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Measuring the Effect of Agricultural Cooperatives on Household Income Using PSM-DID: A Case Study of a Rice-Producing Cooperative in China

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October 2015

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Keywords: Agricultural Cooperative, Farm Household, Treatment Effect, PSM, DID

JEL classification: Q12, Q13, O13

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Abstract

Agricultural cooperatives in China, known as Farmers' Professional Cooperatives (FPCs), are becoming popular and have been intensely promoted by the Chinese government to improve the economic welfare of small farmers. However, very few studies on Chinese agricultural cooperatives have measured the benefits to farmers who participate in FPCs after controlling for time-invariant attributes of farmers. This paper investigates the treatment effect of participation in a rice-producing cooperative in suburban China using propensity score matching (PSM) and difference-in-differences (DID) method. Estimated results show that no significant difference is observed between participants and non-participants of the cooperative in terms of net income from rice production when controlling for the difference in farmers' rice incomes before the treatment. In addition, there is no significant heterogeneity of the treatment effects between large and small farmers, although the probability of participation in the cooperative is significantly higher when the size of cultivated rice farmland is greater. These results indicate that the benefits of the cooperative appear to be overestimated considering the vigorous policy supports for FPCs from the Chinese government.

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1. Introduction

The exclusion of small farmers in developing countries from modern supply value chains has been an area of focus given the rapid intensification of globalization of agricultural transactions (Key and Runsten 1999, Reardon et al. 2009). It has been argued that small farmers in developing countries tend to be excluded from contract farming with agribusiness enterprises. Even when they are not excluded, small farmers often appear to have an inferior status in terms of bargaining power on pricing and contract enforcement in comparison with agribusiness enterprises (Little and Watts 1994, Singh 2002).

However, recent studies show that small farmers are not necessarily excluded from vertical coordination with agribusiness enterprises in developing countries, and the inclusion of small farmers has been extensively reported in the literature (Reardon et al. 2009, Barrett et al. 2012, Abebe et al. 2013). This is because small farmers are willing and able to follow the labor-intensive field management practices required by these business integrators. Moreover, small farmers often strive to form rural producer organizations (RPOs) such as effective agricultural cooperatives to reduce transaction costs and improve their bargaining power in comparison with agribusiness enterprises and brokers (World Bank 2007, Reardon et al. 2009, Bolwig et al. 2009).

Recently, many studies have evaluated the effects of RPOs and contract farming in developing countries (Masakure et al. 2005, Bolwig et al. 2009, Rao and Qaim 2011, Ragasa and Golan 2014). These studies show that the effects of RPOs are not straightforward since the functions of these institutional innovations vary greatly according to local situations and agro-economic conditions. The importance of RPOs is also applicable to China. Since the dissolution of collective farming (People's Communes) and the introduction of the Household Responsibility System (HRS) for agricultural production since the late 1970s, many small farmers have taken responsibility for their own purchasing, production and marketing decisions. Meanwhile, the Chinese government has gradually reduced the budget allocations to agricultural extension stations since the mid-1980s and encouraged them to maintain their organizations on a self-supporting basis. These reforms caused a large-scale reduction in agro-technical staff at the county and township levels, resulting in poor performance of formal agricultural extension services (Hu and Huang 2001, Hu et al. 2012).^{1,2}

¹ In order to reform the formal agricultural information diffusion, a pilot project to reform the agricultural extension system was enforced in selected areas of Sichuan province and Inner Mongolia Autonomous Region in 2005. The project was intended to meet small farmers' demand for extension services as well as to improve the extension service's accountability to farmers. The effects of the introduction of this project are examined in Hu et al. (2012).

² The establishment of FPCs is also closely related with the liberalization of the agricultural input market in the 1980s. According to Deng et al. (2010), the State Council issued a policy document encouraging Agricultural Input Supply and Marketing Cooperatives to work together with local farmers to establish early version of FPCs.

Therefore, new types of RPOs were required to reduce the cost of acquiring technical information on new agricultural varieties, as well as to provide farmers with bulk transaction and marketing services to enhance the profitability of agricultural production. Then, since the mid-1980s, large farmers, agribusinesses, and local governments began to establish agricultural cooperatives, known as Farmers' Professional Cooperatives (*nongmin zhuan ye hezuoshe*, hereinafter FPCs), which were substantially developed in the 1990s. The principal purpose of FPCs at that time was to provide local farmers with agro-cultivation techniques; at the same time, a limited number of FPCs began to engage in bargaining with suppliers and traders to improve terms of trade (World Bank 2006, Deng et al. 2010).

Since the promulgation of the Law of Farmers Professional Cooperatives on July 1, 2007, FPCs have developed more rapidly. With this development, an increasing number of studies have examined the role of FPCs in overcoming small farmers' inherent inefficiency regarding adoption of new technology and pricing of their products. The World Bank (2006) and Shen et al. (2007) comprehensively review the characteristics of FPCs and clarify the importance of FPCs for facilitating agro-industrialization. Based on panel data collected from villages across China, Deng et al. (2010) show that policy initiatives such as the issuance of official documents, financial support, and tax exemption significantly promote the establishment of FPCs within villages. Jia and Huang (2011) and Jia et al. (2012) examine the determinants of marketing channels (traditional, modern, and wholesale) and contract farming adopted by FPCs. These studies reveal that the adoption of modern marketing channels such as direct sales to supermarkets is positively related to transactions with government-driven agribusiness and that the implementation of contract farming is positively correlated with the scale of production by FPCs.³

However, few previous studies address the impact of FPCs on farmers after controlling for the endogeneity of program participation. One exception to this is Ito et al. (2012), in which the average treatment effect of participation in a watermelon cooperative in Jiangsu province is estimated by using the propensity score matching (PSM) method. This study reveals that the treatment effect is highly heterogeneous and significant for only small-scale farms. Regarding contract farming in China, Miyata et al. (2009) evaluate the treatment effect of participation in the contract farming of onions and apples in Shandong province by employing a Heckman selection-correction model. The estimated results show that contract farmers can earn more income than non-participants can even after controlling for household characteristic such as labor availability, educational level, and farm size.

³ Regarding integration by agribusiness in China, Lingohr (2007) has conducted a detailed case study on industrialization of sweet potato production in Sichuan province promoted by "Dragon Head Enterprises" (*longtou qiye*) and FPCs.

Meanwhile, Ito et al. (2012) and Miyata et al. (2009) employ cross-sectional data to evaluate the treatment effect on farm income without controlling for agricultural income before participation in the FPC or contract farming. As pointed out by Heckman et al. (1997), Smith and Todd (2005) and Takahashi et al. (2010), the results of the treatment effect could be biased if unobservable factors affect the participation decision. A combination of the difference-in-differences (DID) method and PSM would be able to estimate less biased results, eliminating the effects of time-specific unobservable factors such as farmers' skill, social networks, and risk and leisure preferences. Thus, the principal purpose of this paper is to examine the treatment effects of participation in an FPC on agricultural income by controlling for these time-invariant unobservable characteristics. More specifically, we focus on a rice-producing cooperative of suburban farmers in Jiangsu province to measure the treatment effect of participation in the FPC by employing the PSM-DID method.

