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Impacts of farmer cooperative membership on household income and inequality: Evidence from a household survey in China

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Abstract

While joining farmer cooperatives has been identified as a way for farmers, especially small farmers, to overcome their limitations in the marketplace and increase their income, this paper presents an analytical framework for examining how farmer cooperative may increase farmer income in rural China, empirically assesses the impacts of such membership on household income, and examines how the membership may affect income inequality. Data from a large-scale survey of rural households in China are used to examine the impacts of farmer cooperative membership and other factors on household income through a multivariate regression analysis and to test whether the impacts are different across income groups through a quantile regression analysis. The propensity score matching technique is used to address potential self-selection bias problems in the dataset and quantile regression is used to examine the impact for different income quantiles or groups of farmers. The empirical results indicate that farmers participating in professional cooperatives, on average, earned significantly higher income than their counterparts, but the positive impact was not statistically significant for low-income quantiles. This finding suggests that encouraging the development of and participation in farmer cooperatives could increase the average income but may not contribute directly to the policy goal of reducing income inequality in rural China.

Keywords: Farmer cooperatives, Farmer household income, Income inequality, Quantile regression, Propensity score matching, China

JEL Classification: D22, Q12, L25, C12

Introduction

Joining farmer cooperatives has been identified as a way for farmers, especially small farmers, to overcome their limitations in the marketplace and increase their income (Ferrier and Porter 1991; Markelova et al. 2009; Ahn et al. 2012; Zhang and Huang 2014; Shumeta et al. 2018; Tadesse et al. 2018; Grashuis and Su 2018). While many studies have assessed the impacts of farmer cooperatives on farmer income in different nations, more studies, especially empirical studies, are needed for better understanding of how farmer cooperatives affect household income, income distribution and inequality. For

example, while increasing farmer income and reducing income inequality and poverty have been the major policy goals of China's agricultural and rural development policies, it is interesting to examine how the rapid development of farmer cooperatives across China has contributed to the two policy goals. The major purpose of this paper is to examine the impacts of farmer cooperative membership on household income and the differences of the impacts across income groups in rural China using data from a nationwide household survey.

Since China joined the World Trade Organization (WTO) in 2001, it has gradually emerged as a large importer of many agricultural products due to the lower prices in the international markets and China's significant reduction in tariffs and other import restrictions committed to under WTO agreements (Yuan 2013; Li 2017). For example, China's soybean imports increased steadily from 13.94 million metric tons (mmt) in 2001 to 100.33 mmt in 2020 (Li 2017; United States Department of Agriculture [USDA] Foreign Agricultural Service [FAS] 2021). China has been the world's largest soybean importer and counted for more than 60% of the total world exports since 2010. In addition to soybeans, China has also become a large importer of many other agricultural products, including pork, powdered milk, vegetable oils, and alfalfa.

The remarkable increase in China's imports of those agricultural products has significantly reduced domestic market prices and profitability for many Chinese farmers. For example, China's national average profit has been negative for rapeseed production since 2012 and negative for soybean production since 2014 (USDA FAS 2018). Many Chinese farmers are struggling with low domestic prices, increasing costs for labor and other production inputs, and increasing government regulations on food safety.

While there is no simple solution to the above problems faced by farmers in China and similar problems in many other nations, the development of farmer cooperatives has been identified as one way to promote the interests of farmers and help farmers overcome many problems associated with their limited market power (Ferrier and Porter 1991; Markelova et al. 2009; Ahn et al. 2012; Zhang and Huang 2014; Shumeta et al. 2018; Tadesse et al. 2018). For example, in Ethiopia, some agricultural policies and programs have been developed to promote agricultural cooperatives in order to provide service in input purchasing, output marketing, finance, agricultural machinery leasing, etc. (Tadesse et al. 2018). In China, because most farms are very small and vulnerable to market changes (Deng et al. 2010), the Chinese government has actively pursued various measures to support the development of farmer cooperatives to facilitate economic cooperation and market integration (Song et al. 2014; Hoken and Su 2018).

The Agriculture Law of the People's Republic of China (PRC), implemented in March 2003, encourages farmers to voluntarily develop various professional cooperatives to provide a wide range of services to their members. The Law of PRC on Specialized Farmer Cooperatives (shortened to "China's Farmer Cooperative Law") was formally put into effect in July 2007 and then revised in 2017. Many provinces and cities in China have also formulated specific policies to support the development of farmer cooperatives. The Chinese government has provided significant fiscal support for the development of farmer cooperatives. For example, from 2007 to 2017, the central government allocated a total of 11.8 billion Chinese *yuan* for farmer cooperative development, with an average annual growth rate of 21.48%. The government support for farmer cooperatives has

focused primarily on the adoption of new crop varieties and new farming technologies, technical training, standardization of farm product classification and processing, and information services. For the distribution of public funding, the central government has generally dispensed funds to provincial governments, and the provincial governments have then dispensed the funds to local governments to support farmer cooperatives that meet local needs. This approach has laid a financial foundation for the development of farmer cooperatives across regions. The provincial and local governments have often added more funds from their budgets for farmer cooperatives (Qiao 2018). According to a survey of 380 villages in 2009, 21% of the surveyed villages developed farmer cooperatives by 2008 (Deng et al. 2010). By the end of the third quarter of 2011, there were about 484,300 farmer cooperatives in China, with more than 38.7 million members (Ding 2012). Farmer cooperatives in China have mainly provided professional services in production, processing, marketing, technical information and training, and agricultural procurement. Huang and Liang (2018) provide a comprehensive review of the development of agricultural organizations and the role of farmer cooperatives in rural China since 1978. Huang and Liang (2018) also predicted that farmer cooperatives would likely continue to remain very important in China's agricultural systems and rural development.

