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The effect of disease outbreaks on shrimp aquaculture and the role of cooperatives in the Mekong Delta

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Abstract

Disease outbreaks are considered the root of drug overuse and the main reason for crop failure in the Mekong Delta. Shrimp cooperatives appear to be a promising solution to struggle with the problem because the cooperative model has been proven to be successful in many sectors such as agriculture, industry, and services. This study examines the effectiveness of a shrimp cooperative in terms of information sharing and price reduction. We employ the propensity score matching method (PSM) to do the analysis, based on the data collected from 256 households in nine communes in the Phu Tan district, Ca Mau province for 2016 and 2017. The study finds limited benefits for farmers who participate in shrimp cooperatives. It further explains why many farmers withdrew after a time. Although shrimp cooperatives have a significant effect on exchanging information related to prohibited substances, shrimp cooperative participants withhold shrimp prices. In addition, we find that the probability of participating in a shrimp cooperative is higher in households with older age or more educated household heads. Moreover, if the farmer has undergone training, the probability of participating in a shrimp cooperative increases.

Keywords: Shrimp aquaculture, Disease, Cooperative, Propensity score matching (PSM)

1. Introduction

In Vietnam, the aquaculture sector began commercially producing for export in the early 1980s with the farming of giant tiger prawns (FAO, 2019). Since then, the shrimp aquaculture sector has played a dynamic role in the country's economic growth. According to the Vietnam

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Association of Seafood Exporters and Producers (VASEP), in 10 years (2008-2018) shrimp exports accounted for the highest proportion from 36% to 50% of the total Vietnamese seafood exports. This places Vietnam as the world's third-highest shrimp supplier, targeting about 100 markets. The top three largest import markets of Vietnamese shrimp are the European Union, Japan, and The United States of America, accounting for approximately 60% of the total shrimp export value. Vietnam is the largest shrimp supplier in Japan, providing about 25.6% of the total imported shrimp (DOF, 2019; VASEP, 2019).

According to the Directorate of Fisheries of Vietnam, in 2018, the country's shrimp farming area was estimated at 720 thousand hectares. The total production of brackish shrimp was estimated at 800 thousand metric tons (MT), including 275 thousand MT of monodon species, which are so-called black-tiger shrimp, 475 thousand MT of vannamei species, which are so-called white-leg shrimp, and other minorities. Although black-tiger shrimp is one of the traditional shrimp species for a long time, white-leg shrimp has been cultivated more widely in many Vietnam provinces. The economic benefits from the white-leg shrimp resulted in an overwhelming contribution to shrimp export value, accounting for 68.7% of shrimp exports. In comparison, black tiger shrimp and marine shrimp accounted for 23% and 8.3%, respectively (VASEP, 2019). This sector has been improving the livelihood of the people living in rural areas, contributing to poverty reduction, and enhancing the food processing industry.

Located in the southern part of Vietnam, the Mekong Delta encompasses 12% of the total landmass. However, this region accounts for over 70% of the total water surface area, a prerequisite for aquaculture development (GSO, 2019). With unique advantages from geologic and climatic features, the broad dissemination of biodiversity, the Mekong Delta is suitable for developing several types of shrimp farming. This region dramatically improved in response to governmental efforts in reinvigorating shrimp production (Tran, 2012). The shrimp farming systems of the Mekong Delta include intensive farming, semi-intensive farming, extensive farming, small amounts of improved-extensive farming, and organic shrimp farming. As a concentrated aquaculture area, Mekong Delta currently is the largest shrimp production area in the country, accounting for over 80% of total aquaculture shrimp volume (GSO, 2019).

As an outdoor production, shrimp aquaculture is significantly impacted by natural conditions. Since its first outbreak in 1993, the disease problem has been the biggest challenge for the sustainable development of the Vietnamese shrimp aquaculture sector (Tran, 2012). Recently, the situation has become increasingly alarming because Vietnamese shrimp have been warned and rejected at ports because of antibiotic and veterinary drug residues (SSA, 2018). These drugs are proven to be harmful to human health and adversely affect the environment, including natural water, micro bio-systems, and other negative impacts (Holmstrom *et al.*, 2003). In compliance with increasing food safety standards and responsible aquaculture, most antibiotic and veterinary drug residues in food products are rejected by importing countries. A variety of reasons lead to this issue; however, the primary cause commonly considered is that the farmers use drugs to treat shrimp disease (UNIDO, 2013).

Accordingly, the Vietnamese government has intensified management solutions, such as strengthening the related regulations and intensifying the national monitoring programs.

It has also recommended shrimp farmers adopt some advanced farming programs. These include Better Management Practices, Good Aquaculture Practices, which are Viet-GAP and Global-GAP, and other safety certificates for farming, such as the Natureland certificate for organic shrimp grown in the mangrove forest, Aquaculture Stewardship Council (ASC), and Best Aquaculture Practices (BAP) as presented in Table 1, (VASEP, 2019; NAFIQAD, 2019).

