China-focused studies have examined the various factors that impact the adoption of FSS. For instance, findings from some studies reveal that service charges and farmers' education levels significantly influence farmers' demand for the FSS (Khan et al. 2017, Jumbe & Nyambose 2016). Family resources endowment, such as non-agricultural household employment size (Zhang et al. 2014), commercial forest presence (Khan et al. 2017), location within economically developed regions, proximity to roads, and credit accessibility positively affect the demand for

social services (Mottaleb 2016). The size of the forest land is a key factor positively influencing both the demand willingness and the adoption of FSS (Jumbe & Nyambose 2016, Rubilar et al. 2018). Large-scale management promotes farmers' investment in production machinery. Conversely, small-scale farmers often refrain from such investments due to cost-benefit considerations, resulting in increased demand for outsourced machinery services (Emerick et al. 2016, Picazotadeo & Reigmartinez 2006). The influence mechanisms for farmers' willingness to purchase socialized agricultural services vary for different product segments (Qu et al. 2022). In addition, forest land fragmentation raises the implementation costs of scientific and technological services, discouraging forest farmers from adopting new forestry technologies (Liu et al. 2017). Household characteristics, biophysical conditions, and community attributes influence the adoption of agricultural socialized services by smallholders (Zang et al. 2022).

Existing studies have examined the adoption behavior of FSS and the factors that influence their adoption. However, the critical impact of varying allocations of factors of production on the adoption behavior and transformation process of FSS across different operation scales has not been thoroughly explored. Research in this area is limited, particularly regarding the adoption of FSS. Moreover, previous studies have mainly utilized logit or probit models, which are suitable when farmers choose from two alternate FSS options. However, since farmers often select from more than two FSS options in terms of quantity and type, and these services also often influence one another, traditional probit models may cause significant estimation issues. Addressing this research gap, our study investigates the key factors that influence the transformation of farmers' demand for FSS into adoption behavior. We focus on the three aforementioned service types, employing the multivariate (Mv-) probit model to analyze the survey data of 800 farmer households in China's Fujian, Jiangxi, and Zhejiang provinces. The multivariate probit model offers a more robust and flexible framework for analyzing situations with multiple, correlated choices or outcomes, providing a deeper understanding of the relationships among these choices and the factors influencing them.

The overall objective of the study is to analyze the impact of different allocations of factors of production on farmers' adoption behavior of FSS and its transformation process among farmers operating at different scales.

Methodology

Theoretical framework

As a "bounded rational economic person," a farmer's decision-making behavior is affected by a variety of economic and non-economic factors. The main economic factors include the potential for time, capital, or human resource savings when accepting FSS, thereby enhancing operational efficiency. However, quantifying the extent of these savings in behavioral research proves challenging (O'Herrin 2013, Boakye-Danquah & Reed 2019). Empirical research highlights the significance of non-economic factors such as factor allocation, operational scale, and location characteristics of farmer households (Zhang & Mehmood 2001, O'Herrin & Shields 2016). Farmers may encounter production difficulties or resource bottlenecks in forestry management, which can subsequently increase their demand for FSS to address these difficulties. Under certain circumstances, this demand willingness transforms into farmers' selection behavior for FSS.

However, in practice, farmers often display inconsistency in their demand willingness and adoption behavior. This means that while farmers may express a desire to adopt FSS, their actual selection behavior may not align with their intentions. This discrepancy arises because the transformation from demand willingness to adoption is affected by various factors (Tan et al. 2010, Hussain et al. 2012), causing deviations between farmers' initial

intentions and their final behavior. With this in mind, this article examines the demand willingness and choice behavior deviation for FSS among farmers from the perspective of heterogeneous production factor endowments. It seeks to analyze the influencing factors and elucidate the direction, degree, and process mechanism through which elements such as factor endowment affect the demand willingness and choice behavior of farmers with heterogeneous business scales, as shown in Fig.1 (for a more detailed discussion of the theoretical framework see Supporting Information).