Although farmer cooperatives have developed rapidly in China in the past decade, and several studies have examined their potential impacts on farmer income and other aspects of agricultural and rural development, there are still many unanswered questions about farmer cooperatives in China. This is partially because the development of farmer cooperatives in China is still in the early stages as compared to that in many other nations and partially because of the lack of data from China. For example, while reducing income inequality and poverty in rural China has been a major policy objective, there is a lack of information on the potential role of farmer cooperatives in achieving this policy objective.

The major purpose of this paper is to assess the impacts of farmer cooperative membership on farmer income, test whether the impacts are different across different income groups, and discuss potential policy implications. Specifically, data from a large-scale survey of rural Chinese households are used to examine the impacts of farmer cooperative membership and other factors on household income through a regression analysis with PSM technique and to test whether the impacts are different across different income groups through a quantile regression analysis. This paper is organized into five sections: Following this section of introduction, "[Literature review](#)" section summarizes the relevant literature, "[Analytical framework and research hypotheses](#)" section presents an analytical framework for examining the mechanisms by which participation in farmer cooperatives may increase farmer income, "[Material and methods](#)" section reports the empirical analysis and results and discusses the empirical findings, and "[Conclusions and policy implications](#)" section summarizes the major conclusions and policy implications.

Literature review

With the rapid development of farmer cooperatives in China, many scholars have analyzed the economic effects of farmer cooperatives based on different data and methods. While most analyses have concluded that farmer cooperatives have contributed to income growth and rural development in China, the specific findings are significantly different across studies. For example, Du (2006) showed that farmer cooperatives steadily and reliably increased the average income of cooperative members and also improved organization efficiency of the participants. Sun et al. (2007) conducted an empirical analysis and found that farmers who joined agricultural cooperatives earned higher income than their counterparts. Similarly, Xue et al. (2012) reported that the net per capita income of households that participated in land cooperatives in Ordos, Inner Mongolia, was significantly higher than that of non-participating households. Zhang et al. (2012) found that joining farmer cooperatives had a significantly positive effect on the net income of farmers, and the positive effect was reflected not only in the agricultural income of full-time farmers but also in the agricultural income and wage income of part-time farmers. Hu (2014) highlighted the role of farmer cooperatives in increasing farmer income in some of China's poor areas. Wen et al. (2015) suggested that farmer cooperatives embodying the principle of reciprocal cooperation could not only promote the division of labor in rural areas and the development of agricultural specialization, but also further increase the income of farmers. Hoken and Sato (2016) found that farmers' participation in cooperatives had a significantly positive impact on their net agricultural income in China. Peng and Huang (2017) analyzed the data from a survey of 1243 farmers in 15 provinces in China and reported that participation in farmer cooperatives increased farmer income by 7.06% on average. Using data from a recent household survey of 481 apple producers in China, Ma and Abdulai (2017) found that farmer cooperative membership has a positive and statistically significant impact on apple price, gross income, farm profit, and return on investment.

Although most of the previous studies are consistent in their conclusion about the positive effects of farmer cooperatives on farmer income, there are some contrary arguments. For example, based on the data from a survey of rice growers in Haiyan County, Jiangsu Province, Su and Chen (2014) used regression with PSM to analyze the effect of cooperative membership on rice farmers. They found that cooperative membership significantly improved the net income of rice growers but that the effect on large-scale farmers was significantly higher than that on small-scale farmers. In contrast, Yi et al. (2011) reported that cooperatives' influence on average income was obvious for small-scale farmers but not significant for large-scale farmers. Using data collected from watermelon farmers in rural Nanjing, Ito et al. (2012) examined the impacts of agricultural cooperatives and publicly funded extension services on individual household economy. Their work revealed that government extension services had limited impacts on farm income, but the positive impacts of farmer cooperatives were robust and substantially large for only small-scale farms. Ma and Abdulai (2016) reported a positive impact of cooperative membership on apple yields, farm net returns, and household income in China. Specifically, their estimation results of switch regression suggested that cooperative membership increased the household income of apple farmers by an average

of 4.66%. They also reported a larger impact (5.73%) for relatively small apple farms than for larger apple farms (3.81%). This conclusion is similar to that of Ito et al. (2012).

This study is expected to contribute to the literature with quantitative evidence on the impacts of farmer cooperative membership on farmer income in rural China based on data from a large-scale survey and an analysis on whether the impacts are significantly different across income groups. This study also discusses the potential roles of farmer cooperatives in China's agricultural and rural development and provides policy recommendations for enhancing the efficiency of farmer cooperatives in increasing farmer income and contributing to rural development goals.

