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Does Application for Quality Assurance Certification by Shrimp Farmers Enhance the Implementation of Traceability Along the Supply Chain? Evidence from Vietnam

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This study investigated the effects of applications of international quality assurance certification at farm level on implementation of traceability along the shrimp supply chain with the evidences from Vietnam. Descriptive statistics was explored to compare in terms of products, information flows, financial efficiency, and willingness to implement traceability between certified and non-certified quality assurance shrimp farms. Binary logistics model was applied to examine the effects of applications of international quality assurance certification and other factors to the willingness to implement traceability of shrimp farmers. Found results showed that the applications of international quality assurance certification of shrimp farmers supported traceability of shrimp products among stakeholders in the supply chain. The certified farmers indicated a higher willingness to implement traceability. However, the profitability of those applications for shrimp farmers was not statistically found. The economics incentives, including farm-gate price differentiation and minimization of production costs should be carefully considered.

Keywords: Traceability, Food Safety, Quality Assurance, Shrimp Supply Chain, Vietnam

Introduction

Various incidents relating to contamination of food supplies that have occurred all over the world have reduced consumer confidence and increased demand for accurate information regarding the safety and quality of food products (Handford et al., 2015). In an attempt to increase consumer confidence, traceability systems have been introduced to enable food chains to be monitored throughout all stages of production, processing, and distribution (Golan et al., 2004; Hall, 2010).

Generally, a traceability system, by itself, does not directly increase the safety and quality of food products (van der Vorst, 2006). It is designed to record and keep information of food producers and other stakeholders in the supply chain, which support to trace from whom and to whom a food product has been obtained and supplied (Marucheck et al., 2011). Therefore, both consumers and food producers are able to identify the source of food contamination, and correct the misconceptions that may occur during production with a systematic view throughout the certain and timely information in relation to food products, which are maintained in traceability systems (Dong, Saito, Hoa, et al., 2019). These systems, then, are to improve the safety and quality of food producers in the supply chain (Pouliot & Sumner, 2013), reduce the operating costs, and increase the economic efficiency for food producers (Umberger et al., 2003; van Kleef et al., 2007; Bosona & Gebresenbet, 2013).

However, it is the fact that consumers in the world are not necessarily interested in traceability implemented for the purchased food, and have not yet demanded separate traceability systems when making food-purchasing decisions (Gellynck & Verbeke, 2001; Giraud & Amblard, 2003; Uchida et al., 2013; Wu et al., 2016). Instead, they have only recently linked traceability to quality and safety issues, and more interested in obtaining information about food quality and ingredients (Dong, Saito, Tojo, et al., 2019). Thus, traceability systems may become more valuable to consumers if they can provide information related to food safety, quality, and ingredients (Hobbs et al., 2005; Verbeke & Ward, 2006; Zhang et al., 2020).

Shrimp is now a major global food product, accounting for 15.5% of the value of all seafood products (Flaaten, 2018). The major suppliers of shrimp products include India, Vietnam, Thailand, China, Indonesia, Bangladesh, and Ecuador (Food and Agriculture Organization [FAO], 2018). More than 40% of shrimp products, which are produced by those countries, are exported to high-living-standard markets such as the United States, Europe, and Japan (FAO, 2018). Those markets have imposed more stringent regulations in terms of food safety, quality, and traceability issues, comparing those of the other importing countries (Charlebois et al., 2014).

Similar as other food products, traceability has not been separately imposed on shrimp, but has been required to achieve various international quality assurance certification systems such as GLOBAL Good Agriculture/Aquaculture Practices (GlobalGAP), the Aquaculture Stewardship Council (ASC), Best Aquaculture Practices (BAP), the Marine Stewardship Council (MSC), and hazard analysis and critical control points (HACCP) certification in addition to food safety, environmental, and social welfare requirements (Dong, Saito, Hoa, et al., 2019). Certified products are labeled to help consumers to identify these products, and signal a commitment regarding quality and safety from shrimp producers. Furthermore, application of quality assurance certification is expected to increase liability on the part of shrimp producers in relation to quality, safety and possibility of implementing traceability along supply chain.

Several scientific studies have indicated that the application of quality assurance practices for seafood products, including shrimp, would enhance their acceptability in global markets (Ha & Bush, 2010, Tran et al., 2013; Suzuki & Nam, 2018). Regarding economics implication, the application of quality assurances certification and implementation of traceability may increase the value adding for seafood products throughout the distribution channels (Bailey et al., 2018). Consumers are willing to pay from 14-24% higher price premium for the certified products (Huynh et al., 2017). Thus, it is estimated that the shrimp producers might increase the financial benefits with the application of quality assurance certification.

