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Can rural cooperatives reduce poverty vulnerability of smallholder households? Evidence from rural Western China

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Introduction: Poverty eradication is one of the global challenges, and rural cooperatives provide an effective path to address smallholder households' poverty. However, the effect of poverty reduction can show heterogeneity depending on the economic capital, human capital, and social capital of households.

Methods: Based on comprehensive research data on the poverty status of 1,622 smallholder households in four provinces in the less developed regions of western China, using OLS and PSM models, this paper empirically analyzes the impact and heterogeneous characteristics of rural cooperatives on the poverty vulnerability of smallholder households.

Results/Discussion: The results show that rural cooperatives have a significant dampening effect on the poverty vulnerability of smallholder farmers, and the findings hold true after robustness tests using multiple methods. The impact of rural cooperatives on the poverty vulnerability of farming households differed significantly across smallholder households with different characteristics. Specifically, participation in cooperatives had a more pronounced effect on reducing poverty vulnerability among non-poor, higher human capital and higher income farm households compared to poor, lower human capital and lower income farm households. The results of the study can provide a useful reference for policy-making on rural mutual assistance and poverty reduction among farmers.

KEYWORDS

rural cooperatives, poverty vulnerability, smallholder households, rural mutual assistance, poverty alleviation

1. Introduction

The alleviation and elimination of poverty is a common goal of human development and a worldwide challenge (Wang et al., 2022). In 2020, the Chinese government announced that it had achieved the goal of eradicating absolute poverty, which is an important milestone in the history of the fight against poverty in humanity. However, smallholder households in rural China, especially in the western region, are still at serious risk of poverty. On the one hand, China's poverty standard is only roughly equivalent to the World Bank's extreme

poverty line,[1] if the low-middle poverty line and the high-middle poverty line are applied, China still has a large number of low-income people; On the other hand, many families are at risk of returning to poverty. Nearly 2 million people who have escaped poverty are at risk of returning to poverty, and nearly 3 million of the marginal population are at risk of becoming poor (Xu and Li, 2023; Zhang et al., 2023). Reducing the risk of poverty among low-income groups is therefore the central task in China's rural revitalization strategy.

Between 1979 and 1984, China's land system underwent a dramatic shift from collective farming based on production teams (equivalent to villages) to a family-based system of responsibility under the household joint production contract. The central feature of this system is the decentralization of the management of arable land from collective to family management. Under China's family contract responsibility policy, farmers' motivation to produce gets a boost. However, it also brings with it the difficulty of agricultural decentralization. Most farming households have a small landholding, with an average household size of less than 0.67 hectares (Yang et al., 2023). The 'small scale' nature of agricultural production activities makes it necessary for smallholder farmers to allocate their resources between rural and urban areas in order to obtain sufficient income to meet household consumption expenditure. This leads mainly to three distinct vulnerabilities of smallholder households (Zhang et al., 2016). How effective is education in fighting poverty? Researchers are still divided on this question. An analysis of Pakistani households found that educational attainment was negatively associated with the incidence of poverty among farming households, and that access to higher levels of education reduced the likelihood of farming households falling into poverty (Jia and Xu, 2021). However, some studies have found that some of the educational reform in Uganda designed for low income groups did not achieve poverty level reductions (Saz-Gil et al., 2021). Finally, social networks are an important part of social capital, enhances action by playing a role in instrumental and expressive action, with resources embedded in social networks. By embedding social capital in external social networks, cooperatives build close and strong relationships with other network actors and gain greater access to knowledge and information exchange to improve the efficiency of resource acquisition. Social capital plays a role in signaling, monitoring, steering, reducing inter-organizational transaction costs, 'collateral' substitution and risk reduction, and by reducing the level of mistrust between individuals, it improves collective cohesion and promotes cooperation (Person et al., 2017; Ajates, 2021). Small farmers, mainly left-behind farmers, have been integrated into the traditional social life of the countryside, where social relations are more closed (Liang et al., 2015; Ma and Abdulai, 2017).

For most smallholder farmers, it is often difficult to effectively enhance their capacity for autonomous development simply by relying on their own efforts. Farmers' cooperatives (hereafter referred to as cooperatives), as 'self-organizations' of farmers, have attracted the attention of many scholars in terms of increasing farmers' incomes and reducing poverty (Deng et al., 2021; Cheng et al., 2022). Some scholars argue that cooperatives should be regarded as an efficient organizational innovation in rural poverty governance because of their ability to fundamentally improve the efficiency of the use of poverty reduction funds and to improve the income, capacity and rights poverty of farm households (Ma and Abdulai, 2017). Cooperatives convey agricultural knowledge while improving the market competitiveness and social adaptability of poor farmers by enhancing their individual capacities, and repairing the capacity deficits of farmers in the new economy (Bacon et al., 2014). The mechanisms inherent in the participation of poor farmers in cooperatives to reduce poverty and increase income are partly the result of the individual empowerment of members through their business, capital and management participation in the cooperative, and this capacity-enhancing effect is greater for middle- and high-income farmers (Bernard et al., 2008; Verhofstadt and Maertens, 2014).

In general, most of the available studies confirm the positive role of cooperatives in reducing poverty and increasing income (Chagwiza et al., 2016; Cafer and Rikoon, 2018; Kumar et al., 2018). Cooperatives have an advantage over scattered smallholder farmers in terms of large-scale farming, use of advanced technologies, coping with market risks and access to policy subsidies, increasing the added value, profitability, labor productivity and employment of farmers engaged in agricultural production (Ito et al., 2012). Co-operatives not only help farmers reduce transaction costs in the procurement of agricultural materials and agricultural production services, but also improve their bargaining power in the sale of agricultural products; they also provide various types of training and activities to help farmers improve their ability to obtain information, express their needs and apply technology, thereby increasing their income (Kumar et al., 2018).

