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Cooperative Membership and Smallholder Farmers' Yields and Profits

- Evidence from Shaanxi and Shandong Provinces, China

Abstract

Cooperatives are regarded as an institutional vehicle to help farmers mitigate market imperfections and improve smallholder welfare. Though much research has been done on what effect cooperatives have on farmers' welfare, the question of how cooperatives affect farmers' welfare remains largely unanswered. By using the case of apple farmers in China, we seek to answer this question by examining the effect of cooperative membership on yield and profit. The empirical analysis is based on field survey data collected among 551 apple farm households in Shaanxi and Shandong. An endogenous treatment regression model is employed to assess the average treatment effects of cooperative membership on the yield and profits per unit area. Our research shows that cooperative membership has a significantly positive effect on yields, but no significant effect on profits per unit area. Two pathways explain the different effects. First, cooperative services change members' production practices, especially the use of inputs that lead to higher land productivity. Second, members on average spend more on fertilizers and use more hired labor than non-members, which results in higher production costs. The extra revenues generated by the increased yields roughly compensates the extra production costs of the members.

Key words

Cooperatives membership, smallholder farmers, yield, profits per unit area, China

1. Introduction

Smallholder farmers play a vital role in the global agricultural community. Collectively, they manage four-fifths of the world's small farms and provide over 80% of the food consumed in the developing countries. Meanwhile, one billion out of the 1.4 billion poor people living on less than US\$1.25 per day earn their living from agriculture ("Smallholders, food security and the environment," 2013). To combat rural poverty, developing countries have been trying to improve small-scale farms' productivity and profitability as well as to develop sustainable smallholder agriculture (Verhofstadt & Maertens, 2014b). However, some small-scale farms face constraints caused by market failures, which impede access to markets and the possibility to improve productivity growth.

Institutional innovations are believed to play a role in assisting farmers to overcome market failures and to improve farmers' welfare. To have an effect on improving their welfare, the emerging institutions need to be both effective and inclusive of heterogeneous farmer groups. Cooperatives are regarded as an advantageous institutional vehicle to help farmers overcome market failures by facilitating participation and improve their bargaining power through joining forces in both input and output markets, as a way to increase agricultural income and reduce rural poverty (Fischer and Qaim, 2012; Hazell et al., 2010; Markelova et al., 2009). Compared with contract farming or other types of institutions, a cooperative is generally more inclusive of smallholders, attributed to its collective actions and social capital (Verhofstadt and Maertens, 2014a).

One constraint on the development of modern agriculture in China is land fragmentation and small-scale farms, which can be ascribed to the household responsibility system since 1979 (Tan et al., 2008). Under circumstances of vertical coordination of a supply chain, small farmers become increasingly vulnerable in the negotiation with other traders in the market. Having realized the potential merits of cooperatives that link smallholders with the market, the Chinese government has been promoting the development of cooperatives since the beginning of the 21st century (Jia et al., 2012). By October 2015, over 40% of farmer households had become members of at least one cooperative¹.

¹ Translated by authors from the news report entitled "1.47 million cooperatives including 40% of farmer households nationwide". The original text is written in Chinese and was released on January 1, 2016; it can be found at <http://politics.people.com.cn/n1/2016/0111/c1001-28035566.html>.

Various research has been done on the issues of cooperatives, ranging from the genesis of cooperatives (Chloupkova, 2002; Cook, 1995; Liang & Hendrikse, 2013), the relationship between cooperatives and farmers (Bijman & Hu, 2011; Kalogeras, Pennings, van der Lans, Garcia, & van Dijk, 2009; Osterberg & Nilsson, 2009) to the internal governance structure of cooperatives (Bijman, Hanisch, & Sangen, 2014; Dunn, 1988). An important branch of research relates to the effectiveness of cooperatives. For example, Wollni and Zeller (2007) and Sauer, Gorton, and White (2012) indicate that cooperatives can improve the output prices that farmers receive. In addition, Abebaw and Haile (2013) and Verhofstadt and Maertens (2014b) find that cooperatives promote farmers to use artificial fertilizers and other agricultural innovations, which helps to improve the agricultural productivity and increase farm incomes. However, Addai, Owusu, and Danso-Abbeam (2014) indicate that farmer-based organization membership exerts no significant impact on technical efficiency or maize yield in Ghana.

As for the case of China, Ito, Bao, and Su (2012) claim that a cooperative enables smallholders to increase farm incomes and is an important avenue to improve their economic status. Similarly, Ma and Abdulai (2016) show that cooperative membership can improve yield and increase household incomes. Both research has answered the question of what effects do cooperatives have on farmers' welfare. However, the question of how cooperatives affect farmers' welfare still needs to be further explored. Insights into this question can be useful to evaluate the Chinese policy of developing modern agriculture by promoting farmers to participate in farmer specialized cooperatives and to foster other new types of agricultural business entities (Hu, 2012). To our knowledge, little research has been done on this issue. The objective of this paper is to fill this research gap by exploring the mechanism of how cooperative membership affects the product yield and the profits from the product per unit area.

We focus our analysis on apple farmers in the two main apple producing areas in China. As the world's leading producer of apples, China produced more than half of the total apple output in 2015 (Frederick et al., 2015). Apples are the fruit crop with the largest acreage and the highest production value in China. Furthermore, they have been the dominant income source of farmers in the two main apple production regions -- the Bohai Gulf area and the Loess Plateau area (Wang and Huo, 2014). The empirical analysis was based on field survey data collected among 529 apple farm households in Shaanxi Province located in the Loess Plateau and Shandong Province in Bohai Gulf. We employ the endogenous treatment