The second purpose of this paper is to explore the factors that influence farmers' decision on whether to participate in an agricultural cooperative. As mentioned above, there has been debate about the extent to which small farmers in developing countries are excluded from modern marketing channels. Lingohr (2007) and Ito et al. (2012) suggest that enrollment in an agricultural cooperative or contract farming is restricted to specific farmers who possess sufficient manpower and experience, and appropriate land quality/quantity, and these factors seem closely related to the incompleteness of market.⁴

Except for the exclusion of farmers through entry barriers, self-selection by farmers determines whether they decide to participate in an agricultural cooperative and is associated with certain unobservable characteristics such as risk aversion, social networks, entrepreneurship, technical ability, interest in agricultural production, and level of trust in the cooperative (Barrett et al. 2012). Ito et al. (2012) highlight psychological barriers for farmers to participate in FPCs stemming from their prior negative experiences in the era of People's Communes.⁵ Recent studies on the adoption of new cultivation technologies and new crop varieties have begun to explore the factors that motivate or prevent their adoption. Masakure and Henson (2005) indicate that four factors (market uncertainty, indirect benefits, income benefits, and intangible benefits) play a significant role in the adoption of high-value export crops in Zimbabwe. Extending the framework of Masakure and

⁴ According to an FPC survey by Kong et al. (2012), the proportion of FPCs that impose entry criteria on farmers such as the amount of production or cultivation skills is relatively low, approximately 15% of total FPCs. The survey suggests that FPCs tend to approve applications from farmers who engage in cultivating specific varieties without strict conditions. In addition, farmers who settle in the village where the headquarters of an FPC is located are given priority to participate.

⁵ Ito et al. (2012) contend that the comparison between the old (People's Communes) and new cooperatives is a major factor preventing farmers from joining the present agricultural cooperatives for fear of losing land utilization rights and farm management control.

Henson (2005), Abebe et al. (2013) conducted an experimental questionnaire survey of potato farmers in Ethiopia to explore the effects that different contract design attributes have on the attractiveness of a contract for small farmers. Takahashi and Barrett (2014) suggest that the adoption of the System of Rice Intensification (SRI) in Indonesia is significantly correlated with water availability, family labor endowment, learning opportunities, and risk preference.⁶

While the DID method appears to enable us to control time-invariant unobservable factors that are related with exclusion and self-selection, we also prepared detailed questions in our farm household survey concerning willingness to acquire new techniques, attitudes toward risk, and image of the era of People's Communes. Thus, when exploring the determinants of participation in the FPC, we estimate probit models for whether these observable characteristics have a significant influence on the farmers' decision to participate in the FPC.

The remainder of this paper proceeds as follows. Section 2 presents a brief overview of the study site and the rice-producing agricultural cooperative. Section 3 describes the estimation framework for discussing the impacts of participation in the agricultural cooperative, explains the sampling procedures, and outlines the datasets used. Section 4 presents econometric analysis of the treatment effects of participation in the FPC using the PSM-DID method. Section 5 summarizes the results and provides policy implications for further development of agricultural cooperative in China.

2. Background

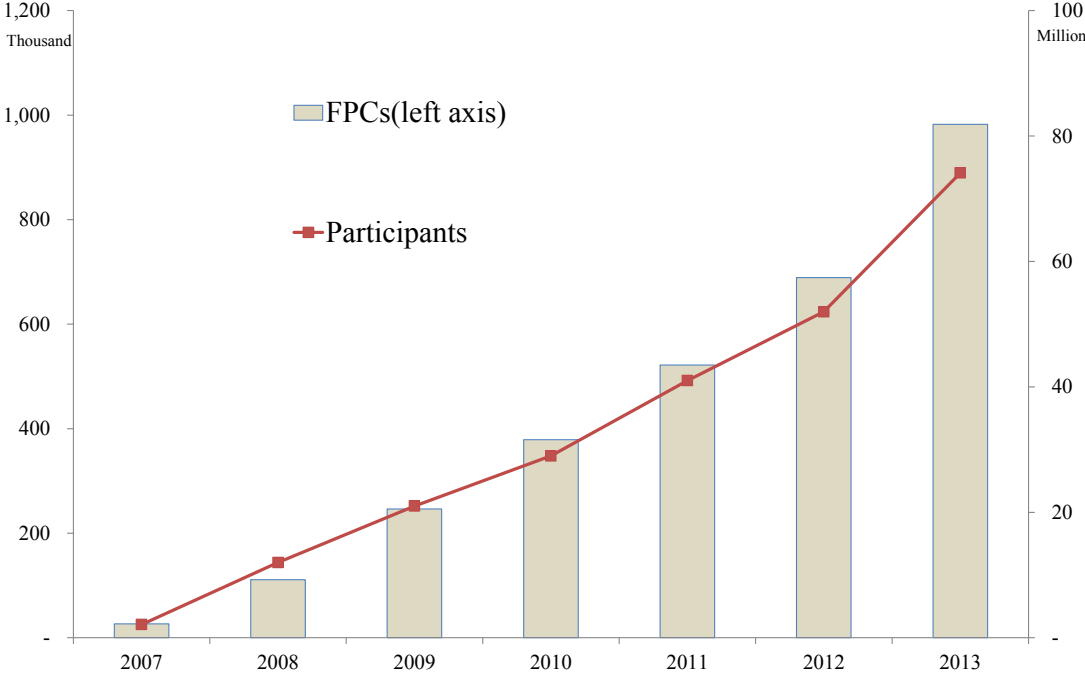
Since the enactment of the Law of Farmers' Professional Cooperatives in 2007, the number of FPCs is skyrocketing. Figure 1 shows the total numbers of FPCs and their registered members from the State Administration of Industry and Commerce. The total number of FPCs has increased from 26,400 to 980,000 organizations between 2007 and 2013, and the total number of farm household participating in FPCs also increased from 12 million to 74 million households, accounting for 28.5% of total rural households.