Analytical framework and research hypotheses

In this section, we first present an analytical framework for examining the mechanisms by which farmer cooperative membership may increase farmers' household income and then present the research hypotheses to be tested through the empirical analysis reported in the next section. The analytical framework can be presented in the following equation:

$$Y = P * Q - TC + OI \quad (1)$$

where Y is the household income, PQ is the total revenues (Q is a vector of farm outputs and P is a vector of the corresponding prices), TC is the total production costs, and OI is the income from other sources.

Farmer cooperative membership may increase farmers' income by increasing agricultural outputs (Q) and prices (P), reducing production costs (TC), and increasing income from other sources. While Q is determined by inputs, technology, management, and other factors, it can be presented by a production function:

$$Q = f(L, G, M) \quad (2)$$

where L is the labor inputs, G is the land, and M includes management and other factors. Farmer cooperatives can increase agricultural outputs by enhancing the availability and utilization efficiency of L , and G in the production function. For example, farmer cooperatives have relatively better agricultural production machinery and equipment, and members can be trained to operate the machinery and equipment efficiently. Further, connecting fragmented land parcels of individual farmers into large parcels through a cooperative makes it possible to use large equipment. Cooperatives can also concentrate the formerly scattered agricultural parcels for production, effectively allocate the agricultural land, and improve the utilization of land according to local conditions to achieve large-scale agricultural production and therefore increase agricultural outputs.

Farmer cooperatives can also increase the sales revenue by raising the prices received by farmers. Farmer cooperatives can sell agricultural products in batches through sale contracts signed prior to the harvest to avoid the market risk of price fluctuation of agricultural products. This benefit has been well documented from the experience of farmer cooperatives in China and many other nations (e.g., Chen and Scott 2016; Huang et al. 2011; Gasson 1977; Ren et al. 2017). Under the model of "cooperative + company," developed in many regions in China, the company buys the agricultural products under contract price and quantity from the cooperative.

Also, the member welfare-maximizing cooperatives showed greater incentives to invest in quality-enhancing innovation than their investor-owned counterparts, thereby improving the nature of product differentiation and the structure of the market (Drivas and Giannakas 2010). The branding of cooperative agricultural products can make agricultural products more distinctive, helping to raise prices greatly. Ding (2012) reported that the member farmers of cooperatives earned over 20% more than the non-member farmers by promoting the standardization and branding of agricultural products in China. Compared with the independent farmers, cooperatives have more scientific storage facilities, such as pressurized cold storage, which can extend the freshness of agricultural products and stabilize the sales price and sales volume over time. Cooperatives can also use market information to make better decisions about the mix of crops, and therefore reduce market risk and uncertainty.

In addition to the potential increases in the total revenues through the outputs (Q) and prices (P), farmer cooperatives can help farmers reduce their production costs through group purchases of such items as fertilizer, seeds, and seedlings, as large-scale purchases have certain bargaining advantages. Further, under the 2004 Law of the PRC on the Promotion of Agricultural Mechanization, farmer cooperatives have certain advantages in obtaining government subsidies. For example, farmer cooperatives can purchase certain agricultural machinery at reduced or subsidized prices. Mechanized production can improve the efficiency of agricultural production and reduce labor input, and large-scale operations can also reduce the costs of transportation and management (Cai 2011).

Farmer cooperatives as an organizational form may also confer some benefits, such as favorable tax treatment (Hendrikse 1998). Under China's Farmer Cooperative Law, farmer cooperatives enjoy tax preferences in agricultural production, processing, distribution, services, and many other agriculture-related economic activities. For example, the law offers an exemption on value-added tax for farmer cooperatives on inputs sold to members and on purchases from other farmer cooperatives and certain companies.

At the end of a production cycle or a calendar year, a farmer cooperative distributes surplus revenue to its members after retaining part of the earnings, thus potentially increasing member farmers' income. According to China's Farmer Cooperative Law, the surplus distribution of cooperatives should be based on the agreement between members and cooperatives (Mi 2008). The surplus is generally distributed in proportion to the trading volumes (amounts) of the cooperative and its members. The law also requires farmer cooperatives to return at least 60% of their distributable surplus to the members.

Using the above analytical framework, the empirical analysis to be presented in the next section will test two research hypotheses: (1) Farmers with cooperative membership earn significantly higher household income than their counterparts, and (2) the impact of farmer cooperative membership on household income is significantly different across income groups.

If the second hypothesis is accepted and the positive impacts is more significant for low-income groups than that for high-income groups, it may suggest that farmer

cooperatives could help to reduce income inequality and, otherwise, they may increase income inequality in rural China.

Material and methods

This section first introduces the survey data, then presents the regression analysis for testing the first research hypothesis and quantile regression results for testing the second research hypothesis, and finally reports the result of testing potential self-selection bias problems using the PSM technique and discusses the empirical findings.