Table 1. Certifications of good aquaculture practices

	International certifications				
	ASC	**BAP**	**Natureland**	**GlobalGAP**	**Total**
Number of farms	30	44	2000	20	2094
Number of farms in assessment	13				13
Number of CoC partners	32				32
Number of hatcheries		12			12
Number of feed mills		11			11
Number of factories		40	5		45
Total area (ha)			9,400		9,400
Volume (MT)	22,946	25,469	4,410	16,635	69,460

Source: Authors' compilation based on the data from VASEP (2019)

The wide adoption of these programs remains a challenge, especially for small-scale farmers. Discussing the pathway toward sustainable shrimp aquaculture in Vietnam, most reports claimed that farmers were unwilling to adopt the Good Aquaculture Practices program because of several constraints such as high investment or variable cost, lack of good input, lack of information, and the great number of small-scale farmers whose outlets relied on small traders (SEAT, 2013; NACA, 2005). In this situation, the shrimp cooperative is expected to be an active farmer self-help group. It may assist farmers in accessing formal information on good practices and official dissemination; furthermore, it may benefit farmers by increasing their bargaining power to maintain lower input and higher output prices.

Since its first appearance in the early 19th century, the success of the agricultural cooperative model has been reported to benefit its members and contribute to rural development in general. However, in developing countries, attempts to organize farmers into cooperatives have often failed, although cooperatives can support farm inputs and market farm products, which are essential for agricultural development (Tran, 2014).

Vietnam has a long history of operating cooperatives, especially in agriculture. As reported in successful cases, cooperatives may play a significant role in technology dissemination, financial support, and solution support for new problems (Tran, 2014; Ortmann and King, 2007). Knowledge, valuable experiences, and innovative farming technologies can be exchanged among members and reviewed for appropriately adopting into their farms. In addition, information on new related regulations, new policies, quality standards, information on disease outbreaks, and environment warnings may be disseminated and updated. Other information such as input price, output price, information of shrimp buyers, input sellers, and excellent seed sources may also be shared. Logically, by obtaining other information sources, farmers may access good input at an optimal price and avoid reducing the prices at the sensitive time of harvesting. If shrimp cooperatives enter into contracts with suppliers in advance for a large volume input, farmers can share the volume at a lower price or at least ensure input quality. While there are many benefits of cooperatives, there is limited literature on why this model remains under-utilized among shrimp farming communities. To bridge this gap, this study analyzes the case of Southern Vietnam and examines the determinants of joining shrimp cooperatives and the effects of joining cooperatives on information sharing and input prices. In this situation, the empirical studies at the micro-level (household) are necessary to give more substantial evidence to explain the issue.

The following section describes the research methods. Section 3 discusses the research results, and section 4 concludes the paper.

2. Research methods

2.1 Sample collection

To answer the above questions, this study focused on examining the effectiveness of shrimp cooperatives. The present analysis is based on the data collected in the Phu Tan district of Ca Mau province, conducted jointly by the University of Tokyo and the Foreign Trade University. Ca Mau Province was selected because Ca Mau produces the largest volume of shrimp aquaculture in the Mekong Delta (approximately 30%). Of the total 1,546 households in all the nine communes in the Phu Tan district, 256 households were randomly selected. Tables 2 and 3 below describe the sampling rate and farming status in the surveys, separated by shrimp species.

Table 2. Sampling by communes, Phu Tan district, Ca Mau province

9 communes (in Phu Tan District)	Total household (farmer list)	Sampling			
		No. of HH	% (Per total)	% (per sample)	Cumulative
Phu Tan	322	54	16.77	21.09	21.09
Phu Thuan	288	41	14.24	16.02	37.11
Cai Doi Vam	124	20	16.13	7.81	44.92
Rach Cheo	17	3	17.65	1.17	46.09
Viet Thang	22	6	27.27	2.34	48.44
Viet Khai	95	17	17.89	6.64	55.08
Phu My	222	40	18.02	15.63	70.70
Tan Hai	114	17	14.91	6.64	77.34
Tan Hung Tay	342	58	16.96	22.66	100.00
TOTAL	**1546**	**256**		**100.00**	

Source: The authors' survey 2016-2017

Table 3. Shrimp farming status

Shrimp species		**Survey 2016**			**Survey 2017**		
		No. of household (%)	**No. of pond (%)**	**No. of crop (%)**	**No. of household (%)**	**No. of pond (%)**	**No. of crop (%)**
One species	white-leg (vannamei)	195 (76.17)	536 (74.24)	825 (75.55)	189 (73.83)	478	
	black-tiger (monodon)	(69.48)	828	72 (6.59)	33 (12.89)	85	
Two species	white-leg (vannamei)	36 (14.06)	125 (17.31)	101 (9.25)	34 (13.28)	125 (18.17)	131 (11.54)
	black-tiger (monodon)			94 (8.61)			77 (6.78)
Total		256 (100)	722 (100)	1092 (100)	256 (100)	688 (100)	1135 (100)

Note: Percentage of total are reported in parentheses.

Source: The authors' survey 2016-2017

In our surveys, some sensitive questions were asked, for example, "Do you know which chemicals are prohibited for use?", "Please list the names", "Do you know which input products contain prohibited elements?". To obtain the most feasible data, the local enumerators conducted the interviews who can talk in a local accent. All of them tried to make friendly conversations with local farmers, and they promised all the information from the interview would be kept secrets and just used for the research purpose.

Data were collected over two years. However, we observed a remarkably high withdrawal rate of shrimp cooperative participants. The data from a 2017 survey indicate that only 14 households (5.47%) continued to participate in shrimp cooperatives compared to the 104 households (40.63%) reported in the 2016 survey. Because of this, the panel data could not be used to conduct quantitative analysis; only the cross-sectional data at the household level from the survey in 2016 were used. In addition, the high withdrawal rate suggests that the shrimp cooperative is not ideal for bringing real advantages and constraint mitigation for farmers in terms of information sharing and input price reduction.

