Better management practices and their outcomes in shrimp farming : evidence from small-scale shrimp farmers in Southern Vietnam

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March 2017

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Keywords: Port rejection, Better Management Practices, Aquaculture, Vietnam
JEL classification: F63, L15, O13, O19

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Better Management Practices and Their Outcomes in Shrimp Farming: Evidence from Small-scale Shrimp Farmers in Southern Vietnam

Aya Suzuki* and Vu Hoang Nam†

Abstract:
Despite the growth of aquaculture exports from developing countries to developed countries in recent years, a high percentage of these products are rejected at developed countries' ports because of non-compliance with international standards. This paper presents a case study of the shrimp aquaculture sector in Vietnam to examine the factors behind the persistence of such port rejections. In particular, we focus on why the so-called Better Management Practices (BMPs) are not appropriately adopted by many farmers and examine whether the number and types of information sources matter in farmers' decisions on BMP adoption and whether BMP adoption actually leads to better performances. On the basis of our estimation using primary data collected in Southern Vietnam, we find that information sources and training experiences indeed matter in the adoption of a higher number of BMPs and that BMP adoption indeed reduces the possibility of disease outbreaks. These results prove the effectiveness of BMPs and suggest the importance of disseminating knowledge regarding them to farmers through experts.

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1. Introduction

Aquaculture has been receiving attention for its potential to provide higher incomes for small-scale farmers and offer higher nutrition to the general public in developing countries. It is estimated that farmed fish will constitute about two-thirds of fish consumption by 2030 (World Bank, 2013). Given the climatic advantages and lower production costs offered by this approach, many developing countries are starting to participate in these high-value aquaculture value chains.

At the same time, farmed products exported from developing countries are often rejected at developed countries' ports because of non-compliance with international standards (UNIDO IDE, 2013). The major reasons for rejections are bacterial contamination, pesticide residues, and veterinary drug residues (UNIDO IDE, 2013). Port rejection is costly for the exporting countries, guidance on good practices to produce acceptable farmed products is widely offered by international organizations, and this sector has experienced growth in recent years; however, despite these favorable factors, the situation has not been improving.

This raises the need to explore the persistence of this non-compliance, including the following questions: (1) How are these farmed fish products being produced in developing countries? (2) Who are the main actors and what kind of production practices do they follow? (3) Why does the problem of port rejections remain important? Unless we understand the answers to these questions, the growth of the aquaculture sector in developing countries will not be sustainable. This paper tries to address these questions by analyzing the case of Vietnam's shrimp aquaculture industry. We particularly examine the determinants of participating in Better Management Practices (BMPs) and whether those practices actually lead to better performances.

On the basis of primary data collected in Southern Vietnam, we find that the information sources available to farmers matter in terms of their practicing BMPs; particularly, we find that the relation with input sellers has a positive effect on their adopting BMPs whereas that with buyers has a negative effect. Previous experiences of technical training also increase the likelihood of adopting BMPs. Furthermore, we find that practicing these BMPs indeed reduces the probability of having a disease outbreak in the pond, confirming the effectiveness of using BMPs. This effect decreases as fewer BMPs are practiced.

The next section (Section 2) describes the study context in greater detail, particularly the trend of port rejection regarding shrimp aquaculture, and provides an overview of Vietnam's shrimp sector. Section 3 clarifies the research questions to be examined and data to be used. Section 4 explains the estimation methods, and Section 5 presents the estimation results. Section 6 presents the conclusion.

2. Study Context

2.1 Shrimp Sector in Vietnam

Shrimp farming has a history stretching back more than 100 years in Vietnam, where the Mekong River Delta is the most important area for shrimp farming. Shrimp products for exports include block frozen shrimp, canned shrimp, and processed shrimp; of these, block frozen shrimp account for the largest proportion of the total export value. Processed shrimp are, however, gradually expected to overtake traditional frozen shrimp in the future. Apart from being exported, shrimp are sold in domestic markets. Big cities in Vietnam are destinations for fresh and boiled shrimp. In 2011, the export value of Vietnamese shrimp reached a new record of 2.4 billion USD, with Black Tiger shrimp accounting for 59.7% and whiteleg shrimp accounting for 29.3% of the total export value of aquaculture products. Vietnamese shrimp were exported to more than 91 countries (VASEP, 2011).

Three major periods can be identified in the development of the aquaculture sector. During the first period, from 1957 to 1980, there were few state-owned processing companies in the industry. The first one was Halong Canned Seafood, which was established in 1957 in Northern Vietnam. Later during this period, 10 more other processing companies were set up in Southern Vietnam. In 1978, the Sea Product Import-Export Corporation (SEPRODEX) was established and went on to become the largest state-owned seafood processing and exporting company in Vietnam. The second period, from 1980 to 1990, saw the establishment of more than 100 state-owned seafood processing companies belonging to SEPRODEX all over the country. The third period runs from 1990 up to present. Economic reform policies (*Doi Moi)* that started in 1986 and came into effect in the 1990s, such as trade liberalization, provision of land-use rights transferability, and encouragement of the private sector including household enterprises, created favorable conditions for the production and export of aquaculture products. The government policy allowing conversion of rice fields and salt pans into shrimp ponds in the Southern Vietnam is considered one of the most important factors that contributed to the development of this industry. Consequently, the number of seafood processing and exporting enterprises increased. Private enterprises have been competing with and replacing state-owned enterprises in processing and exporting aquaculture products.