While rice is one of the principal crops in China, the profitability of rice production has gradually declined since the mid-1990s due to production surpluses and less efficient

⁶ With regard to agricultural technology diffusion, recent studies have explored the impact of social learning on the decision to use new technology in a more sophisticated manner (Matsuchke and Qaim 2009, Conley and Udry 2010, Weber 2012, Wang et al. 2013). Although farmers' participation in FPCs seems to be closely correlated with strong social networks, detailed questions that can distinguish social learning from spatial and serial correlations among neighbors are not included in our survey. Thus, strict examination of the function of social networks is beyond the scope of this study.

state-monopolized grain marketing (Hoken 2014, Zhong 2004). On the other hand, with an expansion of consumer demand for high-quality and safety-guaranteed grains, as well as a series of grain marketing reform beginning in the mid-2000s, many grain cooperatives have been established in China to support farmers in the production of high-quality grains. According to the Ministry of Agriculture (2011), 47.9% of FPCs were principally engaged in crop production in 2010. Among FPCs, vegetable, fruit, and grain cultivation accounted for 28.9%, 27.9%, and 19.4% of total production, respectively. These results indicate that FPCs for grain cultivation are relatively popular in China.

Figure 1. Total number of FPCs and FPC participants in China



Source: *China Agricultural Development Report* (various issues), *Xinhuanet* (<http://www.xinhuanet.com/>, May 5th, 2012), Ministry of Agriculture (2011), Ministry of Agriculture Homepage (<http://www.moa.gov.cn/>, Dec. 13th, 2014). Accessed on May 2015.

FPCs offer a wide range of service to their member households. Based on repeated village surveys in both 2003 and 2009 covering 2,459 villages in six provinces, Deng et al. (2010) shows that more than 90% of FPCs provide members with technological and marketing services, and approximately half of FPCs offer bulk purchasing of agricultural inputs. Technological and marketing services include crop management, breeding, disease control, price information, and

access to marketing channels. More than half of FPCs offer output marketing services through direct or arranged sales by FPCs.⁷ Employing the same data as Deng et al. (2010), Jia et al. (2012) indicate that almost half of grain-producing FPCs sold their products to supermarkets, processing firms, restaurants, and other professional suppliers.

In considering these attributes of FPCs in general, we have selected a relatively well-organized, marketing-oriented cooperative in Chengdong township of Hai'an county in Jiangsu province for our examination. Hai'an is part of Nantong city (district-level city), located in the eastern part of Jiangsu province, and is famous for export-oriented manufacturing industries such as silk spinning and textile manufacture. However, agricultural production in the county also exceeds that in other counties in Jiangsu, and Hai'an obtained the prize of "National Grain Production Advanced Counties" (*quanguo liangshi shengchan xianjin xian*) from the Ministry of Agriculture each year from 2007 to 2010 and in 2013. The double-cropping of rice and wheat is widespread, and the county has maintained the highest grain yield in the province since the beginning of the 2000s.

A rice-producing agricultural cooperative was established in Chengdong in April 2008 with the support of the local government and a grain processing company in the area.⁸ Prior to the establishment of the cooperative, most farmers in the township tended to sell their rice through traditional channels such as the wholesale market and grain trading companies, and local farmers were confronted with severe competition from japonica rice from Northeast China (*Dongbei dami*). Meanwhile, due to frequent incidents concerning food safety in China, consumers' awareness and demand for food safety and quality accelerated.

With careful consideration of these market conditions, relatively large-scale rice farmers in the township decided to establish the rice-producing cooperative to produce safety-guaranteed and high-quality rice through contract farming with foreign-owned supermarkets. In order to supply safety-guaranteed rice to consumers, the cooperative introduced a traceability system in collaboration with a supermarket in January 2009 to comprehensively monitor the production process from cultivation to marketing. This system records the history of products regarding the names of the producer and the amounts of fertilizers and pesticides used. Furthermore, each member of the cooperative must enter into a written contract with the cooperative at the beginning of the cultivation season. The contract specifies detailed procedures for rice cultivation and

⁷ Kong et al. (2012) show that more than 80% of sampled FPCs provide participants with agricultural inputs, technical services, and bulk purchase of agricultural products, while the proportions of FPCs that offer services for credit and processing/transportation are 20% and 36%, respectively. These results indicate that most FPCs engage primarily in cultivation- and marketing-related services.

⁸ The grain processing company was originally a state-owned grain company. After its privatization in 2001, some of the farmers in the township continued to sell their rice to the company. According to 2011 statistics, the company processes 2.49 tons of rice and employs nearly 150 full-time and 40 part-time workers.

procurement with which both the cooperative and members must comply. Following an instruction handbook distributed by the cooperative, members are required to fertilize and spray pesticides according to the regulations prescribed by the cooperative, and farmers are required to record the types and amounts of fertilizer and pesticide applied to their farmland in a specified account book. If excessive levels of pesticide and fertilizer residues are detected or unapproved fertilizer and pesticide are founded through inspections, the cooperative can refuse to purchase a farmer's products under the cooperative's brand. On the other hand, participants who follow the regulations are able to receive an approximately 10% premium over the regular market price from the cooperative, although the cooperative does not offer a minimum price for members.⁹

Meanwhile, the cooperative has to provide participants with specific varieties of seed, fertilizer, and pesticide to allow the participants to grow brand-named rice. These inputs are purchased collectively by the cooperative and supplied to participants at discounted prices. The cooperative also offers free technical advice for member farmers at their request and provides advance payments to some member farmers to facilitate rice production.¹⁰ Since non-member farmers are excluded from these services provided by the cooperative, they have to purchase agricultural inputs by themselves and sell their rice through traders or large farmers. Furthermore, members of the cooperative can obtain dividends from the cooperative which are settled at the end of the budgetary year. Based on the amount of rice sold to the cooperative, as well as the amount of cooperative stock held by each member, dividends are distributed to member households.

According to our interviews with a representative of the cooperative, applicants to the cooperative are required to follow technical advice from agricultural technicians employed by the cooperative, and their farmland must be equipped with irrigation facilities for rice cultivation in order to join the cooperative. Beyond these requirements, no other specific agricultural investment or special cultivation skills are prerequisites to apply for membership. Moreover, the size of cultivated farmland for rice is not a barrier to becoming a cooperative member. This contrasts with

⁹ The central government of China started an initiative to introduce minimum state procurement prices for rice (japonica and indica) and wheat since 2004, and the National Development and Reform Commission (NDRC) announces the regulated prices prior to the planting seasons. Under this policy, if the market price of grain falls below the minimum price, the state agencies are obliged to procure excess grain at the minimum price for the national grain stockpile to sustain grain-producing farmers (Hoken 2014). Because this policy offers price insurance for rice-producing farmers by reducing risk stemming from price fluctuations, the rice-producing cooperative does not necessarily offer guaranteed minimum price for the participants. The official minimum price has been raised regularly, with the minimum price of grade three middle- and late-ripening japonica rice reaching 3,000 yuan per ton in 2014, up from 1,500 yuan per ton in 2004.