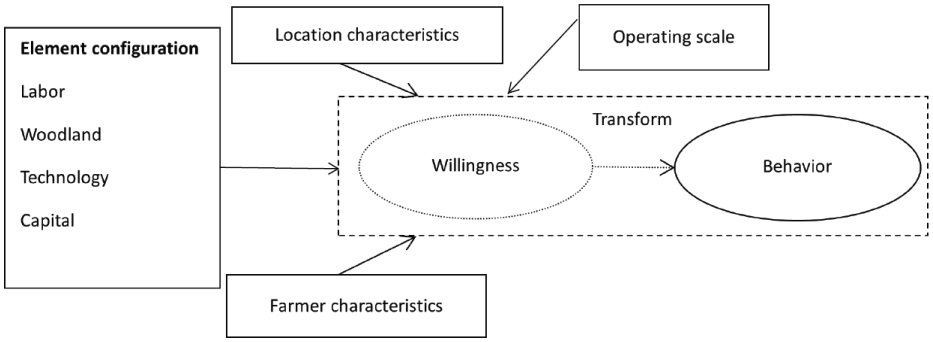

Figure 1 The demand willingness behavior model of FSS.

Variable selection

Dependent variable

This study primarily explores the factors influencing farmers' adoption of FSS by focusing on the dependent variables representing the most pressing[1] needs in forest land management. These needs include forest fine seed and cultivation technology services, pest and disease control services, and forest collection and sale services. The analysis of farmers' engagement with social services is divided into two aspects: (1) the decision to adopt FSS and (2) the level of FSS chosen. Adoption of social services by farmers is a dichotomous variable, with '1' indicating adoption and '0' denoting non-adoption. The "service selection level" is a continuous variable representing the frequency with which a farmer opts for services during production and sales.

Independent variables

As an economics category, factors of production encompass various resources required in production and operational activities. These factors primarily consist of five essential elements: labor force, land, capital, technology, and the operator's entrepreneurial ability (see Supporting Information for more information on the criteria used to select the independent variables and their corresponding hypotheses).

Sample area and survey design

The sample area encompasses three provinces of China: Fujian, Jiangxi, and Zhejiang, which are characterized by mountainous and hilly landscapes. Among the 31 provinces of China, these three provinces have the highest forest coverage rates, with Fujian at 66.8%, Jiangxi at 63.1%, and Zhejiang at 61.1%. They are endowed with rich natural resources and have been at the forefront of collective forest reforms in southern China. Thus, their selection as the sample area is highly representative. Our research group assembled ten survey teams to investigate these areas in 2020. We chose samples using the random stratification principle based on the forestry production conditions in each county. In order to emphasize the importance of the forestry industry, two counties (cities) with the highest and median forestry output values were chosen

[1] These needs were prioritized based on farmers' response through our group discussion before the survey.

in each province. Three towns were selected per county, and three villages per town, resulting in a total of 54 villages.

Next, 10-16 farmers were randomly picked from each village, depending on the number of households in the village. The survey targeted ordinary farmers involved in forestry, excluding cooperative organizations and companies. A total of 850 questionnaires were distributed to farmers, and 820 questionnaires were returned after eliminating those from farmers without forest land. After discarding questionnaires with missing key variables and significant logical contradictions, the final sample consisted of 800 questionnaires, yielding an effective rate of 94%. The content of the survey included farmers' household characteristics, forest land resources, forestry production costs (such as seeds, fertilizers, pesticides, and other costs), forestry output (including timber, bamboo, economic forestry, and other production), and forestry social services among other related topics.

Empirical Model

In most prior studies, the behavioral model used for analyzing farmers' FSS choices has been framed as a binary choice problem, commonly employing the probit model (e.g., Su et al. 2022). This approach estimates each behavior model independently (Greene 2008). However, this study reveals that farmers have three types of FSS options to choose from, which may not be mutually exclusive. Consequently, a simplistic binary probit model is inadequate for addressing the correlations between service choice behaviors. As an alternative, the multivariate (Mv-) probit model can be employed to estimate the regression outcomes for individual service selection behaviors while also providing the likelihood ratio test of the regression results of various services (Cappellari & Jenkins 2003). This approach allows for the determination of correlations between services based on the likelihood ratio, thus enhancing the accuracy and efficiency of estimation (Greene 2008).

Therefore, this study adopts the Mv-probit model to analyze the influencing factors of farmers' choice of social service under factor endowment heterogeneity. The specific form of the model is as follows:

$$y^{*}=\beta_0+\beta_i x_i+\varepsilon_i \quad (1)$$

$$y=\begin{cases} 1, y^{*}>0 \\ 0, else \end{cases} \quad (2)$$

where y^{*} denotes the latent variable, y is the observed form of the dependent variable, x_i denotes the explanatory variable, and i denotes the number of explanatory variables. As can be seen from Eq. (2), when $y^{*}>0$, then $y=1$, which indicates that the demand willingness and behavior of farmer households' service adoption are consistent; β_0 and β_i are the estimated parameters, ε_i is the error term. The estimated value of model parameters can be obtained by simulating the maximum likelihood estimation of Eq. (2).