Since then, the aquaculture sector has gained remarkable achievements in both production and exports. In terms of global aquaculture production, Vietnam ranks third, after China and India (Food and Agriculture Organization [FAO], 2012), indicating the substantial growth in aquaculture production in Vietnam. In 1997, aquaculture production was only 40,000 tons, which is even less than one-tenth of that in 2000. In 2010, production was more than five times that in 2000.

Over the last years, fishery products have become one of the major export products of Vietnam. The export value of fishery products accounted for more than 5% of the country's total export value in 2013 (calculated by the authors using data from General Statistical Office of Vietnam [GSO], 2016). Out of the total export value of fishery products, frozen shrimp and fish accounted for more than 62% in 2013. In fact, there has been a remarkable increase in the export value of frozen shrimp and fish during the last 20 years (Table 1).

Table 1: Export of Fishery Products in Vietnam

	1995	2000	2005	2010	2013
Total export	5449.0	14482.7	32447.1	72236.7	132032.9
Fishery products	621.4	1478.5	2732.5	5016.9	6692.6
Frozen shrimps	290.9	631.4	1265.7	1565.5	2018.2
Frozen fish	35.9	172.4	608.8	2018.4	2176.9
Frozen cuttlefish	68.4	76.8	73.9	97.7	24.3

Source) GSO (2016)

In Vietnam, the main producers of shrimp are small-scale holders. Although some processing companies have their own ponds to produce shrimp internally, the amount that can be cultivated within their own ponds reaches only about 20% of their maximum processing capacity. Thus, processors rely on outside purchases, commonly through collectors. Collectors reside in communes near the production area and purchase from smallholders nearby. As each farmer's pond is too small to fill a container, they mix shrimp purchased from different farmers into a single container to bring to a processor. The relationship between wholesale buyers and processing companies is often a spot market relationship. Contracted farmers often sell shrimp directly to the processing companies. They may, however, sell to the collectors and/or wholesale buyers as it is not always possible to enforce a contract between the processing companies and contracted farmers. According to Loc (2006), about 60% of shrimp are sold to processing companies through collectors and/or wholesale buyers. This system makes it difficult to ensure traceability from the pond of origin.

For export, the shrimp are processed, packed, and delivered to distributers, which are foreign import companies. Some foreign import companies are located in Vietnam, mostly in Ho Chi Minh City. These foreign import companies relabel the final products and sell them to foreign retailers, which then finally sell the shrimp to end users. For the domestic market, shrimp can be sold directly from farmers or from collectors and processors to local markets, supermarkets, and restaurants. In this chain, 83% of the shrimp are exported, with only 17% sold to the domestic market.

2.2 Port Rejection

Although the shrimp sector has shown a remarkable growth in recent years, we also observe that the port rejection rate for Vietnam seafood has been high. For example, Figure 1 shows the number of import rejections at Japanese ports for fish and fishery products between 2006 and 2010. Vietnam's rate is high for all years relative to other countries.

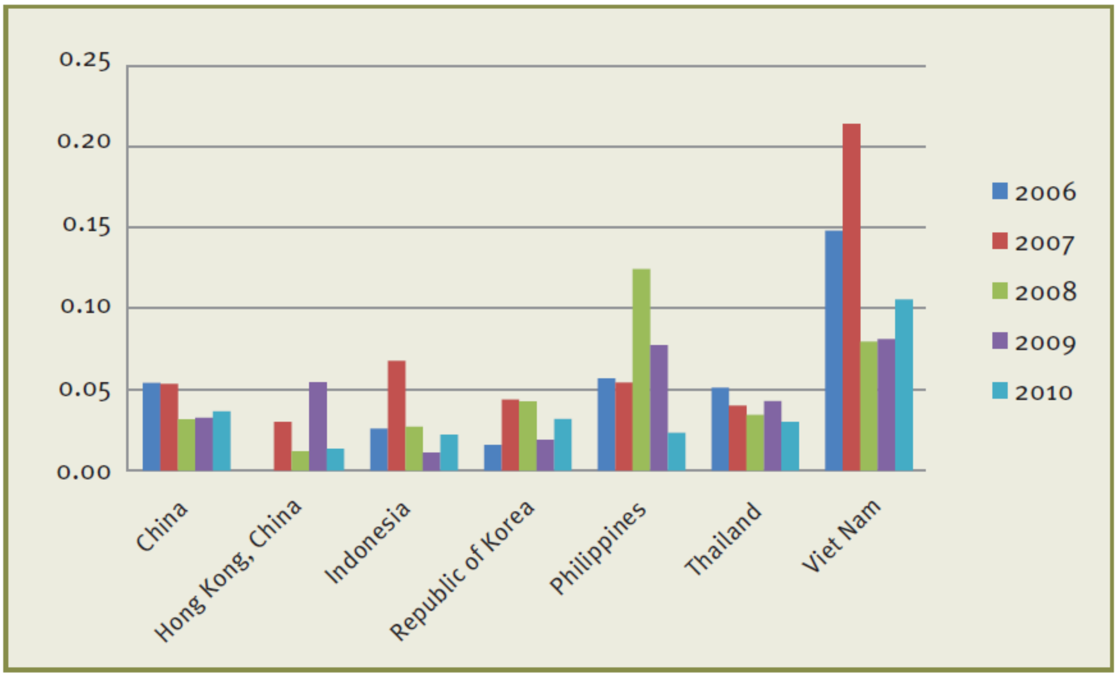

Figure 1: Japanese Import Rejections of Fish and Fishery Products per US$ million imports, 2006-2010.
Source) UNIDO-IDE 2013