However, some scholars have also found that farmer group differences have a key impact on the poverty-reducing effects of cooperatives. Some cooperatives have evolved into "self-run enterprises" that do not contribute to the development of their members or to the income of farmers as a whole (Bernard and Taffesse, 2012). The natural heterogeneity of smallholder farmers in terms of their initial resource endowments, such as production and management capacity, risk tolerance and household livelihood capital, may lead to "elite capture," resulting in the diversion of poverty alleviation resources and misalignment of project implementation, creating new income inequalities (Beuchelt and Zeller, 2013). Some scholars also argue that small and medium-sized members of cooperatives are prone to "free-riding" behavior, unwilling to pay for the cooperative's public services and enjoy the benefits without contributing much, affecting the efficiency of the organization's operations and distributional equity (Tadesse et al., 2019; Ishak et al., 2020).

The above-mentioned studies provide an important theoretical basis for this paper, but there are still shortcomings: firstly, although scholars have focused on the impact of cooperatives on poverty reduction among farmers, they have not yet reached a unanimous conclusion, and most of them are based on theoretical discussions, lacking qualitative and quantitative studies on the impact of cooperatives on farmers' ability to reduce poverty. Secondly, few scholars have studied the heterogeneous effects of cooperatives on the future poverty reduction capacity of smallholder farmers from the perspective of farmer differentiation, especially the lack of discussion of groups of farmers with different poverty attributes and different human capital endowments.

1 In 2018, the World Bank used less than US$1.90, US$3.20 and US$5.50 per person per day as the extreme, low and medium poverty lines and the upper secondary poverty line.

The main contribution of this paper is that it uses the cooperative empowerment dimension as an entry point to quantify the reduction effect of cooperatives on farmers' poverty vulnerability and the differences in their effects on heterogeneous groups between groups, enriching the research framework on the "multidimensional pro-poorness" of cooperatives by using the Predominant Score Matching (PSM) method. The remainder of the paper is organized as follows: Section 2 proposes a theoretical analysis and four research hypotheses. Section 3 introduces the identification strategy, variables, and data for this study. Section 4 tests four hypotheses and presents the regression results and covers the heterogeneity analysis and robustness testing. Section 5 provides the discussions, conclusions and related policy implications.

2. Theoretical analysis and research hypothesis

The main reason for attracting farmers to join a cooperative is the economic return it can bring to them. Attached to the economic function, cooperatives also generate positive externalities by helping farmers to overcome barriers to market access, improve scientific and cultural literacy, increase social capital stock and empower management (Ito et al., 2012; Kumar et al., 2018). They also have positive externalities in terms of helping farmers overcome barriers to market access, improving scientific and cultural literacy, increasing social capital stock and empowering management, which in turn reduce the poverty vulnerability of smallholder farmers (Chagwiza et al., 2016; Zhang et al., 2023).

With the development of the market economy, agricultural markets are becoming more and more mature. For decentralized smallholders, due to their weakness, asymmetric information, high transaction costs and low standardization of production, they face high barriers to market entry and lack sufficient competitiveness and voice in large markets, and are unable to connect effectively with markets (mainly high value-added markets) on their own (Loconto and Simbua, 2012; Richards and Mendez, 2014). Collective action, i.e., the formation of cooperatives, is an effective mechanism to help resolve the conflict between smallholders and large markets and to increase farmers' participation in the market (Beuchelt and Zeller, 2013).

Collective action provides relevant information and services to smallholders, including technical information and services (agricultural extension and research and development), educational services (production skills training, business skills training and general education), etc. It improves the efficiency and management of farmers' access to agricultural technology and also promotes the sustainable and healthy development of the cooperative (Mavimbela et al., 2010; Meador et al., 2016; Tray et al., 2021). The human capital of the farmers is accumulated and the endogenous motivation for development is further stimulated.

In terms of management participation, democratic management and control is the foundation and core principle of the cooperative system. The participation of members in general meetings, councils and supervisory boards, and the full expression of their views and demands, not only helps to safeguard their own property rights and interests and to obtain more residual claims, but also increases trust within the membership, helps to reduce conflicts in decision-making and the cost of control or supervision in management, ensures the smooth implementation of collective decisions, and minimizes opportunistic behavior on the part of cooperative managers (Bender, 1999; Wollni and Zeller, 2007; Ma and Abdulai, 2016). In general, cooperatives are effective in reducing the poverty vulnerability of smallholder farmers through market access, accelerated human (social) capital formation and empowerment of management. On this basis, we propose hypothesis 1.

> *H1*: Cooperatives can reduce the poverty vulnerability of smallholder households.

From the beginning of their development, cooperatives have been characterized by an external market environment embedded in the vertical integration of agriculture and supply chain management (Verhofstadt and Maertens, 2015). Smallholder farmers are at a distinct disadvantage in terms of enjoying the benefits of global value chains due to their low sales volume and limited bargaining power, as well as the fact that smallholder farmers are often severely limited in their participation in markets by human capital and credit. Especially with the increasing trend toward globalization of agricultural markets and the need for higher management skills and logistics techniques to market agricultural products and meet higher standards of food safety certification, the problem of smallholder participation in integrating into global value chains has become more pronounced, and they even face the risk of being marginalized (An et al., 2015; Fan and Garcia, 2018; Ajates, 2020). As far as the internal environment is concerned, with socio-economic development and the expansion of cooperatives, the structure of group membership has stratified and the heterogeneity of members has increased significantly (Mojo et al., 2017). Therefore, when studying the impact of cooperatives on the poverty vulnerability of smallholder farmers, different group characteristic factors should be included in the examination.