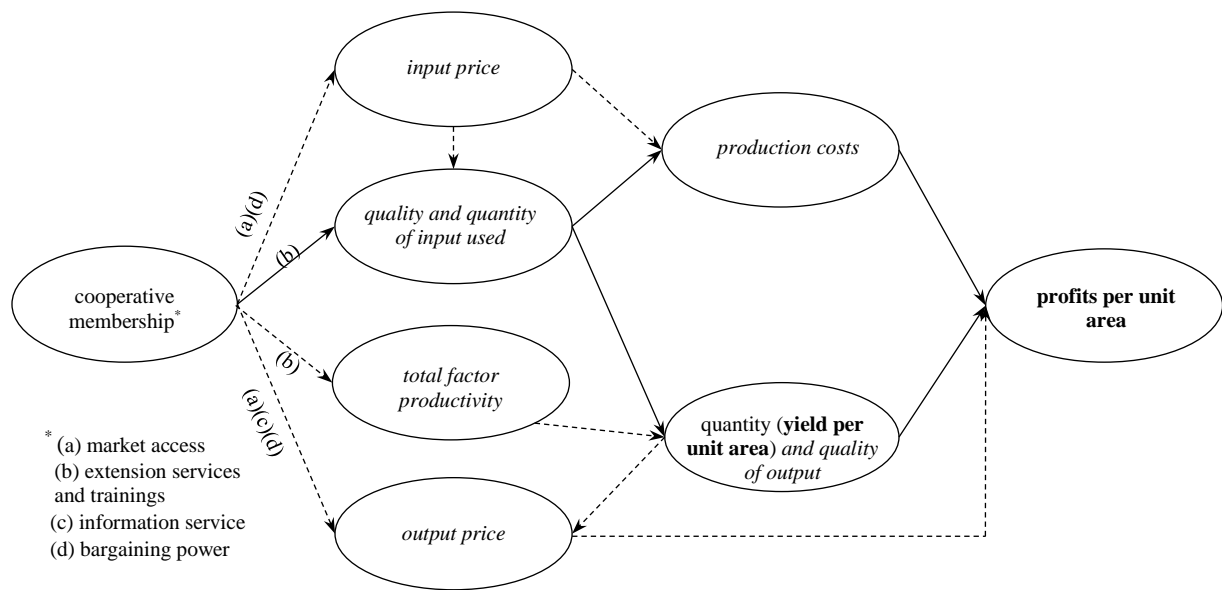
regression model (ETRM) to deal with the potential endogeneity of cooperative membership in estimating its effect on the yield and farmers' profits. Given that ETRM allows interactions between treatment and outcome covariates, we can dive into the question of what factors and additionally how these factors contribute to the difference between the group of member farmers and the group of non-member farmers.

2. Conceptual framework

Figure 1 shows the mechanism of how cooperative membership affects farmers' yield and their profits from production per unit area. We mainly assume that the service provided by cooperatives induces the differences among different groups of farmers.

Generally, cooperatives can help dismantle obstacles caused by market failures due to, for instance, distorted input and output markets and missing credit markets, and facilitate farmers' market access (Markelova, et al., 2009). Firstly, cooperatives can improve farmers' bargaining power through joint collaboration, which allows members to obtain inputs at a lower price and to sell products at a higher price. Secondly, cooperatives offer specific trainings, technical assistance and other extension services of production, from which the member farmers' production benefit. Research shows that cooperatives can generally increase the probability of adopting artificial fertilizers and other improved technologies (Abebaw & Haile, 2013; Verhofstadt & Maertens, 2014a). Therefore, we assume that these services can not only improve members' total factor productivity, but also members' production practices. Particularly, the application of inputs (both in quality and quantity) affect both the quality and quantity of output (yield), which impact the production costs and thus profits from production. Thirdly, cooperatives can smooth the information flow between farmers and the market. Hence, farmers can produce to better meet market requirements (Thorp, Stewart, & Heyer, 2005; Wollni & Zeller, 2007). In addition, cooperatives also help members with marketing by either buying products from their members or sharing marketing information. The marketing service will affect the output price received by members.

Given the reasons above, we assume that member farmers can have more production advantages than non-members. We only focus on the analysis of the mechanism of the effect of cooperatives on farmers' yields and profits from the input aspect, without considering external environmental factors (e.g. the output prices and available marketing channels) in this paper. In Figure 1, the unfocused part has been shown in *Italic font* and the unfocused relationship in dashed arrows.



(External factors are not shown here.)

Figure 1 Conceptual framework

3. *Farm Survey*

We conducted a survey among farm households between January and March 2015² in the Shaanxi Province in the Loess Plateau area and the Shandong Province in the Bohai Gulf area. A multistage sampling procedure was used for the selection of observation units. In the first stage, we used the probability proportional to size (PPS) method to select 7 counties in Shaanxi and 8 counties in Shandong according to the size of apple production in 2014. In each county, we asked the local Agricultural Bureau for the list of apple cooperatives in the county. From these lists, five cooperatives were chosen randomly. However, the chairmen of 12 out of the 75 selected cooperatives could not be reached due to unavailability or due to invalid contact information. Therefore, we dropped these 12 cooperatives from our sample, which resulted in a final sample of 63 cooperatives that were interviewed (30 in Shaanxi and 33 in Shandong). We did face-to-face interviews with the chairperson or others involved in the cooperative management³. Data on the cooperative (e.g. services provided by the cooperative, number of members and initiation) were collected.

Next, each enumerator randomly selected 10 to 12 farm households in the village where the cooperative located. At least 6 cooperative members in each village were interviewed. This gave a total number of 700 farm households that were interviewed, composed of 429 member farm households and 271 non-member households. Information was collected on apple production and marketing in 2009 and 2014 (including input use, costs, yields and output price), and household and farm characteristics (e.g., age, education, farm size and asset investments). Some interviewed farmers were not clear about the profits from apples because they had not yet sold the apples harvested in 2014. We excluded these farmers from our analysis due to the missing information. Therefore, data of 551 farmer households can be used for analyzing the determinants of yield. Specifically, 336 member farmers (185 in Shaanxi and 151 in Shandong) and 215 non-member farmers (109 in Shaanxi and 106 in Shandong) were used in the analysis. However, because we used the logarithm of profits from apple production per *mu* as one of our dependent variables in our analysis, we removed the 23 households with a negative profit from apple production in 2014 (accounting for 4.2% of 551

² Because of the Chinese spring festival in 2015, our survey was conducted in two periods, before and after the spring festival.

³ In two cases, the cooperative chairmen were out of office for business during our survey time. We had no choice but to interview others involved in the cooperative management. Both of them knew their chairmen well and could pass on basic information about the chairmen, such as age, education level and work experience.

households). Finally, data of 528 farmers⁴ were used for analyzing profits/*mu*, including 322 member farmers (174 in Shaanxi and 148 in Shandong) and 206 non-member farmers (103 in Shaanxi and 103 in Shandong).

Given the data constraint, we analyze the effect of cooperatives on farmers' yields and profits from the input aspect. Therefore, we do not discuss other factors of farmers' profits such as marketing channels, output prices, and other external environmental factors.

4. Estimation methodology

4.1 Econometric framework

Based on our conceptual framework, we borrow the ideas about production function from Debertin (1986). The logarithm form of the production function can be written as:

$$\ln Y = \ln A + \alpha_1 \ln K + \alpha_2 \ln L + \alpha_3 \ln T + \alpha_4 \ln I + \gamma C + \delta Z \quad (1)$$

Where Y is the yield; A is the constant; K , L and T represent the capital, labor and land inputs, respectively; I is a vector of variable inputs for agricultural production, C is a vector of product- and farmer-specific characteristics variables and Z is a vector of membership – dummy variables. α_1 - α_4 , γ and δ are the coefficients to be estimated.