3.2 Data analysis method

To examine the impact of shrimp cooperative participation on information sharing and input prices, a dummy variable was introduced to present the household's status at the time of the interview; it equals 1 if the household participates in a shrimp cooperative, and 0 otherwise. This will function as our variable of interest in the estimation equation. If the estimated parameter of the dummy variable (shrimp cooperative participation) is significantly different from 0, shrimp cooperative participation on the outcomes will be statistically supported.

We further employed a set of control variables, including age, gender, education, years of experience of the head, training experience, farm size, whether farmers have tested shrimp in a lab, and whether family members also cultivate shrimp. In the simplest form, we may conduct the following Ordinary Least Square (OLS) equation:

$$Y_i = \beta 1X_i + \beta_2 C_i + f_i + u_i \tag{1}$$

However, conducting an OLS estimation on the above specification may suffer from the problem of endogeneity, as joining a shrimp cooperative is a choice made by households. For example, participating in a cooperative may also be associated with a few unobserved elements such as the attitudes and enthusiasm of the participants and their family members, who are motivated individuals. If these characteristics are causally related to the model's outcomes, which are information sharing and input prices, they will be included in the error term. They will violate one of the Gauss-Markov assumptions of "zero conditional mean" for using the OLS method (Wooldridge, 2013). Another potential reason is that reverse causality may occur. A higher or lower outcome may induce farmers to participate or withdraw from cooperatives. This leads to a non-causal relationship between outcomes and treatment.

To correct for endogeneity, the propensity score matching method (PSM) was employed in this study. The matching method is based on the intuitive idea of contrasting the outcomes of participants, which is the treatment group, with the outcomes of "comparable" nonparticipants, which is the control group (Heckman *et al.*, 1998). A necessary assumption for the implementation of the matching method is the independence of the potential outcomes, which are observed outcome versus unobserved outcome or counterfactual outcome, on treatment assignment, which is called "conditional independence assumption". Another assumption is that observations of each matched pair are different only in the status of treatment. In the case of multi-dimensional vector X, which is a vector of all relevant observed covariates, the so-called balancing scores were suggested by Rosenbaum and Rubin in 1983. Propensity scores are considered balancing scores, and the matching procedures based on this balancing score are known as propensity score matching (Caliendo and Kopeinig, 2005).

In this study, propensity scores are calculated to denote the probability of households participating in the shrimp cooperative, given a set of observable characteristics. The process analyzes:

1) The determinants relating to the shrimp cooperative participation by small farmers.

2) The impact of shrimp cooperative participation on information sharing.

3) The impact of shrimp cooperative participation on input price reduction.

To achieve the first factor, the method of maximum likelihood estimation (MLE) is employed for the binary dependent outcome, which equals 1 if the household participated in a shrimp cooperative in 2016, and 0 otherwise. To choose a model to conduct PSM, several models, including the probit and logit models are performed.

However, based on the MLE method, the logit and probit models have different functions. The logit model is specified by a cumulative distribution function (CDF) of a logistic distribution ^(xi'β). While the probit model is specified by a CDF of a standard normal distribution Φ(x'iβ) (Cameron and Trivedi, 2010).

$$Pr(y = 1/x) = \wedge(x_i'\beta) = \frac{e^{x_i'\beta}}{1+e^{x_i'\beta}} \text{ (Logit model)} \tag{2}$$

$$Pr(y = 1/x) = \Phi(x_i'\beta) = \int_{-\infty}^{x_i'\beta} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz \text{ (Probit model)} \tag{3}$$

Using these models, the marginal effects (ME) of x on the probability of y (equals 1) are estimated as follows:

$$\frac{\partial P(y=1|x\beta)}{\partial x_j} = \wedge(x_i'\beta)\{1 - \wedge(x_i'\beta)\}\beta_j \text{ (ME in Logit)} \tag{4}$$

$$\frac{\partial P(y=1|x\beta)}{\partial x_j} = \phi(x_i'\beta)\beta_j \text{ (ME in Probit)} \tag{5}$$

In the above equations, y=1 denotes shrimp cooperative participation, X is a vector of x, which indicates relevant observed covariates related to shrimp cooperative participation, such as the family head's characteristics, household characteristics, farming status, and the socioeconomic characteristics of the household used in equation (1). β is the vector of estimated coefficients. $\Phi(x'_i\beta)$ is the value of the standard normal probability density function at $x'_i\beta$ and $\wedge(x_i'\beta)$ is the value of the logistic function at $x'_i\beta$. In the study, marginal effects at the means of covariates are performed. In addition, dummy variables for commune are used to control fixed effects. Wald test is conducted to examine the fixed effects.

To evaluate the impact of shrimp cooperative participation using PSM, a model for estimating the propensity scores is necessary. Based on the results of the above models, with a given set of observable characteristics, the model that produces the highest values of log-likelihood and pseudo R^2 is the most appropriate.

To run the matching, the study conducted several matching methods such as kernel matching, nearest neighbor, and radius caliper with different radius levels. Radius caliper (0.1) was selected because it produced the largest mean biased reduction, and no significant independent variable remains after the matching. In contrast to other matching algorithms, radius caliper matching imposed a tolerance level for the maximum distance of the propensity scores. Many tolerant levels were tested to choose the level of 0.1 for the matching.

