**The Determinants of Detecting Veterinary Drugs Residues: Evidence from Shrimp Farmers in Southern Viet Nam**

**Guenwoo Lee[[1]](#footnote-2), Aya Suzuki[[2]](#footnote-3), and Vu Hoang Nam[[3]](#footnote-4)**

**Abstract**While export-oriented shrimp farming has become an important source of income for many small-scale farmers in developing countries, the rate at which products are rejected at the ports of developed countries has remained high mainly due to the overuse of prohibited substances. To reveal what determines the overuse of such substances, we interviewed 201 shrimp farmers in Vietnam in 2015 and collected shrimp samples from each household’s pond for the screening of residual drugs. These tests revealed that residual drugs exceeding acceptable limits by Japanese standards were found in the samples of 40 farmers. We conducted cross-sectional Probit and Tobit regressions to examine whether results of the residue tests are significantly associated with farmers’ characteristics and management practices. This study finds that: 1) receiving BMPs training and keeping a record of shrimp seed have significant and positive effects on reducing residual drugs; 2) risk aversion is positively and significantly related to residual drugs; 3) there is a positive correlation between residual drugs and a dummy for time-inconsistent preferences of farmers; 4) if farmers know multiple extension officers, these relationships have significant and positive effects on reducing residual drugs; 5) farmers with experience of shrimp disease outbreaks reduce use of antibiotics.

**Keywords** Better management practices, Shrimp aquaculture, Veterinary drug, Viet Nam

**JEL Classification** D80**,** Q01**,** Q12

**1. Introduction**

The Food and Agriculture Organization of the United Nations (FAO) has released statistics showing that developing countries account for about 78 percent of total shrimp exports (FAO, 2016). For developing countries, intensive shrimp aquaculture is a profitable business, and a means of acquiring foreign currency. The producing countries use veterinary medicinal drugs to mitigate the risk of crop failures due to shrimp viral diseases, but such inputs contain substances harmful to the human body such as chloramphenicol, enrofloxacin, ciprofloxacin, and oxytetracycline. Accordingly, the EU, Japan, and the US, the major importers of shrimps, have been raising the standards of quarantine inspections on shrimps from developing countries (UNIDO, 2013).

Unless the exporting countries can change the situation, the export volume of shrimps will decline, and it is expected to hold back the economies of the producing countries (Suzuki & Vu, 2013; UNIDO, 2013). Further, another serious problem is the effect of waste water on the residents in surrounding villages as farmers discharge water to canals (Dierberg & Kiattisimkul, 1996; Jackson, Preston, & Thompson, 2004; Pham et al., 2010; Senarath & Visvanathan, 2001; Taya, 2003; Tzachi et al., 2004). According to Taya (2003), this is an important issue for village people who use river water for domestic and agricultural purposes.

The difficulty in changing the situation lies in the fact that shrimps are mainly produced by small-scale farmers in many of the Asian countries, except in the case of Indonesia. As the producers are numerous and dispersed, it is hard to control their farming practices. Collectors, who purchase shrimps from smallholders and sell to exporters, often mix shrimps from many farmers to fill a container; this makes it even harder to trace the source of problems (Suzuki & Vu, 2016).

Shrimp aquaculture in Vietnam has been growing discernibly since the Doi Moi.[[4]](#footnote-5) Between 1986 and 2013, the country’s shrimp exports increased from 20 000 tons to 358 000 tons; in terms of dollar value, it rose from $75 million to over $3 billion over the same period. This represents nearly an 18-fold increase in volume and a 40-fold increase in monetary value, testifying to the remarkable growth achieved by the Vietnamese shrimp industry (FAO, 2016). However, despite the high growth, the port rejection rate, or the share of Vietnamese shrimps that are rejected at the ports of importing countries, continues to grow, mainly due to the overuse of veterinary drugs (UNIDO, 2013).

To understand why this issue persists, we first need to understand what leads to the use of these prohibited substances among small-scale producers. While there are studies examining the determinants of chemical inputs in agriculture (such as Liu & Huang, 2013), empirical studies in an aquaculture context are few and tend to rely on subjective data or use inappropriate methodologies. Thus, we focus on a case of small-scale farmers in southern Vietnam and examine the determinants of antibiotic use in shrimp farming.

We interviewed 201 shrimp farmers randomly selected from the population list in a district in Ca Mau province in southern Vietnam in 2015 and collected shrimp samples from each household’s pond for the screening of residual drugs. The drug residue tests were conducted in a laboratory at Can Tho University in 2016. The tests revealed residual veterinary drugs exceeding acceptable limits set by the Japan Ministry of Health, Labor and Welfare (MHLW) standard[[5]](#footnote-6) in 40 farmers’ shrimps. We also collected data on the farmers’ socio-economic characteristics, social networks, farm characteristics, sales performance, risk and time preferences, and farming behaviors by Better Management Practices (henceforth, BMPs). We conducted Probit and Tobit regressions using cross-sectional data to examine whether results of the residue tests were significantly associated with particular farmers’ characteristics and farm management practices, as mentioned above.

This study finds that: 1) receiving BMPs training and keeping a record of shrimp seed have significant and positive effects on reducing residual drugs; 2) risk aversion is positively and significantly related to chloramphenicol and ciprofloxacin; 3) there is a positive correlation between residual drugs and a dummy for time-inconsistent preferences of farmers; 4) if farmers know multiple extension officers, these relationships have significant and positive effects on reducing residual drugs; 5) farmers with experience of shrimp disease outbreaks reduce use of antibiotics, which contain veterinary drugs because of distrust in the efficacy of these drugs. Our contribution is threefold: 1) we found the above results using objective data on the use of prohibited substances from farmers’ pond samples; 2) we showed that social networks and experience matter in the use of these prohibited substances; and 3) we showed that psychological parameters such as time and risk preferences matter in the veterinary drug residues.

The remainder of the paper proceeds as follows. Section 2 describes Vietnam’s shrimp industry, the port rejection rates due to veterinary drug residues, and the BMPs. In Section 3, we review relevant extant literature on veterinary substance abuse in Thailand, risk preferences and pesticide use by cotton farmers in China, and the impact of BMPs on shrimp farming. Section 4 describes and explains the data used herein, presents summary statistics, and describes experimental designs for eliciting farmers’ risk preferences and distinguishing hyperbolic consumers from other survey respondents. Section 5 describes the estimation methods used, and the results are presented in Section 6. Finally, Section 7 concludes the study.

**2. Previous Literature and Hypotheses**

*2.1. Previous literature*

Currently, there is a dearth of literature examining the determinants of chemical input use in agriculture. Holmstrom et al. (2003) and Liu and Huang (2013) are most relevant to our study, and thus are described below.