In terms of poverty attributes, on the one hand, poor farmers tend to have a strong will to escape poverty, but show vulnerability characteristics such as poor labor skills, sick and disabled members of the family, heavy child-rearing burden and few risk-averse means (Deng et al., 2021). The greater the vulnerability to poverty, the more risk-sensitive and risk-averse they are. They are reluctant to join a cooperative or even if they do join, they are reluctant to invest in shares, thus becoming passive or dormant members. The stratification between poor and non-poor farmers, and the resulting unequal power patterns, may constrain the accumulation of a virtuous cycle of poverty vulnerability reduction among poor farmers (Ma and Abdulai, 2016). On the other hand, from the perspective of cooperatives, although cooperatives are an effective way to reduce poverty through the organic combination of market and government mechanisms, and objectively have a poverty-reducing effect, some cooperatives do not have an obvious motivation to reduce poverty subjectively, let alone a mature concept of poverty alleviation (Grashuis and Su, 2019). Most of the leaders of co-operatives have a philosophy of serving their own economic performance, and their "deliberate care" for the poor tends to be weakened. Based on economic rationality, co-operatives are exclusive toward poor farmers who lack resources and have low development capacity, and tend to favor non-poor groups who are well endowed with large scale operations and dedicated investments in poor areas (Deng et al., 2010). Even when cooperatives open their membership to poor farmers in general, taking care of poor farmers

in a unified operation would mean lower returns for non-poor members (Wollni and Zeller, 2007). The more poor farmers a co-operative takes on, the greater the risk it may face of a decline in overall benefits. On this basis, we propose hypothesis 2.

> *H2*: The effect of poverty vulnerability reduction due to cooperative membership is higher on non-poor farming households than in poor farming households.

Poverty is a vague concept, but it has some basic characteristics, namely that it is mainly marked by "lack," which appears as "low income" and "lack of material and services," but in essence is a lack of "means," "capabilities," "rights" and "opportunities." Education levels are closely linked to the ability of smallholder households to escape poverty (Yang et al., 2023). Better-educated farmers tend to have a greater ability to accept new knowledge and new things and to understand and learn, and their rich knowledge base makes them more likely to accept the organizational system, business philosophy and production techniques of the cooperative, which makes it easier for them to join the cooperative (Ito et al., 2012). Moreover, the stronger the ability to accept new knowledge and technology, the clearer the perception of the cooperative's ability to enhance its own development. On this basis, we propose hypothesis 3.

> *H3*: Cooperatives are more effective in reducing the vulnerability to poverty of households with high human capital endowments than those with low human capital endowments.

Institutional norms of rural cooperatives mainly include formal institutional arrangements and informal institutional norms. We have found that rural cooperatives in China tend to be member-based and rely closely on related enterprises. In terms of management, the cooperative has adopted the practice of "two brands and one set of staff" with the enterprise. The day-to-day management, sales and technical guidance of the cooperative are all dependent on the relevant enterprise, with the core members responsible for the management of the enterprise and the ordinary members only involved in the business work. The heterogeneity of the membership structure of cooperatives is shaped by the differentiation of farming households (van Rijsbergen et al., 2016). This heterogeneity is reflected in the distinction between core members and general members of the cooperative. These two types of members have different levels of income and different levels of participation in the cooperative, resulting in different roles and division of labor, which leads to differences in their ability to improve their skills, showing typical asymmetrical characteristics (Valkila and Nygren, 2010). Compared to core members, general members are usually low-income, low-capital participation groups, and such groups often lack the interest and ability to participate in the public affairs of the cooperative, or even the opportunity to do so (Jitmun et al., 2020). They rarely participate in the day-to-day management and supervision of cooperatives, and are mostly limited to basic aspects such as participation in the purchase of agricultural inputs and materials, the sale of agricultural products, and access to specialized technical services and policy concessions. For core members, their material resource endowments are at an advantage, and they hold the majority of shares in the co-operative, control most of the residual control and residual claims, have more say in the daily production and management activities of the co-operative, and can make full use of their resource endowments and effectively spill over, thus becoming the biggest beneficiaries of the development of the co-operative (Shi et al., 2019; Li et al., 2021). On this basis, we propose hypothesis 4.

> *H4*: Cooperatives are more effective in reducing the poverty vulnerability of middle- and high-income households than of low-income households.

Based on the above analysis, the theoretical analysis framework of this paper is shown in Figure 1.

3. Materials and methods

3.1. Data

The data in this article comes from a comprehensive survey on the status of rural poverty in Southwest China, July–September 2021. The region covers four provinces, Yunnan, Guizhou, Sichuan and Chongqing. Including eight state-defined poor counties (cities) in Fengjie, Wanzhou, Yunyang, Xishui, Puding, Guang'an, Xuyong, and Dongchuan, 136 villages with 12 farmers per village, a total of 1,632 households in the sample. The research sample was selected based on a three-stage sampling: (1) Cluster analysis sampling. The original 592 state-defined poor counties were divided into three categories of overall poverty status, with experts empirically assessing the worst category and selecting sample provinces and counties in the worst category. (2) Probability Proportional Scale Sampling. Sample villages were selected in proportion to the size of the poor population. (3) Random sampling. A sample of 12 farmers was randomly selected in each village to answer the questionnaire. This sample data represents to a large extent the group of farming households that need the most attention in the less developed counties of China, and is representative and typical. Since the focus of this paper is on smallholder households, farmers with average arable land above 0.67 ha are excluded. After data cleaning and elimination of the 10 questionnaires that did not meet the requirements, the actual research population of this paper is 1,622 households.