It is well-known that a profit function can be expressed with the same explanatory variables as a production function when input and output prices do not vary among the units of observations. Given our assumptions in the conceptual framework, we know that the profit per unit area depends not only on the production cost, but also the quality of outputs. Therefore, we include several different variables in the profit function. Detailed explanations of the different explanatory variables included in the profit function can be found in the section Model Specification.

According to the assumptions in the conceptual framework described in Section 2, we learn that the service provided by cooperatives leads to the differences in production practices among farmers, especially the application of variable inputs. We thus assume further that the fixed production factors (K , L and T) as well as the product- and farmer-specific characteristics (C) have a similar impact on yields for members and non-members, but that the

⁴ According to Wicklin (2011), there are two common ways to handle negative values when one wants to log-transform the data. Solution 1 is to translate and then transform. The common technique is to add a constant value to the data prior to applying the log transform. Solution 2 is to handle negative values by marking them as missing values. Here we choose Solution 2.

impact of variable inputs differs between the two groups. The mechanism of how cooperative membership affects the yield can be written as:

$$\ln Y_0 = \ln A + \alpha_1 \ln K + \alpha_2 \ln L + \alpha_3 \ln T + \sum_{j=1}^j \beta_{0j} \ln I_j + \gamma C \quad (2)$$

$$\ln Y_1 = \ln A + \alpha_1 \ln K + \alpha_2 \ln L + \alpha_3 \ln T + \sum_{j=1}^j \beta_{1j} \ln I_j + \gamma C \quad (3)$$

where Y_0 and Y_1 denote the yield obtained by non-members and members, respectively; j is the number of variable inputs; β_{0j} and β_{1j} are the parameters of different effects of variable inputs on the yield to be estimated for non-members and members, respectively, keeping all other variables constant. The profit functions can be expressed in a similar way:

$$\ln P_0 = \ln B + \theta_1 \ln K + \theta_2 \ln L + \theta_3 \ln T + \sum_{j=1}^j \omega_{0j} \ln I_j + \sigma C + \tau S \quad (4)$$

$$\ln P_1 = \ln B + \theta_1 \ln K + \theta_2 \ln L + \theta_3 \ln T + \sum_{j=1}^j \omega_{1j} \ln I_j + \sigma C + \tau S \quad (5)$$

where P_0 and P_1 denote the profits per unit area obtained by non-members and members, respectively; B is a constant; θ_1 , θ_2 and θ_3 are the parameters of capital, labor and land inputs to be estimated, respectively; ω_{0j} and ω_{1j} are the parameters of different effects of variable inputs on the profit to be estimated for non-members and members respectively, keeping all other variables constant. S denotes the variables that are excluded in the yield function but included in the profit function.

4.2 Endogeneity of cooperative membership

Equations (1)-(5) assume that farmer i 's choice of membership is exogenous to either the yield or the profits from apple production. In reality, this may not be the case. Farmers may self-select to join cooperatives because of unobserved factors such as incentives and ability. These unobservable factor may also impact product yields and profits, which makes the error terms of the cooperative membership equation correlate with that of the output equations. In such case, membership is endogenous in both yield and profit equations. We cannot ignore the endogeneity of membership; because neglecting or failing to account for endogeneity will bring about inconsistent estimates and lead to spurious even biased conclusions (Gerber, 1998; Heckman, 1979).

4.3 Treatment effects assessment

A treatment effect is the average causal effect of a binary variable on an outcome variable of scientific or policy interest. In practice, however, simple comparisons of the outcome or even regression-adjusted comparisons may provide misleading estimates of treatment effects

because of endogeneity due to, for instance, unobserved and uncontrolled differences between the control group and the treatment group. Matching and instrumental variables (IV) are the two most commonly used statistical techniques to solve the problem of endogeneity when estimating treatment effects (Angrist, 2010). Both matching and regression are motivated by the assumption that the only source of omitted variables or selection bias is from observed covariates based on the conditional independence assumption (Angrist, 2010). Propensity Score Matching (PSM) has been one of the popular methods to evaluate treatment effects.

But the obvious disadvantage of PSM is that it only controls for observed heterogeneity. The IV method can avoid this disadvantage and control for unobserved heterogeneity in principle (Kabunga, Dubois, & Qaim, 2012). A typical IV treatment effects model is composed of one selection equation and one outcome equation, which assumes that the impact of the selection can be captured by a simple parallel shift with respect to the outcome variable (Kabunga, et al., 2012). This assumption does not fit the fact that cooperative membership is expected to influence not only the output (e.g. yield and net returns from products), but also the input use during the production. These interactions can be depicted through the estimation of the endogenous treatment-regression model (ETRM), which allows interactions between treatment and outcome covariates.

We measure the treatment effect through average treatment effect (ATE), average treatment effect on the treated (ATET) and average treatment effect on the untreated (ATEU). The specific details of ETRM and these models can be found on pp. 36-67 in STATA Glossary and Index (Release 14).

4.4 Model specification

4.4.1 Determinants of outcome equations: yield and profits/mu

According to the conceptual framework and the forms of capital categorized by Uphoff and Wijayaratna (2000), we regroup the explanatory variables into five different categories for the convenience of analysis, viz. social capital, physical assets, human capital and variable inputs and local physical environment. We measure the profit by using farmers' average profits⁵ from the apple production on per unit of land in 2014. Table 1 exhibits the descriptions of variables and expected effects of independent variables on dependent variables of both the treatment equation and outcome equations.

⁵ The cost of family-member-labour (or free labour) input and indirect fixed costs are not subtracted from the average net income.