The closest comparator to this study is provided by Holmstrom et al. (2003), who conducted interviews with shrimp farmers along the Thai coast in 2000. The interviews were based on a questionnaire regarding management practices and the use of chemicals on farms. Their data reveals that norfloxacin, oxytetracycline, and enrofloxacin are the antibiotics most widely used by Thai shrimp farmers. A large proportion of shrimp farmers, 74 percent (56 out of 76 farmers), use those antibiotics in pond management to prevent and treat shrimp diseases. Based on the interviews, Holmstrom et al. (2003) find that farmers who have experienced shrimp disease outbreaks tend to use greater quantities of antibiotics than farmers who are not experienced in this respect. Furthermore, they find that the age of ponds is also associated with antibiotic use: older ponds were at greater risk of disease outbreaks. In other words, farmers who have recently established farms are less likely to use antibiotics than farmers who have longer-established farms, because they have a lower risk of suffering from shrimp disease outbreaks. Also, they point out that 88 percent of the farmers they interviewed used antibiotics simultaneously with probiotics. One interpretation of such behavior is that a large number of farmers have insufficient or inaccurate information on the effects of antibiotics and probiotics (Holmstrom et al., 2003). While this study exhibits similarities with our aims and objectives, Holmstrom et al. (2003) do not employ inferential quantitative methods such as regression analysis; they rely solely on farmers’ subjective answers to questions regarding the use of antibiotics and pesticides. Thus, their answers may not generalize well beyond these subjectively ascertained answers. By contrast, our study provides objective indicators for drug residues.

Another important study in this domain is Liu and Huang (2013), which revealed a relationship between Chinese cotton farmers’ risk preferences and pesticide use—to combat *Bacillus thuringiensis* (Bt)—using primary data collected by the Center for Chinese Agricultural Policy (CCAP) in four provinces (Shandong, Hebei, Henan, and Anhui) in 2006. These data consist of detailed information about 320 farmers’ inputs to and outputs from cotton plots, experiences of pesticide poisoning, and risk preferences. Their methodology was mainly based on the experimental design of Tanaka, Camerer, and Nguyen (2010). Results therein revealed that more risk-averse farmers applied greater amounts of pesticides in an effort to minimize infestation risks, while more loss-averse farmers tended to use fewer pesticides. In terms of the latter group, the authors note that loss aversion was conceptualized and characterized in terms of aversion to negative health impacts incurred because of pesticide poisoning, rather than aversion to economic (cotton yield) losses (Liu & Huang, 2013).

As shrimp farming is known for its environmental externalities, a guide for good aquaculture practice, called better management practices (BMPs).[[6]](#footnote-7) The purpose of BMPs is to improve farmers’ management practices, delivering increased profitability and environmental performance through more efficient use of resources (Khiem et al., 2010; Mantingh and V.H., 2008; NACA, 2006, UNIDO, 2013).

In particular, NACA has implemented BMPs in several countries, such as Indonesia, Thailand, and Vietnam. According to NACA (2016), well-designed and -implemented BMPs support smallholder shrimp aquaculture to 1) increase productivity by reducing the risk of shrimp disease outbreaks, 2) mitigate the impacts of farming on the environment, 3) improve food safety and the quality of shrimp farm products, and 4) improve the social benefits from shrimp farming and its social acceptability and sustainability. BMPs are likely to play a significant role in enhancing the quality of shrimp, as well as the welfare of farmers.

During the 2004 crop, NACA implemented a project to promote BMPs as a useful disease control method in Vietnam—in Ca Mau, Nghe An, Ha Tinh, Quang Ninh, and Khanh Hoa provinces. To promote BMPs to these pilot farming communities, they provided advice on pond preparation, stocking practices, pond management, and health management for shrimp farmers and distributed materials about BMPs to the farmers. Overall, pilot farmers accepted a solution for shrimp health problems that involved no use of antibiotics or other chemicals. The farmers also recognized the importance of keeping records on management practices and started to keep records concerning water quality and shrimp health status (NACA, 2006). NACA’s analysis shows the differences between the shrimp mortality experiences of pilot farmers who followed BMPs and the experiences of a comparison (control) group during the production cycle. Their results reveal that the application of BMPs by farmers significantly decreases shrimp mortality, and that pilot farmers’ productivities are considerably higher than farmers who do not follow BMPs (NACA, 2006).

In summary, these studies point out that the use of chemicals seems to correlate with farmers’ prior experiences of shrimp disease outbreaks, the age of shrimp ponds, risk and time preferences of famers, and experience of BMPs training.

*2.2. Hypotheses*

Based on the previous studies, we specify the following hypotheses.

*Hypothesis 1:*

The adoption of BMPs decreases farmers’ use of antibiotics, because farmers who follow BMPs can control shrimp diseases without antibiotics.

*Hypothesis 2:*

More risk-averse farmers will use greater amounts of antibiotics in their ponds to minimize the risk of shrimp mortality.

*Hypothesis 3:*

Farmers with inconsistent time preferences (“hyperbolic consumers,” as explained below) will overuse antibiotics because they tend to buy on impulse.

*Hypothesis 4:*

Farmers who know more extension officers or more shrimp input sellers will not use products that contain prohibited elements because they are able to get more and various information on products from multiple sources.

As mentioned in Section 4, residual quantities of four substances form the basis of our hypothesis testing, i.e., chloramphenicol, enrofloxacin, ciprofloxacin, and oxytetracycline. [[7]](#footnote-8)

**3. Study Context, Data, and Summary Statistics**

*3.1. Vietnamese shrimp industry and port rejection rates*

Since market liberalization, the Vietnamese government has fostered a more strategic approach to shrimp aquaculture. Consequently, in 2013, Vietnam was ranked as the largest exporter of shrimp in the world (UNIDO, 2013; FAO, 2016). Figure 1 shows the trend in the country’s shrimp exports between 1990 and 2013. During this period, Vietnamese shrimp exports increased from 20 000 tons to 358 000 tons. This represents nearly an 18-fold increase in volume, and shrimp farming has become a multi-billion-dollar industry.

According to the United Nations Industrial Development Organization (UNIDO) (2013), the Vietnamese fish and fishery products are rejected the most at the ports of Japan relative to those from other countries between 2006 and 2010.[[8]](#footnote-9) The reasons for the port rejections of Vietnamese fish and fishery products are shown in Table 1. In terms of veterinary drug residues in products between 2006 and 2010, Japan, the EU, and the US rejected imports of Vietnamese fish and fishery products 297, 172, and 170 times, respectively. The number of rejected cases by Japan due to drug residues represents more than half of all import rejections of these products at the Japanese border, and the number of rejected cases by the EU due to the same reason represents about 40 percent of the EU’s total rejections of fish and fishery products. The rejection rate due to veterinary drug residues at the US border is relatively small compared to Japan and the EU. Regarding quantity, the Vietnamese shrimp industry has unequivocally grown, yet it appears that a number of problems remain, such as veterinary drug residues, that diminish the quality profile of this growth.