The matching needs to be "balanced" in which the two groups, which are treatment group and control group, became similar. Based on this, the differences between the outcomes of the treatment group and the outcome for the controlled group were estimated within the region of common support. In addition, bootstrap standard errors are used along with statistical inferences of average treatment effect on the treated (ATT).

$$ATT = E(Y_i^1 \mid T = 1) - E(Y_i^0 \mid T = 1) \tag{6}$$

$$ATT = E(Y_i^1 \mid T = 1) - E(Y_i^0 \mid T = 0) \tag{7}$$

In theory, ATT is defined by Equation (6) based on the difference between the outcomes of two stages “the treatment group treated” $E(Y_i^1 | T = 1)$ and “the treatment group if untreated” $E(Y_i^0 | T = 1)$. However, the stage $E(Y_i^0 | T = 1)$ is counterfactual, which is unobservable. Therefore, ATT is estimated using equation (7) based on the difference between the outcomes of two stages “the treatment group treated” $E(Y_i^1 | T = 1)$ and “the control group untreated” $E(Y_i^0 | T = 0)$ in the condition of zero “self-selection bias” (Caliendo and Kopeinig, 2005).

To conduct the analysis, the study uses the software package STATA version 14.

PSM is employed to correct for endogeneity; however, the method controls only observed variables. Other unobserved variables that affect assignment into treatment and the outcome variable simultaneously might lead to a problem of “hidden bias” (Caliendo and Kopeinig, 2005). This is a limitation of the study.

3. Estimation results and discussion

3.1 The determinants for shrimp cooperative participation.

Table 4. Household characteristics and outcome by cooperative participants

Variables	**Total (N=256)**	**Non-member (N=152)**	**Cooperative member (N=104)**	**Diff (0) - (1) [p-value]**
	Means	**Mean (0)**	**Mean (1)**	
Gender (=1 if male)	0.832	0.822	0.846	-0.024
	(0.375)	(0.383)	(0.363)	[0.619]
Age	47.801	46.967	49.019	-2.052
	(12.403)	(12.216)	(12.630)	[0.194]
Years of education	8.313	7.987	8.788	-0.802**
	(3.104)	(3.255)	(2.817)	[0.0422]
Farming experience (years)	5.387	5.224	5.625	-0.401
	(2.174)	(2.011)	(2.382)	[0.147]
=1 if experience training	0.879	0.836	0.942	-0.107***
	(0.327)	(0.372)	(0.234)	[0.010]
=1 if experienced lab-test	0.707	0.651	0.788	-0.137**
	(0.456)	(0.478)	(0.410)	[0.018]
=1 if parents or siblings cultivate shrimp	0.781	0.770	0.798	-0.028
	(0.414)	(0.422)	(0.403)	[0.592]
Farming area (ha)	0.739	0.747	0.728	0.019
	(0.561)	(0.628)	(0.448)	[0.789]

Notes: Standard deviations are reported in parentheses. P-values are reported in brackets, * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Compiled by the authors

The differences between the two groups, cooperative members and non-members were observed by conducting mean-comparison tests (t-tests). Table 4 presents the differences in household characteristics, including the family head's characteristics and farming status. Certain variables are statistically significant, such as years of education, training experience, and lab-test experience. These significant differences between the two groups must be controlled by matching.

Both probit estimation and logit estimation were conducted to examine the determinants of shrimp cooperative participation. The results presented in Table 5 indicate that age and years of education of the family head are statistically significant at the 1% and 5% levels, respectively. If the farmer experienced the training, the probability of participating in the shrimp cooperative increased by approximately 20%, significantly at the 5% level. In all four columns, the dummy commune variables are included to control for commune fixed effects.

Table 5. Determinants of shrimp cooperative participation

VARIABLE	LOGIT_1 (1)	PROBIT_1 (2)	LOGIT_2 (3)	PROBIT_2 (4)
Gender (=1 if male)	0.00640	0.000623	-0.00885	-0.0154
	(0.0909)	(0.0892)	(0.0922)	(0.0904)
Age	0.00524*	0.00527*	0.00524*	0.00523*
	(0.00310)	(0.00301)	(0.00310)	(0.00302)
Years of education	0.0282**	0.0273**	0.0277**	0.0275**
	(0.0123)	(0.0119)	(0.0123)	(0.0119)
Farming experience (years)	0.0131	0.0124	0.0124	0.0124
	(0.0158)	(0.0156)	(0.0159)	(0.0157)
=1 if experience training	0.261**	0.235**	0.252**	0.224**
	(0.122)	(0.112)	(0.123)	(0.113)
=1 if experienced lab-test			0.124	0.131*
			(0.0768)	(0.0753)
=1 if parents or siblings cultivate shrimp			0.00404	0.00704
			(0.0852)	(0.0828)
Farming area (ha)			0.0489	0.0405
			(0.0751)	(0.0725)
Pseudo R^2	0.1331	0.1309	0.1425	0.1408
Log-likelihood	-149.902	-150.281	-148.285	-148.563
Observations	256	256	256	256

Notes: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ in all 4 columns, commune fixed effects are included (Marginal Effects reported)

Source: Estimated by the authors

3.2 The impact of shrimp cooperative participation on information sharing

To run the matching for examining the impact of shrimp cooperative participation on information sharing, Logit model 2, which is in Column 3 in Table 5, is chosen based on its higher value of the log-likelihood and pseudo-R. The histogram of the propensity score and the density of the propensity score before matching are exhibited in Figures 1 and 2, respectively. The overlapping range is from 0.0427802 to 0.7933728, which fits in the propensity score range of the treatment group. The two figures confirm the feasibility of the matching method adopted in the common support area.