Results and discussion

Descriptive statistics

Our results reveal that a large majority of the sampled farmers (86.9%) are highly willing to adopt FSS (Table 1). Specifically, farmers have the strongest willingness to adopt pest control services (IPTS) (80.3%), followed by timber collection and sales service (TCSS) (68.4%) and fine seeds and cultivation technology services (SCTS) (68%). The farmers were divided into three groups based on operation area size: small-scale (less than ten mu, Chinese land unit, 15 mu = hectare), medium-scale (10-59 mu), and large-scale (more than 59 mu) (following the existing research like Bao et al. 2010). It is observed that medium and large-scale farmers have a stronger demand for FSS than small-scale farmers, with medium and large-scale farmers having higher proportions of IPTS and TCSS.

There are differences in the choice behavior of different services by farmers of different scales. The adoption rates for IPTS, SCTS, and TCSS are 67.63%, 37.63%, and 23.50%,

Table 1 The adoption of FSS by farmers of different scales.

	Total sample		Small-scale		Middle-scale		Large-scale	
	Households	%	Households	%	Households	%	Households	%
Demand Willingness								
Fine seed and cultivation Technology Services (SCTS)	544	68.00	153	66.23	223	67.99	168	69.71
Pest control services (IPTS)	642	80.25	175	75.76	269	82.01	198	82.16
Timber Collection and Sales Service (TCSS)	547	68.38	145	62.77	229	69.82	173	71.78
Behavior								
Fine seed and cultivation Technology Services (SCTS)	301	37.63	91	39.39	131	39.94	80	33.20
Pest Control Services (IPTS)	541	67.63	125	54.11	233	71.04	157	65.15
Timber Collection and Sales Service (TCSS)	188	23.50	60	25.97	89	27.13	49	20.33

respectively, with medium-scale farmers having higher adoption rates than small and large-scale farmers. The study also noted that farmers' demand willingness to adopt FSS is not always consistent with their actual adoption behavior. In the service adoption process, demand willingness is transformed into choice behavior, where farmers' decision-making is affected by several factors that may hinder the effectiveness of willingness conversion behavior. A detailed description of explanatory variables is given in Table 2 and Fig. 2.

Table 2 Description and definition of the variables.

Variable	Definition	Mean	SD
Labor factors			
Family labor	Number of laborers in the household	2.812	1.240
Labor transfer	Non-agricultural labor force / Total number of household labor	0.333	0.240
Woodland factors			
Fragmentation	The ratio of number of forest plots to forestland area	0.109	2.272
Area	≦10 mu = 1; 10 ~ 59 mu = 2; ≧ 60 mu = 3	2.033	1.110
Distance	The distance between the largest forest land and the highway	0.841	1.929
Technology elements			
Management difficulty	Whether experienced management difficulties (Yes=1; No=0)	0.816	0.346
Harvesting indicator	Whether experienced difficulties in harvesting (Yes=1; No=0)	0.713	1.704
Capital factors			
Borrowing	Main source of operating funds (Borrowed funds=1; Own funds=0)	0.900	0.919
Subsidy	Whether obtained forestry subsidies (Yes=1; No=0)	0.915	0.321
Income	The percent of forestry revenue (≦10%=1; 10%～50%=2; ≧50%=3)	0.190	2.261
Farmer's demographics			
Education	Below primary=1; Primary=2; Junior high school =3; High school=4; College degree or above=5	2.571	0.698
Age	0~30=1; 31~40=2; 41~50=3; 51~60=4; ≧60=5	3.620	0.947
Location control variable			
Economy	Per capita disposable income of rural areas/year (1=<3000 RBM; 2=3000~3999 RBM; 3=4000～5999 RBM; 4=6000～6999 RBM; 5=7000～9999 RBM; 6=>9000 RBM)	2.662	0.948
Terrain	Flatland=1; Hill=2; Mountain=3	2.870	0.337

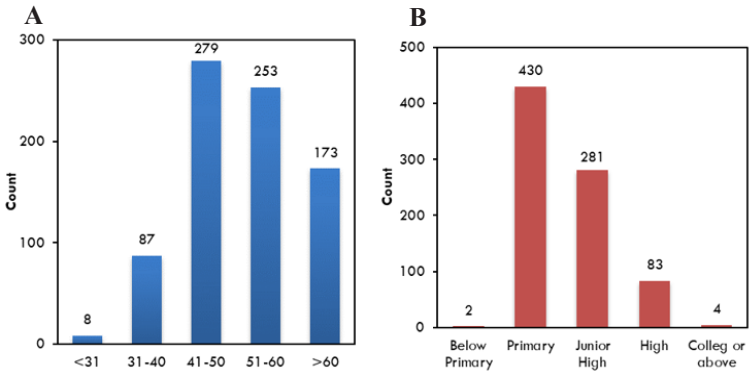

Figure 2 A- Age distribution of respondents. B - Distribution of education.