¹⁰ Based on the surveys in 2009, Deng et al. (2010) showed that the almost no FPCs provide credit services to their members. However, the implementation of financial services was approved for selected FPCs by the official notification issued by China Banking Regulatory Commission in February 2009. In fact, according to our FPC survey, the share of member farmers who obtain advance payments accounts to approximately 30% of total members, and the average amounts per participant households reaches 2,955 yuan.

the case studies by Lingohr (2007) and Ito et al. (2012), which show that FPCs are likely to select relatively large-scale farmers as members.¹¹ In addition, the rice-producing cooperative subcontracts certain duties such as searching for potential member farmers and monitoring rice cultivation processes to local cadres and agricultural technicians to minimize transaction costs. The land rental market is far less developed in the surveyed area, where only about 1% of farmers engage in renting or renting out farmland. Therefore, the cooperative does not set strict entry barriers on cultivated farmland, and is rather eager to accept motivated small farmers in order to coordinate them.

When the cooperative was established, there were only 156 member households. Since then, the number has increased to 1,056 member households as of the end of 2010. According to our interviews, the cooperative deals with more than 18,000 tons of rice, and purchases rice from approximately 16,000 farmers, including member participants, in 2011. In addition, the cooperative acquired “pollution-free” (*wu gonghai*) farm product certification in 2008 from the Center for Agricultural Food Quality and Safety in the Ministry of Agriculture, and the cooperative’s branded rice was registered as a famous-brand product of Jiangsu province in 2011. The cooperative was recognized as an “Advanced Organization of Professional Farmers’ Cooperative” by the Nantong Government in 2011 and a “Model Agricultural Cooperative” in 2012 by the All-China Federation of Supply and Marketing Cooperatives.

3. Estimation Strategy and Data

3.1. Empirical Strategy

Next, we explore the impacts of farmers’ participations in the agricultural cooperative as measured by the average treatment effect on the treated (ATT). This method estimates the average difference in outcomes of participants and non-participants in the agricultural cooperative. As Key and Runsten (1998) and the World Bank (2007) point out, the impacts of contract farming and agricultural cooperatives are multi-dimensional and may include offering credit and insurance to participants to cope with market imperfection and reducing transaction costs associated with search, screening, and the transfer of goods. However, it appears that most of these multi-dimensional

¹¹ As examined in Key and Runsten (1999) and Barrett et al. (2012), the level of transaction costs associated with searching for farmers, monitoring, and enforcing their contracts is fixed and does not depend on farmland size. Further, agricultural productivity increases with the scale of production. Therefore, cooperatives are likely to prefer larger farmers to maximize their profits.

effects are closely related to and summarized in farm income. In addition, the principal objective of agricultural cooperatives in China is to increase the economic welfare of farmers. Thus, we adopt farm income as outcome variable (Y) and define it as follows:

$$\begin{aligned} ATT_1 &= E(y_{i,1}|D_i = 1) - E(y_{i,0}|D_i = 1) \\ &= E(y_{i,1}|D_i = 1) - E(y_{i,0}|D_i = 0) + E(y_{i,0}|D_i = 0) - E(y_{i,0}|D_i = 1) \end{aligned} \quad (1)$$

where $E(\cdot)$ denotes the expectation operator, y_{i1} is the outcome of interest for household i participating in the FPC and y_{i0} is the outcome of the same household not participating in the FPC, and D_i is a binary indicator that equals 1 if farmer participates in FPC and 0 otherwise.

In estimating ATT, we cannot observe $(y_{i,1}|D_i = 1)$ and $(y_{i,0}|D_i = 1)$ simultaneously for the same household. Simple comparison between the treatment group and control group involves selection bias whose magnitude is shown in $E(y_{i,0}|D_i = 0) - E(y_{i,0}|D_i = 1)$ if participation in the FPC is not randomly determined and participation is undertaken by the farmer's own initiative. Thus, we introduce the program evaluation method of PSM proposed by Rosenbaum and Rubin (1983) to estimate ATT. The method assumes that the outcome is independent of program participation conditional on a set of observable characteristics (\mathbf{W}). This is called the conditional independence assumption. The assumption can be expressed as $y_{i0} \perp D_i | p(\mathbf{W})$, where \perp denotes independence and $p(\mathbf{W})$ denotes the propensity score to participate in the FPC with a set of covariates \mathbf{W} . Therefore, propensity score matching can eliminate selection bias caused by the observable characteristics of households.¹²

However, it should be noted that PSM is appropriate only if observable characteristics affect the selection process. If unobservable characteristics affect participation and outcomes, utilization of PSM cannot guarantee the conditional independence of $y_{i0} \perp D_i | p(\mathbf{W})$, resulting in a biased estimation of ATT. As pointed out by Heckman et al. (1997), Bratberg et al. (2002), Smith and Todd (2005), and Takahashi et al. (2010), the DID method appears to be suitable for mitigating the problem of selection by unobservable characteristics. This is because DID can control time-invariant unobservable characteristics such as farmers' skill, social network, and risk and

¹² As is well known, PSM is justified when performed over the region where the distributions of matching scores are overlapping between the treated and non-treated subsample. This is called the common support condition. As pointed out by Heckman et al. (1997), the inclusion of an observation sample that belongs to the region of non-overlapping support gives rise to serious evaluation bias. Thus, in this paper, only the subset of the comparison group whose propensity score is overlapping with that of treatment group is used to evaluate ATT.

leisure preferences.

The DID is estimated as the difference in the outcome variable before (t-1) and after (t) participation in the agricultural cooperative for participants compared with the difference in the outcome variable for non-participants over the same period. ATT for an outcome variable before and after the participation (Δy_i) can be formally specified as follows:

$$\begin{aligned} ATT_2 &= E(\Delta y_{i1} | D_i = 1) - E(\Delta y_{i0} | D_i = 1) \\ &= [E(\Delta y_{i1} | D_i = 1) - E(\Delta y_{i0} | D_i = 0)] - [E(\Delta y_{i0} | D_i = 0) - E(\Delta y_{i0} | D_i = 1)] \end{aligned} \quad (2)$$

where $y_{i,t}$ is the outcome of interest for household i at time t participating in the agricultural cooperative and $y_{i,0,t}$ is the outcome of a household not participating in the agricultural cooperative.

Note that the first term on the right-hand side of equation (2) on the second line is equivalent to the DID estimator between the participants and non-participants. The second term represents estimation bias when a change in outcome before and after the treatment for the control group (non-participants) is not identical to a hypothetical change in outcome if the control group were treated ($E(\Delta y_{i0} | D_i = 0) \neq E(\Delta y_{i0} | D_i = 1)$). Thus, the same as in equation (1), the adoption of PSM for DID contributes to the elimination of selection bias. However, the principal advantage of PSM-DID is that the assumption of $\Delta y_{i0} \perp D_i | p(\mathbf{W})$ is less restrictive than the assumption of the standard PSM ($y_{i0} \perp D_i | p(\mathbf{W})$) since the effect of time-invariant unobservable is eliminated through the first difference. Thus, the adoption of PSM-DID under the assumption $\Delta y_{i0} \perp D_i | p(\mathbf{W})$ provides an unbiased estimator for ATT.