When we examine the reasons reported for these rejections, we see that veterinary drugs residues rank first, followed by bacterial contamination (Figure 2). The detected veterinary drug residues must originate in the production stage, as the residues are found in the bodies of fish and fishery products. Bacterial contamination can happen even after the production stage, for example, even on the ship to Japan from Vietnam. Although this is a simple summary, we can infer from Figure 2 that the major reasons behind the high rejection rate of Vietnamese exports occur at the producers' level. This is an important finding in terms of considering how to solve the problem of port rejection. In fact, from field observations, shrimp farmers in Vietnam use veterinary drugs (i.e., antibiotics) to prevent and treat of shrimp diseases. Although some of these antibiotics are prohibited, farmers nevertheless use them. It seems that the most effective solution is to change farming practices at the producer level.

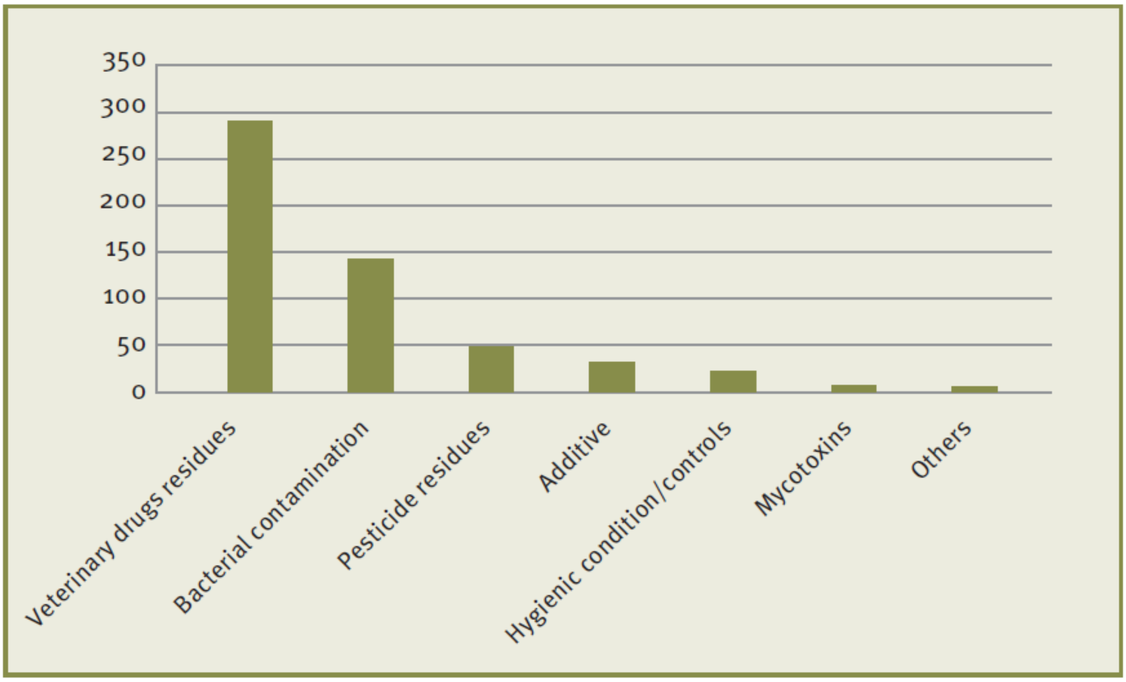

Figure 2: Reasons for Japanese Rejections of Vietnamese Food Products, 2006-2010

Source) UNIDO-IDE 2013

For reference, Figure 3 shows the same data for Thailand. We observe that the principal reason for rejection is bacterial contamination, and rejection due to detecting veterinary drug residues is very small. Although the use of antibiotics in Thailand was common in the past, farming practices changed as the sector experienced a huge drop in exporting volume. According to our field survey and interviews with experts, probiotics are now widely used among shrimp farmers and antibiotics are rarely used.