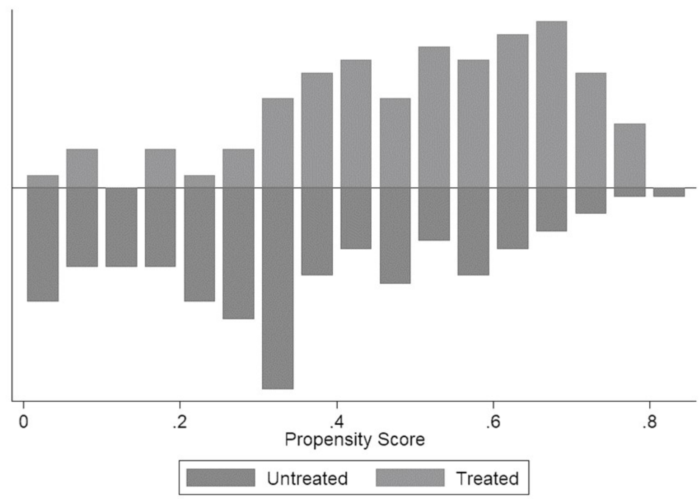

Figure 1. Histogram of propensity score by the groups

Source: Compiled by the authors

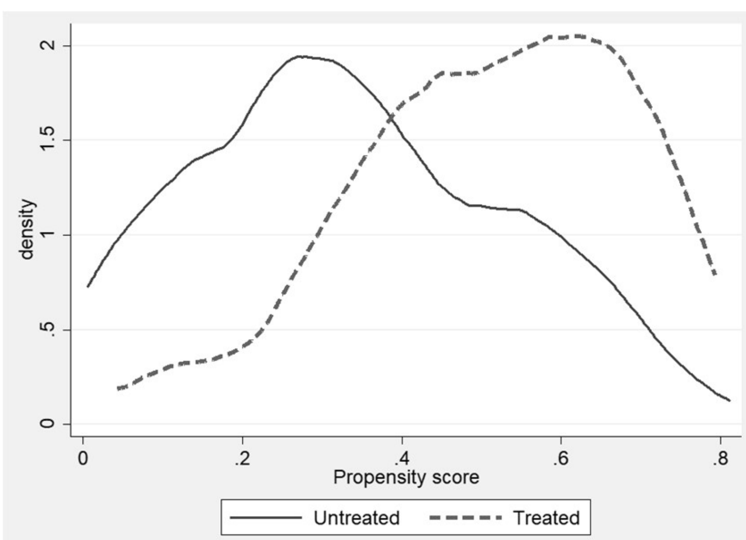

Figure 2. The density of propensity score by the groups

Source: Compiled by the authors

The results of the balancing test are presented in Table 6. For caliper matching, several tolerance levels were tested. Based on the results, radius caliper matching with a tolerance level of 0.1 is selected because it produces the largest mean bias reduction, and the number of significant variables is reduced to 0 after the matching. The other measures fit well for further estimation.

Table 6. Balancing test for matching

Methods	No. of significant independent variables	Pseudo R^2	P > chi^2	Mean Bias
Before matching	7	0.141	0.000	19.9
After matching by:				
Kernel	0	0.013	0.999	4.7
Nearest neighbor	1	0.036	0.795	9.5
Radius caliper (0.01)	0	0.016	0.998	6.2
Radius caliper (0.05)	0	0.012	1.000	4.6
Radius caliper (0.1)	0	0.008	1.000	3.4
Radius caliper (0.3)	0	0.034	0.874	9.2
Radius caliper (0.5)	6	0.104	0.018	16.3

Source: Compiled by the authors

By radius caliper (0.1) matching, the mean bias reduces from 19.9% to 3.4%, Figure 3 below:

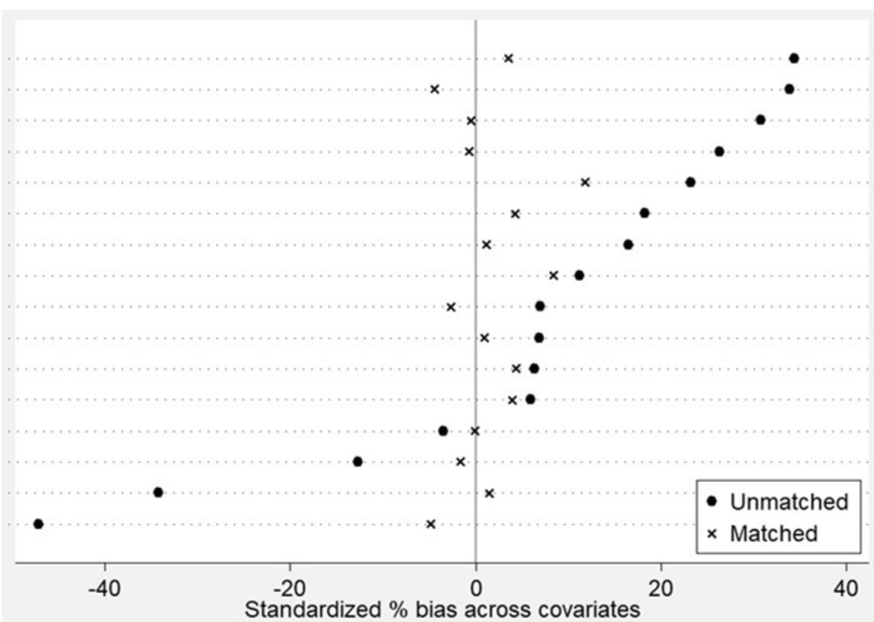

Figure 3. Bias reduction cross covariates

Source: Compiled by the authors

Table 7 presents the effects of the shrimp cooperative participation on information sharing, in which the ATT for each outcome is reported.