Moreover, the willingness to implement traceability of shrimp producers was positively reflected by the awareness and perception about the traceability systems (Lusk & Norwood, 2008). The certified shrimp producers were well-trained in attempt to achieve the quality assurance certification (Dong, 2019). They, then, are estimated to have a better awareness about the necessary of traceability implementation for their products, compared with the non-certified producers.

In Vietnam, shrimp production plays an important role in terms of rural development, increased incomes, and improved livelihoods (Duc, 2009; United Nations Development Programme [UNDP], 2016). Vietnamese shrimp products are mainly exported, accounting for 70–80% of total production (Portley, 2016; Tran et al., 2013).

In 2017, Vietnam's shrimp exports were valued at 3.85 billion USD, with the main markets being the United States, Europe, and Japan, which accounted for more than 50% of the total export value (Vietnam Association of Seafood Exporters and Producers [VASEP], 2017). Vietnam's Mekong Delta was the largest area for farmed shrimp production, accounting for more than 70% of Vietnam's total production (Vietnam General Statistics Office [Vietnam GSO], 2017).

Vietnamese shrimp supply chain includes local and global side (Loc, 2006). Among these, the local participants in supply chain include input suppliers (i.e. hatchery, feed, drug and chemical suppliers), farmers, middlemen (i.e. collectors, brokers, and traders), processors and exporters. In global side, the shrimp agents in supply chain are importers, distributors, retailers, and consumers. Recent concerns regarding food quality, safety, and traceability in the main importing countries, and competition from other exporting countries requires a response from Vietnamese shrimp producers in local side if they expect to access international markets.

Among the local agents, shrimp processors and exporters have well-invested the internal information management systems, which may support the traceability of inputs-outputs flows of shrimp products among those processing and exporting companies and their backward suppliers and downward customers (Nga Mai et al., 2010). In addition, those processors and exporters have also applied the international quality assurance certifications, which have been required for seafood factories and companies in concordance with the requirements of their targeted customers in the global side. Notably, requirements of traceability, quality and safety issues imposed on shrimp products from the global side firstly come to the processors and exporters (Dong, 2019). Hence, the requirements of global customers in relation to traceability, quality and safety for

Vietnamese shrimp products are entirely satisfied if other local shrimp agents of the supply chain are willing to comply these requirements.

However, application of quality assurances and implementation of traceability activities have not been paid attention by other agents in the local side (Loc, 2006). There is no separated traceability systems that have been recently implemented by those local agents (Dong, 2019). An unwillingness to obtain quality assurance certification and implement traceability systems of local shrimp producers in the supply chain was found (Uddin, 2009; Dong, Saito, Hoa, et al., 2019). Regarding the application of international quality assurance certification, an approximate 88% of total shrimp production areas in Vietnam has not currently certified yet (Boyd et al., 2018). It was because the lacking of budgets for application of quality assurance certifications (e.g. registration, audits and preparation) and maintenance the systems of local shrimp producers, who are out of reach those costs, less awareness of financial benefits, differentiation in farm-gate price between the certified and non-certified of shrimp products.

To the best of our knowledge, no previous studies have scientifically investigated the affecting of application of quality assurance certification at the farm level to the implementation of traceability systems along the shrimp supply chain in Vietnam and all over the world. Particularly, there is no current studies figure out the differences in relation to the movement and traceability of information between certified and non-certified shrimp products correlation with distribution channels of the supply chain. Furthermore, the allocation of benefits to shrimp farms and the farmers' willingness to implement traceability systems, which have been effected by the application of quality assurances, have not scientifically studied yet.

Therefore, this study investigates the effects of shrimp farmers' application of quality assurance certifications on the probability of the traceability implementation along supply chain. For this purpose, empirical evidence from the Vietnamese shrimp supply chain was analyzed to examine the differences in traceability between shrimp products with the quality assurance certification and products from non-certified shrimp farms. In addition, financial efficiency of shrimp farms and factors affecting to farmers' willingness to implement traceability systems were even investigated in an attempt to identify differences between certified and non-certified shrimp farms.

Materials and Methods

Data collection

An interview survey was conducted in July 2017 that covered the supply chain including farmers, collectors, brokers, processors, and exporters. The main study area was Ca Mau province, which accounts for 44% of all shrimp production in the Mekong Delta region and 36% of Vietnam's total production. In this study, a total of 114 shrimp farmers were included in the survey sample. The sample structure is shown in Table 1.

[INSERT TABLE 1 HERE]

Hence, to achieve the purposes of this study, two groups of shrimp farmers were interviewed. The sampling included 114 shrimp farmers, who were the certified and the non-certified farmers. Of these, 32 farmers, who are the members of the Cai Bat Cooperative in Ca Mau province, Vietnam, had been awarded the ASC certification. The Cai Bat Cooperative was the successful shrimp cultivation area of application of ASC certification for shrimp products. The other 82 were individual farmers in Cai Nuoc district, Phu Tan district, and Ca Mau city of Ca Mau province had been randomly chosen according to the list of shrimp farms, which managed by the Ca Mau Provincial Department of Fisheries (see Figure 1).