The survey further revealed the basic characteristics of heads of forestry-operating households in the sample, with primary school (six years of schooling) being the most common educational (42.5%). The most common age bracket for household heads was 41-50 (34.9%), followed by 51-60 (31.6%) (Figure 2). The majority of households had 3-5 family members (66.13%), and small-scale farmer households accounted for 45.2% of the sample, followed by medium-scale (31.9%) and large-scale farmer households (22.9%).

Results for Multivariate (Mv-) probit model of farmers' demand willingness

SCTSM (Model 1), IPTSM (Model 2), and TCSSM (Model 3) are regression results of the Mv-probit model on the demand willingness of fine seed and cultivation technology services (SCTS), pest and disease control services (IPTS), and timber collection and sales services (TCSS), respectively (Table 3). The VIF (variance inflation factor) value of the model is 1.23, indicating the absence of multicollinearity. The likelihood ratio test was also conducted and found to have a 1% significance level, indicating that the demand willingness for three services was not independent of each. This justifies the use of the multivariate probit model in this study. Furthermore, the correlation coefficients (atrho) also passed the significance test.

Labor factors

The results suggest that labor factors are important in the adoption of forestry social services (FSS). Specifically, the size of the labor force is significant and positively correlated with the adoption of FSS in all three models analyzed (Table 3). This suggests that families with a larger labor force have better factor allocation ability and can release more income channels, which leads to a stronger willingness to demand FSS. This finding is consistent with previous studies, which have shown that labor availability is a significant factor in the adoption of new agricultural technologies and practices. For example, a study by Mercer and Pattanayak (2003) found that family labor endowments, proxied by the number of labor days spent on agriculture, positively influence the adoption of sustainable agroforestry choices. Similarly, a study by Danso-Abbeam et al. (2017) found that labor availability was positively associated with the adoption of improved maize varieties in Ghana. The degree of labor transfer also plays a role in the adoption of FSS. Surprisingly, the results show that a higher degree of labor transfer improves the demand for the IPTS and the TCSS, which is contrary to our hypothesis. However, this outcome is consistent with Mottaleb et al.'s (2016) findings, which suggested that a high degree of family labor transfer of farmers can bring in more labor earnings that can reduce dependence on the rural labor force. This result implies that labor transfer can effectively promote the development of FSS, helping overcome the impact of labor shortages on forestry production.

Forestland elements

The results suggest that forestland elements, such as fragmentation, size, and woodland to road inconvenience, play a crucial role in the adoption of FSS in forestry production.

Specifically, the study found that the fragmentation of managed forest land and the size of the managed forest land area have a significant impact on farmers' willingness to adopt TCSS and SCTS. The findings indicate that high fragmentation in the managed forest land inhibits the demand willingness for these services. This may be because a higher level of fragmentation can raise the per-unit cost of FSS, making it more expensive for farmers and thus reducing their willingness to demand these services. Similarly, the study found that the larger the managed forest land area by farmers, the higher the specialization. This leads farmers to increase their self-supply of FSS and decrease their demand for FSS from others. This finding suggests that farmers with larger forestland areas may be more self-sufficient and less reliant on external sources for FSS. Additionally, the study found that the inconvenience of woodland roads negatively correlates with the adoption of IPTS. This finding implies that the distance of forestland from the road can significantly impact the cost of pest control for farmers, inhibiting their willingness to demand IPTS. This result highlights the importance of access to infrastructure and transportation in forestry production and the adoption of FSS.

Previous literature has highlighted the importance of forestland elements in the adoption of FSS in forestry production. For example, Gebremedhin and Swinton (2003) found that land fragmentation can lower

Table 3 Estimation results of farmers' adoption of social forestry service.