Table 7. The effects of shrimp cooperative participation on information sharing

No.	Variables	Observed coefficient	Bootstrap Std. Err.	P>|z|
1	The number of information source on technology, input use, disease treatment	0.195	0.820	0.812
2	= 1 if farmer knew any prohibited substances or its product	0.157 **	0.079	0.047
3	=1 if farmer knew any input products contain prohibited substances	0.373 ***	0.068	0.000
4	The number of shrimp buyers that the farmer knew	-2.378	2.242	0.289
5	The number of people that farmer talks about his shrimp price	-1.443 **	0.817	0.077
6	The number of input seller that the farmer knew	0.335	0.548	0.541
7	The number of seed sellers that the farmer knew	-0.745	1.065	0.485

Source: Compiled by the authors

In terms of information sharing within the shrimp cooperative, there are findings as follows:

By participating in a shrimp cooperative, the probability of knowing prohibited substances or their products (drugs) increases significantly by 15.7% at the 5% level, and the probability of knowing the input products that contained prohibited substances also increases by 37.3% significantly at the 1% level. Although the variable of information source on technology, input use, and disease treatment is not significant, the positive coefficient indicates that farmers might obtain more information on farming if participating in a cooperative.

The coefficients of both variables, which are the number of shrimp buyers that the farmers knew and the number of people that farmers talked about their shrimp prices, were negative. The number of people that the farmers confer with about their selling price reduces significantly at the 5% level. The results indicate that farmers are likely to withhold details of shrimp prices and information about their shrimp buyers if they participate in shrimp cooperatives. This result explains the role of traders in the shrimp outlet market. As reported by the surveys, at harvest time, farmers contact several traders for purchasing agreements, then the outlets are sold to one or specific traders. The shrimp price is competitive based on the shrimp volume, quality, and relationship between the buyer and seller. Farmers claimed that the shrimp price was unstable and heavily reliant on demand, decided mainly by the traders. If many farmers had good crops, the price of shrimp might have dropped. It is understood that farmers are unwilling to share information about shrimp buyers and shrimp prices. Although the coefficients are not significant, the sign of the coefficients reveals that participating in the shrimp cooperative, the farmers are aware of a greater number of input sellers with a positive coefficient and fewer seed sellers with a negative coefficient. The results can be explained by the fact that accessing certified shrimp seeds is still challenging in this region. In contrast, farmers are likely to share other inputs, such as shrimp feed, chemicals, and bio-products, because they are widely distributed and easy to obtain.

3.3 The impact of shrimp cooperative participation on input price

To examine the impact of shrimp cooperative participation in terms of input price using PSM, it is noticeable that shrimp seed price and industrial feed price depend on the type of shrimp. Two types of shrimp were cultivated in the case of vannamei species, which are white leg shrimp, and monodon species, which are black tiger shrimp. Of the 256 households in the sample, 25 households were cultivating only black tiger shrimp, of which five belonged to the shrimp cooperative (see Table 4 above about shrimp farming status). In addition, seven households did not use certified seeds. Thus, PSM was conducted to examine the impact of shrimp cooperative participation on the vannamei seed price and the industrial feed price for vannamei shrimp. Therefore, the observations of those who cultivated only black tiger shrimp or used uncertified seed were excluded from the matching. All the steps for running the PSM were repeated. A logit model with a complete set of variables was used to calculate the propensity score, radius caliper (0.1), and common support were selected to run the matching (see the results in Tables 8 and 9 and Figures 4, 5, and 6 in the Appendix). The PSM results are presented in Table 10.

Table 10. The effects of shrimp cooperative participation on input price

No.	Variables	Observed coefficient	Bootstrap Std. Err.	P>|z|
1	ln (price of vannamei industrial feed)	-0.041	0.032	0.204
2	Price of vannamei industrial feed (1000VND)	-3.762	3.535	0.287
3	ln (price of vannamei seed)	0.020	0.013	0.111
4	Price of vannamei seed (VND)	1.974	1.472	0.180

Source: Compiled by the authors

All the coefficients are not significant. However, the above results suggest that farmers participating in the cooperative and being aware of a greater number of input sellers might lead to a reduction in the input price, and fewer seed sellers might lead to an increase in seed price.

4. Conclusion

Related to shrimp cooperative participation, the study finds that households with older heads and higher levels of education, or training experience, tend to join the cooperative. However, participating in a cooperative does not bring real advantages and constraint mitigation. Although obtaining more information about prohibited substances, farmers tend to withhold their shrimp prices significantly. Under highly competitive pressures, unstable shrimp prices, and difficulty accessing good shrimp seeds in the market, farmers are likely to share less on their shrimp outlet, which is their buyers or their shrimp price, and shrimp seed.