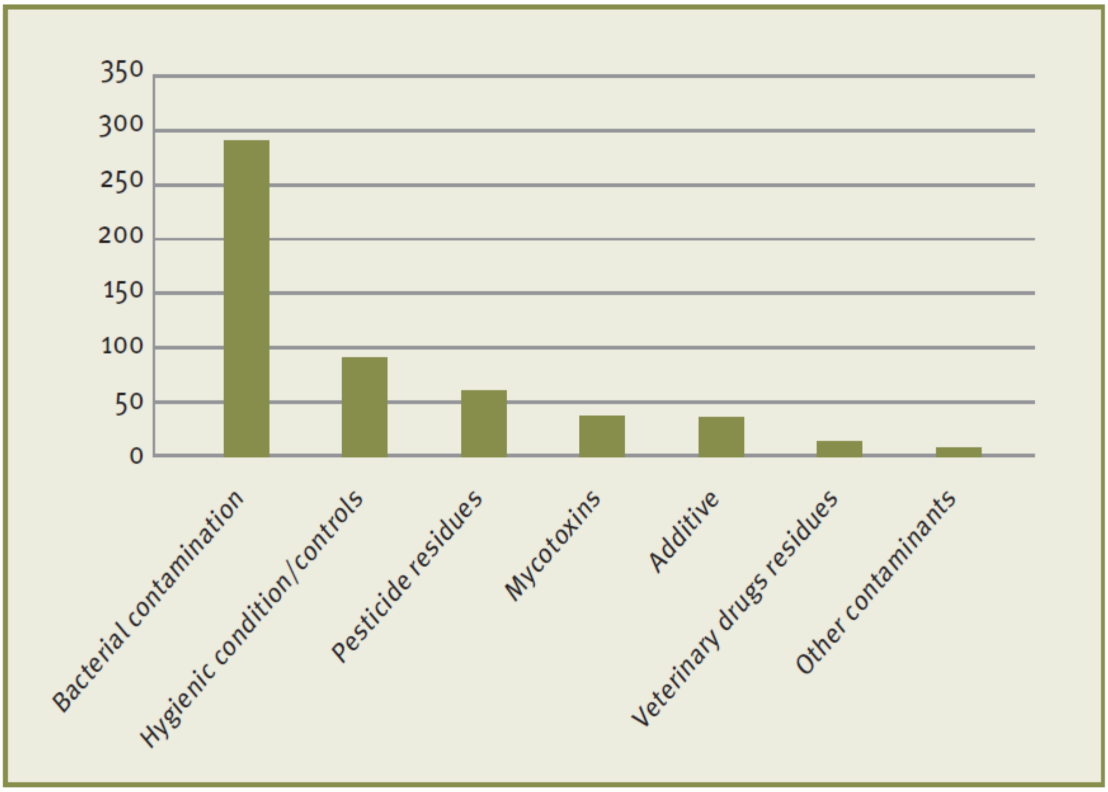

Figure 3: Reasons for Japanese Rejections of Thai Food Products, 2006-2010
Source) UNIDO-IDE 2013

2.3 Better Management Practices (BMPs)

The public has not been ignorant of this issue, and this catalyzed steps to try to address these problems. In the 1990s, there was pressing concern among the international public that the growing aquaculture sector is also deteriorating the environment. Thus, the FAO issued the Code of Conduct for Responsible Fisheries in 1995. Then, to provide a specific code of conduct for the shrimp sector, an international consortium was established in 1999, involving organizations such as the World Bank, the Network of Aquaculture Centres in Asia-Pacific (NACA), the World Wildlife Fund, and FAO. They led a series of discussions and meetings among stakeholders for many years and issued the International Principles for Responsible Shrimp Farming in 2006 (FAO *et al.* 2006). This document provides basic principles to follow when farming shrimp. We also have an increasing number of international standards and certifications, such as GLOBALGAP, Safe Quality Food, a series of ISO standards, and Aquaculture Stewardship Council certifications, which assure the quality of seafood products (Corsin *et al.* 2007, Suzuki and Nam 2013). In Vietnam, to support these international principles and standards, the NACA and the Directorate of Fisheries, Ministry of

Agriculture and Rural Development of Vietnam, in collaboration with a Danish aid organization, launched a project to promote responsible shrimp farming and developed BMPs (Corsin *et al.* 2008). These BMPs were very simple to adopt and were disseminated across the country (Corsin *et al.* 2008). However, the port rejection data indicate that these BMPs are not being fully followed. Thus, we examine the extent to which these practices are actually being implemented in the field.

3. Research Questions and Data

3.1 Research Questions

To understand why port rejection remains an important issue despite international as well as governmental efforts to promote sustainable practices in shrimp farming, we identify and examine the factors associated with farmers using the developed BMPs. We examine socioeconomic characteristics of farmers such as age and education, numbers and types of information sources they have regarding shrimp aquaculture, and their past experiences of receiving technical training and having their shrimp tested in labs.

Particularly, we offer the following hypotheses:

Hypothesis 1:

Farmers are more likely to adopt BMPs if they have more information sources for technical advice, have received technical training, and have had their shrimp tested in a laboratory in the past.

Second, we examine whether practicing these BMPs in fact lead to good results, as farmers will otherwise not be motivated to use BMPs. For the outcome, we use variables of whether or not they experienced an outbreak of shrimp disease during the same production cycle.

Hypothesis 2:

If farmers use BMPs, they are less likely to experience an outbreak of shrimp disease.

3.2 Data

We conducted a primary household survey among 210 farmers in Phu Tan District, Ca Mau province, Vietnam, in 2015. Ca Mau is the largest shrimp-producing province in Vietnam, and Phu Tan district is located on the west coast of the peninsula. Using the official list of shrimp farmers in Phu Tan, we relied on stratified sampling. We first chose communes and randomly selected 210 farmers from this list for our survey. We conducted face-to-face interviews with these farmers based on a structured questionnaire, and the interviews were conducted in a local language. The survey includes questions related to farmers' socioeconomic characteristics as well as the details of their shrimp production practices and marketing.