To minimize the likelihood and magnitude of bias due to selection-on-unobservables, we conducted a detailed questionnaire survey of farmers to address how household attributes, attitudes toward agricultural production, and image of the People's Commune System affected participation in the agricultural cooperative. These variables were derived for the period before the treatment year (2007) to avoid reverse causality. Several kinds of matching estimators have been developed in the literature, such as caliper matching, radius matching, kernel matching, and local linear matching. As examined by Caliendo and Kopeinig (2008), a trade-off between bias and variance tends to arise

among the matching algorithms when the size of the sample for the estimation is small.¹³ Thus, we will adopt several matching algorithms such as radius matching with $\|P_i - P_j\| < 0.01$, kernel matching, and local linear matching to check the consistency of the estimates.

3.2. Sampling Design and Descriptive Statistics

For assessing the effect of participation in the rice-producing cooperative, we have adopted two-stage stratified sampling to select farm households. In the first stage, we selected three villages from Chengdong township, where the participants of the cooperative are distributed. Then, we randomly chose participants from the list of cooperative member as well as non-participants from the list of village members, reflecting a balance of population between the two groups. In total, we selected 378 farm households, which include 207 participants and 171 non-participants. Due to missing data for major variables, we mainly use data on 355 farm households for the estimations.¹⁴

A field survey was conducted in 2011 to collect data on households for 2007 and 2010.¹⁵ As we mentioned above, the rice-producing cooperative was established in April 2008 and contract farming with supermarkets began in the spring of 2009. All the participants in our sample joined the cooperative in 2008. Thus, it appears appropriate to evaluate the impact of the agricultural cooperative using the 2007 and 2010 datasets. All sample households were engaged in rice cultivation in both years. To control for reverse causality, we utilize variables concerning 2007 to estimate the probabilities of farmers joining the cooperative.

The descriptive statistics on sample households are shown in Table 1. Per capita income of sampled households in 2010 was 14,221 yuan, which is much higher than the national average (5,919 yuan) and also higher than the provincial average (9,118 yuan) but to a lesser degree. This is due to abundant off-farm employment opportunities in the surveyed area. Approximately 64% of all workers in the township and the county are off-farm laborers. Thus, the share of income from off-farm work to total income is remarkably higher in the surveyed area than in other areas in the province, constituting 78% and 84% of income for participants and non-participants, respectively. However, no significant differences are observed in total income and income from off-farm work

¹³ Smith and Todd (2005) point out that local linear matching is preferable to kernel matching when comparison group observations are distributed asymmetrically around the treated observations or when there are gaps in the propensity score distribution.

¹⁴ Three observations were excluded from the estimations since their total incomes were less than zero. To control the effects of outliers, we set a criterion that observations whose total incomes are more than four times of standard deviation of total income are to be excluded from the estimations; as a result, four observations are deleted.

¹⁵ Financing for this household survey came from a Grant-in-Aid for Young Scientists (B) from the Ministry of Education, Culture, Sports, Science and Technology of Japan, and from the Japan Society for the Promotion of Science (JSPS) [#23730293].

between participants and non-participants.

Table 1. Descriptive Statistics of Participants and Non-Participants

	Total		(1) Participants		(2) Non-participants		t-Value (1) vs. (2)
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Income per capita (yuan)	14,211	9,696	14,700	10,040	13,607	9,250	1.056
Total income in 2010 (yuan)	64,024	50,102	61,991	54,264	66,531	44,479	-0.849
Income from off-farm work (yuan)	51,814	44,258	48,441	46,479	55,971	41,119	-1.598
Net rice income in 2007 (yuan)	2,318	1,376	2,654	1,539	1,904	1,004	5.302 ***
Rice yield in 2007 (kg/mu)	438	118	456	91	417	141	3.178 ***
Rice price in 2007 (yuan/kg)	1.92	0.35	2.00	0.37	1.82	0.30	4.864 ***
Price margin of rice in 2007 (yuan/kg)	1.46	0.35	1.52	0.36	1.38	0.33	3.606 ***
Net rice income in 2010 (yuan)	4,194	2,183	4,643	2,416	3,640	1,709	4.412 ***
Rice yield in 2010 (kg/mu)	537	74	543	82	529	62	1.746 *
Rice price in 2010 (yuan/kg)	2.85	0.25	2.91	0.23	2.77	0.26	5.177 ***
Price margin of rice in 2010 (yuan/kg)	2.16	0.38	2.22	0.39	2.09	0.37	3.262 ***
Age of household head (year)	56.68	11.00	56.12	10.50	57.36	11.59	-1.063
Years of education of household head (year)	6.39	3.57	6.26	3.58	6.54	3.56	-0.737
CCP dummy	0.11		0.11		0.10		0.351
Cadre dummy	0.10		0.11		0.10		0.199
Female household head dummy	0.05		0.06		0.04		1.002
Size of contracted farmland (mu)	3.58	1.43	3.80	1.55	3.32	1.23	3.138 ***
Size of cultivated farmland for rice in 2010 (mu)	3.51	1.39	3.74	1.53	3.22	1.13	3.506 ***
Size of cultivated farmland for rice in 2007 (mu)	3.50	1.40	3.72	1.55	3.23	1.13	3.360 ***
Number of household workers	2.77	1.20	2.77	1.23	2.77	1.17	-0.016
Number of household members	4.46	1.46	4.28	1.47	4.67	1.42	-2.535 **
Willingness to adopt new agricultural techniques (1 = less willing, 2 = normal, 3 = very willing)	2.74	0.55	2.83	0.44	2.64	0.65	3.386 ***
Dependent coefficient (ratio of number of HH member age 6 and below and 65 and above to household size)	1.19	0.86	1.06	0.85	1.35	0.86	-3.204 ***
Image of People's Communes (1 = has an influence, 0 = does not have an influence)	0.05	0.21	0.07	0.25	0.02	0.14	2.151 **
Attitude toward risk	1.62	0.75	1.65	0.77	1.58	0.72	0.786
Observations	355		196		159		

Source: Authors' estimation from farm household survey.

Note: *** significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

Regarding rice production, the net rice incomes in 2007 and 2010 of participants are significantly higher than those of non-participants. This is mainly due to higher profitability of rice production by participants, which result from significantly higher price margins (unit price minus unit input cost) and yield of rice production by participants. It is worth noting that the profitability of rice production in 2007 by future cooperative participants was significantly higher than that by

non-participants before the establishment of the FPC. Compared with non-participants, average sizes of cultivated farmland for rice and contract farmland of cooperative participants are significantly larger. These data appear to indicate that the cultivation skills and marketing abilities of participants were originally higher than those of non-participants.