Table 1 Descriptions of variables and expected effects

	Variable Name	Expected effects on yield/ <i>mu</i>	Expected effects on profits/ <i>mu</i>	Expected effects on membership	Description
Output	log_yield	0	0	0	logarithm of yield per <i>mu</i> ⁶ (unit: <i>jin</i> ⁷)
	log_profit	0	0	0	logarithm of profit from apple production per <i>mu</i> in 2014(unit: yuan)
Social capital	membership	+/-	+/-	0	cooperative membership
	village cadre	+/-	+/-	+	whether the household head or any other family member has the work experience of being village cadre (1= yes;0=no)
Physical asset	fruit_year	+/-	+/-	0	years of bearing fruits of apple trees
	dwarf rootstock	+/-	+/-	0	whether the apple trees are grafted on dwarf rootstocks (1=yes;0=no)
	bearing size	+/-	+/-	+/-	area of land bearing apples (unit: <i>mu</i>)
	plots	+/-	+/-	0	number of land plots cultivated by the household
	specialization	0	+	+/-	the area of apple land in the total land area of the household in 2009
	quality index	0	+	+/-	the ratio of apples without blemishes in the total apple output in 2009
	income_2009	+	+	+/-	total incomes from apple production in 2009 (unit: yuan)
	non-farm	0	0	+/-	Household head's participation in non-farm work (1=no participation;2=part-time participation;3=full participation)
	gender	+/-	+/-	+/-	gender of the household head (1=male;0=female)
	age	+/-	+/-	+/-	age of the household head
Human capital	education	+	+	+	years of education of the household head
	training	0	0	+	Frequency of participation in technical training in 2009
	skill level	+	+	+	self-evaluated level of producing skills (1=bad;2=mediocre;3=good;4=excellent)
	fertilizer	+	+/-	0	total fertilizer cost per <i>mu</i> for apple production (unit: yuan)
	pesticide	+	+/-	0	total pesticides cost per <i>mu</i> for apple production (unit: yuan)
Variable inputs	self-labour	+	+/-	0	Cost free labour input per <i>mu</i> for apple production (unit: labour/day)
	hired-labour	+	+/-	0	Hired labour input per <i>mu</i> for apple production (unit: labour/day)
	irrigation	+	+/-	0	frequency of irrigation for apple trees in 2014
	bagging	+	+/-	0	whether double-layer bags have been used for bagging apples in 2014 (1=yes;0=no)
	weather	-	-	0	whether there is production loss caused by extreme weather in 2014 (1= yes;0=no)
Local physical environment	loss	0	0	+	whether there was production loss caused by extreme weather from 2009 to 2013 (1= yes;0=no)
	region	+/-	+/-	+/-	regional dummy variable (1=Shaanxi; 0=Shandong)

Note: “+”, “-” and “0” stand for positive effect, negative effect and no effect, respectively. “+/-” denotes ambivalent effect.

⁶ *mu* is the traditional Chinese unit of area (1 hectare = 15 *mu*).

⁷ *jin* is the traditional Chinese unit of weight (1 kg = 2 *jin*)

The focus of our research is the effect of cooperative membership on the farmer's yield and profits. Thus, the variable of cooperative membership is the most important explanatory variable in this paper. To some extent, cooperative membership can be a measurement of an aspect of social capital. Besides the dummy variable of membership, we also include whether the household head or other members in the household have the work experience as a village cadre as the second proxy of social capital. Given that we can find literature about both the positive (Grootaert, 1999) and negative effect (Adhikari & Goldey, 2010; Crespo, Réquier-Desjardins, & Vicente, 2014) of social capital on household welfare and collective action, we cannot specify the signs of their effects on production yield or profits from apple production on the unit area of land.

Physical assets mainly refer to farm characteristics, including characteristics of fruit trees (including years of bearing fruit of apple trees and the rootstock of apples grafted on), land size (indicated by the area of land bearing apples), degree of land fragmentation (measured by number of plots each household owns), level of specialization in apple production and the fruit quality. The profitability of an apple orchard depends on fruit quality and, more precisely, on fruit size. It has been proven that tree age and rootstocks of apple cultivar grafted on partly determine the size of apples and thus their impact on fruit quality (Marini et al., 2002; Treder et al., 2010). Farm characteristics, such as land size and number of plots each household owns, have a direct effect on production. For example, on the one hand, large farms can decrease production costs due to the economy of scale and their higher flexibility in crop use and risk bearing (Chambers and Foster, 1983). On the other hand, the negative relationship between farm size and output per hectare has also been confirmed to some extent by Chayanov (1926) and Lipton (2009). Additionally, farmers with more plots but of smaller scale tend to use more labor and fewer modern technologies, which then impacts the production cost (Tan et al., 2008). Specifically, we need to note that the variables of quality and the degree of specialization in apple production are not included in the estimation of the determinants of yield, but is included in the profit equation.

The total incomes from apple production in 2009 are used as the proxy of cash access. We expect that with increasing profits from apple production in previous years, the farmer has more access to cash and credit, which can decrease liquidity constraints when farmers invest in inputs and technologies needed for production. The decreasing liquidity constraints can impose positive effect on apple yields, but ambivalent impact on the profit from apple production.

Variable inputs for production mainly includes fertilizers, pesticides, labor input (including free self-labor mainly from household members and hired labor), bagging and irrigation during the growth period. We hypothesize that the increasing input will exert a positive effect on the yield, but an unclear effect on the profit from apples per *mu*.

The local physical environment is represented by production loss due to extreme weather during the growth period in 2014 and in the previous five years (from 2009 to 2013), respectively and a regional dummy variable to distinguish the different geographical characteristics between Shaanxi and Shandong. Extreme weather will harm both the yield and the net incomes from apple production.

4.4.2 Determinants of treatment equation: Cooperative membership

We note that the aim of the treatment equation is not to perfectly explain farmers' decisions about cooperative membership, but to account for unobserved heterogeneity that could bias the effect of membership on either apple yields or profits in the outcome equations. For this purpose, we mainly include variables of farm characteristics and of human capital in the equation. Additionally, the degree of specialization may also influence the incentive to participate in group activities (Fischer & Qaim, 2014). We thus also include the variable of specialization in the membership equation.

In principle, the parameters of the model (consisting of both treatment and outcome equations) can be identified, even though the treatment equation uses identical covariates as the outcome equation. However, Deb and Trivedi (2006) suggest that using exclusive restrictions or instruments can result in more robust identifications. For instance, we can include predictors in the treatment equation that are not included in the outcome equation. We thus include two extra variables in the treatment equation as instruments – a dummy variable for whether the household suffered apple production loss due to extreme weather from 2009 to 2013 and another for the frequency of accepting trainings in regards to apple production in 2009 (to avoid endogeneity).

5. Descriptive analysis

Table 2 shows the statistical descriptions of variables both of input and output and mean differences between member farmers and non-member farmers. Mean yield per *mu* for members is 4,140 *jin*⁸ (S.D. 2045.15), about 290 *jin* more than non-member farmers, which is not significantly different from zero. Mean profits from apple production per *mu* for members are 7838 yuan (1043 euro⁹) and 7498 yuan (998 euro⁷) for non-members. The difference between these two groups is 340 *yuan*. which is not statistically significant.