[INSERT FIGURE 1 HERE]

A structured questionnaire had been used for the interview survey at farm level, consisting of items related to (i) socioeconomic demography, productivity, unit prices, and production costs, (ii) distribution flows of the harvested shrimp, (iii) the procedures of information management (e.g. recording, keeping and exchanges of information activities), and (iv) willingness to implement traceability activities.

During the time of survey, the information of productivity, unit farm-gate price, and production costs were investigated based on the latest cultivated harvest in 2017, which finished before conducting survey. The procedures used to investigate shrimp farmers' willingness to implement traceability systems are shown in Figure 2.

[INSERT FIGURE 2 HERE]

A pre-test survey indicated that the shrimp farmers' decision to implement a traceability system was liable to change after the attributes of a traceability system were explained. Therefore, during the interview, shrimp farmers were asked the same question before and after our explanation of traceability systems to confirm their willingness to implement a traceability system. Those who responded in the affirmative to the second question were willing to implement a traceability system.

Furthermore, the implementation of traceability systems, which focused on the requirements of recording, keeping, and exchange of information between the shrimp farms and the buyers, were carefully interpreted to shrimp farms in the interview. The benefits and costs of these activities were particularly proposed. Shrimp farmers, who answered that he/she was willing to comply with those requirements from the buyers and accepted the proposed benefits and costs, were defined as willing to implement traceability.

Information regarding the other actors in the shrimp production process was obtained based on their point of entry along shrimp supply chain. To accommodate with the traceability rule "one step back and one step forward", the information of the downstream actors along supply chain was traced, and collected based on the information collected from the upstream agents.

Accordingly, to achieve this purpose, the information of shrimp buyers, who directly bought the harvested shrimp from farmers was identified, and contacted to do interviews. The other agents in the next stages of the supply chain, then, had been continuously asked and interviewed through the information provided by the previously interviewed agents concordant with the flows of harvested shrimp. The information of these actors, which focused on operating attributes such as capital, infrastructure, organization, and business experience, management of the flows of inputs and outputs, including price, quantity, quality, origin, and traceability-related matters (i.e. information recording and keeping, buyer requirements, perceptions, implementation, management, challenges, and customer requirements regarding traceability systems) was obtained by face-to-face interviews.

Data analysis

The distribution flows, information flows and implementing traceability along the supply chain were compared to investigate the differences of those between certified and non-certified shrimp products.

Regarding the investigation differences in the financial efficiency between certified and non-certified farms, the comparisons of productivity, unit farm-gate price, production costs, and profits between certified and non-certified farms were explored by using descriptive statistics, including mean, frequency, and percentage. T-tests were used to identify statistical significant differences between the certified and non- certified shrimp farms in terms of financial efficiency.

Binary logistic regression, which models the probability that shrimp farmers were willing to implement traceability for their farms with an assumption of standard logistic distribution of errors as suggested by Hensher and Greene (2003), was explored to estimate the factors influencing to the willingness to implement traceability of shrimp farmers, given by the basic form as follow:

$$\text{Logit}[Pr(WTI_i = 1|X)] = \frac{\log[Pr(WTI_i=1|X)]}{1-log[Pr(WTI_i=1|X)]} = \beta_0 + X_i^{'}\ \beta_i$$

where, $X^{'}$ is the transpose of X; $X_i^{'}$ $(i = 1, n)$ was explanatory variables which were observed as the potentially influencing factors to WTI, β_0 is intercept; β_i indicates the parameters respective to the explanation of $X_i^{'}$ on WTI. The chi-square tests was explored to measure the goodness-of-fit of the model and the setting a maximum p-value of 10% was used as suggested by Duc (2010).

The prior explanatory variable included in the model was the state of application of international quality assurance certification at shrimp farms to test its effects on the willingess to implement traceability of farmers, and ability to implement traceability along the shrimp supply chain in advance. The certified shrimp farmers were assumed to indicate a higher probability to implement traceability as discussed in the previous study (Bailey et al., 2016; Dong, Saito, Hoa, et al., 2019; Dong, Dan & Duy, 2019). Besides that, the perception of farmers about the role of the application of quality assurance certification for shrimp productswas hypothesized as an important affecting determinant to increase the willingness to implement traceability of shrimp farmers (Loc, 2006; Uddin, 2009).

Socio-demographic characteristics, including age of respondents and experiences of shrimp farmers were included into the model because of their role in decision making for the shrimp farm activities, such as the implementation of traceability systems (Coughenour & Swanson, 1992; Frey & Stutzer, 2002; Duc, 2010).