Moreover, participants in the rice cooperative seem more willing to adopt new agricultural techniques. We gauge the willingness of farmers to adopt new agricultural technique by using farmers' self-evaluation on an three-point scale from 1 (less willing) to 3 (more willing). Attitude toward risk are evaluated on a three-point scale from 1 (risk averse) to 3 (greater risk tolerance).¹⁶ As shown in Table 1, willingness to adopt new agricultural technique of cooperative participants is significantly higher than that of non-participants, while there is no significant difference between participants and non-participants in attitude toward risk. Image of the People's Communes is a dummy variable that takes a value of 1 if the farmer's decision to participate in the cooperative was influenced by his or her image of the People's Commune system, and 0 otherwise. Although the percentage of the farmers who recognize that their decision was influenced by their image of People's Communes is quite low, the percentage of participants with this recognition is significantly higher than for non-participants, suggesting that their image of the collective farms has a somewhat positive effect on the decision to participate in the cooperative.

Meanwhile, concerning the characteristics of the head of household, we cannot detect significant differences in age, years of education, and political status (i.e., Chinese Communist Party (CCP) and cadre membership dummies) between participants and non-participants. Yet, there is a significant difference in demographic composition between the two groups. Specifically, the dependent coefficient (the ratio of the number of household member who are below 15 and over 65 to the total number of household members) is lower for participants than for non-participants. This suggests that the households with more children and old parents are less likely to participate in the cooperative.

¹⁶ Regarding the measurement of attitude toward risk, the choice question developed by Binswanger (1980) was to be employed at the beginning of the study. However, as a result of discussions with collaborators in the Nantong government and the representative of the FPC, we simplified the question into a 1–3 scale to let respondents understand the question more easily.

4. Estimation results of DID-PSM

4.1. Probit Models for Matching

To control for factors affecting participation in the rice cooperative, we calculate the propensity score for participation in the cooperative by employing probit models.¹⁷ The dependent variable is a binary that takes 1 if households join the cooperative and 0 otherwise. The independent variables consist of three groups of related variables. The first group is variables for characteristics of the household head such as age, years of education, political status (cadre and CCP membership dummies), and a dummy variable for female household head. The second group includes variables for household characteristics such as the sizes of contracted farmland and cultivated farmland for rice, total number of household members, total number of worker between 15 and 65 years of age, and the dependent coefficient. The third group consists of self-evaluation variables on willingness to adopt new agricultural techniques, attitude toward risk, and image of People's Communes. Since the features of the third group may be time-invariant, models with and without the third group are estimated to compare the results.

The estimated results of the probit models are presented in Table 2. Model (1) in the second column is a benchmark equation consisting of the variables for household head and household characteristics. The coefficients on age and age-squared show significant positive and negative signs respectively, indicating that participation in the cooperative and age of household head have an inverse-U shape relationship, with the peak of the age curve at approximately 50 years old. Specifically, the probability of participation in the cooperative increase with the age of household head, but the marginal effect diminishes after 50 years of age. Other coefficients for household head characteristics such as years of education, political status, and gender are not significant.

Regarding household attributes, the coefficient on number of household members is significantly negative. This finding suggests that households with fewer members are more likely to participate in the cooperative, and thus tend to be more agriculture-oriented. The sign of the coefficient on size of cultivated farmland for rice is also significantly positive at the 10% level. This result implies that as the amount of cultivated land increases, the probability of farmers participating in the cooperative is higher, even after controlling for the size of contracted land.

¹⁷ Estimation of propensity score and ATT were performed by using the “psmatch2”, “att(r,k)”, and “bootstrap” commands in STATA Ver. 13. In exploring the factors affecting participation in FPCs, Ito et al. (2012) try to distinguished two aspects of non-participation: exclusion by FPCs due to the inability of farmers to meet entry conditions and self-selection by farmers. However, both aspects are usually interrelated. For example, more motivated farmers are likely to rent farmlands from neighboring farmers to meet the entry requirements for farmland set by FPCs. Hence, we interpret the estimated results of the probit model as a mixture of both aspects.

According to the literature on the exclusion of small farmers in China, the results are mixed. Namely, Lingohr (2007) and Ito et al. (2012) contend that small farmers are excluded from agricultural cooperatives, while Miyata et al. (2009) and Huang et al (2009) insist that small farmers engaged in horticulture are not necessary excluded from contract farming or modern supply chains.¹⁸ Thus, our results appear to support the self-selection of farmers toward participation in agricultural cooperatives, rather than restriction or exclusion by the cooperative since entry barriers for cultivated farmland are not specified by the cooperative. Other variables such as the number of household workers, the size of contract farmland and the coefficient of dependence are not significant.

Model (2), shown in the third column of Table 2, incorporates the self-evaluation variables on the image of People's Communes, willingness to adopt new agricultural technique, and attitude toward risk. The results of Model (2) are basically consistent with those of Model (1) with respect to the coefficients on household head and household features. Namely, the coefficients on age and number of household members are significant, although the coefficient on cultivated land for rice is positive but not significant. In contrast, the coefficient on image of People's Communes is positive and significant, completely opposite to the findings of Ito et al. (2012). This result suggests that experiences during the era of People's Communes are not uniform among the regions. Thus, oversimplification of the historical experiences is inappropriate for the re-organization of agricultural cooperatives, although memories of the era appear to be related to participation in the agricultural cooperatives.

The significant positive coefficient on willingness to adopt new agricultural technique is consistent with our expectation, indicating that the more motivated farmers are more likely to participate in the cooperative. The coefficient on attitude toward risk is positive but not significant, suggesting that attitude toward risk does not necessarily influence participation in the cooperative. This is likely because the minimum state procurement price for rice is regulated by the central government; thus, the price of rice is more secure than the prices of other crops. Since the goodness of fit as measured by pseudo R^2 for Model (2) (0.139) is relatively higher than that for Model (1), we apply the results of Model (2) to the estimation of propensity score.¹⁹

¹⁸ Miyata et al. (2009) claim that there is some selection bias in becoming a contract farmer, according to labor availability and social distance between farmers and village leaders, rather than farm size.

¹⁹ The inclusion of retrospective variables on self-evaluation might cause bias for statistical matching. Thus, we computed the propensity score using the coefficients of Model (1). The effects of participation in the cooperative on rice income remain qualitatively unchanged regardless of the probit model used.