Data source

Data used in this paper are from the Chinese Household Income Project (CHIP) 2013 survey, conducted in 2014 by the Institute of Economic Research of the Chinese Academy of Social Sciences and the National Bureau of Statistics. The survey collected data of 11,013 rural households from 236 counties in 12 provinces, two municipalities, and one autonomous region; however, the final dataset used in our empirical analysis includes 1945 households in five provinces, two municipalities, and one autonomous region. There are two reasons behind the reduction in the number of observations: First, the observations with missing or invalid data on farmer cooperative membership, household income, and other key variables were excluded. For example, data from two provinces were missing the cooperative membership variable, and data from five other provinces included fewer than five households with farmer cooperative membership. Since the survey was administrated through the government statistical bureau system from the central government to provincial government and then county government, data on some variables were not collected from many counties, likely due to the shortage of budget and manpower. Summary statistics and other information about the dataset are available from the authors. Second, farmers' household income in 2013 might have influenced their decision to join a cooperative in 2013 or 2014, and this potential correlation may cause endogenous bias in the regression analysis. To eliminate this potential endogenous bias, farmers who joined cooperatives in 2013 or 2014 were excluded from the data for the regression analysis.

Overall regression analysis for testing the first research hypothesis

The first research hypothesis is tested through the estimation of the following regression model:

$$\ln Y_i = \alpha + \beta D_i + \gamma_1 \ln L_i + \gamma_2 \ln G_i + \sum \rho_j X_{ij} + \varepsilon_i \quad (3)$$

where $\ln Y$ is the logarithm of household disposable income in 2013; D is a dummy variable with a value of 1 if the household joined one or more farmer cooperatives and 0 otherwise; $\ln L$ and $\ln G$ are the logarithms of agricultural production time and cultivated land in 2013, respectively; X is a vector of control variables, including household head's age, years of formal education, gender, marital status, cadre (village or community leadership) status, health status, and household size; α is a constant; β , γ_1 , γ_2 and ρ represent the coefficients of corresponding variables; and ε is the error term.

Table 1 Variable definition and descriptive statistics

Variables	Definition	Mean	SD	Min	Max
lnY	Logarithm of household disposable income	10.3213	0.7574	6.3969	13.2177
D	Whether or not joined at least one cooperative, 1 = yes, 0 = no	0.0519	0.2219	0	1
lnL	Logarithm of the total number of hours engaged in farming activities during farming seasons	5.9345	1.0755	2.0794	8.284
lnG	Logarithm of cultivated land in 2013 (in the unit of Mu)	1.5442	0.9252	-2.3026	5.0752
lnSize	Logarithm of the household size	1.2924	0.4061	0	2.3026
lnAge	Logarithm of the age	3.9355	0.218	2.5649	4.4659
lnEdu	Logarithm of the years of formal education	1.8614	0.4081	0	2.8332
Gender	1 = male, 0 = female	0.8391	0.3676	0	1
Carder	1 = village cadre, 0 = not village cadre	0.0545	0.2271	0	1
Health	Self-reported health status (1 = very healthy, 2 = healthy, ..., 5 = not healthy)	2.2720	0.8984	1	5
Outwork	Whether or not migrated out for work or business in 2013, 1 = yes, 0 = no	0.0900	0.2862	0	1
Sala	Whether or not engaged in local wage-earning work in 2013, 1 = yes, 0 = no	0.2982	0.4576	0	1
Nonagr	Whether or not engaged in local non-agricultural production or business in 2013, 1 = yes, 0 = no	0.0925	0.2899	0	1