*3.2. Shrimp survey*

Figure 2 presents our study site, Ca Mau province, which is located in the southernmost part of Vietnam and is surrounded by water on three sides. Ca Mau attained and maintained a shrimp industry by virtue of its geographical advantages. In an effort to grow the industry, Ca Mau converted 150 000 hectares of paddy fields to shrimp ponds, and the extent of shrimp ponds in this province reached 257 000 hectares in 2008, which was nearly 50 percent of the total area in Ca Mau. As a result, the value of the province’s shrimp exports increased from $662 million to $3 billion between 2000 and 2013, representing around 80 percent of Vietnam’s total shrimp exports (Ngo, 2011; Ca Mau Province, 2008).

To examine the determinants of antibiotic use by shrimp farmers in Vietnam, we conducted a household survey in Ca Mau province in 2015, collecting information from 201 households.[[9]](#footnote-10) Concomitantly, shrimp samples were taken from the ponds of these 201 households and screened for residual antibiotics. The respondents were chosen randomly among shrimp farmers on population lists that were obtained from the Ca Mau provincial government. The data include information on farmers’ social networks, farm characteristics, sales performance, and behavior regarding BMPs, as well as their socio-economic characteristics. The cornerstone of these data is the results from laboratory tests for antibiotic residues. We chose four substances for the purposes of drug residue testing: chloramphenicol, enrofloxacin, ciprofloxacin, and oxytetracycline.[[10]](#footnote-11) The tests were conducted in the food safety laboratory of the Department of Aquatic Nutrition and Product Processing in the College of Aquaculture and Fisheries, Can Tho University. Shrimp samples were collected directly from farmers’ ponds by university staff and transported in ice-cold storage boxes. Residues were analyzed using liquid chromatography–mass spectrometry (LCMS). The results revealed that chloramphenicol, enrofloxacin, ciprofloxacin, and oxytetracycline were indeed detected in the shrimp produced by 13 households, 22 households, 15 households, and 11 households, respectively. Specifically, and importantly, substances found in 40 samples exceeded amounts allowed by the MHLW standard, as shown in Table 2.

Table 3 summarizes respondents’ socio-economic characteristics, farm characteristics, and sales performance. The average age of interviewees is about 50 years old, and most of them are male. On average, they have completed eight years of formal school education and resided for 45 years in each commune. While the detection group’s shrimp farmland is approximately 0.29 hectares larger than that of the non-detection group, the revenue of the non-detection group averages 688 million VND (Vietnamese dong) more than that of the detection group. This difference between both groups’ incomes seems to be due to shrimp mortality. Significant differences are found in shrimp farming experience, and in the cost of shrimp feed, both of which are higher (lower) in the detection (non-detection) group.

Table 4 illustrates respondents’ social network characteristics and their behaviors regarding BMPs. The farmers in the non-detection group know more buyers, seed sellers, and input sellers than do farmers in the detection group, and 73 percent of the farmers in the non-detection group answered that they had received BMPs training. This is about 13 percent higher than the detection group; however, these differences between the two groups are not statistically significant. Nearly 85 percent of farmers in both groups do not know the exact names of prohibited elements and which inputs contain these elements.

Lastly, Table 5 describes the informants whom respondents rely on to obtain information on shrimp cultivation technologies and shrimp disease control; in each case respondents were permitted to select only one answer. Regarding shrimp cultivation technology, 92 percent of all respondents stated that they obtained information from their friends, with only 3 percent of respondents depending on extension officers. Concerning shrimp disease treatment information, most people also responded that they acquired this information from their friends. However, the number of respondents depending on extension officers in this respect increased 11 percent compared to the previous question. Furthermore, we observed a difference between the two groups in terms of the degree of reliance on extension agents to obtain information. For both shrimp cultivation and treatment of diseases, the share of farmers relying on extension officers is higher for the undetected group.

*3.3. Risk preferences*

Several studies posit that farmers’ risk preferences play a significant role in agricultural decision-making (Feder, 1980; Just et al., 1983; Liu & Huang, 2013). Liu and Huang (2013) empirically test the correlation between Chinese cotton farmers’ risk preferences and pesticide use (to combat Bt) and find that more risk-averse farmers use greater quantities of pesticides. Based on their findings, we assume that shrimp farmers’ risk preferences have significant effects on the use of veterinary drugs.

To elicit individual risk preferences, either prospect theory (henceforth, PT) or expected utility theory (henceforth, EUT) approaches can be employed. PT adopts three parameters, such as risk aversion, loss aversion, and nonlinear probability weighting, for determining the shape of the utility function. On the other hand, EUT uses risk aversion as the sole parameter. Agricultural economists have debated which theory is most suitable to capture farmers’ risk preferences (Kahneman & Tversky, 1979; Liu & Huang, 2013; Moscardi & Janvry, 1977; Tanaka et al., 2010). This study adopts Suzuki’s approach, which follows EUT instead of PT, favoring the simplicity of this method to elicit individual risk preferences in order to create risk-aversion indices for farmers (Suzuki, 2015).

Each farmer’s risk-aversion index is based on the results of a survey-based risk preference game (see Table 6). This risk preference game has six stages and two options, namely, projects A and B, with different probabilities of receiving prizes. To elaborate, farmers who choose project A, definitely win (100 percent chance) a prize at each stage, while if farmers select project B, they have a fifty-fifty chance of winning the reward. Apart from stage six, the amount of the prize associated with project B is higher than project A, but the risk is also higher. Because their decisions are considered irrational, we drop those observations where project B is chosen in stage 6. The risk-averse index, then, is as follows:

|  |  |
| --- | --- |
|  | (1) |

where denotes each stage of the risk preference game; equals 1 if project A is chosen at stage , and zero otherwise; and is the risk-averse index. The index ranges from 1 (least risk-averse) to 6 (very risk-averse). Table 3 indicates that farmers in the non-detection group have lower risk-averse indexes than the detection group. In other words, it appears that farmers in the detection group tend to avoid risks more than do the non-detection group. However, this difference between the two groups is not statistically significant.