The indicators in relation to the financial efficiency, including current farm-gate price received from the buyers, variable costswere estimated to be the important determinnants of the expectation of shrimp farmers to implement traceability (Ling et al., 1999; Hasan, 2007). The shrimp farmers were supposed to increase the acceptability if they were able to gain a better price, and save more costs.

The farming conditions, such as shrimp species and the participations into Cooperatives and/or Collaborative Organization (i.e. Farmer's Local Organization) were added to examine the influencing of those factors to the willingness to implement traceability of shrimp farmers as suggested by Dong (2019).

In this study, the total land used for shrimp farms was included to explore the influencing of farming scale to the willingness to implement traceability of shrimp farmers. The production scale might reflect to the differences in the decision-making for farms operation investments, choosing the buyers of farmers and distribution flows of the harvested shrimp products. Large-scale farmers were hypothesized to have more negotiation power about the farm-gate price with the buyers, comparing to small-scale farmers (Suzuki & Nam, 2018). During the interview survey, the important role of land to decision-making procedures of shrimp farmers was found. Land not only was a directly resource to use for farming activities, but also was the most assets of shrimp farmers, who were able to mortgage their own land to lend the cash from formal bank systems. Hence, shrimp farmers with more land, therefore, might have more advantages to extend more investments to the farms, including the implementation of traceability activities.

The description of explanatory variables included in the model is described in Table 2.

[INSERT TABLE 2 HERE]

Results

Traceability of the Vietnamese shrimp supply chain: evidence from the interview survey in Ca Mau province, Vietnam's Mekong Delta region

Figure 3 showed the distribution flows and current traceability of shrimp products along the supply chain in the Mekong Delta region in Vietnam. Overall, the flows of shrimp products and information from the farms to the processing companies reflected the current state of application of quality assurance certification (i.e. ASC certification as in our interview survey), cultivation methods used on the farms and the shrimp species cultivated. In the samples, shrimp farmers were cultivating two shrimp species, namely, black tiger shrimp (*Penaeus monodon*) and white leg shrimp (*Litopenaeus vannamei*). The cultivation systems included extensive and intensive farming[i]. The details are as follows.

Shrimp products provided by non-ASC certified shrimp farms

Extensive farms. The results of the survey indicated that shrimp farms using an extensive cultivation system had not signed contracts with buyers. Instead, their products were distributed to collectors, who contacted them directly and purchased around 2−10 kg per day per farm.

The collectors sold these shrimp products to either brokers or traders. The transactions between the collectors and both the upstream (farmers) and downstream (brokers or traders) agents were based on family networks and involved verbal agreements.

Collectors provided about 70–75% of the total quantity collected to brokers and/or traders. The remaining 25–30% of the quantity collected from extensive farms was provided directly to processing companies.

Intensive farms. Shrimp products from intensive farms were forwarded to processing companies, either with or without the intervention of brokers and/or traders. Of the sample, 97.5% of non-ASC certified intensive farms sold their shrimp products to brokers or traders, while only 2.5% had signed a contract to provide their shrimp products directly to processing companies.

Information flows and traceability. To implement a traceability system, information needs to be recorded at the shrimp farms and then exchanged with other agents along the supply chain. In relation to information recording and keeping activities, 72/82 ($\sim \mathbf{87\%}$) of non-ASC certified farms in the sampling did not record information related to their production activity. Other farmers have recorded the information related to the price and quantity of inputs and the farm-gate price and quantity of harvested shrimp to manage the farms' performance.

Shrimp products provided by ASC certified shrimp farms to processing companies

The ASC certified farms participating in the Cai Bat Cooperative provided all of their shrimp products to the contracted processing company. In response to the information-recording requirements under the ASC standards, the shrimp farmers recorded and retained information regarding their production process. This information was recorded on the official forms provided by the contracted company. The Cooperative's committee was responsible for ensuring that the information regarding the production process and the quality of shrimp products complied with the ASC standards. Thus, processors were able to monitor the information that was provided with the support of the Cooperative's committee. The shrimp farmers forwarded the information to the processing company at harvest time, and the information was recorded on the processing company's internal database and used for traceability procedures at the processing company.

[INSERT FIGURE 3 HERE]

Management of product and information flows of shrimp farming inputs at processing companies

Processing companies paid close attention to traceability to ensure that they could meet the requirements of global customers. Inputs were provided to the processing companies by shrimp farmers (i.e. ASC certified farms and contracted farms), collectors, and brokers. The processors recorded the information supplied by the ASC certified farms under their contract using the forms provided (see Figure 4).