Table 2 Estimation results of the OLS and quantile regression

Variables	OLS	Q5	Q10	Q25	Q50	Q75	Q90	Q95
D	0.1935*** (0.0691)	0.0113 (0.1608)	0.0704 (0.1361)	0.1367 (0.1258)	0.1714* (0.0989)	0.2391** (0.0957)	0.2032 (0.3236)	0.8539** (0.422)
lnL	0.0050 (0.0153)	0.017 (0.0386)	-0.0017 (0.0293)	0.0115 (0.0241)	0.0052 (0.0189)	0.0111 (0.0185)	0.0073 (0.0229)	-0.0376 (0.053)
lnG	0.0776*** (0.0179)	0.1357*** (0.0441)	0.0732 (0.0487)	0.0805** (0.0325)	0.0839*** (0.024)	0.0473* (0.0251)	0.0275 (0.0268)	0.1317** (0.0648)
lnSize	0.6807*** (0.0389)	0.7499*** (0.1073)	0.67*** (0.0804)	0.7018*** (0.0605)	0.7036*** (0.0524)	0.6704*** (0.0443)	0.6903*** (0.069)	0.5165*** (0.1585)
lnAge	0.1830** (0.0862)	0.1191 (0.1928)	-0.0893 (0.1927)	0.2163* (0.1218)	0.2983*** (0.0898)	0.2292** (0.1066)	0.1062 (0.1772)	0.1059 (0.3155)
lnEdu	0.2570*** (0.0400)	0.1384 (0.1034)	0.1861** (0.0871)	0.2583*** (0.0587)	0.338*** (0.0436)	0.3386*** (0.046)	0.3474*** (0.0818)	0.2934 (0.2292)
Gender	-0.1424*** (0.0448)	-0.2837*** (0.096)	-0.0707 (0.0927)	-0.1129 (0.0762)	-0.2195*** (0.0603)	-0.1339*** (0.0471)	-0.0743 (0.0991)	-0.1588 (0.1591)
Cadre	0.0640 (0.0756)	0.0946 (0.2715)	0.1391 (0.1636)	0.1421 (0.099)	0.1012 (0.0734)	0.1539* (0.083)	-0.0048 (0.1266)	-0.0796 (0.1896)
Health	-0.1058*** (0.0180)	-0.0689 (0.047)	-0.1022** (0.0416)	-0.1252*** (0.0314)	-0.1076*** (0.0216)	-0.0854*** (0.0217)	-0.0713** (0.0297)	-0.0752 (0.0598)
Outwork	-0.0316 (0.0549)	0.0891 (0.1159)	0.0301 (0.1163)	0.0176 (0.0846)	-0.0301 (0.0742)	-0.054 (0.075)	-0.2727*** (0.0611)	-0.4233* (0.2219)
Sala	0.0819** (0.0350)	0.2085*** (0.0729)	0.1661** (0.0762)	0.1691*** (0.0485)	0.0207 (0.0384)	0.019 (0.0504)	-0.0244 (0.0578)	-0.0031 (0.1414)
Nonagr	0.1924*** (0.0539)	0.2105** (0.1025)	0.1868 (0.1295)	0.2223*** (0.0557)	0.1511*** (0.0513)	0.1695** (0.0705)	0.0409 (0.0944)	0.2018 (0.4166)
Constant	8.3941*** (0.3641)	7.4759*** (0.8848)	8.7246*** (0.8504)	7.7507*** (0.5529)	7.8886*** (0.4145)	8.5025*** (0.4885)	9.5303*** (0.7644)	10.3615*** (1.3847)
N	1945	1945	1945	1945	1945	1945	1945	1945
F statistic	41.30***							
R ²	0.2176							
Adj. R ²	0.2123							
Pseudo R ²		0.1302	0.1206	0.1225	0.1230	0.1164	0.1166	0.1486

*, **, and *** indicate significance levels of 10%, 5%, and 1%, respectively; and numbers in parentheses are the standard errors of the corresponding coefficients

The variable definition and descriptive statistics are reported in Table 1. The correlation between variables used in the analysis are reported in “Appendix A.” Note that the demographic variables such as age and health status are for the household head. The estimation results of OLS regression are reported in the second column of Table 2.

The values of F -statistic, R -squared, and adjusted R -squared, reported in Table 2, suggest that the estimated regression model fits the data reasonably well for such a cross-sectional dataset. The potential multicollinearity problem of independent variables was also tested through the variance of inflation factor (VIF), and the testing result indicates that there was no significant multicollinearity problem. This is also confirmed by the correlation matrix between the variables reported in “Appendix A.” However, the OLS results are subject to potential self-selection bias problem and this potential problem is examined through PSM technique and the results are reported in “PSM estimation” section.

With the coefficient of the dummy variable for cooperative membership (D) estimated at 0.19 and significant at the 1% level, the result indicates that households with farmer cooperative membership earned, on average, significantly higher household income than their counterparts. This result indicates that the first research hypothesis presented in the previous section is accepted. The other variables with significant and positive impacts on the household income include cultivated land ($\ln G$), household size ($\ln \text{Size}$), age ($\ln \text{Age}$), education ($\ln \text{Edu}$), and engagements in non-agriculture income activities (Sala and Nonagr). The two variables with significant and negative impacts on household income are gender and health status, suggesting that female-headed households and households with healthy household heads tended to have higher household income when other factors are controlled.

Quantile regression analysis for testing the second research hypothesis

While the OLS regression results reported in Table 2 provided very useful information on the average impact of farmer cooperative membership and other variables or predictors on farmer household income, it does not address an important question: Does farmer cooperative membership affect household income differently for households with different household incomes or how the membership may affect income inequality? Quantile regression can be used to provide a more comprehensive picture of the impacts of independent variables or predictors on the dependent variable (Koenker and Bassett 1978; Koenker and Hallock 2001). Different from the ordinary regression model, the quantile regression method proposed by Koenker and Bassett (1978) models the impacts of independent variables on the specific percentiles or quantiles of the observations according to the dependent variable. It has the advantage that it is not only relatively unaffected by extreme values, but its results are also more robust. In addition, it helps determine the different income effects of heterogeneous households joining professional cooperatives.

Quantile regression was used to estimate the model presented in Eq. (3) for seven household-income quantiles (5th, 10th, 25th, 50th, 75th, 90th, and 95th), and the results are reported in Table 2. Coefficient equality tests, not reported in the table, indicate that the null hypothesis that “the coefficients for different income quantiles are equal” was rejected for variable D and all other independent variables at the 0.01 significance level.