*3.4. Hyperbolic discounting*

Hyperbolic discounting has an advantage in terms of explaining an individual’s time-inconsistent preferences (Ainslie, 1996). For that reason, the number of studies that adopt hyperbolic discounting functions is increasing (Angeletos et al., 2001; Kubota & Fukushige, 2009; Laibson, 1996; Morimoto, 2009). Furthermore, Morimoto (2009) identified differences between hyperbolic consumers (time inconsistency) and non-hyperbolic consumers (time consistency) vis-à-vis spending behavior, using panel data from a household survey in Japan. According to Morimoto (2009), the hyperbolic consumer is inclined to spend money on impulse even if s/he has a saving plan for the future. On the other hand, non-hyperbolic consumers are more likely to adhere to personal spending plans and saving schemes.

To demarcate hyperbolic consumers, we tested respondents using a time preference game (see Table 7). This game has ten stages in two series and two options—project A and B—associated with different paydays and different amounts of money. In series 1, a player who chooses project A receives an immediate prize in each stage. If the player prefers project B, the award is paid three months from now. Overall, the amount of money associated with project B is higher than project A. Series 2 has the same conditions as series 1. Because their choices are considered irrational, we dropped the observations who switched to project A. Based on the results of this game, we use a dummy variable for indicating whether a farmer is a hyperbolic consumer or not as follows:

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| --- | --- |
|  | (2) |

where / is a discount factor for series 1; / is a discount factor for series 2;is the hyperbolic consumer dummy, equal to one if series 2’s discount factor is greater than series 1’s and 0 otherwise. Table 3 shows that 53 percent of the farmers are hyperbolic consumers. Among the detection group, this is about 8 percent higher, although the difference between the two groups is not statistically significant.

**4. Empirical Strategy**

Using the combined data from the household survey and the screenings for residual antibiotics, we first evaluate the average marginal probability effects (AMPE) in the Probit model to test the hypotheses stated above:

|  |  |
| --- | --- |
|  | (3) |

where *i* denotes individual, *j* denotes veterinary drug, and *k* denotes commune; is the detection dummy for each veterinary drug *j* (chloramphenicol, enrofloxacin, ciprofloxacin, and oxytetracycline) equal to one where a sample is found to contain more than the MHLW permissible amount of that antibiotic and 0 otherwise; *SC* captures individual *i*’s socio-economic characteristics and *FP* is individual *i*’s farming characteristics and sales performance relevant to the abuse of antibiotic *j*; *BMP* is a dummy variable set for BMPs; *SN* refers to individual *i*’s social network characteristics, such as how many shrimp input sellers and extension officers individual *i* knows; is the risk-averse index of individual *i*; is the hyperbolic consumer dummy variable; is commune fixed effect; and is the error term.

Next, equations (4) and (6) are estimated using the Tobit model, because our dependent variable is a mixture of observations with zero and positive values (Cameron & Trivedi, 2010). Among the four substances tested, for three (i.e., chloramphenicol, enrofloxacin, and ciprofloxacin), any amount detected is subject to rejection, while for oxytetracycline there is a threshold for rejection set by the MHLW. We therefore created an index that shows the total number of substances detected, and also used the quantity of oxytetracycline as dependent variables. The regressions are as follows:

|  |  |
| --- | --- |
|  | (4) |

|  |  |
| --- | --- |
|  | (5) |

where *o* denotes oxytetracycline; is the total number of substances detected—for example, if two of the four drugs are detected, the value is two—the variable’s minimum (maximum) value is zero (four); and denotes the amount of oxytetracycline residue—if the substance is not detected the value is zero parts per billion (ppb).

**5. Estimation Results**

We evaluate AMPE in the Probit model to examine the determinants of chloramphenicol, enrofloxacin, ciprofloxacin, and oxytetracycline residues. The AMPE results shown in most columns in Table 8 indicate that the probability of drug residues, except oxytetracycline, increases as the age of respondents increases. The results in column (5) show that the probability of oxytetracycline residue decreases as the years of shrimp farming increase. The BMPs training dummy indicates a negative and significant impact on both chloramphenicol and enrofloxacin residues: receiving this training decreases the probability of detecting any drug residues by 11 percent. Where farmers are networked with extension officers, the probability of detecting any drug residue decreases by 7 percent and, again, this decrease is statistically significant. These results support hypotheses 1 and 4. The risk aversion and hyperbolic consumer coefficients are positive and significant in different substances. These results thus support hypotheses 2 and 3.

Tables 9 and 10 show the results from estimating the Tobit model in terms of equations (4) and (5), respectively. The total number of elements detected is the dependent variable in Table 9. The amount of oxytetracycline residue is explained by independent variables in Table 10. Depending on the model, both tables include different explanatory variables as listed below. Column (1) includes variables for individual *i*’s socio-economic characteristics, farm characteristics, and sales performance, but excludes the dummy set for BMPs, risk-aversion index, hyperbolic consumer dummy, and individual *i*’s social network features. Column (2) excludes the risk-aversion index, hyperbolic consumer dummy, and individual *i*’s social network features. Column (3) excludes individual *i*’s social network characteristics only. The models in columns (4) contain all of the variables in equations (2) and (3).

In Table 9, the Tobit results shown in all columns confirm that the sum of detected veterinary drugs increases as the age of respondents increases. The dummy variables pertaining to receiving BMPs training and keeping records of seed use are statistically significant in most models and decrease the sum of detected veterinary drugs substantively. This result directly supports hypothesis 1. On the other hand, the results concerning the recording of input use are opposite to the results just described, despite this representing one of the BMPs. Both risk aversion and hyperbolic consumer variables are insignificant.

Table 10 indicates that prior experience of shrimp disease outbreaks decreases the amount of oxytetracycline residue significantly. The BMPs training dummy is significant in column (4) only. Keeping records of seed use, one of the BMPs, has a significant and negative impact on the quantity of oxytetracycline residue. Keeping records of input use shows opposite results compared to keeping records of seed use, despite them both being BMPs.

**6. Conclusion**

Solving problems arising from veterinary drug residues is considered an important strategy to improve both shrimp producers’ welfare and food safety for consumers. To optimize appropriate intervention strategies, determinants of drug use should be identified, and the impact of existing management efforts should be measured. Although many shrimp-exporting and -importing countries have maintained interest in this issue, few studies have attempted to quantitatively examine these determinants or estimate these impacts.

Therefore, we conducted a survey to collect information from 201 farmers in Vietnam. Based on regression analyses of these data we note that: 1) receiving BMPs training and keeping records of shrimp seed had positive, significant effects on reducing veterinary drug residues; 2) risk aversion is positively and significantly related to chloramphenicol and ciprofloxacin; 3) there is a positive correlation between residual drugs and a dummy for time-inconsistent preferences of farmers; and 4) where farmers are networked with extension officers this has a significant and positive effect on preventing use of prohibited substances. Unlike the study of Holmstrom et al. (2003), our results suggest that farmers with prior experience of shrimp disease outbreaks use smaller quantities of antibiotics. Therefore, arguably, farmers distrust the efficacy of antibiotics because prior experience of using these drugs did not reduce shrimp mortality as expected. Overall, this study contributes to revealing the determinants of detecting veterinary drugs residues in shrimp farming in multiple (social, economic, psychological) dimensions.