3.2. Method

3.2.1. Poverty vulnerability measurement

Poverty vulnerability, which connects risk shocks to the degree of household welfare, is often seen as unobservable, dynamic, and forward-looking, with a focus on poverty generation expectations (Wang et al., 2022). Poverty vulnerability is the probability that a household or individual will fall into poverty or fail to escape from poverty as a result of exposure to uncertainty risk shocks. Poverty vulnerability is calculated as follows.

$$\hat{V}_i = Prob\left(\ln c_i < \ln z \middle| X_i\right) = \Phi\left[\frac{\left(\ln z - X_i\,\hat{\beta}_{FGLS}\right)}{\sqrt{X_i\,\hat{\theta}_{FGLS}}}\right] \quad (1)$$

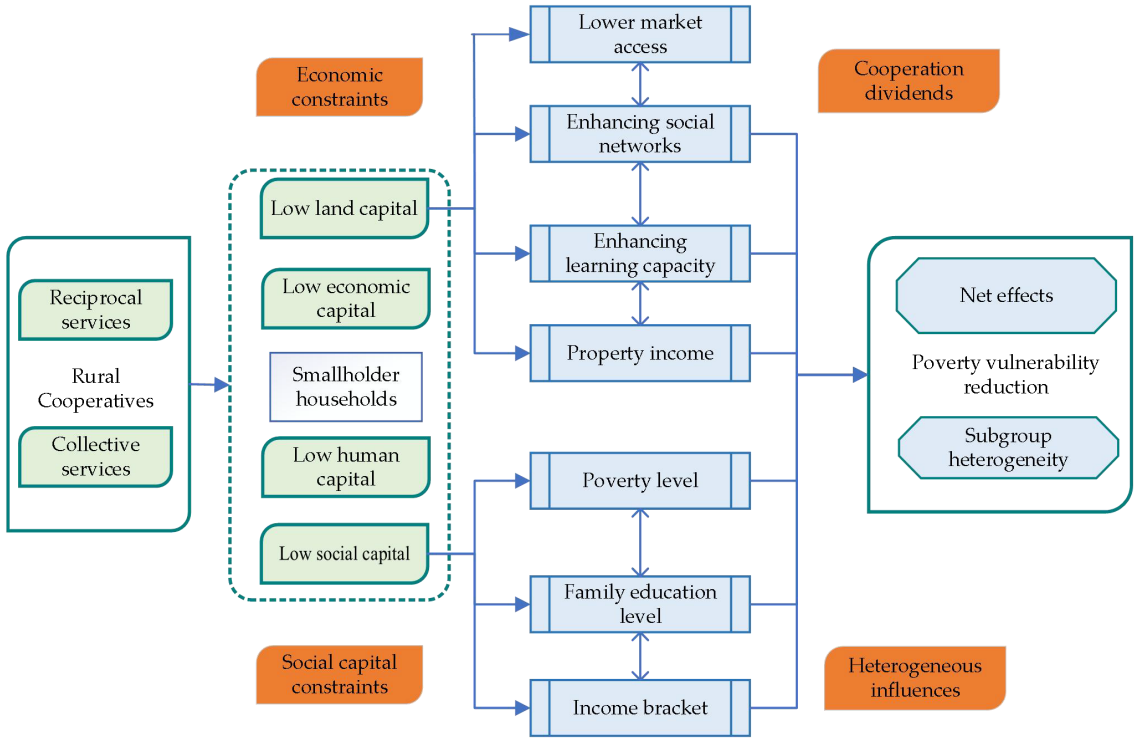

FIGURE 1
A theoretical model of the impact of cooperatives on poverty vulnerability of smallholder households.

Where $\hat{V}_i$ is an estimate of the probability of future poverty for farmer *i*, c_i is the value of *per capita* household consumption, z is the delineated poverty line, Φ is the cumulative distribution function of the normal distribution, $\hat{\beta}_{FGLS}$ and $\hat{\theta}_{FGLS}$ denote the expected value and variance of future household consumption estimated by the FLGS method, respectively. X_i is an observable variable, referring to Wang et al. in their examination of poverty vulnerability by introducing household characteristics variables (including household income, household size, land assets, liabilities, agricultural machinery, etc.) and household head characteristics variables (including age, gender, education, etc.).

3.2.2. Econometric model

We constructed an OLS model to examine the impact of cooperatives on poverty vulnerability of smallholder households. The OLS model is set up as in Equation (2):

$$y_i = \alpha + \beta Cooperatives_i + \theta X_i + \varepsilon_i \quad (2)$$

Among them, y_i is the poverty vulnerability of smallholder households. $Cooperatives_i$ represents the participation in a rural cooperative, and X_i indicates a series of control variables, mainly including family characteristics, village characteristics and head of household Characteristics.

3.2.3. Propensity score matching (PSM) model

The propensity score matching method is a counterfactual inference method, the basic idea of which is to find a sample of controls similar to the treatment group to compare their effects, thus effectively solving the endogeneity problem arising from sample selection bias (Yang et al., 2023). Since differences in farmers' initial endowments can directly cause a "selective bias" in their willingness or behavior to join a cooperative, and whether or not to join a cooperative often reflects the ideological tendency of rational farmers to pursue optimal utility, a simple OLS regression of Equation (2), which estimates the capacity-enhancing effect of farmers ignores their own subjective initiative, yields only the conditional expectation effect of the explanatory variables on the explanatory variables, and the results obtained may be biased. The PSM propensity value matching method can effectively solve these problems by finding a control group (uninvolved farmers) with similar characteristics that can simulate the counterfactual state of the treatment group (involved farmers), thus maximizing the elimination of endogeneity problems due to self-selection bias. The specific steps are as follows.

Step 1: we used a logistic model to calculate the conditional probability of a household Participating in rural cooperatives, i.e., the propensity score.

Step 2: based on the propensity scores obtained through three methods: nearest neighbor matching, radius matching and kernel matching, we found a sample of farmers in the control group with propensity scores as similar as possible to those in the treatment group, in order to control and eliminate selectivity errors.