Table 2. Estimated Results of Probit Models

	Model (1)		Model (2)	
	coefficient	z-Value	coefficient	z-Value
Age of household head	0.129	1.898 *	0.129	1.850 *
Age of household head squared	-0.001	-2.066 **	-0.001	-2.050 **
Years of education of household head	-0.046	-0.761	-0.058	-0.942
Years of education of household head squared	-0.001	-0.195	-0.001	-0.100
CCP dummy	0.255	1.000	0.266	1.025
Cadre dummy	0.076	0.283	0.052	0.192
Female household head dummy	0.407	1.114	0.486	1.291
Contracted farmland	0.051	0.340	0.038	0.201
Size of cultivated land for rice in 2007	0.279	1.797 *	0.316	1.632
Number of household workers	0.085	0.820	0.044	0.414
Number of household members	-0.297	-2.783 ***	-0.305	-2.773 ***
Dependence coefficient	-0.023	-0.170	-0.020	-0.143
Willingness to adopt new agricultural technique			0.430	3.124 ***
Image of People's Communes			0.976	2.404 **
Attitude toward risk			0.138	1.409
Constant	-2.714	-1.456	-3.947	-2.019 **
Number of observations	355		355	
Log likelihood	-220.03		-210.21	
LR $\chi^2(19)$	48.21 ***		67.86 ***	
Pseudo R ²	0.099		0.139	

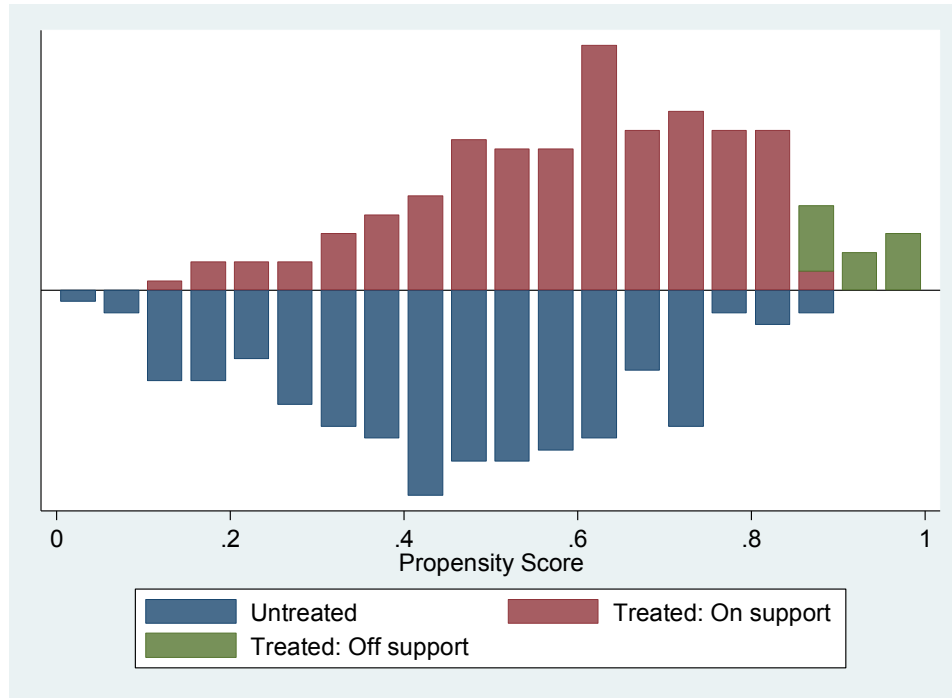
Note: *** = significant at the 1% level, ** = significant at the 5% level, and * = significant at the 10% level.

The histogram of propensity score matching is shown in Figure 2 to confirm the distributions of propensity score between participants and non-participants. The horizontal and vertical axes indicate the estimated propensity score and observed frequency of observations, respectively. While the distribution of participants appears to be relatively skewed toward the right, the distribution of non-participants is quite symmetric. Thus, the observations of participants whose propensity scores are higher than the maximum of non-participants are excluded from the ATT estimations to restrict the observations to the region of common support.²⁰ For radius matching, 17 households are

²⁰ To confirm the comparability of the sample between the treatment and control farmers, we have implemented balance

excluded due to lack of common support; however, there are slight differences in the number of observations excluded among the different matching algorithms.

Figure 2. Histogram of propensity score



4.2. Estimated Results of PSM-DID

Based on the propensity score computed from the probit model, propensity score matching are performed. In estimating the ATT using PSM-DID, the effects are measured by two kinds of DID dependent variables: net rice income and net rice income per cultivated rice farmland.²¹ Because our survey relies on retrospective data for 2007, we must check the validity of our estimated results through different specification on the dependent variables.²² The standard errors of PSM-DID are obtained by bootstrapping with 500 replications. To compare the results with PSM-DID, we also estimate the treatment effects through ordinary least squares (OLS) without controlling for sample

tests for each variables used in the probit model. If no significant differences in the observable variables are observed for all variables, it is safe to presume that there are no systematic differences between the two groups. The results of the balance test show that there are no significant variables at the 10% level after matching, indicating that the matched sample possesses appropriate features.

²¹ In addition to these, gross rice income is employed as a dependent variable. The estimated results are highly consistent with those of net rice income.

²² Originally, we planned to include a question about the number of working days for farming in 2007. However, compared with the data on yield, price, and cultivated land for rice, the data on working days tended to be inaccurate. Thus, we deleted the question on this topic.

selection bias.²³

The estimated results for the DID are shown in the upper part of Table 3. Regarding net rice income, the coefficients of ATT are negative, but not statistically different from 0 at the 10% level for both OLS and PSM-DID estimations. This result indicates that participation in the cooperative has no significant impact on participants, as measured by net rice income. The estimated results for net rice income per area of cultivated rice farmland are almost the same as those for net rice income. Specifically, no significant impacts on the participants are observed regardless of matching methods.

In addition, estimations of the treatment effect using only net rice income in 2010 are also performed to make comparison with those of the DID model. The results are shown in the lower part of Table 3. The treatment effects measured by net rice income in 2010 are significantly positive for all the specification of the dependent variables regardless of whether OLS or PSM is used. These results indicate that the estimated treatment effect of the cooperative using single year data appear to be overestimated since the time-invariant characteristics of farmer are not controlled. As shown in Table 2, the amount of rice income in 2007 was already significantly higher for participants than non-participants.

These results indicate that farmers who joined the cooperative in 2008 were equipped with unobservable abilities such as higher cultivation skills, preferences for agricultural production and broader social networks compared with those of non-participants. Since these time-invariant unobservable factors tend to affect both participation and outcomes, the estimation of treatment effects through PSM without DID appears to be difficult in terms of satisfying the conditional independence assumption, causing upward biased for the ATT estimate. Thus, adoption of the PSM-DID method is preferable for estimating unbiased treatment effects, and participation in rice-producing cooperative does not contribute to increasing the rice income of the participants.

Furthermore, to examine the differences in the effects of the cooperative between relatively large and small farmers, we divide the sample into two groups according to the size of cultivated farmland in 2007, specifically whether the size of cultivated farmland for rice is 3.5 *mu* or above (15 *mu* equals 1 hectare). The size threshold of 3.5 *mu* is used to balance the sample size into two groups. The estimated results when partitioning the sample by land area are shown in Table 4.²⁴ For households whose cultivated rice farmland was 3.5 *mu* or above, there is no significant difference

²³ Income data for 2010 are deflated by the consumer price index of rural Jiangsu province (the base year is 2007).