Further, almost all the farmers in our sample did not know the exact names of elements that are prohibited, or which inputs contain these elements. Judging from these findings, it can be presumed that farmers’ lack of knowledge about antibiotics led to an increase in veterinary drug use despite the fact that the farmers had kept records of input use.

Based on our findings, we suggest that BMPs are likely to play significant roles in reducing port rejections arising from the presence of veterinary drug residues. Thus, a way of spreading the effects of BMPs training to other farmers who do not currently receive this training should be considered. This is likely to decrease farmers’ use of veterinary drugs. Moreover, we propose that efforts to improve producers’ knowledge about antibiotics and chemicals is necessary to decrease port rejection rates given the results herein concerning inadequate knowledge. Taken together, optimizing management interventions will enhance the economic and environmental sustainability of shrimp farming.

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**Table 1. Reasons for Import Rejection of Vietnamese Fish and Fishery Products**

**between 2006 and 2010**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Japan | EU | United States |
| Bacterial contamination | 145 | 127 | 961 |
| Other contaminants | 1 | 24 | 209 |
| Additives | 32 | 33 | 120 |
| Pesticide residues | 50 | 4 | 0 |
| Adulteration/ missing document | 0 | 7 | 103 |
| Hygienic condition/ controls | 23 | 20 | 981 |
| Mycotoxins | 7 | 0 | - |
| Packaging | 2 | 2 | 0 |
| Veterinary drug residues | 297 | 172 | 170 |
| Labelling | 0 | 2 | 349 |
| Heavy metals | 0 | 61 | 0 |
| Others | 6 | 6 | 21 |
| Other microbiological contaminants | 0 | 26 | - |
| Total | 563 | 484 | 2914 |
| Source: UNIDO dataset and analysis, based on EU RASFF, US OASIS, AQUIS, and Japanese MHLW data | | | |

**Table 2. The Veterinary Drug Residue Testing Results**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Substances | Undetected | Share | Detected | Share |
| Veterinary drug | 161 | 80% | 40 | 20% |
| Chloramphenicol (CML) | 188 | 94% | 13 | 6% |
| Ciprofloxacin (CIPRO) | 186 | 93% | 15 | 7% |
| Enrofloxacin (ENR) | 179 | 89% | 22 | 11% |
| Oxytetracycline (OTC) | 190 | 95% | 11 | 5% |

Source: From own survey

**Table 3. Socio-economic and Farm Characteristics, and Sales Performance**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | (a) Undetected | |  | (b) Detected | | Dif. |
| Variable | Unit | Obs | Mean |  | Obs | Mean | (a) - (b) |
| ***Socio-economic Characteristics*** |  |  |  |  |  |  |  |
| Gender | Female=0 | 161 | 0.94 |  | 40 | 0.93 | 0.01 |
|  | Male=1 |  | [0.24] |  |  | [0.27] | (0.04) |
| Age | Years | 161 | 49.78 |  | 40 | 52.90 | -3.12 |
|  |  |  | [12.31] |  |  | [10.75] | (2.12) |
| Education | Years | 153 | 7.87 |  | 37 | 7.70 | 0.17 |
|  |  |  | [2.83] |  |  | [3.21] | (0.53) |
| Can read in English | No=0 | 161 | 0.01 |  | 40 | 0.00 | 0.01 |
|  | Yes=1 |  | [0.08] |  |  | [0.00] | (0.01) |
| Non-farm activities | No=0 | 161 | 0.16 |  | 40 | 0.10 | 0.06 |
|  | Yes=1 |  | [0.36] |  |  | [0.30] | (0.06) |
| (Risk aversion) | Index | 147 | 5.47 |  | 35 | 5.77 | -0.30 |
|  |  |  | [1.20] |  |  | [0.69] | (0.21) |
| (HC) | No=0 | 161 | 0.53 |  | 40 | 0.45 | 0.08 |
|  | Yes=1 |  | [0.50] |  |  | [0.50] | (0.09) |
| ***Farm & Sales Performance*** |  |  |  |  |  |  |  |
| Shrimp farming experience | Years | 160 | 7.95 |  | 40 | 5.48 | 2.47\*\* |
|  |  |  | [7.41] |  |  | [4.72] | (1.23) |
| Total farm land | ha | 161 | 1.33 |  | 40 | 1.48 | -0.14 |
|  |  |  | [1.66] |  |  | [1.83] | (0.30) |
| Shrimp farm size | ha | 161 | 1.16 |  | 40 | 1.45 | -0.29 |
|  |  |  | [1.53] |  |  | [1.85] | (0.28) |
| # of ponds | Number | 161 | 2.73 |  | 40 | 2.80 | -0.07 |
|  |  |  | [2.23] |  |  | [1.59] | (0.37) |
| Shrimp seed density | Piece/ | 150 | 79.70 |  | 37 | 80.89 | -1.19 |
|  |  |  | [90.01] |  |  | [88.44] | (16.29) |
| Shrimp seed price | VND/piece | 151 | 95.88 |  | 38 | 96.45 | -0.57 |
|  |  |  | [18.75] |  |  | [10.41] | (3.16) |
| Cost of shrimp seed | Million VND | 160 | 157.00 |  | 39 | 139.00 | 18.00 |
|  |  |  | [263.00] |  |  | [189.00] | (447.28) |
| Cost of shrimp feed | Million VND | 161 | 838.00 |  | 40 | 289.00 | 549\* |
|  |  |  | [1850.00] |  |  | [304.00] | (294.00) |
| Cost of permanent labors | Million VND | 161 | 21.30 |  | 40 | 15.90 | 5.47 |
|  |  |  | [53.40] |  |  | [48.30] | (9.26) |
| Cost of casual labors | Million VND | 161 | 9.61 |  | 40 | 5.63 | 3.98 |
|  |  |  | [29.30] |  |  | [19.60] | (4.89) |
| Revenue | Million VND | 161 | 1840.00 |  | 40 | 1150.00 | 688.00 |
|  |  |  | [10700.00] |  |  | [2480.00] | (1710.00) |
| *Notes*: Standard deviations are reported in brackets. Standard errors are reported in parentheses. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%. | | | | | | | |