Step 3: PSM model requires that the variables used for matching meet the common support domain assumption and the balance test, and after the sample has been matched and the matching effect has been achieved, we calculate the average treatment effect (ATT). The ATT is calculated as shown below.

$$PS_i = \Pr\left[D_i = 1|\mathrm{X_i}\right] = \mathrm{E}\left[D_i = 0|\mathrm{X_i}\right] \quad (3)$$

$$ATT = \frac{1}{N^t}\sum_{i\in I^t\cap S}\left\{Y_i - \sum_{j\in I^c\cap S} W_{ij}Y_j\right\} \quad (4)$$

Among them, N^t is the number of samples, I^t is the sample set of the disposal group (Participating in rural cooperatives), I^c is the sample set of the control group (Not Participating in rural cooperatives), Y_i is the observed value of the sample of the disposal group, and Y_j is the sample of the control group. The observations of j, S is the common support domain set, W_{ij} is the matching weight, and ATT is the average disposition effect.

3.3. Variables

3.3.1. Dependent variables

To forecast household poverty vulnerability, this article uses household *per capita* consumption. One reason for using consumption to define poverty is that income is easily underestimated in micro-surveys, whereas consumption can better reflect the level of family welfare, and the other is that using income as an explanatory variable can easily lead to strong endogenous problems in the measurement model. Regarding the choice of the poverty line, there are primarily two standards of *per capita* daily consumption of US$1.9 and US$3.1 proposed by the World Bank in 2015, which we convert into ¥2,800 and ¥4,570 *per capita* annual consumption based on China's average purchasing power and CPI index (Wang et al., 2022). In the subsequent analysis, we focus on ¥4,570 as the poverty standard line.

3.3.2. Independent variables

The core independent variable is whether or not one participates in a cooperative. The ability of cooperatives to bring significant capacity enhancement effects to farmers at different stages of agricultural production depends on whether or not farmers participate in cooperatives. The core explanatory variable is "whether or not the farmer participates in a cooperative," which describes the impact of cooperatives on the poverty vulnerability of smallholder households.

3.3.3. Control variables

With reference to existing studies, this paper introduces three types of control variables, namely, variables on individual household head characteristics, variables on household characteristics and variables on village characteristics (Scripcariu et al., 2020; Yin et al., 2020; Ma and Jin, 2022). Household head characteristics include gender, age, and education level; Household characteristics include the number of household labors, net household income *per capita*, level of household poverty, whether there are family members working in the city, total productive assets and annual gift expenses; village characteristics include village transportation conditions and economic status. The descriptive statistical characteristics of the specific variables are shown in Table 1.

4. Empirical results

4.1. Benchmark regression results

Table 2 reports the results of the benchmark regression of the impact of rural cooperatives on the poverty vulnerability of smallholder households. In Model 1, we only control for the characteristic variables of the household head. In Model 2, we further controlled for household characteristics variables of smallholder farmers. In Model 3, we included household head characteristics, household characteristics and village residence characteristics as control variables. The results show that, controlling for a range of variables, participation in cooperatives can significantly reduce the poverty vulnerability of smallholder farmers. The impact factor is −0.0162, and is significant at the 5% level, which basically supports hypothesis 1 that cooperatives can reduce the poverty vulnerability of smallholder farmers.

The coefficients and signs of the control variables remain consistent with existing studies. The level of education of the household head, the net household income, social capital and the distance from the village to the county have a significant positive impact on the reduction in poverty vulnerability of smallholder farmers. Age of head of household and level of household poverty have a significant negative effect on reduction in poverty vulnerability of smallholder farmers. In addition, the number of laborers and migrant workers also show a negative impact on the reduction of poverty vulnerability, which may be closely related to the demographic disadvantage of smallholder households.

4.2. Robustness tests of the PSM model

The benchmark regression results show that joining a rural cooperative can significantly reduce the poverty vulnerability of smallholder farmers. However, there is also a potential problem that OLS regression results are susceptible to sample selection bias, and those factors that are not observed may affect the precision of the estimates. In order to ensure the credibility and robustness of the regression results, we further used the come PSM model to verify the poverty vulnerability reduction effect of cooperatives on farm households. We have selected control variables that were significant in the baseline regression model for the propensity score matching, in order to eliminate the variability of the characteristic variables between the two sample groups.

After propensity score matching, the question of conditional independence between the two sample groups needs to be checked, i.e., there are no significant differences in the characteristics variables between the matched sample groups, except for differences in the poverty vulnerability of the farmers. Table 3 reports the results of the conditional independence hypothesis tests for the explanatory variables before and after PSM matching. After PSM matching, the pseudo R^2 decreases from 0.013 before matching to 0.001–0.003 after matching. LR chi2, B-values and mean bias-value have all fallen substantially. All p values are greater than 10%. Thus, after matching by the PSM model, we significantly eliminate systematic differences in the distribution of explanatory variables between the treatment and control groups, minimize sample selection bias, and propensity score estimation and sample

matching are more successful, significantly weakening estimation bias due to self-selection.

In Table 4, we used five PSM methods to estimate ATT, ATU and ATE for the impact of cooperatives on the poverty vulnerability of smallholder farmers. Among them, ATT represents the average treatment effect of the treatment group; ATU represents the average treatment effect of the control group; ATE is the average treatment effect for the overall sample. The results show that the five matching methods ATT, ATU and ATE all passed the test at the 1% significance level, which indicates that the results of matching between samples are relatively robust. The mean value of ATT is −0.0252, which suggests that cooperatives have a significant dampening effect on the poverty vulnerability of farm households. In other words, the poverty vulnerability of farmers who joined cooperatives was reduced by 0.0252 compared to those who did not join cooperatives.

4.3. Results of the heterogeneity analysis

4.3.1. Heterogeneity analysis based on educational level of household heads

The level of education of the household head is largely representative of the overall human capital endowment of the smallholder household. Therefore, we examine the heterogeneity of the effect of cooperatives on reducing the vulnerability of farm households to poverty in terms of the educational attainment of the

TABLE 1 Definition and descriptive statistics of the variables involved.