[INSERT FIGURE 4 HERE]

As for the collectors and brokers, the processors required them to provide a range of information including the name of the supplier, date, shrimp species (black tiger shrimp or white leg shrimp), size, quantity, price, quality-testing results, and cultivation area, together with invoices and/or other documents relating to their transactions. Processors identified the cultivation area of the shrimp inputs as the area of operation of the suppliers.

The shrimp farming inputs have to pass a quality inspection, which was audited by the quality management department. Inputs that passed the inspection procedure were allocated a trace code and the information provided by the suppliers was recorded as part of the internal traceability system. Processors were able to use that information to track shrimp products back to the brokers and the suppliers of inputs to the shrimp farmers.

Financial efficiency of shrimp farmers in terms of ASC certification

Comparisons between ASC certified and non-ASC certified farms based on the survey responses regarding unit prices, costs, and profits are shown in Table 3.

[INSERT TABLE 3 HERE]

The results in Table 3 showed that the application of ASC certification did not lead to higher profits[ii]. The farm-gate price for certified shrimp products was less than that for non-certified products. Unit price aside, the productivity was not improve under ASC application. Moreover, it was found that the shrimp farmers under ASC application paid a higher production costs, compared to non-ASC farmer. The higher production costs of ASC farmers was found, suggesting that to shrimp famers might need to spend more money to invest for farms' operation in attempt to apply ASC certification.

Regarding black tiger shrimp, the ASC certified farms incurred a loss, as opposed to the non-ASC certified farms, which showed a profit, while for white leg shrimp, the ASC certified farms' profits were less than half those of the non-ASC certified farms. However, neither of these differences was statistically significant at the 0.05 level when T-tests were used to compare the means. Similarly, the differences between the total costs of the ASC certified and non-ASC certified farms for both shrimp species were not statistically significant at the 0.05 level. As for black tiger shrimp, the results showed that there was no statistically significant difference between the farm-gate prices received by ASC certified and non-ASC certified farms ($p < 0.05$), while for white leg shrimp, the farm-gate price received by ASC certified farms was significantly lower than that received by non-ASC certified farms ($p < 0.05$).

Shrimp farmers' willingness to implement traceability systems

The results of the survey indicated that the shrimp farmers' willingness to implement traceability systems increased after the benefits of traceability were explained to them. Prior to the explanation, 74 shrimp farmers (65%) confirmed that they were willing to invest in traceability systems, but following the explanation, this rose to 96 farmers (84%) (see Figure 5).

[INSERT FIGURE 5 HERE]

The results also confirmed the relationship between shrimp farmers' application of ASC certification and their willingness to invest in traceability systems. All of the ASC certified shrimp farms confirmed that they were willing to invest in the traceability system, while for non-ASC certified farms, their willingness to invest in the traceability system increased following the explanation of the traceability system, as shown in Figure 6. Prior to the explanation, 42 non-ASC certified shrimp farms (51%) confirmed that they were willing to invest in the traceability system. However, after the system was explained, 64 non-ASC certified shrimp farms (78%) confirmed that they were willing to implement traceability systems. Shrimp farmers who were seeking ASC certification were better trained and more aware of the requirements of global markets in relation to food safety, quality, and traceability than non-ASC certified farmers. Therefore, ASC certified shrimp farmers were more aware of the importance of traceability implementation. In contrast, non-ASC certified shrimp farmers were initially undecided regarding traceability. Thus, our explanation of the potential benefits was help to increase their willingness to implement traceability systems.

Factors influencing to shrimp farmers' willingness to implement traceability systems

As can be seen in Table 4, the proportional odds test (χ^2=39.31, Pseudo R^2=0.40) confirms that the binary logistic model is relevant to explore the effect of related determinants on the dependent variable (probability of willingness to implement traceability of shrimp farmers). The chi-square tests for goodness-of-fit of the model justify that the regression results are significant ($p < 0.01$).

[INSERT TABLE 4 HERE]

The estimated results of logistic model confirmed the positive effects of application of quality assurance certification to the probability of willingness to implement traceability of shrimp farmers ($p < 0.01$), suggesting that the certified shrimp farmers indicated a higher ability to be willing to implement traceability.

Moreover, the perception of shrimp farmers about the important role of application of quality assurance certification did negatively influence their willingness to implement traceability's probability ($p < 0.01$). This result did not corresponded our prior hypothesis and the previous findings of Rahman et al. (2017), who indicated that the highly perceived important role of quality and safety issues of farmers positively effected on their decision making to implement traceability. Probably, the shrimp farmers participated in our interview might not really be familiar with a seperated traceability systems. Instead of that, they might speculate that the application of quality assurance certification might be a better alternative.

The statistical significance of farming conditions variables, including age, shrimp cultivation speicies, and the participation to cooperatives of shrimp farmers ($p < 0.05$) were suggesting the important role of those factors to the implementing traceability.