In general, apple farmer households are highly specialized in apple production, with the mean of 0.84 in the degree of specialization in apple planting (S.D.= 0.23). Their farms are dispersed (indicated by the average 3.71 plots per household) and of small scales (indicated by the mean bearing size - 8.59 *mu*¹⁰). Though no significant difference exists between these two groups relating to bearing size, members have significantly more plots (with the mean of 3.84 plots) of land than non-member farmers. We can also learn that there is not much difference between these two groups with regard to physical assets and variable inputs in production. However, differences in human capital and social capital are significant. Compared with non-members, member farmers have higher education levels and participate in more production trainings. Member farmers and their family members also have a higher probability of having the experience of village cadres.

With regard to costs of variable input, there is no significant difference between the two groups except for the labour cost, one of the most important components of costs for apple production¹¹. Specifically, non-member farmers use more self-labour input per *mu* than member farmers do. Member farmers tend to use more hired labour during production, though the total labour input on average in apple production per *mu* is not significantly different between these two groups.

⁸ *jin* is the traditional Chinese unit of weight (1 kg = 2 *jin*).

⁹ The calculation is based on the exchange rate of EURO to RMB on 31-12-2014: 1 EURO=7.512 RMB.

¹⁰ 1 hector=15*mu*.

¹¹ According to Huo, Liu, and Liu (2015), the average labour costs of apple production account for 45% and 46% of the total production costs in the Bohai Gulf Area and the Loss Plateau Area, respectively in 2014 (the original test is in Chinese and translated by the authors).

Table 2 Descriptive statistics of sampled farm households

	Variable Name	Members Mean (S.D. ^a)	Non-members Mean (S.D.)	Difference (S.E. ^b)	Full sample Mean (S.D)
Output	yield	4140.70 (2045.15)	3851.78 (2326.67)	288.90 (188.45)	4028.16 (2162.70)
	profit	7838.45 (7308.46)	7497.75 (6671.75)	340.70 (621.17)	7705.75 (7063.01)
	fruit_year	17.59 (7.1)	18.01 (7.28)	-0.42 (0.62)	17.75 (7.17)
	dwarf rootstock	0.11 (0.31)	0.07 (0.26)	0.04 (0.02)	0.10 (0.26)
Physical asset	bearing size	8.91 (11.85)	8.08 (23.82)	0.83 (1.53)	8.59 (17.50)
	plots	3.84 (2.25)	3.50 (1.63)	0.34 ^{**} (0.177)	3.71 (2.04)
	specialization	0.83 (0.23)	0.85 (0.22)	-0.02 (0.02)	0.84 (0.23)
	quality index	0.84 (0.17)	0.82 (0.17)	0.01 (0.01)	0.83 (0.17)
	income_2009	36027.60 (58970.04)	29465.12 (70345.06)	6562.48 (5554.59)	33471.56 (63660.92)
	non-farm	1.12 (0.36)	1.13 (0.38)	-0.01 (0.03)	1.12 (0.36)
	gender	0.99 (0.12)	0.97 (0.17)	0.02 (0.01)	0.98 (0.14)
	age	52.00 (7.98)	52.12 (9.78)	-0.12 (0.76)	52.05 (8.71)
	education	9.39 (2.20)	8.86 (2.51)	0.53 ^{***} (0.20)	9.18 (2.34)
	training	2.05 (2.14)	1.20 (1.72)	0.85 ^{***} (0.17)	1.72 (2.03)
Human capital	skill_level	2.25 (0.68)	2.03 (0.66)	0.22 ^{***} (0.06)	2.16 (0.68)
	membership	1.00 (0.00)	1.00 (0.00)	0.00 (0.00)	0.61 (0.49)
	village cadre	0.31 (0.46)	0.19 (0.39)	0.12 ^{**} (0.04)	0.26 (0.44)
	fertilizer	2177.17 (1448.21)	1986.10 (1260.03)	191.07 (120.28)	2102.75 (1379.95)
Variable inputs	pesticide	460.94 (320.18)	463.50 (304.81)	-2.565 (27.43)	461.93 (314.00)
	self-labor	19.87 (14.76)	21.97 (1.00)	-2.10 [*] (1.28)	20.69 (0.628)
	hired-labour	10.64 (9.14)	8.89 (10.44)	1.74 ^{**} (0.84)	9.95 (0.41)
	total labour ¹²	30.5 (16.66)	30.85 (17.53)	-0.36 (1.48)	30.63 (16.98)
	irrigation	2.88 (3.11)	2.60 (2.83)	0.28 (0.26)	2.77 (3.00)
	bagging ¹³	0.87 (0.34)	0.81 (0.39)	0.06 (0.03)	0.84 (0.36)
	weather	0.82 (0.39)	0.79 (0.41)	0.03 (0.03)	0.80 (0.40)
	loss	0.68 (0.467)	0.62 (0.48)	0.06 (0.04)	0.66 (0.48)
	region	0.55 (0.50)	0.51 (0.50)	0.04 (0.04)	0.53 (0.50)
	distance	7.23 (8.43)	7.12 (8.46)	0.11 (0.74)	7.19 (8.43)
Number of observations		336	215	--	551

Note: ***, ** and * denote the significance levels of 1%, 5% and 10%, respectively. “a” denotes standard deviations. “b” denotes standard errors.

¹² The total labour input is not one of the explanatory variables that are used for the explanation later.

¹³ Bags here refer to the bags used to cover the fruit during the growth period to protect them from environmental hazards. According to our data, all the sampled households used bags in 2014 for apples. Four types of bags were used, viz. plastic bags, plastic bags, single-layer paper bag, double-layer bags with two colours and double-layer bags with three colours (with the price ranking from low to high). We transformed the categorical variable into a dummy variable (whether the household used two-layer bags or not).

6. Estimation Results

First, we check the potential multicollinearity of explanatory variables on the basis of variance inflation factors (VIFs) of the two linear regression models and one linear probability model after using OLS to estimate these explanatory variables. For the yield equations, the highest VIF is 18.15 (average of 3.6). The two square terms (tree age and bearing size) contribute to the high VIF. If we remove these two terms from the OLS regression model, the average VIF will decrease to 1.33, and the highest VIF will decrease to 2.77. We deal with the square terms in the same way for the profit equation; then the highest VIF decreased to 2.95 (average of 1.34). As for the membership regression model, the highest value of VIF is 7.92 (average of 1.92). The values are lower than the common chosen critical value of 10 (Spanos & McGuirk, 2002). Therefore, we can claim that these explanatory variables are not suspected of multicollinearity. The estimated results are shown in Table 3.

The Wald test in the last row of Table 3 indicates that we can reject the null hypothesis of no correlation between the treatment-assignment errors and the outcome errors for the control and treatment groups (non-member and member groups). The values of p are significant at the 10% and 5% level, respectively. These findings support the premise that the cooperative membership is endogenous in both yield and profits equations.