Estimation results of the quantile regressions suggest three major findings: First, the impact of farmer cooperative membership (D) on household income is significantly different across income groups and therefore the second research hypothesis is accepted. Also, the coefficient of D increases when the quantiles move up. Specifically, the impact is positive for all income quantiles, but statistically significant for the 50th, 75th, and 95th quantiles and statistically insignificant for the 5th, 10th, 25th, and 90th income quantiles. This finding suggests that participating in farmer cooperatives alone played a limited role in increasing the household income of low-income farmers. This empirical finding is consistent with Hu's finding (2014) that farmer cooperatives in poor areas could promote the growth of farmer average income but the impacts on members with higher per capita assets was much more significant than that on poor members. This finding also suggests that farmer cooperatives may increase income inequality among the farmers who have joined farmer cooperatives in rural China.

Second, land has a positive and significant income for households in the 5th to 90th income quantiles except for the 10th and 90th income quantiles, suggesting that land is an important factor for rural households. Third, the impacts of other independent variables on household income are similar to those from the ordinary regression reported in Table 2 but with some exceptions. For example, village cadre status showed a positive and significant impact on household income for households in the 75th quantile only.

PSM estimation

Due to the possibility that some factors may simultaneously affect rural household income and whether to join professional cooperatives, this potential self-selection problem may invalid the conclusion from OLS estimation. The PSM method has been frequently used to estimate the treatment effects of microscopic data, especially for large sample sizes and with more covariates (control variables). While many earlier PSM estimates calculated standard errors assuming that the estimated propensity score is the true propensity score, the standard error may not be correct and therefore lead to bias. Abadie and Imbens (2012, 2016) proposed an improved method of calculating the correct standard error for the PSM estimation. Compared with matching based on the true propensity score, this matching is more efficient for using the estimated propensity score. In addition to estimating the econometric model using the whole sample, this study has also estimated the model using two sub-samples, one with the household

Table 3 PSM estimation results

	Matching methods		
	nn (4): 4 neighbors	Caliper (0.15)	nn (4) and caliper (0.15)
ATE: D (1 vs. 0)	0.1454* (0.0798)	0.0612 (0.1088)	0.1454* (0.0798)
ATE: D (1 vs. 0)	0.1641** (0.0740)	0.1997*** (0.0696)	0.1641** (0.0740)
Number of obs	1945	1945	1945

ATE—average treatment effect, ATE_T—average treatment effect on the treated

*, ** and *** indicate significance levels of 10%, 5%, and 1%, respectively; and numbers in parentheses are the AI Robust standard errors of the corresponding coefficients

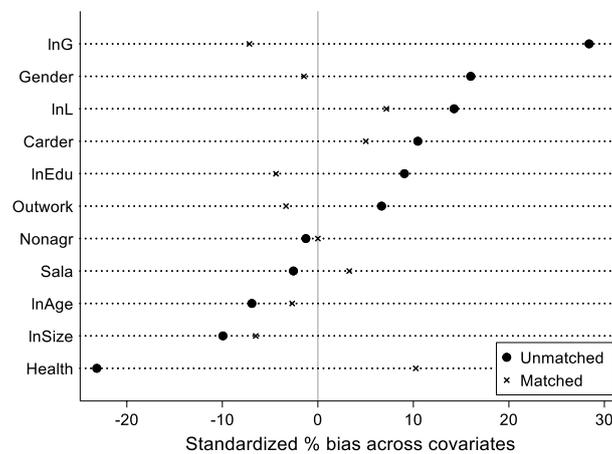


Fig. 1 Standardized percentage bias across covariates

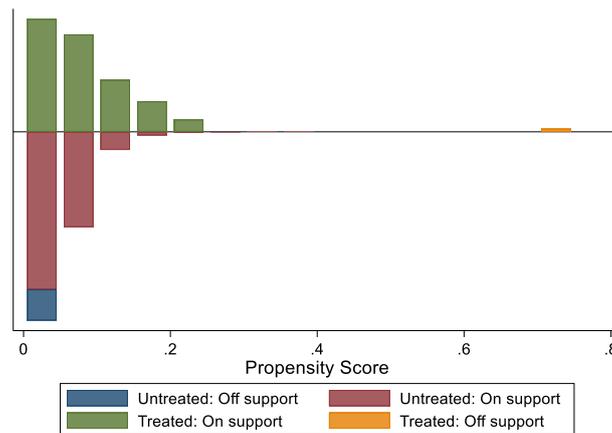


Fig. 2 PSM common support areas

income less than the sample mean and the other with the household income greater than the sample mean, respectively. With the effort of using the maximum number of available covariates, 13 covariates (*lnL*, *lnG*, *lnSize*, *lnAge*, *lnEdu*, *Gender*, *Carder*, *Health*, *Outwork*, *Sala*, and *Nonagr*) are used in the procedures.

The PSM estimates with AI robust standard errors are reported in Table 3. The PSM estimation results based on different matching methods show that farmer cooperative members earned significantly higher household income, confirming the conclusion for the OLS estimation. To valid the PSM results, the standardized percentage bias across covariates the PSM common support areas are reported in Figs. 1 and 2, respectively. Results reported in both figures suggest that the PSM results are statistically sound.