Variables	Definition	Mean	SD
Dependent variables			
Vulnerability	Poverty vulnerability of smallholder households	0.1414	0.2089
Independent variables			
Cooperative	Whether or not to participate in a cooperative	0.2429	0.4289
Control variables			
Age	Age of the head of household (Years)	48.8199	11.3194
Gender	Gender of head of household. Female = 0; male = 1	0.6374	0.4808
Education	Years of education of the head of household	5.6535	4.3273
Income	Logarithm of net household income *per capita*	8.6364	1.2595
Labor	Number of members in household aged 15–64	3.3083	1.6904
Poverty	Whether the household is households registered as living under the poverty line. Yes = 1; No = 0	0.5720	0.3775
Migrant	Whether there are family members working in the city. Yes = 1; No = 0	0.5758	0.4943
Assets	Logarithm of total productive assets	11.9661	1.1318
S-capital	Logarithm of total gift expenses	7.3053	2.0172
Distance	Distance between the settlement and the county (km)	51.9343	40.824
Economic	Settled village economic status assessment	4.1003	1.0108
SiChuang	Whether the province is SiChuang. Yes = 1; No = 0	0.3218	0.1509
YuNan	Whether the province is Yunnan. Yes = 1; No = 0	0.1849	0.2514
ChongQing	Whether the province is ChongQing. Yes = 1; No = 0	0.3817	0.3499
GuiZhou	Whether the province is Guizhou. Yes = 1; No = 0	0.1116	0.1724
Observation	1,622		

TABLE 2 Baseline regression results of the impact of rural cooperatives on the poverty vulnerability of smallholder households.

Variables	(1)	(2)	(3)
Cooperatives	−0.0443 *** (0.0112)	−0.0182 ** (0.0072)	−0.0162** (0.0076)
Age	0.0032*** (0.0004)	0.0036 *** (0.0002)	0. 0036*** (0.0002)
Gender	0.0424*** (0.0103)	0.0282*** (0.0067)	0.0246*** (0.0060)
Education	−0.0135 *** (0. 0011)	−0.0050 *** (0.0007)	−0.0039*** (0.0006)
Income		−0.0897 *** (0. 0046)	−0.0763*** (0.0041)
Labor		0.0580*** (0.0018)	0.0595 *** (0.0164)
Poverty		0.1332*** (0.0112)	0.0452*** (0.0163)
S-capital		−0.0039*** (0.0007)	−0.0035 *** (0.006)
Migrant		0.0198*** (0.0066)	0.0175*** (0.0059)
Economic			−0.0072 (0.0199)
Distance			−0.0294*** (0.0014)
Province-FE	Yes	Yes	Yes
N	1,622	1,622	1,622
R^2	0.1464	0.6433	0.7165

The standard error is shown in parentheses. ** and *** are statistically significant at 5%,1% levels, respectively. Province-FE represents provincial fixed effects.

TABLE 3 Results of conditional independence hypothesis tests for explanatory variables before and after matching.

Matching method	Ps R^2	LR chi2	MeanBias	B-value	Value of *p*
Unmatched	0.013	24.27	7.8	37.9	0.002
Nearest neighbor matching ($k=4$)	0.001	1.01	2.1	7.2	0.998
Radius matching	0.000	0.54	1.4	5.2	0.997
Kernel matching	0.000	0.51	1.4	5.1	0.999
Mahalas matching	0.001	1.30	1.5	8.1	0.996
Partial linear regression matching	0.002	3.81	1.6	7.6	0.874

household head. China has a 9-year compulsory education system. Based on China's school system, this paper classifies the years of education for heads of households into two categories, namely lower education group (0–9 years), and higher education group (more than 9 years).

As shown in Table 5, the effect of cooperatives on reducing poverty vulnerability is 2.05 times greater in the high quality group (−0.0387) than in the low quality group (−0.0188) for the education level of the household heads, which suggests that farmers with high quality human capital endowments are more likely to improve their poverty status after joining a cooperative than those with low quality. Hypothesis 3 was tested.

4.3.2. Heterogeneity analysis based on the level of household poverty

We divided the sample into two groups according to whether the households were registered as living under the poverty line or not. As shown in Table 6, cooperatives have a negative impact on the poverty vulnerability of farmers across different poverty attributes, but there are differences in the magnitude of the effect. The reduction effect of cooperatives on poverty vulnerability of non-poor households (0.0570) is 4.37 times greater than that of poor households (0.0130). This shows that non-poor households are more likely to benefit from co-operative seeds than poor households. Hypothesis 2 is verified.

4.3.3. Heterogeneity analysis based on the household incomes

This paper classifies farm households into lower-income and higher-income groups based on their median *per capita* income levels, and removes the variable of net household income from the regression. As shown in Table 7, the reduction effect of cooperatives on poverty vulnerability of higher income households is greater than that of lower income households. Overall, the cooperatives had a dampening effect on poverty vulnerability for both the lower and higher income groups of farmers, but there were differences in the magnitude of the effect, with a greater reduction effect for the higher income group than for the lower income group (−0.0406 > −0.0184), and hypothesis 4 is tested.

TABLE 4 Propensity score matching estimates of the impact of cooperatives on the poverty vulnerability of smallholder farmers.

Matching method	ATT	ATU	ATE
Nearest neighbor matching ($k=4$)	−0.0239**	−0.0299***	−0.0265***
Radius matching	−0.0235***	−0.0284***	−0.0272***
Kernel matching	−0.0222***	−0.0377***	−0.0340***
Mahalas matching	−0.0238**	−0.0335***	−0.0288***
Partial linear regression matching	−0.0324***	−0.0229***	−0.0276***
Average value	−0.0252	−0.0305	−0.0288

The standard error is shown in parentheses. ** and *** are statistically significant at 5 and 1% levels, respectively. Significance tests for ATT, ATU, and ATE values were obtained using the bootstrap method of repeated sampling 500 times.