6.1 Treatment equation: Determinants of cooperative membership

The estimates of the determinants of cooperative membership is shown in Column Treatment Equation¹⁴. We can learn that the land size has a nonlinear effect on the cooperative membership. With the increase of the bearing area, farmers seem to be more inclined to participate in the cooperative. When the area reaches 150 mu ¹⁵, the probability of participation, however, will decrease afterwards. The degree of specialization exerts a negative effect on membership. The possible reason can be related to the production decision rights. The more specialized the apple farmer is, the more the farmer prefers to have control over production. But participating in cooperatives can mean losing decision rights over production, to some extent.

¹⁴ Here we take the estimated treatment equation for yield as an example. The estimated coefficients of the treatment equation for profits can be found in Table C in Appendix. Though the results are different with respect to magnitudes, they are similar in signs.

¹⁵ The result can be obtained through the first order conditions of the Lagrange equation of membership: $0.03/(2*0.0001)=150$. Two households own more than a 150 mu apple plantation.

In addition, village cadre has positive effect on cooperative membership. It is plausible because village cadres in China are supposed to fulfil state tasks (Kung et al., 2009), and they are generally quick responders not only to new agricultural technologies and techniques, but also to the government's policy calls. Given the Chinese government's policy of supporting the development of cooperatives, the experience of being a village cadre exerts a positive effect on a farmers' choice to become a member.

Incomes from apple productions in 2009, quality index, training and skill level have positive impacts on membership. The results may partly reflect the effects of farmers' motivation and ability on the participation in cooperatives to some extent. Given the service provided by most cooperatives in China, some farmers, especially the ones with the need of trainings to improve their production skills, are more likely to participate in cooperatives than others.

Table 3 Outcome models of yield and net income per *mu*

Variable Name	Outcome equations		Treatment equations
	Coefficients (log yield)	Coefficients (log profits)	Coefficients (membership)
	S.D.	S.D.	S.D.
fruit_year	0.05*** (0.02)	0.00 (0.02)	--
square_fy	-0.001** (0.00)	0.00 (0.00)	--
dwarf rootstock	0.05 (0.07)	0.03 (0.10)	--
bearing size	-0.02*** (0.01)	-0.01** (0.00)	0.03*** (0.01)
(bearing size) ²	0.0001*** (0.00)	0.00 (0.00)	-0.0001*** (0.00)
plots	0.00 (0.01)	-0.01 (0.01)	--
specialization	--	-0.22 (0.17)	-0.52** (0.23)
quality index	--	1.18*** (0.25)	0.81* (0.42)
income_2009 ¹⁶ (log)	0.03* (0.02)	0.07*** (0.02)	0.05** (0.02)
non-farm	0.03 (0.08)	-0.01 (0.10)	-0.08 (0.17)
gender	0.00 (0.19)	-0.12 (0.21)	-0.30 (0.43)
age	0.00 (0.00)	0.00 (0.00)	0.00 (0.01)
education	0.00 (0.01)	-0.01 (0.01)	0.03 (0.03)
training	--	--	0.09** (0.04)
skill level	-0.01 (0.06)	0.08 (0.06)	0.26*** (0.08)
membership(M)	1.17 (0.88)	0.31 (1.01)	--
village cadre	-0.11* (0.06)	-0.11 (0.09)	0.26* (0.14)
Cross terms of membership and input variables	^a M ₀ *(log_fertilizer)	0.04 (0.08)	0.00 (0.10)
	^b M ₁ *(log_fertilizer)	0.09*** (0.03)	0.076** (0.04)
	M ₀ *(log_pesticide)	0.17*** (0.07)	0.11 (0.08)
	M ₁ *(log_pesticide)	-0.05 (0.05)	0.05 (0.07)
	M ₀ *(log_selflabour)	0.03 (0.10)	-0.01 (0.10)
	M ₁ *(log_selflabour)	0.07 (0.06)	-0.09 (0.07)
	M ₀ *(log_hirelabour)	0.07 (0.04)	0.08* (0.05)
	M ₁ *(log_hirelabour)	0.20*** (0.04)	0.14*** (0.04)
	M ₀ *(irrigation)	0.01 (0.02)	-0.03 (0.03)
	M ₁ *(irrigation)	0.02 (0.01)	-0.04 (0.03)
	M ₀ *(bagging)	0.03 (0.06)	0.03 (0.07)
	M ₁ *(bagging)	0.02 (0.04)	-0.01 (0.06)

¹⁶ Here we include the logarithm of incomes from apple productions in 2009 as one of the explanatory variables. Our data shows that 18 out of 528 households got zero incomes, accounting for 3% of the total households. We assign “1” to these zero values. Given the concern of biasing the estimation, we borrow Battese’s idea (1997) to deal with the ‘zero-observation’ problem in the estimation of Cobb-Douglas (or translog) production functions by including a dummy variable such that efficient estimators are obtained using the full data set without any bias being introduced. We found that the dummy variable is not significant in either the regression of yield or profits/*mu*.

Variable Name	Outcome equations		Treatment equation
	Coefficients (log yield) S.D.	Coefficients (log profits) S.D.	Coefficients (membership) S.D.
weather	0.00 (0.06)	0.04 (0.08)	--
loss	--	--	0.19* (0.11)
region	-0.24*** (0.08)	-0.38*** (0.11)	0.09 (0.13)
constant	5.71 (0.85)	6.22*** (1.01)	-1.37 (0.93)
ρ	-0.50* (0.25)	0.43** (0.16)	--
Wald χ^2	2.70*	5.20**	--
No. of observations	551	528	551

Note: ***, ** and * denote the significance levels of 1%, 5% and 10%, respectively.

“a” denotes the estimated coefficients for the group of non-members; “b” denotes the estimated coefficients for the group of members.

6.2 Outcome equation: Determinants of yield

The first two columns of Outcome Equations in Table 3 presents the estimates of determinants of the apple yield. From the cross terms of membership and variables of input, we can tell the different effects of input on two groups of farmers. Given the importance of the cross terms for our analysis, we will discuss them further in Section 6.4.

The results show that both the age of apple trees and bearing size have a nonlinear effect on the yield. Before the tree is 25¹⁷ years old, the yield will increase with the age of the apple tree. Then the yield will decrease with the age afterwards. Similarly, the yield decreases with the increase of bearing size. When the size reaches 100¹⁸ *mu*, the yield will increase afterwards. The result reflects the fact that most Chinese farms are small in scale and most of them have not reached economies of scale. The incomes from apples in 2009 have a positive effect on the yield, which is in line with our hypothesis.