Model	SCTSM		IPTSM		TCSSM		Degree	
Variables	**Coefficient**	**St.Er.**	**Coefficient**	**St.Er.**	**Coefficient**	**St.Er.**	**Coefficient**	**St.Er.**
Labor factors								
Family labor	0.111**	0.047	0.065*	0.037	0.108**	0.049	0.047	0.072
Labor transfer	0.144	0.249	0.502**	0.245	0.488**	0.256	0.047*	0.027
Woodland								
Fragmentation	-0.909**	0.450	0.097	0.363	-0.796*	0.451	-1.173**	0.557
Area	-0.165**	0.073	0.016	0.072	-0.191**	0.074	-0.076	0.049
Distance	-0.018	0.027	-0.034*	0.026	-0.004	0.027	-0.050	0.037
Technology								
Management difficulty	0.241**	0.096	0.198**	0.095	0.159*	0.098	0.389*	0.141
Harvesting indicator	-0.069*	0.047	0.031	0.045	-0.070*	0.039	-0.067	0.066
Capital factors								
Borrowing	-0.037	0.052	-0.073*	0.047	-0.137**	0.062	-0.169**	0.076
Subsidy	0.723***	0.115	0.493***	0.105	0.741***	0.124	1.233***	0.159
Income	0.166	0.142	0.234*	0.154	0.189	0.149	0.361*	0.219
Farmer's Demographic								
Education	-0.014	0.016	-0.023*	0.014	0.005	0.161	-0.011	0.023
Age	-0.064	0.522	-0.018	0.051	-0.001	0.054	0.023	0.081
Location control variable								
Economy	0.295***	0.061	0.197***	0.059	0.130**	0.062	0.226**	0.086
Terrain	0.507***	0.162	0.163	0.152	0.221	0.166	0.257	0.224
Prob > chi2	0.000		0.000		0.000		0.000	
Pseudo R^2							0.1322	
Atrho	1.160***	0.085	0.652***	0.074	0.578***	0.066		

Note: ***, **, * indicate significance at 1%, 5%, and 10% statistical significance levels, respectively. SCTSM (fine seed and cultivation technology service); IPTSM (forest insect pest prevention and treatment service); TCSSM (timber collection and sales services).

farmers' interest and motivation to invest in sustainable land management practices due to higher transaction costs. Additionally, Teklewold et al. (2013) have shown that better road infrastructure and access to a public transportation system can facilitate farmers' adoption of sustainable agricultural practices. The findings of our study provide further support for the importance of considering forestland elements when designing and implementing FSS programs, especially for small-scale forest owners who may have limited access to these services.

Technical elements

Technical elements, i.e., difficulties in managed forestry and the difficulty in applying for logging permits, play a crucial role in determining the demand willingness of farmers for forestry-related services. Firstly, the study finds that the significant difficulties in managed forestry improve the demand willingness of FSS. This indicates that farmers who encounter challenges in operation and production of their managed forestry areas are more likely to seek social services to solve the bottlenecks in the management process (Table 3). It can be inferred that farmers who face challenges in managing their forestry areas may lack the necessary skills or resources to manage the forests effectively. Therefore, they may seek the help of forestry social services to overcome these challenges, including technical assistance, training, or access to resources such as seeds, fertilizers, and equipment. Previous work, e.g., Nugusse et al. (2013), found that farmers who received training were more willing to participate in a forest farmers' organization that mobilizes non-industrial private farmers to upscale tree-growing practices. Similarly, Apipoonyanon et al. (2020) reported that receiving services such as community forestry management (CFM) can increase households' participation in sustainable rural and forest development in Thailand.

Secondly, the study finds that the difficulty in applying for logging permits significantly and negatively affects the demand willingness for SCTS and TCSS. This finding is consistent with the actual situation in the field, as obtaining logging permits can be a complicated and time-consuming process. When farmers think it is challenging to apply for logging permits, they may face difficulties realizing forestry resources, which may inhibit their enthusiasm for forestry production input and timber-cutting sales. This finding highlights the importance of streamlining the process of obtaining logging permits, which could encourage farmers to invest more in forestry production and increase their demand for forestry-related services. These results are in line with some previous studies; for instance, Gritten et al. (2015) found that prohibitive and complex regulations were significant obstacles to the sales of timber and timber products.

Capital factors

The results suggest that the primary source of operating funds has an inverse relation with the willingness to adopt FSS in the form of IPTS and TCSS. Specifically, farmers who use their savings as their primary source of operating funds are more willing to demand FSS than those who borrow funds. This may be because farmers who use their savings will likely have better financial stability, which gives them more confidence in investing in FSS. On the other hand, farmers who borrow funds may have to consider the cost of borrowing and may be less willing to spend on FSS. Most farmers who obtain loan funds are professional households or family farms, which may have better access to formal financial institutions or private lending channels. These farmers may also have better resources to purchase machinery and equipment for their supply of forestry services, which could weaken their demand for FSS. The finding that farmers who use their savings as their primary source of operating funds are more willing to demand FSS than those who borrow funds is consistent with some previous studies. For example, a

study conducted by Cafer and Rikoon (2014) in Ethiopia found that farmers with access to credit were more likely to adopt sustainable intensification technologies in agriculture. Similarly, a study conducted by Sabasi et al. (2021) in the U.S. found that improved access to credit can increase productivity and residual returns to resources of the farmers.