Addition, the statistical contributions of the farm-gate price to the probability of shrimp farmer's willingness to implement traceability were found ($p < 0.1$). On the other hand, the spending of variable costs for shrimp farms presented for the investment to shrimp farms activities. The negative influence of this variable was suggesting that an increase in investments of the input factors might lead to an decrease in the probability of willingness to implement traceability of shrimp farmers ($p < 0.05$). In other words, shrimp farmers were estimated to pay acareful considerations of shrimp farmers in decision-making to impelement traceability if they did have to spend more costs.

Discussion

The comparison of the traceability between certified and non-certified shrimp products along the supply chain indicated that the information management system at shrimp processing companies might supported them to trace from whom the shrimp farming input had been provided and to whom the output shrimp had been sold. This was concordant with the situation in other shrimp exporting countries such as Thailand, Bangladesh, Laos, and the Philippines, which traceability systems have well-developed at processing companies in relation to comply with the requirements of buyers in global markets (Uddin, 2009; Dong, Saito, Hoa, Dan & Matsuishi., 2019).

The traceability and exchange of information among the various local agents in the supply chain were depended on the flow of shrimp products (Dong, 2019; Loc, 2006; Tran et al., 2013). Processing companies confirmed were able to obtain information about the area of cultivation of their input shrimp, which coincided with the area of operation of the suppliers or the cultivated area of shrimp farmers, who directly signed the contracted agreement with these companies. Our results have responded to the previous scholars of Ha and Bush (2010); Lap et al. (2015).

It was found that contracts involved a complicated production process undertaken by the processors. Therefore, this might probably make the difficulties to secure contracts with the non-certified shrimp farmers (Suzuki & Nam, 2018). For example, in our survey, contracted farms were strictly monitored in relation to the use of antibiotics. Two days before harvest, processors would collect a sample batch of shrimp for inspection. If any antibiotics were discovered, the processors would deny the contracted agreement that had been signed with shrimp farmers. Conversely, the uncontracted farms might freely sell the harvested shrimp to the buyers, who were able to negotiate a higher farm-gate price at the time of harvests without any requirements in relation to traceability, quality and safety issues. Consequently, the shrimp farmers did not have sufficient motivation to implement the traceability systems.

On the other hand, the survey responses revealed that shrimp collectors and brokers might travel to other districts to buy shrimp products if they were able to negotiate a lower farm-gate price with the shrimp farmers. Hence, if processors were basing their information regarding the area of cultivation on the standard location of brokers and collectors, that information might be inaccurate.

In this study, the application of ASC certification might involve the traceability among stakeholders in the supply chain, corresponding to the previous scientific works of Hobbs et al. (2005); Tran et al. (2013); Suzuki and Nam (2018). The application of ASC certificates was significantly contributed to increase the willingness to implement traceability of shrimp farmers as results of the binary logistics models. This result suggested that the integration of applications for international quality assurance certification and the implementation of traceability systems might be an alternative means of enhancing the implementation of traceability systems over the entire supply chain (Dong, 2019). In this way, the information that was recorded and retained to support the application of quality assurance certification might also be used in the implementation of traceability procedures (Bailey et al., 2016).

However, the application of international quality assurance certification did not create an increase in the profit of shrimp farmers as our prior hypothesis. In this study, the differences in production costs between certified and non-certified shrimp products were separately compared by shrimp species, including black tiger shrimp and white leg shrimp. The production costs of certified farms indicated a higher amount than this of non-certified farms, for both shrimp species.

Regarding black tiger shrimp, the non-certified farmers indicated a lower production cost than those of the certified farms. These was probably because the differences in the cultivated methods (i.e. extensive and intensive systems) were applying by each group of farmers (Ling et al., 1999). During our survey, the certified farmers were included both extensive and intensive systems, which required a huge investment. Conversely, the non-certified shrimp farmers mostly applied extensive methods, which did not require a large amount of production cost. However, a separated comparison by cultivated systems between certified and non-certified farmers might not be conducted due to the limitation of sample size.

Regarding the white leg shrimp, the intensive systems were mostly applied by both, certified and non-certified shrimp farmers in our survey. This was corresponded to the previous scholars of Portley (2016); Hasan (2007). The costs were mainly spent for labors and input factors such as feed, seed, chemical and drug. As the comparison results, the total production costs of certified farmers were higher than those of non-certified farmers. However, it was found that the certified shrimp farmers might save more costs for feed, chemical and drug than those of the non-certified farmers, suggesting a better utilization of input uses at the certified farms (Lusk & Norwood, 2008; Wang & Chen, 2016). Hence, the application of quality assurance certifications may probably lead to a decrease in the production costs for shrimp farmers in the future. Since an increase in production costs of shrimp farms would reduce the willingness to implement traceability as indicated in the binary logistic regression model. Our results supposed that the application of quality assurance certification was estimated to enhance the decision-making to implement traceability of the certified-farmers (Mishan & Quah, 2007).