Discussion of the empirical findings

While the empirical results from regression analyses indicate that farmer cooperative membership had likely increased the household income on average, but the impact is

not statistically significant for low-income households, this subsection discusses the potential reasons that might lead to these results, compares our findings with that from previous studies, and discusses potential lessons learned from China's experience.

According to China's Farmer Cooperative Law, farmer cooperatives should have both business and rural development goals and functions. On one hand, each farmer cooperative as a business organization should provide services and maximize the returns to its members. On the other hand, each farmer cooperative as a community organization supported by the government should contribute to the accomplishment of rural development goals such as reducing income inequality and poverty in rural China, especially in poor areas with high poverty rate. While the empirical results of our quantile regression suggest that farmer cooperatives in China have helped high-income households much more than low-income households, at least three factors might have contributed to the distorted impacts. First, many local governments in China have emphasized on economic growth commonly measured by total or per capita GDP or income and, as a result, they have paid most of their attention to the number of registered farmer cooperatives, the number of participating farmers, and the total sales and profits of the farmer cooperatives in fund allocation and performance evaluation (Shao and Zhu 2014; Li and Lu 2018).

Second, as the allocation of public funds from upper levels of government for the development of farmer cooperatives in China is generally based on the number and size of proposed farmer cooperatives, many local government officers and village leaders have cheated to receive more funds. For example, some operating enterprises located in rural areas just changed their names to become farm cooperatives with the owners, relatives and neighbors as cooperative members. In some cases, there were fake or "empty shell" farmer cooperatives for the purpose of obtaining government funds and they are actually not in operation (Pan 2011; Jiang and Zheng 2014; Shao and Zhu 2014; Mao et al. 2017; Li and Lu 2018).

Third, many farmer cooperatives in rural China are initiated and established with financial support from the government by a small number of farmers with social capitals such as connection with government officers, entrepreneur and business experience, and communication skills to recruit other farmers to join the cooperatives. As a result, many farmer cooperatives are controlled by a small number of farmers, and they used farmer cooperatives to pursue their own financial benefits. Most of the farmer members, especially the low-income farmers who are struggling to meet the basic needs of their families, do not participate in any decision-making process and have limited information about the performance and returns of the farmer cooperatives (Tong and Wen 2009; Huang and Shao 2009; Pan 2011; Lund and Saito-Jensen 2013; Liang and Wang 2014; Gong 2015; Xu et al. 2017; Liu 2019). This is similar to the elite capture problems of farmer cooperatives reported in the literature (Platteau et al. 2014; Arcand and Wagner 2016).

Although farmer cooperatives have a relatively short history in China as compared to that in many other countries, they have developed rapidly across China in the past decade due to increased government investment and on-going commercialization of agricultural products. With a centrally-planned economic system from 1949 to 1978, China's economic reforms, started in rural areas in 1978, have gradually increased the

roles of markets in the production, distribution and consumption of food and other agricultural products. For example, Chinese farmers now have to plan their production according to market conditions, and farmer cooperatives have played an increasing role in providing professional services to small-scale farmers with very limited market information and power. China's experience in farmer cooperatives may suggest three lessons:

First, it is necessary to balance the business and rural development functions and goals of farmer cooperatives. As discussed above, the distorted impacts of farmer cooperatives on high-income households vs low-income and medium-income households in rural China are due to the lack of emphasis on farmer cooperatives' goal of reducing income inequality and poverty. Second, farmer cooperatives should be owned by their members giving all members rights and encouraging them to participate in the decision-making. They also need to balance the roles and benefits of the elite members and other members, especially the members with limited resources and low income. Farmer cooperatives need to set up risk sharing mechanisms, bind up the interests of the elite members and other members together, share benefits and risks, and give incentives to all members.

Third, the government needs to monitor and enforce the laws and regulations to reduce elite capture and other corruptions in farmer cooperatives. This is very important for China and other rural economies in which the governments are playing much more important roles than that in market economic systems. The Chinese government has provided significant financial support for the development of farmer cooperatives but needs to establish monitoring and assessment regulations and procedures to reduce the number of fake and "empty shell" farmer cooperatives and to enhance the performance and efficiency of farmer cooperatives.

Conclusions and policy implications

This paper has first presented an analytical framework for examining the mechanisms by which participation in farmer cooperatives may affect farmer household income and then tested two research hypotheses on the impact of farmer cooperative membership on household income and income distribution through ordinary and quantile regression analyses. PSM method was also used to examine the potential self-selection bias problems in the dataset. The analytical framework shows that farmer cooperatives can increase farmers' income by increasing agricultural output, raising sales price, reducing costs, and realizing surplus distribution from the cooperatives. The farmers liberated from agricultural land can also engage in other industries to obtain non-agricultural income. For example, many farmers have contracted their land to land cooperatives and found year-round or seasonal jobs outside their villages or communities.

This paper provides strong and quantitative evidence that joining a farmer cooperative induces a significantly positive impact on household income on average, but the impact is not statistically significant for low-income quantiles. Both the analytical framework and empirical analysis presented in this paper are expected to contribute to the literature on the potential impacts of farmer cooperatives on farmer income as well as the potential roles of farmer cooperatives in reducing income inequality and poverty in rural China.