**Table 4. Social Network Characteristics and Better Management Practices**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | (a) Undetected | |  | (b) Detected | | Dif. |
| Variable | Unit | Obs | Mean |  | Obs | Mean | (a) - (b) |
| ***Social Network*** |  |  |  |  |  |  |  |
| # of shrimp buyers | Number | 161 | 7.80 |  | 40 | 6.18 | 1.62 |
|  |  |  | [6.53] |  |  | [6.28] | (1.14) |
| # of shrimp seed sellers | Number | 161 | 4.82 |  | 39 | 4.05 | 0.77 |
|  |  |  | [6.09] |  |  | [3.78] | (1.02) |
| # of shrimp input sellers | Number | 161 | 4.39 |  | 39 | 4.03 | 0.36 |
|  |  |  | [6.10] |  |  | [3.87] | (1.03) |
| ***Better Management Practices*** |  |  |  |  |  |  |  |
| BMPs training | No=0 | 161 | 0.73 |  | 40 | 0.60 | 0.13 |
|  | Yes=1 |  | [0.45] |  |  | [0.50] | (0.08) |
| Knowledge on antibiotics | No=0 | 161 | 0.18 |  | 40 | 0.15 | 0.03 |
|  | Yes=1 |  | [0.38] |  |  | [0.36] | (0.07) |
| Knowledge on products | No=0 | 161 | 0.12 |  | 40 | 0.13 | -0.01 |
|  | Yes=1 |  | [0.32] |  |  | [0.33] | (0.06) |
| Recording water quality | No=0 | 161 | 0.16 |  | 40 | 0.18 | -0.02 |
|  | Yes=1 |  | [0.36] |  |  | [0.38] | (0.06) |
| Recording seed use | No=0 | 161 | 0.47 |  | 40 | 0.48 | -0.00 |
|  | Yes=1 |  | [0.50] |  |  | [0.51] | (0.09) |
| Recording input use | No=0 | 161 | 0.30 |  | 40 | 0.43 | -0.12 |
|  | Yes=1 |  | [0.46] |  |  | [0.50] | (0.08) |
| Recording feeding | No=0 | 161 | 0.42 |  | 40 | 0.48 | -0.05 |
|  | Yes=1 |  | [0.50] |  |  | [0.51] | (0.09) |
| Recording sales price | No=0 | 161 | 0.40 |  | 40 | 0.43 | -0.02 |
|  | Yes=1 |  | [0.49] |  |  | [0.50] | (0.09) |
| Recording sales volume | No=0 | 161 | 0.31 |  | 40 | 0.33 | -0.01 |
|  | Yes=1 |  | [0.46] |  |  | [0.47] | (0.08) |
| *Notes*: Standard deviations are reported in brackets. Standard errors are reported in parentheses. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%. | | | | | | | |

**Table 5. Types of Information Sources for Shrimp Cultivation in each Household**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Undetected | Detected | Total |
| ***Shrimp Cultivating Technology*** |  |  |  |
| Friends | 144 (89%) | 40 (100%) | 184 (92%) |
| Input seller | 5 (3%) | 0 (0%) | 5 (2%) |
| Extension officer | 6(4%) | 0 (0%) | 6 (3%) |
| Others | 6 (4%) | 0 (0%) | 6 (1%) |
| Total | 161(100%) | 40 (100%) | 201 (100%) |
| ***Treating Diseases*** |  |  |  |
| Friends | 120 (75%) | 32 (80%) | 152 (76%) |
| Input seller | 6 (4%) | 2 (5%) | 8 (4%) |
| Extension officer | 25 (16%) | 4 (10%) | 29 (14%) |
| Family | 2 (1%) | 0 (0%) | 2 (1%) |
| Others | 8 (4%) | 2 (5%) | 10 (5%) |
| Total | 161 (100%) | 40 (100%) | 201 (100%) |

**Table 6. Risk Preference Game**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Project A** | **Project B** | |
|  | You obtain for sure: | 50% chance of obtaining: | 50% chance of obtaining |
| S1 | 1 million VND | 2 million VND | 0 VND |
| S2 | 1.2 million VND | 2 million VND | 0 VND |
| S3 | 1.4 million VND | 2 million VND | 0 VND |
| S4 | 1.6 million VND | 2 million VND | 0 VND |
| S5 | 1.8 million VND | 2 million VND | 0 VND |
| S6 | 2 million VND | 2 million VND | 0 VND |

**Table 7. Hyperbolic Discounting**

|  |  |  |
| --- | --- | --- |
| *Series 1* | **Project A** Today (a) | **Project B** 3 months later (b) |
| S1 | 2 million VND | 2.2 million VND |
| S2 | 2 million VND | 2.4 million VND |
| S3 | 2 million VND | 2.6 million VND |
| S4 | 2 million VND | 2.8 million VND |
| S5 | 2 million VND | 3 million VND |
| S6 | 2 million VND | 3 million VND |
| S7 | 2 million VND | 3.4 million VND |
| S8 | 2 million VND | 3.6 million VND |
| S9 | 2 million VND | 3.8 million VND |
| S10 | 2 million VND | 4 million VND |
| *Series 2* | **Project A** 3 months later (c) | **Project B** 6 months later (d) |
| S1 | 2 million VND | 2.2 million VND |
| S2 | 2 million VND | 2.4 million VND |
| S3 | 2 million VND | 2.6 million VND |
| S4 | 2 million VND | 2.8 million VND |
| S5 | 2 million VND | 3 million VND |
| S6 | 2 million VND | 3.2 million VND |
| S7 | 2 million VND | 3.4 million VND |
| S8 | 2 million VND | 3.6 million VND |
| S9 | 2 million VND | 3.8 million VND |
| S10 | 2 million VND | 4 million VND |