Moreover, in this study, family labor costs were estimated at market price to hired labor for shrimp farms or the wages that shrimp farmers were able to receive from other activities in relation to agriculture, fisheries and aquaculture in the rural areas of Vietnam (Dan, 2017, Bjornlund *et al.,* 2017). In reality, the family labor costs were the non-cash costs. Thus, the shrimp farmers did not have to pay for this cost. Hence, if the family labor costs of both, certified and non-certified white leg shrimp farms were skipped, the production costs of certified farms would be lower than those of non-certified farms (see Table 3).

On the other hand, the differences in the farm-gate price between certified and non-certified shrimp products were not even statistically confirmed. It was fact that, farmers were eager to apply the quality assurance certification because they expected the higher financial benefits, and the farm-gate price was the most important motivation affecting their decision-making for application (Morris & Young, 2000; Mishan & Quah, 2007; Tien & Thong, 2014). In our study, the non-certified farmers could freely choose and negotiate the farm-gate price with their shrimp buyers as mentioned above. Therefore, they supposed to receive a higher farm-gate price than that of certified farmers. On the other hand, the processing companies, who signed the contracted agreement with certified farmers, did cover the application costs of ASC certification to certified shrimp farmers. Therefore, the farm-gate price paid to certified farmers might probably reduce to be concordant with those sponsorships. These suggested that the economic incentives, especially the differentiation of the farm-gate price should be considered to call for attention of shrimp farmers in terms of application of international quality assurance and implementation of traceability (Karipidis et al., 2009; Dong, Saito, Hoa, et al., 2019).

Notably, the shrimp farmers, who participated to Farm Cooperatives revealed a higher probability of willingness to traceability implementation. This results consited with the previous findings of Verhaegen and Huylenbroeck (2001); Jonell and Henriksson (2015). Recent limitation of production costs of Vietnamese shrimp farmers might probably cause difficulty of the application of quality assurance certificates by the individual farms (Lap et al., 2015; Dong, Saito, Hoa, et al., 2019). Therefore, the establishment of Cooperatives might be probably a practical alternative to call for the sharing the costs, not only of operational costs, but also of application of quality assurances certificates, and involvement the implementation of traceability and other tools related to improvement of product's quality and safety.

Conclusion

It was concluded that application of ASC certification by shrimp farmers were helpful regarding the traceability and management of quality and safety, and played as an alternative to involve the implementation of traceability systems for the entire shrimp supply chain. These shrimp products were produced to ASC standards, including information recording and keeping, which provided confidence that they could meet the requirements of international customers in relation to safety, quality, and traceability.

Shrimp farmers who had applied for international quality assurance certification were willing to implement traceability systems, suggesting that the implementation of traceability systems might be more feasible once certification has been received. However, the limited understanding of small-scale farmers of the benefits of international quality assurance certification is a barrier to improved performance, not only in relation to certification, but also regarding the implementation of traceability systems for the overall shrimp supply chain in Vietnam.

In the future, the application of international quality assurance certification and the implementation of traceability systems will act as a passport enabling shrimp products to meet the food safety and quality requirements of the global markets. Thus, the results of the current study are an evidence to put forward for consideration of economic incentives to enhance the implementation of those procedures, including the differentiation of the unit farm-gate price for the certified shrimp products, together with the better management in the input factors used have to be highly considered.

Besides that, the calling for the integration and collaboration activities of shrimp farmers, such as the establishment of the Cooperatives might probably be the meaningful works to enhance the implementation of traceability.

Conflict of interest. No potential conflict of interest was reported by the authors

Footnotes.

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[i] The extensive shrimp farming system is typically used to produce large, high-quality black tiger shrimp. Under this system, the shrimp pond is not well built, and the pond size varies from 1 to 15 ha. In the past, shrimp was stocked naturally during the water intake. However, in recent years, farmers have had to stock the ponds each month using hatchery seed (post-larvae (PL)). Shrimp feed is not supplied to the system, and the shrimp rely on food that grows in the ponds such as plants, copepods, nematodes, insert larvae, and snails. The shrimp are harvested in accordance with the lunar cycle using fyke nets.

Conversely, an intensive shrimp farming system requires advanced technology and large amounts of capital. One crop of black tiger shrimp takes six months to mature, while a crop of white leg shrimp takes three to four months to mature. Intensive cultivation systems are located in areas designated by the local planning authorities because of the effects on the environment. Pond sizes range from 0.5 to 1 ha, and the shrimp are stocked once for each crop, with stocking density varying from 25–40 PL/m^2 for black tiger shrimp to 80–200 PL/m^2 for white leg shrimp. High-quality commercial feed is used throughout the cultivation period.