All three models show that subsidies positively and significantly influence the demand for FSS, i.e., farmers who receive forestation subsidies have a high enthusiasm for forest management, which enhances their demand for FSS. This finding implies that subsidies can play a crucial role in promoting the adoption of FSS among farmers. This finding aligns with the literature, which suggests that larger, more established farms are more likely to have access to credit and can, therefore, more easily invest in capital-intensive services like forestry management (e.g., Gebremedhin & Swinton 2003). Similarly, a study conducted by Zemo and Termansen (2018) found that subsidies for constructing biogas plants can boost farmers' willingness to invest collectively in such projects. The results for the control variables show that the more educated farmers are more likely to adopt forestry social services. Similarly, the farmers who manage woodland in hilly or mountain areas are more likely to need the SCTS to help them cope with the rugged terrain.

Analysis of the transformation from farmers' demand to behavior

Based on the research findings mentioned above, this study further aims to investigate the reasons behind the discrepancies observed between the behavior of farmers in choosing forest social services (FSS) and their willingness to do so. To achieve this objective, the study examines the extent to which farmers' demand for FSS aligns with their choice behavior. Previous studies have highlighted that for farmers to choose interrelated processes of harvesting timber and seeking assistance, it is inappropriate to consider these decisions separately. Mv-probit models provide a suitable solution to this issue (e.g., Gan & Kebede 2005). Against this backdrop, this study adopts the Mv-probit model to explore and analyze the factors that influence the transformation of farmers' willingness to demand social services to their actual choice behavior, particularly among farmers with different scales of forest land management.

Results of regression model

This section combines small-scale and medium-scale woodlands into a single category called "small-medium scale." Here, we examine the factors that influence the transformation from farmers' demand to behavior in forest production and sales link from the perspective of factor endowments. The results of the Mv-probit models for SCTS, IPTS, and TCSS services are presented in Table 4, which indicate that the correlation coefficients (AtRho21), (Atrho31), and (Atrho32) for superior seed and technical cultivation services, timber collection and sales services, and pest control services have passed the significance test. The positive coefficients suggest that these three types of services mutually reinforce farmers' demand willingness to engage in transformation behaviors.

Regression analysis

We find that he number of significant factors that influence the demand willingness to transformation behavior decreased significantly when compared to the willingness to adopt social services. Additionally, the farmers' factor endowment inhibited their willingness to demand changes in their behavior.

Labor factors

Labor is a crucial factor in transforming farmers' demand for SCTS. Specifically, the quantity of available labor force has a positive and significant impact on this transformation, not only for SCTS but also for all FSS on a small-to-medium scale. Given the small size of forest lands, most farmers treat their involvement in the forest land industry as a part-time job.

Table 4 Regression results of transformation of farmers' demand and behavior of social service on different scales.