TABLE 5 Results of heterogeneity analysis on the relationship between the cooperatives and educational level of household heads.

Variables	ATT	
	lower education (0–9 years)	higher education (more than 9 years)
Nearest neighbor matching ($k=4$)	−0.0191*	−0.0463***
Radius matching	−0.0179*	−0.0337**
Kernel matching	−0.0180*	−0.0440***
Mahalas matching	−0.0121	−0.0326***
Partial linear regression matching	−0.0271**	−0.0369***
Average value	−0.0188	−0.0387

The standard error is shown in parentheses. *, ** and *** are statistically significant at 10, 5, and 1% levels, respectively. Significance tests for ATT, ATU, and ATE values were obtained using the bootstrap method of repeated sampling 500 times.

5. Discussion and conclusions

5.1. Discussions

Our explorations of the heterogeneous characteristics of smallholder farmers leads to a topic worth exploring, namely whether cooperatives in reality can meet the development aspirations of a wide range of disadvantaged groups and whether they really have the desired organizational effectiveness in driving smallholder farmers. According to classical co-operative theory, alleviating the inherent tension between smallholders and the larger market is the purpose of forming a cooperative for 'weak' smallholders (Lennard-Jones and Devonshire, 1939; Bleaney, 1963; Elliott et al., 1971). However, an important prerequisite for the effective operation of cooperatives is a high degree of homogeneity in membership. In reality, farmers are highly heterogeneous, and this is difficult to eliminate in the short term (Cai, 2002). As a result, the organizational objectives of cooperatives deviate from the assumptions of classical cooperative theory, and the organizational performance is biased toward members with superior resource endowments (Cai, 2002; Wagstaff et al., 2009). Thus, the organizational objectives of cooperatives deviated from the assumptions of classical cooperative theory, and organizational performance was biased in favor of members with superior resource endowments, so that the development and profitability of small farmers was reduced.

Cooperatives are an important vehicle for industrial poverty alleviation (Bernard and Spielman, 2009). The vast majority of studies have affirmed the positive role of cooperatives in reducing poverty and increasing income (Sun et al., 2009; Mojo et al., 2017). Cooperatives have an advantage over scattered smallholder farmers in terms of large-scale operation of farmland, use of advanced technology, coping with market risks and access to policy subsidies, increasing the added value, profitability, labor productivity and employment rate of farmers engaged in agricultural production (Sun et al., 2009; Babiarz et al., 2010). Co-operatives not only help farmers reduce transaction costs in the procurement of agricultural materials and agricultural production services, and increase their bargaining power in the marketing of agricultural products; they also provide a variety of training and activities to help farmers improve their viable capacity to access information, express their needs and apply technology, which helps reduce the poverty vulnerability of smallholder households (Dao et al., 2023).

In practice, some researchers have focused on the alienation of cooperatives caused by differences in groups of farmers (Dai et al., 2023; Zeren et al., 2023). Some co-operatives have evolved into 'self-run enterprises' that do not contribute to the development of their members, nor do they contribute to the incomes of farming households as a whole (Wilmsen et al., 2022; Dong et al., 2023). The natural heterogeneity of smallholder farmers in terms of their initial resource endowments, such as production and management capacity, risk tolerance and household livelihood capital, may lead to "elite capture," resulting in deviated resources for poverty alleviation and misplaced project implementation, creating new income inequalities (Gilcrease et al., 2022). Some scholars also argue that small and medium-sized members of cooperatives are prone to "free-riding" behavior, unwilling to pay for the cooperative's public services and enjoy the benefits without contributing much, affecting the efficiency of the organization's operations and distributional equity (Ito et al., 2012).

TABLE 6 Results of heterogeneity analysis on the relationship between cooperatives and the poverty levels of farmers.

Variables	ATT	
	Under the poverty line	Above the poverty line
Nearest neighbor matching ($k=4$)	−0.0133**	−0.0407*
Radius matching	−0.0128**	−0.0548**
Kernel matching	−0.0068***	−0.0623***
Mahalas matching	−0.0132***	−0.0655**
Partial linear regression matching	−0.0191**	−0.0617**
Average value	−0.0130	−0.0570

The standard error is shown in parentheses. *, ** and *** are statistically significant at 10, 5 and 1% levels, respectively. Significance tests for ATT, ATU, and ATE values were obtained using the bootstrap method of repeated sampling 500 times.

TABLE 7 Results of heterogeneity analysis on the relationship between cooperatives and the household incomes.

Variables	ATT	
	Lower income families	Higher income families
Nearest neighbor matching ($k=4$)	−0.0173***	−0.0458 ***
radius matching	−0.0181**	−0.0384**
kernel matching	−0.0168***	−0.0423***
Mahalas matching	−0.0202**	−0.0355**
partial linear regression matching	−0.0195**	−0.0413**
Average value	−0.0184	−0.0406

The standard error is shown in parentheses. ** and *** are statistically significant at 5 and 1% levels, respectively. Significance tests for ATT, ATU, and ATE values were obtained using the bootstrap method of repeated sampling 500 times.