4. Estimation Method

To determine factors associated with BMP use, we estimate the following equation:

$$y_{ij} = \mathbf{X_{ij}}\boldsymbol{\beta}' + \mathbf{Z_{ij}}'\boldsymbol{\gamma} + \delta_j + \varepsilon,$$

where *y* is a dependent variable of a BMP score of a farmer *i* in a commune *j*, which we created on the basis of the questionnaire; X is a vector that includes variables related to the number and types of information sources that a farmer has; Z is a vector that includes socioeconomic characteristics of farmers; and δ is commune fixed effects to control for heterogeneity across the communes. We run ordinary least squares (OLS) regression on the above equation and use robust standard errors in estimation. The BMP score is an index with a maximum of 5 and the minimum of 0, consisting of five aspects: (1) frequency of water testing (= 1 if farmers test water more than once a week), (2) whether farmers use feed trays, (3) whether farmers keep records of their production practices (such as water quality, seed use, feeding time, sale prices, and volumes), (4) whether farmers have a reservoir pond for water replacement, and (5) whether farmers removed waste soil before starting to stock. These practices are also recommended by the local government. As our dependent variable is in the range of 0 to 5, in addition to employing OLS, we also estimate the same equation using the two-limit Tobit model, censoring from above and below.

Furthermore, we estimate the impact of using BMPs on an outcome, which is the outbreak of shrimp disease in this study. As the use of BMPs is up to individual farmers, we face a problem of endogeneity if we use it as an independent variable for the outcome equation. As our data are cross-sectional data, we rely on propensity score-matching estimation methods to correct for endogeneity. We use Kernel matching as it offers the greatest bias reduction, as discussed below, and use boot-strapped standard errors for estimating the impact of BMPs on the possibility of having shrimp disease.

5. Results

Socioeconomic characteristics of the interviewed shrimp farmers are summarized in Table 2. Column (1) shows the average and standard deviation for all samples, whereas

Column (2) shows data for the farmers who adopted more than four BMPs and Column (3) shows data for farmers who adopt fewer than four BMPs. We observe that there are some statistically significant differences between these two groups of farmers. Non- or low adopters of BMPs are more likely to have siblings or parents who also cultivate shrimp, and the total size of their shrimp ponds tend to be larger. This may suggest that if farmers have family members who also cultivate shrimp, they learn from each other and tend not to seek professional advice. Low or non-adopters having larger ponds may indicate that larger ponds make it more costly to adopt BMPs and these therefore farmers do not follow these practices.

Table 3 presents the results of the determinants of BMP usage. Columns (1) and (2) provide the basic covariates on farmers' socioeconomic characteristics. These findings indicate that if farmers belong to a cooperative, they are more likely to adopt a higher number of BMPs. This is as expected, as cooperatives may promote BMPs among their members. In contrast, if farmers' siblings also cultivate shrimp, farmers are less likely to adopt these BMPs. This may suggest that if a farmer's family members cultivate shrimp, the farmer is likely to adopt traditional practices without referring to the recommended BMPs. Although not statistically significant, parental shrimp cultivation also shows a negative coefficient.

In Columns (3) and (4), we find that information sources indeed matter for adopting BMPs, thereby confirming Hypothesis 1. Knowing a higher number of input sellers is associated with a farmer adopting more BMPs, whereas the effect is the opposite for shrimp buyers. This finding indicates that farmers are receiving more appropriate technical information from input sellers than from buyers. This is understandable as the buyers are mostly collectors, who do not test the shrimps at the purchase, as explained in section 2.1. We also find that a greater number of information sources concerning technical issues is positively associated with BMP adoption. Furthermore, we find that past experience of receiving technical training also positively affects BMP adoption, thereby supporting Hypothesis 1. Thus, offering trainings to farmers seems to be effective in promoting the adoption of BMPs. However, the experience of having shrimp tested in a lab was insignificant, even though it did have a positive coefficient.

Table 2: Socio-economic Characteristics of Shrimp Farmers

Variable	All (201) (1)	BMP active adopters (56) (2)	Non- or low BMP adopters (145) (3)	p-value of diff (4)
=1 if male	0.935	0.964	0.924	0.30
	(0.247)	(0.187)	(0.266)	
Age	50.40	51.02	50.16	0.65
	(12.05)	(12.11)	(12.06)	
Years of education	7.84	7.86	7.84	0.96
	(2.90)	(2.61)	(3.00)	
Years of shrimp cultivation	7.45	6.63	7.77	0.30
	(7.02)	(4.92)	(7.67)	
=1 if belong to a cooperative	0.10	0.05	0.12	0.14
	(0.31)	(0.23)	(0.33)	
=1 if parents cultivate shrimp	0.26	0.14	0.30	0.02**
	(0.44)	(0.35)	(0.50)	
=1 if siblings cultivate shrimp	0.66	0.54	0.71	0.02**
	(0.47)	(0.50)	(0.45)	
Total size of shrimp ponds (ha)	1.22	0.86	1.36	0.05**
	(1.60)	(1.24)	(1.70)	
# shrimp buyers I know	7.47	6.54	7.83	0.20
	(6.49)	(6.43)	(6.50)	
# seed sellers I know	4.67	4.82	4.61	0.82
	(5.71)	(3.95)	(6.28)	
# input sellers I know	4.32	4.25	4.34	0.92
	(5.73)	(3.72)	(6.35)	
# info source on technical issues	6.29	5.85	6.45	0.69
	(9.45)	(6.81)	(10.30)	
# info source on shrimp prices	5.93	5.68	6.02	0.65
	(4.83)	(5.11)	(4.74)	
=1 have received trainings before	0.70	0.66	0.72	0.43
	(0.46)	(0.48)	(0.45)	
=1 have had shrimps tested in a lab before	0.42	0.36	0.44	0.28
	(0.49)	(0.48)	(0.50)	

Note) Standard deviations are reported in parentheses. **indicates statistical significance at 5% level.