The variable of village cadres has a negative effect on the apple yield per *mu*. The possible reason is related to the distribution of time on production for village cadres. Distracted by village affairs, these village cadres may spend less time in apple production than other villagers. Being a village cadre means a higher probability of having a larger social network and more social capital than other ordinary villagers, which also increases the probability of getting income from more channels, especially from non-farm activities.

6.3 Outcome equation: determinants of profits from production

The estimates of the determinants of profits from apple production are shown in Column 5 in Table 3.

With the increase of the bearing size, the profits/*mu* will decrease. This can be ascribed to the inadequate labor and other inputs for apple production. For Chinese smallholder farmers, the most important labor force is from the household members. With constraint of capital for investment and labor supply, increasing the land size is likely to harm the profits because of inadequate investment. Particularly, Table A shows that with the increase of bearing size, farmers tend to hire more labor. With the increasing cost of employing labor, the room for profit will decrease undoubtedly, given the homogeneous price level of apples to farmers.

¹⁷ The result can be obtained through the first order conditions of the Lagrange equation of the yield. $0.05/(2*0.001)=25$.

¹⁸ The result can be obtained through the first order conditions of the Lagrange equation of the yield. $0.02/(2*0.0001)=100$.

The quality index exerts a positive effect on the profits/*mu* at the 1% level. It is intuitively reasonable that the higher the quality of apples the farmer produces, the more profits the farmer can get due to securing comparatively better prices. Similarly, the incomes from apple production in 2009 have a significantly positive impact on the profits. Better access to cash and credit can increase the probability to adopt new technologies and increase the input, which can possibly lead to improved profits from the production. The result confirms our hypothesis.

From the coefficient of the regional dummy variable, we can learn that compared with farmers in Shandong Province, farmers in Shaanxi Province have both lower yields and profits from apples per unit area on average. The result implies that farmers in Shandong have a higher productivity than farmers in Shaanxi. Reasons can be attributed to the input use for apple production. See Table B.

6.4 Group specific variation in input use

From the cross terms of the dummy variable for membership and the variables of various inputs, we can learn the pathways how the different effects of the inputs on both yield/*mu* and profit/*mu* bring about for both the member and non-member group. The main results are as follows.

Firstly, the application of fertilizer can significantly improve both the yield and profits per unit area for the member group, but has no significant effects on improving either yield or profit for the non-member group. Secondly, the input of hired labor exerts a significantly positive impact on members' yields, but no significant impact on non-members' yields. Furthermore, we can learn that the input of hired labor has a bigger and more significant effect on the profit/*mu* for the member group than for the non-member group. In contrast, the cost of pesticides is significantly different from zero at the 1% level for non-member group's yields, but no significant effect for member-group's.

The results can be explained by the effects of cooperative service on apple farmers' production practices. As explained in the Conceptual Framework, cooperatives can improve farmers' access to both input and output markets, which may allow members to obtain inputs with cheaper prices and of better quality. This access can thereby lead to changes both in the quality and quantity of inputs used by farmers. Furthermore, cooperatives offer specific trainings, technical assistance and other extension services of production, which can influence

the production practice of member farmers. For example, member farmers may apply specific kind of fertilizers at specific times during the apple growth period according to the suggestions or guides of the cooperative. This specific practice may result in changes in both the quality and quantity of apple outputs.

Similarly, cooperatives also advise members to use different types of pesticides during production, mainly due to the specific requirements of pesticide practices determined by a certain production certification (e.g. organic products) or a buyer's stringent requirements of the pesticide residues left on apples in response to the increasing food safety concern. These pesticides can usually be less toxic and thus probably less effective than traditional pesticides. Members, therefore, are probably inefficient in pesticide use. This notion may explain the insignificant effect of pesticides on the yield improvement for members.

In summary, the services provided by the cooperative can make a difference both in the quality and quantity of the used inputs for apple production, which result in the difference in effectiveness and efficacy of inputs used. Hence, the outputs (or yields and profits) are different between the two groups. Our previous assumptions have been confirmed by the results above.

6.4 Estimating treatment effects

We estimate the treatment effects of membership on the yield/*mu* and the net incomes/*mu* from apple production by measuring ATET, ATUT and ATE, which are presented in Table 4. More detailed results of treatment effects can be found in Table D and Table E in Appendix. We can learn that ATET (in percentage) for the yield/*mu* is 7.57%, which means that if the members had not participated in the cooperatives, their average yield/*mu* would have been 7.57% lower, keeping other variables constant. ATEU is 5.33%, which means that non-member farmers could have gained an increase of 5.33% in the yield/*mu* had they participated in the cooperatives, keeping other variables constant. ATE is 3.53%, meaning the predicted yield/*mu* of the treatment group (member farmers) is 3.53% more than that of the control group (non-member farmers) on average.

As for the treatment effects on the profits/*mu*, however, we can learn that neither ATET, ATEU nor ATE is statistically significant. Therefore, we can conclude that the treatment effect of membership on the profits/*mu* from apple production is not different from zero.

Table 4 Treatment effect of cooperative membership on apple yield/*mu* and profits/*mu*

	Treatment effect Contrast (members vs non-members)					
	ATET	ATET in %	ATEU	ATEU in %	ATE	ATE in %
yield/ <i>mu</i>	0.59**	7.57**	0.55*	5.33*	0.57**	3.53**
profits/ <i>mu</i>	-0.41	-0.07	-0.42	-3.01	-0.41	-1.63

Note: ***, ** and * denote the significance levels of 1%, 5% and 10%, respectively.

The significantly positive treatment effect of membership on the apple yield can be explained through the difference between members and non-members in the effectiveness and efficacy of input used for production, which has been explained in the previous section.

The possible reason for the insignificant treatment effect of membership on the profits from apple production lies in the difference between the value of extra outputs and the extra cost of inputs. We can generally conclude that member farmers make more investment in inputs than non-members from Table 2, especially in fertilizers and hired labour. With the increasing prices of fertilizers, pesticides and other inputs in the domestic market, namely the labour costs, the gained profits from the extra yields may not cover the extra input costs. Therefore, even though the members have a higher average yield/*mu* than non-members, their profit from apple production per *mu* is not significantly different from their counterparts.

7. Conclusion and Discussion

To further explore the answer to the question of how agricultural cooperatives affect farmers' welfare, we have analyzed the effect of cooperative membership on the yield and the profits/*mu* from apple production. We find that although cooperative membership has significantly positive treatment effects on the apple yield, it has no significant treatment effect on the profits/*mu*. The empirical analysis is based on the field survey data of 551 (and 528, respectively) apple farm households in Shaanxi and Shandong, China.