²⁴ To check the validity of threshold, we also estimate the ATT using size thresholds of 3 and 4 *mu*, respectively. The estimated results are almost the same with those of 3.5 *mu*, although some of the bootstrap z-values for local linear regression do not converge due to small sample size.

between the participants and non-participants for all estimation methodologies and all definitions of dependent variables, although the coefficients of ATT by PSM-DID tend to be negative. The estimated coefficients for households with less than 3.5 *mu* are positive, but not significant in all the cases.

Table 3. Estimated Results for ATT by OLS and PSM-DID

	OLS		Radius matching		Kernel matching		Local linear regression	
	ATT	z-Value	ATT	z-Value	ATT	z-Value	ATT	z-Value
DID (2007-2010)								
Net rice income	-88.4	-0.87	-39.2	-0.24	-88.6	-0.63	-46.8	-0.29
Net rice income per rice cultivated area	-2.7	-0.11	-8.2	-0.25	-18.2	-0.60	-15.5	-0.46
Single year (2010)								
Net rice income	365.4	3.21***	539.3	2.12**	509.2	2.49**	553.1	2.30**
Net rice income per rice cultivated area	112.1	3.57***	102.4	2.52**	107.8	2.79***	116.9	2.85***

Notes : 1) *** significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

2) The standard errors of PSM-DID are obtained by bootstrapping with 500 replications.

Our estimated result that the treatment effects are homogeneous is a striking contrast with the results of Ito et al. (2012), which claims that the treatment effect of agricultural cooperatives is highly heterogeneous and the effect is significant for only small farmers of watermelon in China.²⁵ This disagreement appears to be due to differences in the type of agricultural cooperatives examined. Specifically, the watermelon-producing cooperative was established by private entrepreneurs, who placed a higher priority on economic interests than on social inclusion.²⁶ However, considering the result of a relatively large-scale survey on FPCs (Kong et al. 2012) which points out that less than 20% of FPCs impose entry criteria to enroll, the watermelon-producing cooperative seems somewhat exceptional. In contrast, the main founders of the rice-producing cooperative were a former state-owned grain processing company and the local government, promoting more local farmers to participate in the cooperative. In addition, since the land rental market is less developed,

²⁵ Employing a Cobb-Douglas frontier production function for pear-cultivating farmers in Zhejiang, Liang (2014) indicates that the effect of economies of scale is heterogeneous among farmers. More specifically, economies of scale are observed for only small (less than 5 *mu*) and large (more than 30 *mu*) participant farmers, even though the technical efficiency of small participant farmers is considerably lower than that of non-participants. However, it should be noted that this study does not control for the endogeneity of participation in FPCs and performs only a simple comparison between participants and non-participants.

²⁶ Ito et al. (2012) point out that the membership is restricted to the farmers whose cultivated area is 3 *mu* or above. Regardless of the qualification, however, some farmers whose cultivated area is less than 3 *mu* are also allowed to participate in the cooperative.

rice-producing farmers in our survey are considerably homogeneous, and the distributions of their contracted and cultivated farmlands are concentrated considerably in the range from 2.5 to 4 *mu*. Hence, the rice-producing cooperative is more community-oriented, and the qualifications to become a member are less restrictive, although the cooperative requires participants to meet strict cultivation management requirements and monitors their products through a traceability system.

Table 4. Estimated Results of ATT by Cultivated Area

	OLS		Radius matching		Kernel matching		Local linear regression	
	ATT	z-Value	ATT	z-Value	ATT	z-Value	ATT	z-Value
3.5 mu or above								
Net rice income	-182.31	-0.952	-396.74	-1.161	-340.46	-1.114	-465.87	-1.235
Net rice income per cultivated farmland		-0.730	8.96	0.138	-64.33	-1.148	-12.10	-0.189
Less than 3.5 mu								
Net rice income	-0.35	-0.004	62.54	0.346	25.96	0.211	78.34	0.563
Net rice income per cultivated farmland	32.52	0.937	45.83	0.883	41.95	1.127	53.92	1.175

Notes: 1) *** significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.

2) The standard errors of PSM-DID are obtained by bootstrapping with 500 replications.

5. Conclusion

This paper investigated the treatment effect of participation in a rice-producing agricultural cooperative on the rice income of member households as compared with that of rice-cultivating non-participants. Few existing studies on RPOs, such as FPCs and contract farming, in China have attempted to estimate the effects of participation using PSM-DID to control for time-invariant unobservable characteristics. We selected a relatively well-organized rice-producing cooperative to estimate the treatment effect of participation. The estimated results show that no significant difference between participants and non-participants in the cooperative is observed in terms of net income from rice production after controlling for the differences in farmers' rice income before the treatment. Moreover, there is no significant heterogeneity in the treatment effects between large and small farmers, although the treatment effects measured by net rice income in 2010 are significantly

positive regardless of whether the OLS or PSM method is used.

On the other hand, the estimated results show that the probability of participation is positively but weakly correlated with the size of cultivated rice farmland before participation. However, this does not mean that the cooperative excludes small farmers by the use of entry barriers since other specific agricultural investment and special cultivation skills are not prerequisites to apply for membership. Relatively loose entry barriers seem to be intimately related with the type of crop grown and the economic structure of the surveyed area. Specifically, rice cultivation itself is greatly familiar to local farmers and additional agricultural investment is not required to enroll in the cooperative. However, participants have to follow strict regulations for cultivation specified by the cooperative. In addition, since the main founders of the rice-producing cooperative were a former state-owned grain processing company and the local government, the cooperative is promoting more local farmers to participate and making it easier for them to do so.

Furthermore, the estimated results for enrollment show that the probability of participation is significantly and positively related to farmers' willingness to adopt new agricultural techniques. Since opportunities for off-farm employment are abundant in the surveyed area, less-motivated farmers are unwilling to participate in the cooperative to increase their farm income and instead maintain agricultural production just to obtain relatively low but less volatile rice income.

Therefore, we can conclude that the effects of agricultural cooperatives tend to be overestimated due to time-invariant unobservable factors such as cultivation skills and motivation for agriculture, and that the adoption of PSM-DID method is preferable for estimating unbiased treatment effects. Since the Chinese government regards FPCs as a promising measure to enhance the economic welfare of rural farmers, as well as a way to overcome the exclusion of small farmers from modern supply chains, FPC-supporting policies have been intensified to promote their establishments. However, rigorous evaluation on the economic functions of FPCs is required to encourage more effective policy tools to enhance farm income and to overcome market imperfections. Moreover, the organizational characteristics of FPCs and their relationship with local farmers are considerably varied according to agro-economic circumstances. Therefore, careful examination is required to determine whether small farmers are excluded from agricultural cooperatives.

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