Table 3: Determinants of BMP score (5 max)

	OLS (1)	Tobit (2)	OLS (3)	Tobit (4)
=1 if male	-0.238	-0.245	-0.171	-0.181
	(0.88)	(0.95)	(0.56)	(0.64)
Age	0.007	0.008	0.005	0.005
	(1.32)	(1.43)	(0.83)	(0.92)
Years of education	0.011	0.012	0.005	0.007
	(0.44)	(0.50)	(0.23)	(0.30)
Years of shrimp cultivation	0.001	0.002	0.003	0.004
	(0.19)	(0.25)	(0.41)	(0.51)
=1 if belong to a cooperative	0.401**	0.402**	0.417**	0.415**
	(2.12)	(2.21)	(2.09)	(2.22)
=1 if parents cultivate shrimp	-0.026	-0.039	-0.035	-0.047
	(0.16)	(0.24)	(0.19)	(0.27)
=1 if siblings cultivate shrimp	-0.505***	-0.509***	-0.443***	-0.450***
	(3.50)	(3.64)	(2.86)	(3.04)
Size of shrimp ponds	-0.014	-0.014	-0.022	-0.021
	(0.26)	(0.26)	(0.38)	(0.38)
# shrimp buyers I know			-0.026*	-0.026*
			(1.82)	(1.96)
# seed sellers I know			-0.037	-0.041*
			(1.64)	(1.75)
# input sellers I know			0.060**	0.063**
			(2.01)	(2.14)
# info source on technical issues			0.010*	0.010*
			(1.68)	(1.84)
# info source on shrimp prices			0.003	0.006
			(0.22)	(0.34)
=1 have received trainings before			0.293*	0.292*
			(1.69)	(1.79)
=1 have had shrimps tested in a lab before			0.098	0.092
			(0.59)	(0.58)
Constant	3.067***	3.051***	2.906***	
	(7.45)	(7.72)	(5.90)	
Sigma		0.857***		0.831***
		(15.71)		(15.39)
R2	0.22		0.27	
N	173	173	170	170

Note) * p<0.1; ** p<0.05; *** p<0.01. All includes commune fixed effects. Absolute values of robust t-statistics in parentheses.

We decomposed this BMP score and examine determinants of each practice in Table 4. We conducted both OLS and probit estimations as the dependent variable is binary, but report the OLS results only as the results are consistent across estimation methods and one probit model did not achieve convergence for one practice (having removed waste soil before stocking shrimps). We find that having siblings or parents cultivate shrimp are again negative and significant in explaining the adoption of some BMPs (use of feed tray, water quality testing, and whether removed waste soil). Those shrimp farmers who start shrimps as family business seem to be inactive in adopting these BMPs. Among the variables of information sources, we find that number of input sellers known is positive and statistically significant in explaining having reservoir ponds. On the other hand, the numbers of seed sellers or shrimp buyers known correlate negatively to having reservoir ponds. The number of shrimp buyers known is also negatively associated with water quality testing. This may be indicating that those who are very active about selling to markets are not very keen about good farming practices. Input sellers seem to be source of information for farming practices for small-scale farmers. This confirms what we heard during the fieldwork from farmers. When they have problems with shrimp farming, they tend to seek advices from input sellers. Further, having previous experience of training positively correlates with the use of feed tray, water quality testing, and having reservoir pond. Lastly, having tested shrimps in laboratories before correlates positively with water quality testing but negatively with removing waste soil.

We now examine the impact of BMP adoption on disease outbreak. Table 5 shows the probit estimation used to obtain the propensity score for the use of BMPs. We use the same set of independent variables as in the previous analysis. According to the estimation results, some variables are statistically significant for practicing BMPs, indicating that we need to control for these differences between BMP users and non-users. Thus, we match samples on the basis of the estimated propensity scores. Among the many matching methods, we tried four different matching methods and choose Kernel matching as it offers the greatest bias reduction among the four. The results of the matching process are shown in Table 6, and a histogram of the propensity scores is depicted in Figure 4.

Table 4: Determinants of each BMP (OLS)

	Feed tray	Test water daily	Record keeping	Have reservoir pond	Removed waste soil
	(1)	(2)	(3)	(4)	(5)
=1 if male	0.067	-0.049	-0.287***	0.035	0.059
	(0.71)	(0.31)	(2.82)	(0.29)	(0.66)
Age	0.001	0.000	-0.002	0.004*	0.000
	(0.64)	(0.13)	(0.66)	(1.84)	(0.35)
Years of education	-0.003	0.001	-0.002	0.004	0.003
	(0.41)	(0.04)	(0.18)	(0.43)	(0.54)
Years of shrimp cultivation	-0.001	-0.007	0.002	0.006*	0.003
	(0.22)	(1.63)	(0.47)	(1.67)	(1.46)
=1 if belong to a cooperative	0.034	0.218	0.028	0.116	0.042
	(0.62)	(1.63)	(0.26)	(1.06)	(1.47)
=1 if parents cultivate shrimp	-0.099*	0.069	0.018	-0.002	-0.029
	(1.84)	(0.79)	(0.25)	(0.03)	(0.78)
=1 if siblings cultivate shrimp	-0.213***	-0.142*	0.077	-0.100	-0.067**
	(3.62)	(1.73)	(1.24)	(1.54)	(2.29)
Size of shrimp ponds	-0.030*	0.001	-0.020	0.025	0.006
	(1.83)	(0.03)	(0.85)	(1.61)	(0.97)
# shrimp buyers I know	-0.006	-0.015**	0.008	-0.011*	-0.001
	(1.41)	(2.15)	(1.57)	(1.79)	(0.21)
# seed sellers I know	-0.009	0.006	-0.002	-0.023**	-0.012
	(1.23)	(0.55)	(0.29)	(2.44)	(1.57)
# input sellers I know	0.013	-0.000	0.006	0.032***	0.013
	(1.60)	(0.01)	(0.68)	(3.32)	(1.65)
# info source on technical issues	0.003	0.003	0.000	0.002	0.001
	(1.35)	(0.63)	(0.02)	(1.39)	(1.49)
# info source on shrimp prices	-0.007	0.009	0.002	-0.002	0.002
	(1.39)	(1.07)	(0.29)	(0.31)	(1.08)
=1 have received trainings before	0.115**	0.138*	-0.052	0.125*	0.003
	(2.12)	(1.84)	(0.82)	(1.70)	(0.10)
=1 had shrimp tested before	-0.057	0.169**	0.096	-0.034	-0.082**
	(1.04)	(2.17)	(1.47)	(0.54)	(2.37)
Constant	0.453**	0.588**	0.458**	0.522**	0.908***
	(2.54)	(2.21)	(2.27)	(2.41)	(10.06)
R^2	0.38	0.28	0.25	0.19	0.22
N	185	185	185	171	172