By estimating determinants of yield/*mu* and profits/*mu* from apple production respectively, we try to explore the pathways of how cooperative membership produces a difference between the member group and non-member group. Particularly through the estimates of the cross terms of the dummy variable of membership and the variables of various inputs in ETRM, we learn that the fertilizers and hired labour input mainly contribute to the difference. The application of fertilizers and hired labour can significantly improve both yield and profits

per unit area for members, but not for the non-member group. The results have confirmed our assumptions in the conceptual framework to some extent.

Due to the production trainings and other services provided by the cooperatives, on the one hand, the two groups can have differences in both effectiveness and efficacy of inputs use. Benefiting (from the training) member farmers can have higher yields than non-members in general. On the other hand, members tend to spend more costs on variable inputs than non-members. With the increasing prices of inputs, especially the labour costs, the gains from the extra yield may not cover the extra input costs. Therefore, even though the members have a higher average yield/*mu* of apples than non-members, their profits from apple production per *mu* is not significantly different from their counterparts. Cooperative services contribute to differences both in the quality and quantity of the used inputs for apple production, which impact both quality and quantity of the output (yield).

Owing to data limitations, we analyze this question mainly from the input aspect, without considering the external market environment. For the same reason, we estimate the treatment effect of membership on the yield and profits per unit area by comparing the member and non-member groups based on the cross-sectional data. If panel data were provided, we could do a comparison between ex-ante and ex-post (participating in cooperatives) among farmers to gain a deeper insight into the treatment effect and the corresponding reasons.

Most of the existing research indicates that the cooperative exerts a positive effect on farmer incomes (Ma & Abdulai, 2016; Sauer, et al., 2012; Verhofstadt & Maertens, 2014b). Our research puts a question mark to this statement. The Chinese government has been implementing the agricultural policy of developing modern agriculture by promoting farmers to participate in farmer cooperatives and to foster other new types of agricultural business entities since 2012. The conclusion from the paper suggest a reevaluation of the effectiveness of this policy. Meanwhile, our conclusion brings about other further questions: since cooperatives cannot increase farmers' profits effectively, what is the rationality for farmers' participation and continuation in cooperatives? Can Chinese cooperatives develop sustainably? Furthermore, given the effect of cooperatives on farmers' production practices, especially the use of fertilizers, further research can be done on the impact of the cooperative policy and other related policies on environment and food quality issue.

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Appendix

Table A Correlation of input with bearing size

Input variables	Correlation	P-value
fertilizer	0.01	0.77
pesticide	0.07	0.11
employed labor	0.39	0.00***
self-input labor	-0.19	0.00***
total labor	0.06	0.19
irrigation	0.02	0.58

Note: ***, ** and * denote the significance levels of 1%, 5% and 10%, respectively.

Table B Statistical comparison of input between Shandong Province and Shaanxi Province

Input variables	Shandong Province	Shaanxi Province	Difference
	Mean (S.D.)	Mean (S.D.)	
fertilizer/ <i>mu</i>	2263.70 (1144.76)	1998.35 (1585.23)	265.34**
pesticide/ <i>mu</i>	533.55 (314.62)	390.11 (280.62)	143.44***
employed labor/ <i>mu</i>	9.55 (9.94)	10.46 (9.62)	-0.91
self-input labor/ <i>mu</i>	24.49 (17.25)	17.76 (11.54)	6.73***
total labor input/ <i>mu</i>	34.04 (17.99)	28.22 (15.86)	5.82***
irrigation	5.08 (2.59)	0.73 (0.96)	4.35***
tree age	18.43 (7.73)	17.30 (6.34)	1.13*

Note: S.D denotes standard deviations. : ***, ** and * denote the significance levels of 1%, 5% and 10%, respectively.

Table C Estimation of treatment equation for the model of profits/*mu*

Variable Name	Coefficients
bearing size	0.04 ^{***} (0.01)
(bearing size) ²	-0.0001 ^{***} (0.00)
specialization	-0.45 [*] (0.28)
quality index	0.52 (0.37)
income_2009(log)	0.03 (0.03)
non-farm	-0.05 (0.17)
gender	-0.33 (0.41)
age	0.00 (0.01)
education	0.03 (0.03)
training	0.12 ^{***} (0.04)
skill level	0.28 ^{***} (0.09)
village cadre	0.26 [*] (0.15)
loss	0.16 (0.12)
region	0.02 (0.13)
constant	-1.14 (0.89)
No. of observations	528

Note: ^{***}, ^{**} and ^{*} denote the significance levels of 1%, 5% and 10%, respectively.

Table D Average treatment effect of cooperative membership on yield

Farmer subsample	Membership decision			
	Participation (Treatment=1)		Non-participation (Treatment=0)	
	^a Mean yield/ <i>mu</i> ¹⁹	^a S.E.	Mean yield/ <i>mu</i> ²⁰	S.E.
Members	8.18	0.02	8.10	0.02
Non-members	8.11	0.03	8.05	0.03
Difference in %	7.57% ^{**}	0.03	5.33% ^{*21}	0.03

Note: ^{***}, ^{**} and ^{*} denote the significance levels of 1%, 5% and 10%, respectively.

^a stands for standard errors.

¹⁹ The mean yield/*mu* when the treatment is received.

²⁰ The mean yield/*mu* when the treatment is not received.

²¹ 5.33% is the average treatment effect of yield/*mu* on the untreated group (non-member farmers) in percentage.

Table E Average treatment effect of cooperative membership on profits/mu from apple production

Farmer subsample	Membership decision			
	Participation (Treatment=1)		No-participation (Treatment=0)	
	^a Mean profits/ <i>mu</i> ²²	S.E.	Mean profits/ <i>mu</i> ²³	S.E.
Members	8.73	0.02	8.60	0.02
Non-members	8.73	0.03	8.63	0.03
Difference in %	-0.07%	0.04	-3.01% ²⁴	0.04

Note: S.E. denotes standard errors. ^aThe yield/mu and the profits/mu shown are predictions based on the coefficients estimated with the endogenous treatment regression model (ETRM). As the dependent variables in ETRM outcome equations are the logarithms of yield/mu and profits/mu respectively, the predictions are also given in log forms. Converting the means back to original numbers would lead to inaccuracies, due to the inequality of arithmetic and geometric means (AM-GM inequality) (Kabunga, et al., 2012).

***, ** and * denote the significance levels of 1%, 5% and 10%, respectively.

²² The mean net incomes/*mu* when the treatment is received.

²³ The mean net incomes/*mu* when the treatment is not received.

²⁴ -3.01% is the average treatment effect of profits/*mu* on the untreated group (non-member farmers) in percentage.