Notably, in terms of input price, farmers do not benefit from participating in a cooperative. In addition, although farmers are likely to share more information on other input product information such as input price, input seller, banned substances, and banned inputs, the reduction in feed price is relatively small and insignificant. These findings indicate that the activities of shrimp cooperatives are still limited.

In conclusion, the study restates the aforementioned hypothesis that shrimp cooperatives do not work as an active self-help group to support farmers, as expected. For this reason, an extremely high withdrawal rate of shrimp cooperatives was observed in the 2017 survey compared to the number of cooperative members in 2016. Further investigation during the surveys reported that the shrimp cooperatives act as independent self-help farmer groups. The shrimp cooperative collects membership fees for its activities. If farmers do not derive substantial benefit from cooperative participation, they will withdraw after a few crops.

The empirical studies at the micro-level (household) give strong evidence to explain why the cooperative model remains under-utilized among shrimp farming communities. To strengthen cooperative participation, the study's findings support the need for training experience. However, the effectiveness of the shrimp cooperative should be especially concerned. The study concludes with some implications to enhance the cooperative activities in Mekong Delta. Firstly, a strong union among cooperative members needs to be set up. Secondly, each cooperative should have its optimal activity plans. To support these activities, the study suggests the role of local government and information canals. For example, finding and generating successful cooperative models should be promoted widely. Experiences of these models help to strengthen the activities of other cooperatives.

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Appendix

Table 8. Determinants of shrimp cooperative participation

VARIABLE	LOGIT_1 (1)	PROBIT_1 (2)	LOGIT_2 (3)	PROBIT_2 (4)
Gender (=1 if male)	0.0151	0.0102	0.000869	-0.00415
	(0.0991)	(0.0971)	(0.101)	(0.0985)
Age	0.00530	0.00515	0.00521	0.00503
	(0.00332)	(0.00322)	(0.00334)	(0.00325)
Years of education	0.0270**	0.0262**	0.0261**	0.0260**
	(0.0128)	(0.0125)	(0.0129)	(0.0125)
Farming experience (years)	0.00527	0.00515	0.00409	0.00474
	(0.0166)	(0.0165)	(0.0166)	(0.0165)
=1 if experience training	0.197	0.183	0.176	0.158
	(0.128)	(0.121)	(0.130)	(0.123)
=1 if experienced lab-test			0.136	0.141*
			(0.0827)	(0.0810)
=1 if parents or siblings cultivate shrimp			0.0203	0.0231
			(0.0901)	(0.0876)
Farming area (ha)			0.0486	0.0401
			(0.0800)	(0.0771)
Pseudo R^2	0.1117	0.1103	0.1223	0.1214
Log-likelihood	-136.104	-136.319	-134.484	-134.621
Observations	225	225	225	225

Notes: Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1 in all 4 columns, commune fixed effect was included (Marginal Effects reported)