Note) * p<0.1; ** p<0.05; *** p<0.01. All includes commune fixed effects. Absolute values of robust t-statistics in parentheses.

Table 5: Probit Estimation for BMP adoption

	Coefficient (1)	ME (2)
=1 if male	0.500	0.124
	(1.084)	
Age	0.001	0.0002
	(0.087)	
Years of education	0.033	0.010
	(0.849)	
Years of shrimp cultivation	-0.006	-0.002
	(0.369)	
=1 if belong to a cooperative	-0.392	-0.103
	(0.964)	
=1 if parents cultivate shrimp	-0.616**	-0.163
	(2.269)	
=1 if siblings cultivate shrimp	-0.374*	-0.117
	(1.650)	
Size of shrimp ponds	-0.095	-0.029
	(0.960)	
# shrimp buyers I know	-0.094***	-0.028
	(3.029)	
# seed sellers I know	0.027	0.008
	(0.694)	
# input sellers I know	0.003	0.001
	(0.080)	
# info source on technical issues	-0.006	-0.002
	(0.461)	
# info source on shrimp prices	-0.001	-0.0004
	(0.049)	
=1 have received trainings before	-0.127	-0.039
	(0.536)	
=1 have had shrimps tested in a lab before	0.023	0.007
	(0.102)	
Constant	-0.250	
	(0.342)	
Pseudo R2	0.12	
N	185	

Note) * $p<0.1$; ** $p<0.05$; *** $p<0.01$. All includes commune fixed effects. Absolute values of robust t-statistics in parentheses.

Table 6: Balancing Test Results

	# significant variables	Pseudo R2	P-value LR test	Mean Bias
Before matching	4	0.231	0.001	11.1
Nearest Neighbor	1	0.165	0.322	9.3
Caliper	0	0.072	0.985	8.4
Kernel	0	0.010	1.000	2.7
Local Linear Regression	1	0.165	0.322	9.3