Variables	All samples			Mid-Small-scale			Large-scale		
	SCTSM	IPTSM	TCSSM	SCTSM	IPTSM	TCSSM	SCTSM	IPTSM	TCSSM
Labor factors									
Family labor	0.079*	0.053	0.010	0.107**	0.131**	0.119**	0.021	-0.130	-0.011
	(0.045)	(0.050)	(0.045)	(0.054)	(0.060)	(0.052)	(0.081)	(0.092)	(0.080)
Labor transfer	-0.114	0.359	0.122	-0.149	0.461	0.120	-0.234	0.156	0.141
	(0.234)	(0.258)	(0.233)	(0.283)	(0.305)	(0.278)	(0.419)	(0.466)	(0.412)
Woodland									
Fragmentation	0.087	-0.033	-0.030	0.171	-0.061	-0.064	-9.019***	0.244	-1.857
	(0.164)	(0.183)	(0.145)	(0.174)	(0.191)	(0.150)	(2.506)	(0.980)	(1.558)
Area	-1.474**	0.047	-0.069**	-	-	-	-	-	-
	(0.717)	(0.034)	(0.034)						
Distance	-0.025	-0.197	-0.334**	-0.036	-0.041	-0.052	-0.050	-0.018	-0.060*
	(0.133)	(0.152)	(0.132)	(0.049)	(0.050)	(0.048)	(0.036)	(0.035)	(0.033)
Technology									
Management difficulty	-0.0070	-0.0043	0.0076	-0.0706	-0.233	-0.3720**	0.0469	-0.121	-0.0492
	(0.044)	(0.047)	(0.044)	(0.156)	(0.179)	(0.154)	(0.251)	(0.285)	(0.258)
Harvesting indicator	-0.133**	-0.120**	-0.228***	-0.011	0.018	0.082	-0.004	-0.124	-0.121
	(0.053)	(0.049)	(0.057)	(0.048)	(0.053)	(0.048)	(0.111)	(0.111)	(0.117)
Capital factors									
Borrowing	-0.046	0.076	-0.001	-0.083	-0.032	-0.172**	-0.139*	-0.193***	-0.168**
	(0.156)	(0.171)	(0.155)	(0.0775)	(0.086)	(0.082)	(0.075)	(0.067)	(0.078)
Subsidy	-0.053	-0.203***	-0.041	-0.114	0.126	0.134	-0.155	-0.141	-0.242
	(0.049)	(0.051)	(0.049)	(0.192)	(0.208)	(0.189)	(0.237)	(0.259)	(0.250)
Income	-0.013	-0.029*	-0.011	-0.054	-0.185***	-0.017	-0.058	-0.264***	-0.052
	(0.016)	(0.017)	(0.015)	(0.059)	(0.063)	(0.058)	(0.089)	(0.093)	(0.089)
Farmer's Demographic									
Education	-0.052	-0.018	-0.012	-0.008	-0.032*	-0.023	0.0013	-0.033	0.027
	(0.050)	(0.055)	(0.050)	(0.017)	(0.018)	(0.016)	(0.036)	(0.038)	(0.035)
Age	0.217***	0.092	0.041	-0.044	-0.039	-0.011	-0.072	0.086	-0.013
	(0.055)	(0.058)	(0.054)	(0.057)	(0.063)	(0.056)	(0.097)	(0.103)	(0.096)
Location control variable									
Economy	0.380**	-0.1120	0.139	0.1501**	0.110	0.0752	0.293**	0.116	-0.153
	(0.148)	(0.164)	(0.149)	(0.065)	(0.068)	(0.064)	(0.140)	(0.145)	(0.140)
Terrain	-1.384**	1.437**	-0.399	0.371**	-0.149	0.173	1.232	-4.018***	-0.008
	(0.603)	(0.665)	(0.606)	(0.149)	(0.167)	(0.150)	(0.764)	(0.020)	(0.746)
Constant	-1.388**	1.431**	-0.357	-1.2533*	1.2284*	-0.658	-3.668	13.63***	0.139
	(0.603)	(0.666)	(0.603)	(0.641)	(2.450)	(24.01)	(2.412)	(0.641)	(0.705)
Atrho21	1.108***(0.0728)			0.584***(0.0790)			1.002***(0.149)		
Atrho31	0.493***(0.0641)			1.234***(0.0873)			0.516***(0.119)		
Atrho32	0.533***(0.0658)			0.485***(0.0770)			0.505***(0.125)		
Log Likelihood	-1287.4852			-939.7882			-373.9437		

Note: ***, **, * indicate significance at 1%, 5%, and 10% statistical significance levels, respectively. The parentheses in the regression coefficient are standard errors. SCTSM (fine seed and cultivation technology service); IPTSM (forest insect pest prevention and treatment service); TCSSM (timber collection and sales services).

Additionally, these farmers tend to have an attachment to their land and are reluctant to give up forestry management. When they allocate their labor to other activities, they often prefer to entrust their forest land to obtain forestry income. This makes them more likely to rely on FSS, such as SCTS, as a way to generate additional income.

Woodland factors

The fragmentation of forest land has a significant and negative impact on the behavior of large-scale farmers when it comes to adopting SCTS. As the fragmentation of forest land increases, the average number of land plots owned by farmers also increases, and the cost of adopting SCTS becomes higher. This hinders the behavior change from the demand willingness to adopt among large-scale farmers. The scale of operation of forest land continues to negatively impact the willingness of farmers to adopt SCTS and TCSS. The degree of inconvenience caused by forest land roads also has a negative effect on the transformation of farmers' willingness to demand forest timber collection and sales services, with a significant impact on large-scale farmers only. The underlying reason could be that as the distance between forest land and the highway increases, infrastructure conditions, including accessibility and traffic on forest land, tend to deteriorate. This increases the cost of the service process for farmers and restricts their ability to obtain services. Compared to the demand willingness model, the negative impact of inconvenient forest land roads changes from pest control services to timber collection and sale services.