Source: Estimated by the authors

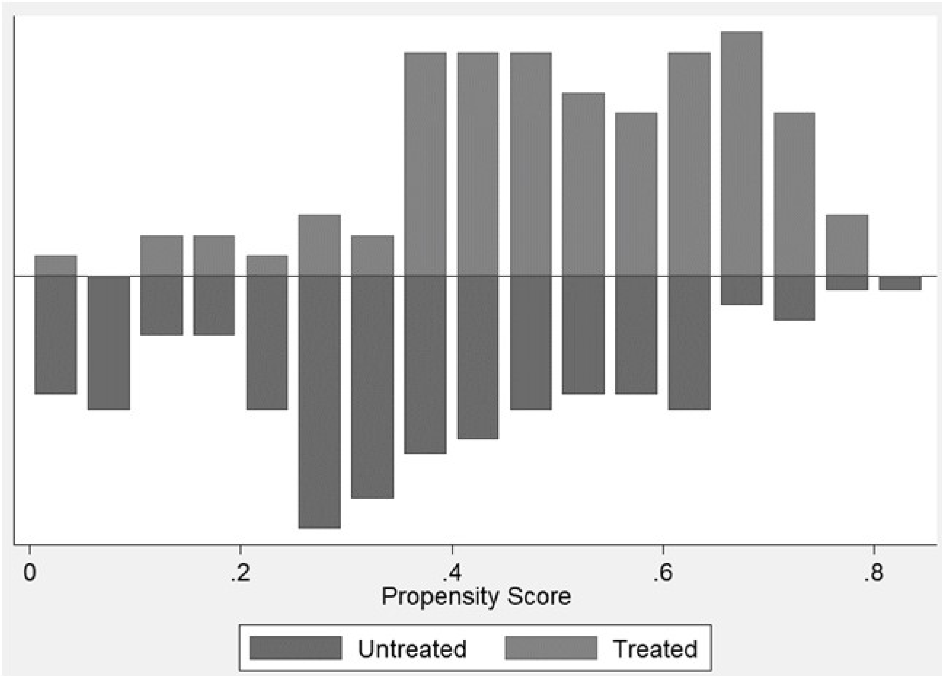

Figure 4. Histogram of propensity score by the groups

Source: Compiled by the authors

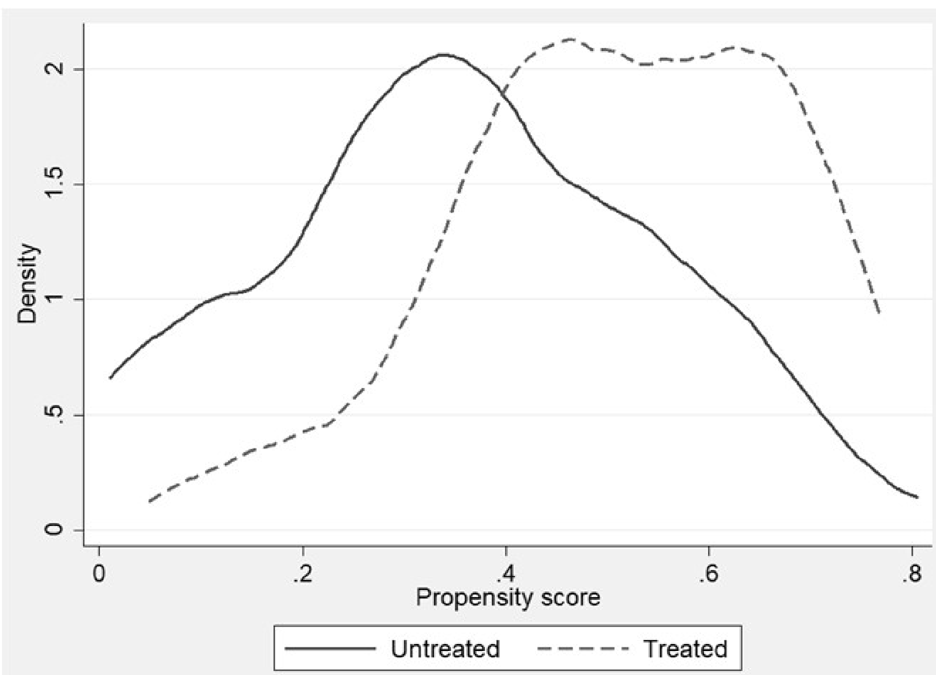

Figure 5. Density of propensity score by the groups

Source: Compiled by the authors

Table 9. Balancing test for matching

Methods	No. of significant independent variables	Pseudo R^2	$P > chi^2$	Mean Bias
Before matching	7	0.121	0.001	19.4
After matching by:				
Kernel	0	0.010	1.000	4.4
Nearest neighbor	1	0.048	0.628	9.7
Radius caliper (0.01)	0	0.015	0.999	5.8
Radius caliper (0.05)	0	0.010	1.000	4.5
Radius caliper (0.1)	0	0.007	1.000	3.2
Radius caliper (0.3)	0	0.036	0.857	9.8
Radius caliper (0.5)	5	0.094	0.052	16.3

Source: Compiled by authors

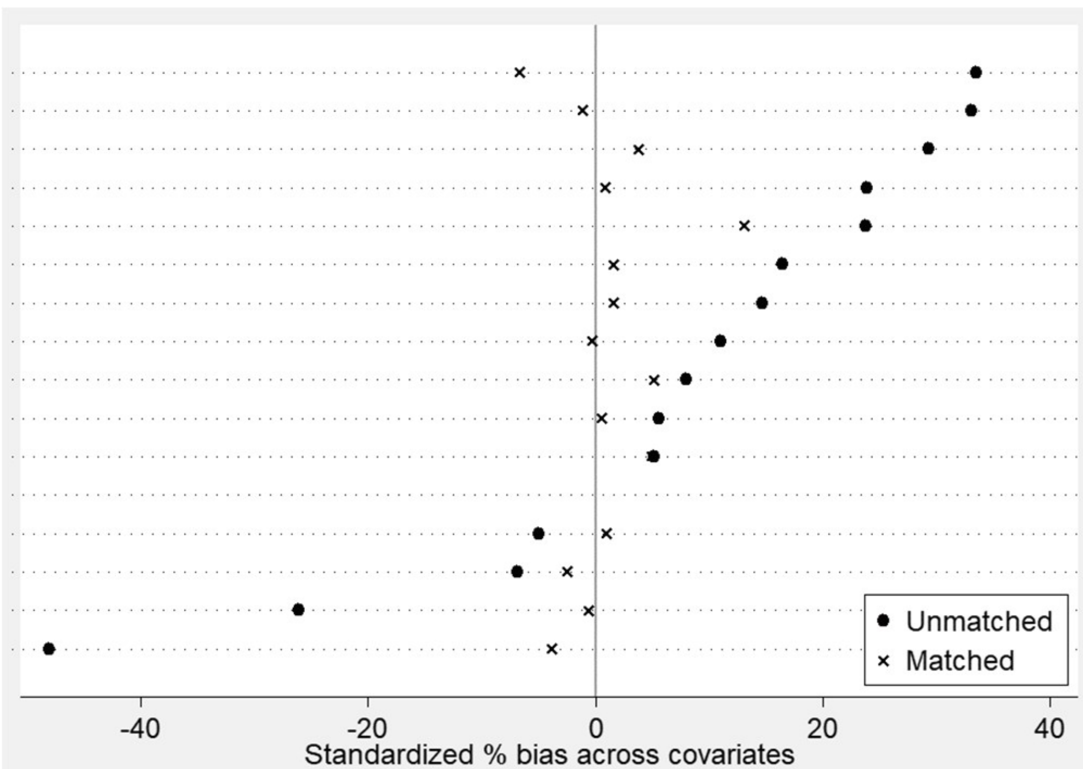

Figure 6. Bias reduction cross covariates

Source: Compiled by the authors