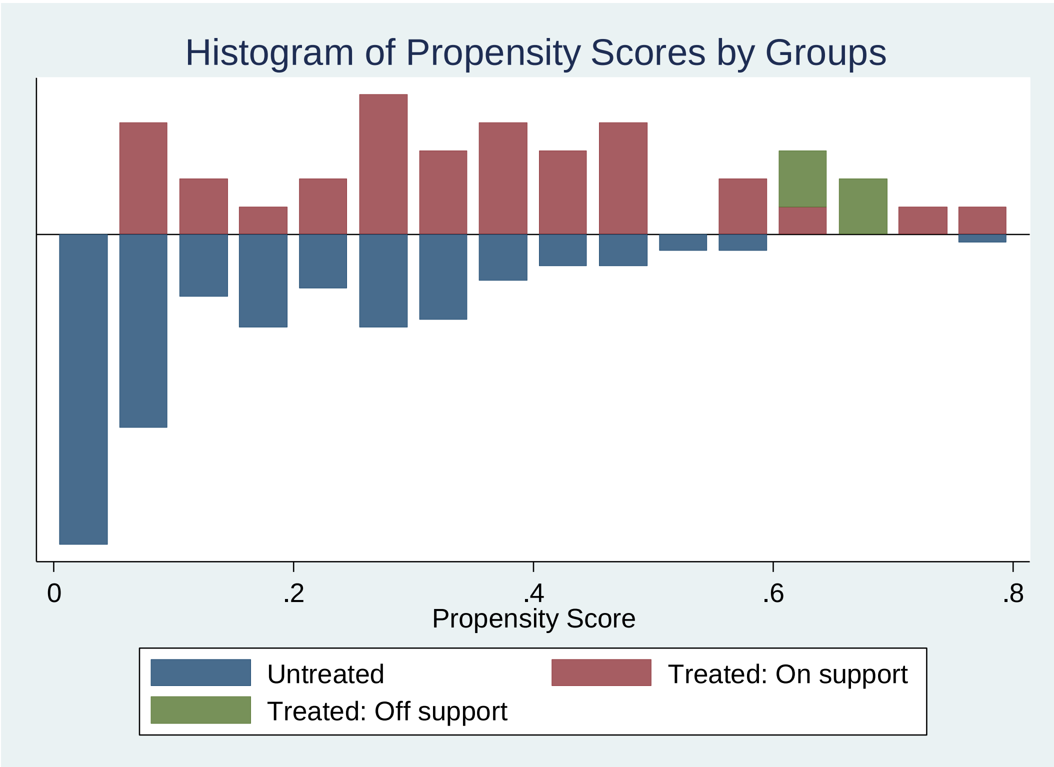

Figure 4: Histogram of Propensity Scores

Based on the Kernel matching, Table 7 presents our PSM results of the effect of BMP adoption on the outbreak of shrimp disease. Column (1) shows that if farmers adopt four or more practices out of the five, the probability of their farms having a shrimp disease outbreak is reduced by 38.1%. This finding is statistically significant at the 1% level. If farmers adopt three or more BMPs, then the probability of their shrimp having disease will be reduced by 15.6%. When farmers use two or more BMPs, then the impact on the disease outbreak is no longer statistically significant, although it still shows a negative coefficient. These findings support Hypothesis 2, which states that BMP adoption indeed results in farmers facing fewer outbreaks of shrimp disease.

Table 7: Effect of BMP Adoption on Disease Outbreak (PSM, Kernel matching)

More than 4 BMPs	More than 3 BMPs	More than 2BMPs
(1)	(2)	(3)
-0.381***	-0.156*	-0.213
(3.51)	(1.70)	(0.78)

Note) Bootstrapped t-statistics reported in parentheses. * p<0.1; ** p<0.05; *** p<0.01

The above-mentioned findings allow the conclusion that Hypothesis 1 is mostly supported. Information sources, both in terms of quantity and type, seem to matter in BMP adoption. Training experience also positively affects BMP adoption. These finding validate the efforts made to promote and disseminate effective technical information to local farmers. We also find that BMP adoption indeed affects the occurrence of shrimp disease, further supporting the effectiveness of BMPs.

6. Conclusion

In this paper, we examined factors associated with the use of BMPs by farmers, employing a case study of shrimp farmers in Southern Vietnam. We find that being a member of a cooperative; having many advice sources, particularly from input sellers; and having training experiences are positively related to the use of BMPs. In contrast, having siblings also in the shrimp sector was negatively associated with BMP use.

We further found that the use of BMPs actually decreases the probability of having a shrimp disease outbreak. The number of practices also mattered for this result, i.e., practicing fewer than three BMPs will not decrease the probability of disease but practicing more than three will. Although this result is as expected, the fact that this relation indeed holds on the basis of data from actual farmers' ponds is very encouraging. This study’s results support the need for formal training and highlight the importance of disseminating appropriate technical information. BMPs should be well-promoted to reduce the probability of disease and thus decrease the probability of farmers using antibiotics in their ponds, which in turn will lead to a lower port rejection rate at developed countries’ ports.

References

Corsin, F., S. J. Funge-Smith, and J. Clausen. (2007). *A Qualitative Assessment of Standards and Certification Schemes Applicable to Aquaculture in the Asia-Pacific Region*. RAP Publication 2007/25. FAO Regional Office for Asia and the Pacific, Bangkok, Thailand.

Corsin, F., C.V. Mohan, A. Padiyar, K. Yamamoto, P. Chanratchakool, and M.J. Phillips. (2008). "Codes of Practice and Better Management: A Solution for Shrimp Health Management?" In Bondad-Reantaso, M.G., Mohan, C.V., Crumlish, M. and Subasinghe, R.P. eds. *Diseases in Asian Aquaculture VI*. Fish Health Section, Asian Fisheries Society, Manila, Philippines: 419-432.

Food and Agriculture Organization. (2012). *The State of World Fisheries and Aquaculture*. Rome: Food and Agriculture Organization of the United Nations.

FAO/NACA/UNEP/WB/WWF. (2006). International Principles for Responsible Shrimp Farming. Network of Aquaculture Centres in Asia-Pacific (NACA). Bangkok, Thailand. 20 p.

General Statistical Office of Vietnam. (2016). Online database. https://www.gso.gov.vn/Default_en.aspx?tabid=491

Loc, Vo Thi Thanh. (2006). "Seafood Supply Chain Quality Management: The Shrimp Supply Chain Quality Improvement, Perspective of Seafood Companies in the Mekong Delta, Vietnam." University of Groningen, Groningen, the Netherlands.

Suzuki, A. and V.H. Nam (2013). "Status and Constraints of Costly Port Rejection: A Case from the Vietnamese Frozen Seafood Export Industry." *IDE Discussion Paper* No. 395, Institute of Developing Economies.

United Nations Industrial Development Organization (UNIDO) and Institute of Developing Economics (IDE) (2013). *Meeting Standards, Winning Markets Regional Trade Standards Compliance Report East Asia 2013*. United Nations Industrial Development Organization, Vienna, Austria: 2013

Vietnam Association of Seafood Exporters and Producers (VASEP). (2011). *Report on Vietnam Seafood Export Qiv-2011*. Ho Chih Minh City: Vietnam Association of Seafood Exporters and Producers (VASEP).

World Bank. (2013). *Fish to 2030: Prospects for Fisheries and Aquaculture*. Agriculture and Environmental Services Discussion Paper 03, Washington DC.