Heterogeneous characteristics make a difference in both the motivation of farmers to join and their factor inputs, resulting in differences in the impact of cooperatives on farmers' incomes (Gorczyca et al., 2022). It has been generally agreed that farmers with better resource endowments and more factor inputs are more likely to seek more control over their surplus. To accurately detect the impact of co-operatives on the poverty vulnerability of farm households, it is necessary to distinguish between the heterogeneity of farm households and focus on which groups co-operatives work more significantly for. The findings of this paper also confirm this phenomenon (Fernandes and Silva, 2022). Farmers whose heads have higher levels of education, non-poor families and higher household incomes have gained a more pronounced reduction in their poverty vulnerability after joining the cooperative. In research in less developed areas, poverty alleviation work generally suffers from strong policy input but weak endogenous motivation enhancement, etc. Most cooperatives only objectively absorb poor farmers into their societies as a matter of policy, but subjectively they do not pursue the effectiveness of bringing poverty, and are not willing to absorb poor farmers. In addition, the risk-averse nature of poor farmers with inherent lack of production endowments and social network resources often makes them reluctant to join the society, or even if they do, the shares they put in are low due to financial constraints, which inevitably leads to the problem that the cooperatives are "pro" the capable rural people and "anti" the disadvantaged (Bernard and Spielman, 2009; Chagwiza et al., 2016). The problem is that cooperatives are inevitably "pro" rural people and "pro" disadvantaged groups. However, it is also important to note that the value of cooperatives in benefiting the poor should not be dismissed because of their "affinity" to the rural and disadvantaged groups (Xu and Li, 2023). The empirical results also show that even if poor farmers find it difficult to participate in co-operatives because they are 'excluded' or less willing to join them, they can still benefit indirectly through the spillover effects of co-operatives.

Additionally, Farmers in different income brackets and education levels have different levels of involvement in the operations and management of the cooperative, leading to differences in their poverty vulnerability reduction. Farmers with less physical capital and less learning capacity have less control and say in the day-to-day operations of the cooperative, and tend to be in a lower position in the cooperative than those with more material resources and higher levels of education (Bouichou et al., 2021). Accordingly, cooperatives are also less effective in reducing their poverty vulnerability than members with superior physical capital and high levels of education. Conversely, farmers with strong economic resource endowments usually have sufficient accumulation of their own resource factors and can make full use of and effectively spill over their economic resource endowments (Alam et al., 2021). As a result, the decision to join the society is more effective and more rewarding for these farmers.

5.2. Conclusion

Based on micro-survey data from smallholder farmers in eight counties in four provinces in the underdeveloped regions of western China, this paper analyses the impact of farmers' membership in cooperatives on their poverty vulnerability and further explores the differences in the poverty reduction effects of cooperatives on groups with different poverty attributes, different human capital endowments (education level of the household head), and different income class heterogeneity. The main conclusions are as follows.

(1) Cooperatives have a significant dampening effect on the poverty vulnerability of smallholder farmers. Cooperatives have a positive external impact in terms of helping farmers to overcome barriers to market access, accelerating the formation of human (social) capital and empowering management, which in turn has a combined effect on improving the ability of farmers to develop themselves, which has a combined effect on the improvement and enhancement of farmers' capacity for autonomous development.
(2) After overcoming the sample selection bias using the PSM model, the results show that participation in cooperatives still reduces the poverty vulnerability of smallholder farmers by an average of −0.0252, and the result remains robust to multiple tests of the methodology.
(3) The impact of cooperatives on the poverty vulnerability of smallholder farmers is significantly heterogeneous across groups. Specifically, participation in cooperatives has a more pronounced effect on poverty reduction among non-poor, higher human capital endowment and higher income bracket households than among poor, lower human capital endowment and lower income bracket households.

The validated conclusions outlined above can contribute and assist in emerging policy enlightenment. Firstly, enhancing the linkages between the interests of rural 'elite' figures and 'weak' small farmers. Policy makers should guide and encourage farmers to join or start cooperatives and support the development of cooperatives as an effective initiative to reduce poverty among smallholder farmers, but they should also see the limitations of the effectiveness of policy implementation. A top-down push for cooperative development and the pursuit of incremental growth in order to achieve an increase in the ability of farmers to reduce poverty will likely lead to a further widening of the gap in the ability of farmers to escape poverty in the future. The government should, on the basis of cultivating the stock of cooperatives, keenly identify the fit between "elite" figures and "weak" small farmers in terms of business areas and cooperative relationships, and strengthen the linkage between the interests of cooperatives and small farmers in order to minimize the negative effect of "elite capture." Secondly, cooperatives are an effective way for smallholder farmers in less developed areas to escape poverty. Even if poor farmers find it difficult to participate in cooperatives because they are 'excluded' or have a low willingness to join, they can still benefit indirectly through the spillover effects of cooperatives.

There are still many limitations in this paper, which can be seen in the following aspects: Firstly, we have focused more on the heterogeneity of farmers and neglected the heterogeneity of the cooperatives themselves. The variables in this paper are selected from the perspective of farmers only, and are based on a single dimensional characteristic of farmers, without detailed descriptions and statistics of cooperatives. Second, the paper does not consider the willingness of cooperatives to take on board. Whether farmers can become members of cooperatives is not only based on whether they have a demand for membership, but also on whether cooperatives have the willingness to open up membership to the public, which is the result of a combination of demand and supply factors. However, on the supply side, the willingness of cooperatives to take up membership varies depending on the organizational model, governance and other characteristic factors of cooperatives in less developed western regions. Thirdly, social capital and the governance model of cooperatives play an important role in the poverty reduction effect of rural cooperatives. However, we did not conduct an in-depth analysis of these two areas due to the availability of data. Finally, the paper does not include the factors of policy intervention in cooperatives in its examination. If the policy is to support excellence and strength, cooperatives will choose to exclude the rural disadvantaged because they want to improve their competitiveness; in contrast, if the policy is to regulate the development of cooperatives and advocate their pro-poor attributes, then the relevant policy interventions will affect the exclusion decision of cooperatives as well as the demand of farmers to join the society. Policy interventions affect both the willingness of co-operatives to take in and the demand of farmers to join. The construction of an analytical framework that incorporates policy interventions, cooperative and farmer characteristics is an important direction for future research.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

MY: conceptualization, validation, data curation, and supervision. ZZ: methodology and resources. MY and JL: software, writing—original draft preparation, writing—review and editing, and visualization. JL, MY, and JL: formal analysis. JL: investigation. All authors have read and agreed to the published version of the manuscript.

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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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