**Table 8. Determinants of the Veterinary Drug Residue: Average Marginal Probability Effects (AMPE) from the Probit Model**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Dependent variable | Dummy drug | Dummy  CML | Dummy ENR | Dummy CIPRO | Dummy  OTC |
|  | (1) | (2) | (3) | (4) | (5) |
| Respondent’s age | 0.004\*\* | 0.0000000005\*\* | 0.003\*\* | 0.0000002\* | -0.0000009 |
|  | (0.002) | (0.000000002) | (0.002) | (0.0000003) | (0.000001) |
| Years of education | 0.01 | 0.0000000001 | 0.01 | 0.0000002 | -0.0000005 |
|  | (0.01) | (0.0000000007) | (0.00) | (0.0000006) | (0.000003) |
| Shrimp farming experience | -0.003 | -0.0000000003 | -0.001 | -0.0000002 | -0.000004\*\* |
|  | (0.003) | (0.000000001) | (0.002) | (0.0000003) | (0.000005) |
| Shrimp seed density/ | 0.0003 | 0.00000000002 | 0.0003\*\* | -0.000000003 | -0.00000003 |
|  | (0.0003) | (0.00000000008) | (0.0002) | (0.00000002) | (0.00000007) |
| Shrimp farm land | 0.005 | -0.000000006\*\* | 0.02\*\* | 0.000002 | -0.00001\*\*\* |
|  | (0.01) | (0.00000002) | (0.01) | (0.000002) | (0.00002) |
| Shrimp seed price/piece | -0.00003 | 0.00000000003 | -0.0003 | -0.00000004 | 0.0000002 |
|  | (0.001) | (0.0000000001) | (0.0004) | (0.00000006) | (0.0000002) |
| Cost for feeding/ha | -0.0001\*\*\* | -0.00000000002 | -0.00001 | -0.000000001 | -0.000000007 |
|  | (0.00004) | (0.00000000005) | (0.000009) | (0.000000002) | (0.00000001) |
| Disease outbreak | -0.11\*\* | 0.000000003 | -0.14\*\*\* | -0.00001 | 0.00001 |
|  | (0.07) | (0.00000001) | (0.06) | (0.00002) | (0.00001) |
| BMPs training | -0.11\*\* | -0.00000006\* | -0.06\* | -0.00001 | -0.000002 |
|  | (0.07) | (0.0000003) | (0.05) | (0.00001) | (0.00002) |
| Recording water quality | -0.01 | 0.0000002 | -0.05\* | -0.000002 | 0.001\*\* |
|  | (0.07) | (0.0000009) | (0.02) | (0.000003) | (0.003) |
| Recording seed use | -0.21 | -0.00000005 | 0.14\* | 0.000006 | -0.00945\*\*\* |
|  | (0.15) | (0.0000002) | (0.10) | (0.00001) | (0.01) |
| Recording input use | 0.10 | 0.000000004 | 0.12\*\*\* | 0.00003\*\* | -0.00002\* |
|  | (0.09) | (0.00000002) | (0.07) | (0.00004) | (0.00003) |
| Recording feeding | 0.11 | 0.00000004 | -0.26\*\*\* | -0.00003\*\* | 0.003\*\*\* |
|  | (0.15) | (0.0000002) | (0.10) | (0.00004) | (0.005) |
| (Risk aversion) | 0.01 | 0.00000003\*\*\* | -0.002 | 0.00004\*\*\* | -0.000008 |
|  | (0.02) | (0.0000001) | (0.01) | (0.00004) | (0.00001) |
| (HC) | -0.02 | -0.000000001 | -0.03 | -0.000005 | 0.00008\*\* |
|  | (0.04) | (0.000000007) | (0.03) | (0.000006) | (0.0001) |
| No. shrimp input sellers | -0.001 | -0.0000000001 | 0.001 | 0.0000002 | -0.000001 |
|  | (0.004) | (0.0000000007) | (0.003) | (0.0000003) | (0.000002) |
| No. extension officers | -0.07\* | -0.000000004 | -0.02 | -0.000002 | -0.0003 |
|  | (0.04) | (0.00000002) | (0.02) | (0.000003) | -0.0004 |
| Commune fixed effect | Yes | Yes | Yes | Yes | Yes |
| Observations | 147 | 147 | 147 | 147 | 147 |
| Pseudo R2 | 0.25 | 0.45 | 0.24 | 0.23 | 0.40 |
| *Notes*: Standard errors in parentheses are clustered for 9 communes. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%. CML is the abbreviation for chloramphenicol, ENR is the abbreviation for enrofloxacin, CIPRO is the abbreviation for ciprofloxacin, OTC is the abbreviation for oxytetracycline. Nine communes exist in our data set. | | | | | |

**Table 9. The Sum of Veterinary Drugs: Tobit Model**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dependent variable | Total number of substances detected (0-4) | | | |
|  | (1) | (2) | (3) | (4) |
| Respondent’s age | 0.04\* | 0.05\*\* | 0.05\* | 0.05\*\* |
|  | (0.02) | (0.02) | (0.02) | (0.02) |
| Years of education | 0.09 | 0.08 | 0.07 | 0.07 |
|  | (0.08) | (0.09) | (0.09) | (0.09) |
| Shrimp farming experience | -0.08\*\* | -0.06 | -0.05 | -0.05 |
|  | (0.04) | (0.04) | (0.04) | (0.04) |
| Shrimp seed density/ | 0.003 | 0.003 | 0.003 | 0.003 |
|  | (0.003) | (0.003) | (0.003) | (0.003) |
| Shrimp farm land | 0.19 | 0.15 | 0.14 | 0.08 |
|  | (0.18) | (0.18) | (0.19) | (0.19) |
| Shrimp seed price/piece | -0.001 | 0.0003 | 0.0005 | -0.00 |
|  | (0.01) | (0.01) | (0.01) | (0.01) |
| Cost for feeding/ha | -0.001\*\*\* | -0.001\*\* | -0.001\*\* | -0.001\*\* |
|  | (0.0004) | (0.0005) | (0.0004) | (0.0005) |
| Disease outbreak | -0.88 | -1.01\* | -1.12\*\* | -1.17\*\* |
|  | (0.58) | (0.56) | (0.55) | (0.56) |
| BMPs training |  | -1.11\* | -1.05\* | -1.20\*\* |
|  |  | (0.59) | (0.60) | (0.60) |
| Recording water quality |  | -0.23 | -0.38 | -0.23 |
|  |  | (1.00) | (0.98) | (0.97) |
| Recording seed use |  | -2.91\* | -2.79\* | -2.54 |
|  |  | (1.61) | (1.61) | (1.59) |
| Recording input use |  | 1.29\* | 1.35\* | 1.29 |
|  |  | (0.73) | (0.78) | (0.81) |
| Recording feeding |  | 0.98 | 1.02 | 0.95 |
|  |  | (1.59) | (1.57) | (1.53) |
| (Risk aversion) |  |  | 0.25 | 0.21 |
|  |  |  | (0.25) | (0.25) |
| (HC) |  |  | -0.31 | -0.28 |
|  |  |  | (0.58) | (0.58) |
| No. shrimp input sellers |  |  |  | -0.01 |
|  |  |  |  | (0.05) |
| No. extension officers |  |  |  | -1.25 |
|  |  |  |  | (0.84) |
| Commune fixed effect | Yes | Yes | Yes | Yes |
| Constant | -4.08\*\* | -3.65 | -4.81\* | -4.18 |
|  | (2.00) | (2.27) | (2.68) | (2.68) |
| Observations | 147 | 147 | 147 | 147 |
| *Notes*: Robust standard errors in parentheses. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%. Nine communes exist in our data set. | | | | |