Technology factors

The analysis shows that small and medium-sized farmers who intend to adopt TCSS may face significant difficulties operating and utilizing the related technologies. This is contrary to the demand willingness model, which suggests that small-scale farmers who make some sales are eager to receive external support to help them survive. However, even if they receive such help, the transaction costs for the farmers may still be significantly higher, and there may also be issues with intentional service supply shortages. Furthermore, the difficulty in applying harvesting indicators can hinder the demand willingness of farmers to adopt the three types of service demands associated with FSS. Nevertheless, there is no noticeable difference in the performance of farmers of different scales. This represents a shift from the demand willingness model, as the role and direction of demand willingness transformation behavior are altered by the challenges and opportunities presented by FSS adoption.

Capital factors

The results show that while the primary source of forestry business capital is not significant in the overall sample, relying on borrowed funds negatively affects the transformation behavior of small-medium and large-scale farmers in terms of SCTS and IPTS. This negative influence is consistent with the demand willingness model, which suggests that large-scale farmers usually have self-provision of services, and the farmers who rely on borrowed funds have reduced purchasing power due to financial constraints. One of the main channels for borrowing funds is forestry property rights mortgage loans. However, financial institutions are cautious about this type of business, and there is a large difference between the amount demanded by farmers and the funds provided. Additionally, the loan term is often too short, leading to further constraints for farmers relying on borrowed funds.

Interestingly, the ratio of forestry subsidies and income significantly inhibits the conversion behavior of demand willingness for IPTS, regardless of the scale of the farmers. This is contrary to the influence direction of the demand willingness model. Farmers who receive forestry subsidies and those with a higher percentage of forestry income are often more specialized in managing forestry and tend to be more cautious about pest control. In fact, our survey found that farmers who planted

oranges and other economic forests expressed dissatisfaction with the current social services that use drones to spray pesticides, as they feel that such services only reach the surface of the canopy and fail to penetrate the trunk part of the tree. Instead, they opt for self-administered manual spraying, underscoring a significant distinction in adopting pest and disease control services.

Conclusions and Suggestions

To promote the modernization of the collective forestry social services (FSS) system, it is important to understand how different factors affect farmers' willingness and choice behavior to use FSS, particularly those with different farm sizes. This study uses survey data from 800 farmers in three Chinese provinces and a multivariate probit model to identify how farmers' resources and characteristics affect their demand and choice of three different types of FSS: fine seed and cultivation technology service (SCTS), forest insect pest prevention and treatment service (IPTS), and timber collection and sale service (TCSS).

The findings suggest that large-scale farmers are more willing to demand FSS, but the actual adoption behavior is low. Additionally, only the labor force variable has a significant positive impact on the transformation behavior of SCTS, while many variables inhibit the transformation behavior of FSS.

In light of these results, the study also provides some policy suggestions. Policymakers should strengthen the technical and functional training of the rural labor force, improve the off-farm employment availability for the rural labor force, and guide the rural labor force to transfer to cities or non-agricultural industries in a reasonable and orderly manner. Rural social pension security systems should be improved to reduce the rural population's dependence on woodland for livelihood. Additionally, the potential adoption of farmers for forestry social services can be stimulated by promoting the transfer of forest land among farmers, improving the forestry resource assessment institutions and transfer intermediary institutions, and reducing the degree of fragmentation of forest land.

Furthermore, the study suggests accelerating the development of inclusive rural finance and expanding its benefits to solve farmers' loan problems through multiple channels and ease their financial constraints. To break the constraints of farmers' operating funds, relevant supporting policies such as establishing special funds, reducing the loan interest rate, or implementing financial policy discount interest should be introduced. The study also recommends that the government change the unitary main body of forestry service supply and further foster the crucial role of leading enterprises in providing FSS simultaneously. The government should establish a comprehensive regional platform for FSS and shift the focus of cultivation to the less developed rural areas to stimulate and induce farmers' demand willingness transforming to adopt behavior with high-quality and efficient services.

Overall, the study highlights the importance of understanding the factors influencing farmers' willingness and behavior to use different types of FSS to promote the modernization of the collective forestry social services (FSS) system. The policy suggestions can help policymakers and relevant stakeholders address the challenges and enhance the adoption of FSS among farmers, particularly those with different farm sizes.

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Declaration of the authors

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