This paper suggests three policy recommendations: First, the government should continue to support and intensify the positive influence of professional cooperatives on farmer income in China. Farmer cooperatives can realize large-scale operation by encouraging intensive land use and centralized agricultural production. Embedding farmer cooperatives in the agricultural industry chain can effectively reduce intermediate links and transaction costs, solve some asymmetric information problems, and thus enhance farmers' ability to resist market risks and realize risk sharing. At the same time, through centralized management and unified distribution of income, benefit sharing can be realized, and the effect of increasing farmers' income can be achieved. Speeding up the development of farmer cooperatives and actively guiding farmers to join cooperatives will not only help raise farmer income level and stabilize the basic management system in rural areas but also help promote rural economic development, narrow the gap between urban and rural areas, and realize the rejuvenation of the countryside. However, it is worth noting that with the rapid increase in the number of farmer cooperatives in recent years, some farmer cooperatives have not performed their expected functions. For example, significant government subsidies for new farmer cooperatives have enticed some enterprises to change their identities to be farmer cooperatives merely to obtain state subsidy funds, without a corresponding change in function. As a farmer cooperative's performance is significantly associated with its organizational boundary—the type and range of goods or services it provides to its members—farmer cooperatives should focus on services that are easily excludable and balance the number of service provisions with their organizational capability (Tadesse et al. 2018). Therefore, government departments should introduce strict regulations to support and inspect the development and performance of farmer cooperatives, with a focus on their services rather than registration or administrative matters.

Second, the development of farmer cooperatives needs to be accompanied by measures for reducing income inequality and poverty in rural China. The above analysis shows that farmer cooperative membership has positive and significant effects on the income of farmers in the high-income quantiles but positive and insignificant impacts for low-income and medium-income quantiles. Therefore, for the policy goal of precision poverty alleviation, government organizations such as village committees should develop measures to assist farmers in poverty or with low or medium incomes. Farmer cooperatives can take the lead in encouraging large farms to help small farms, and high-income farmers to help low-income farmers, through their cooperatives. It is also possible to explore the establishment of a new type of cooperative, with a focus on “company + cooperative + poor households,” where poor households receive assistance from companies and cooperatives. For example, some large companies in China have provided funding in recent years to help poor communities in rural areas to increase income and exit poverty, and such efforts should be encouraged by the government.

Third, it is necessary to constantly improve and innovate policies and programs to ensure success in the management system of farmer cooperatives and to promote rural economic development. The relevant government departments and organizations should advocate for the development of large unions of multiple farmer cooperatives, support

the development of collective economies, enhance the service function of collective organizations, and cultivate new farmer cooperatives. For example, online marketing and sales have helped many farmer cooperatives to go beyond their local markets, and some farmer cooperatives have helped their members to set up online businesses.

The empirical analysis presented in this paper is limited by the data. For example, the analysis has assessed the overall impact of farmer cooperatives on household income, but the data limitations prevented the empirical analysis from testing each of the mechanisms presented in the analytical framework. However, these mechanisms may form the basis for collecting data for future research on the subject.

Appendix A: Correlation matrix of the variables used in the regression analysis

	lnY	D	lnL	lnG	lnSize	lnAge	lnEdu	Gender	Carder	Health	Outwork	Sala	Nonagr
lnY	1.00												
D	0.06	1.00											
lnL	0.03	0.03	1.00										
lnG	0.14	0.06	0.31	1.00									
lnSize	0.39	-0.02	0.03	0.16	1.00								
lnAge	-0.11	-0.01	-0.07	-0.08	-0.20	1.00							
lnEdu	0.18	0.02	-0.04	-0.04	0.05	-0.26	1.00						
Gender	-0.02	0.03	0.13	0.18	0.01	0.15	0.05	1.00					
Carder	0.05	0.03	-0.06	0.00	-0.01	0.03	0.13	0.08	1.00				
Health	-0.21	-0.05	-0.08	-0.06	-0.14	0.26	-0.19	0.00	-0.04	1.00			
Outwork	0.00	0.02	-0.01	0.00	0.04	-0.16	0.07	0.11	-0.05	-0.01	1.00		
Sala	0.05	-0.01	-0.10	-0.06	0.00	-0.13	0.10	0.13	0.13	-0.08	0.03	1.00	
Nonagr	0.09	0.00	-0.06	-0.01	0.02	-0.07	0.08	0.07	-0.01	-0.09	-0.04	-0.08	1.00

Acknowledgements

The authors would like to thank Nankai University and the University of Vermont for their support of this study and Sarah Waterman and Angela Tweedy for their assistance in editing this paper.

Author contributions

The first author conceptualized the study, obtained the data, conducted the data analysis and drafted the paper, and the second author contributed to the data analysis and writing of the article. Both authors read and approved the final manuscript.

Funding

This study was supported by the National Social Science Fund of China (Project 17ZDA067).

Availability of data and materials

The data are available from the first author.

Declarations

Competing interests

The authors declare that we have no competing interests with any organization or individual.

Received: 10 November 2021 Revised: 3 March 2022 Accepted: 1 June 2022

Published online: 20 June 2022

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