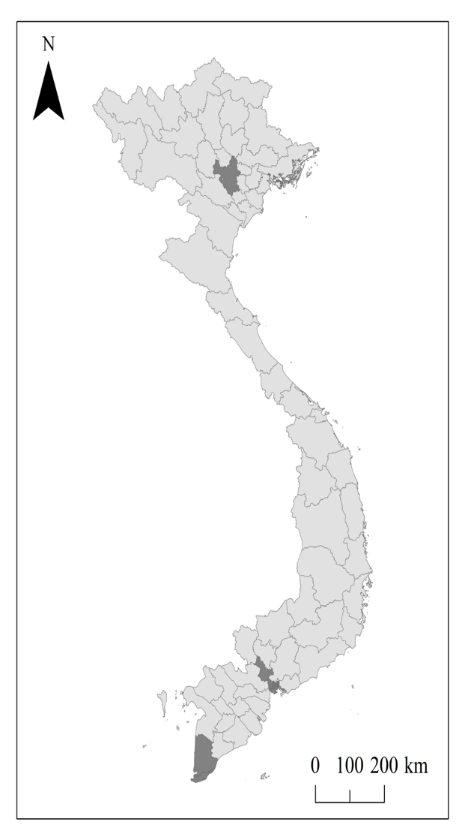
**Table 10. The Amount of Oxytetracycline Residue: Tobit Model**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Dependent variable | Amount of OTC detected | | | |
|  | (1) | (2) | (3) | (4) |
| Respondent’s age | -5.32 | -3.35 | -3.39 | -2.90 |
|  | (4.40) | (4.95) | (4.93) | (4.84) |
| Years of education | -4.71 | -10.48 | -10.60 | -6.43 |
|  | (20.93) | (22.08) | (22.16) | (21.34) |
| Shrimp farming experience | -7.77 | -5.81 | -6.41 | -5.72 |
|  | (7.76) | (8.18) | (7.76) | (7.97) |
| Shrimp seed density/ | 0.38 | 0.50 | 0.53 | 0.54 |
|  | (0.67) | (0.69) | (0.69) | (0.69) |
| Shrimp farm land | 19.64 | 9.01 | 9.69 | -1.74 |
|  | (25.17) | (26.77) | (26.60) | (27.47) |
| Shrimp seed price/piece | 1.54 | 2.02 | 2.00 | 1.83 |
|  | (2.44) | (2.42) | (2.46) | (2.50) |
| Cost for feeding/ha | -0.04 | -0.04 | -0.04 | -0.05 |
|  | (0.06) | (0.05) | (0.06) | (0.06) |
| Disease outbreak | -192.48 | -207.36\* | -197.63\* | -190.07\* |
|  | (116.46) | (112.09) | (109.41) | (110.72) |
| BMPs training |  | -193.00 | -195.38 | -224.16\* |
|  |  | (121.81) | (125.24) | (123.46) |
| Recording water quality |  | -28.04 | -19.93 | 28.02 |
|  |  | (181.88) | (172.75) | (175.94) |
| Recording seed use |  | -790.89\* | -805.32\* | -727.41\* |
|  |  | (433.23) | (426.85) | (411.66) |
| Recording input use |  | 425.97\* | 422.53\*\* | 376.68\* |
|  |  | (219.54) | (206.88) | (200.73) |
| Recording feeding |  | 373.49 | 377.28 | 346.83 |
|  |  | (373.25) | (365.25) | (357.48) |
| (Risk aversion) |  |  | -13.20 | -14.38 |
|  |  |  | (40.97) | (41.07) |
| (HC) |  |  | 23.21 | 35.62 |
|  |  |  | (105.58) | (106.25) |
| No. shrimp input sellers |  |  |  | -7.82 |
|  |  |  |  | (10.88) |
| No. extension officers |  |  |  | -225.93 |
|  |  |  |  | (175.72) |
| Commune fixed effect | Yes | Yes | Yes | Yes |
| Constant | -63.30 | -29.56 | 39.23 | 68.62 |
|  | (393.06) | (404.50) | (481.21) | (491.11) |
| Observations | 147 | 147 | 147 | 147 |
| *Notes*: Robust standard errors in parentheses. \* significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%. OTC is the abbreviation for oxytetracycline. Nine communes exist in our data set. | | | | |



Source: FAO

**Figure 1. Viet Nam’s Shrimp Exports between 1990 and 2013**



Ho Chi Minh

Hanoi

Ca Mau

Source: GADM (2015)

**Figure 2. The Map of Viet Nam**

1. Corresponding author: Department of International Studies, Graduate School of Frontier Sciences, University of Tokyo, Environmental Studies Building #706, 5-1-5 Kashiwanoha, Kashiwa-shi, Chiba-ken 277-8563 Phone: +81 80-4726-6874 email: 0872607264@edu.k.u-tokyo.ac.jp [↑](#footnote-ref-2)
2. Department of International Studies, Graduate School of Frontier Sciences, University of Tokyo [↑](#footnote-ref-3)
3. Faculty of International Economics, Foreign Trade University [↑](#footnote-ref-4)
4. Doi Moi is the Vietnamese for the English renovation. The economic reform of Viet Nam initiated in 1986 with the goal of creating a socialist-oriented market economy (World Library Foundation, n.d.). [↑](#footnote-ref-5)
5. If the MHLW detects an amount of oxytetracycline residue from shrimp samples above 0.2 ppm, they reject these shrimp imports. The MHLW rejects shrimp imports depending on the presence of chloramphenicol, enrofloxacin, and ciprofloxacin residues (The Japan Food Chemical Research Foundation, 2015). [↑](#footnote-ref-6)
6. BMPs was developed by the international community, spearheaded by the World Bank, the Network of Aquaculture Centers in Asia-Pacific (NACA), the World Wildlife Fund (WWF), FAO, and the United Nations Environment Program (UNEP) (NACA, 2006). [↑](#footnote-ref-7)
7. The residual drugs may come from different sources such as antibiotics, industrial feeds, shrimp seeds, and so on. Therefore, it is possible to detect these residuals even if farmers do not use antibiotics. [↑](#footnote-ref-8)
8. Between 2006 and 2010, average rejection rates of Vietnamese fish and fishery products rank 9th in the EU, 6th in the US, and 10th in the Australia, respectively. [↑](#footnote-ref-9)
9. This survey was granted permission by Ca Mau Department of Agriculture and Rural Development. [↑](#footnote-ref-10)
10. This was based on advice from industry experts, as these are the most frequently tested and detected substances at the ports of developed countries. [↑](#footnote-ref-11)