[ii] The costs of ASC application certification have been sponsored by the contracted processing companies. These, therefore, have not been included to investigate the financial efficiency of shrimp farmers.

Regarding the family-land cost, depreciation was in accordance with the regulation in Law 45/2013/QH13 on land issued by the Vietnamese government, which states that "the term for land allocation and recognition of agricultural land use rights for households and individuals directly engaged in agricultural production is 50 years." Based on this regulation, the land costs were amortized into each crop using the function LF = VF/50/k, where LF was the depreciated value of family land, V was the market price of the land at the time of our survey, and k was the number of crops per year.

Regarding the hired-land cost, the depreciation value was given by LR = F/k, where LR was the total rent payment for one crop, F was the total annual rent, and k was the number of crops per year.

Regarding infrastructure, the allocation was represented by Ii = Mi/n/k, where Ii was the depreciated value of infrastructure i, M was the market price of infrastructure i at the time of our survey, n was the total number of years the infrastructure could be used, and k was the number of crops in one year (i = 1, n).

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List of Tables

Table 1. Data collection summary

Shrimp agents	Observation	Collection methods
Farmers	114	Structured Questionnaires
ASC certified	*32*	*Structured Questionnaires*
Non-ASC certified	*82*	*Structured Questionnaires*
Processors and Exporters	2	Face to Face interview
Brokers	2	Face to Face interview
Collectors	2	Face to Face interview

Table 2. Definition of variables in binary logistics model

Variables	Descriptions	Mean (N = 108)	Standard deviation
WTI	Dependent variable: WTI = 1 if shrimp farmers answer he/she is willing to implement traceability after our explanation; WTI = 0 if otherwise	0.83	0.37
ASC (X_1)	ASC application of shrimp farmers 1 = ASC certified farmers 0 = non-ASC certified farmers	0.27	0.45
QApercep (X_2)	Perception of shrimp farmers about Quality assurance certification: 1 = yes; 0 = no	0.56	0.50
Cooperatives (X_3)	1 = Coop Members; 0 = otherwise	0.35	0.48
Age (X_4)	Age of respondents (years old)	51.09	11.37
Shrimp (X_5)	Shrimp cultivation species: 1= Black tiger shrimp; 0 = White leg shrimp	0.38	0.49
Experience (X_6)	Total year of cultivated shrimp farms (years)	12.15	5.18
Price (X_7)	Farm-gate price of shrimp products at the harvest date (USD per kg)	8.55	2.97
Scale (X_8)	Total land used for shrimp farms: 1 = less than 2ha; 0 = otherwise	0.81	0.40
Variable costs (X_9)	Unit variable costs of shrimp products at shrimp farms (USD per kg)	6.90	6.97

Table 3. Unit prices received, costs, profits, and productivity of shrimp farms (USD per kg)

Categories	Black tiger shrimp (N=71)			White leg shrimp (N=43)		
	ASC (N=9)	Non-ASC (N=61)	Differences	ASC (N=23)	Non-ASC (N=20)	Differences
Variable costs (1)	10.85	8.12	2.73	4.62	4.22	0.40
Seed	*0.93*	*0.93*	*0.00*	*0.39*	*0.33*	*0.06*
Feed	*1.69*	*1.04*	*0.65*	*2.07*	*2.17*	*-0.10*
Drug	*0.45*	*0.23*	*0.23*	*0.40*	*0.59*	*-0.19*
Chemical	*0.12*	*0.19*	*-0.07*	*0.16*	*0.28*	*-0.12*
Pond treatment	*0.00*	*0.01*	*0.00*	*0.01*	*0.01*	*0.00*
Water	*0.06*	*0.07*	*-0.01*	*0.07*	*0.05*	*0.02*
Interest	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Electricity	*0.24*	*0.13*	*0.11**	*0.25*	*0.19*	*0.06*
Transportation	*0.00*	*0.02*	*-0.02*	*0.00*	*0.00*	*0.00*
Labor (Family)	*7.26*	*5.43*	*1.83*	*1.14*	*0.57*	*0.57**
Labor (Hired)	*0.07*	*0.05*	*0.01*	*0.07*	*0.02*	*0.05*
Others	*0.01*	*0.02*	*-0.01*	*0.03*	*0.00*	*0.03*
Fix cost (2)	0.01	0.06	-0.05*	0.01	0.02	-0.01
Infrastructure	*0.00*	*0.01*	*0.00*	*0.01*	*0.01*	*0.00*
Land (Hired)	*0.00*	*0.02*	*-0.02*	*0.00*	*0.00*	*0.00*
Land (Family)	*0.01*	*0.04*	*-0.03*	*0.00*	*0.01*	*-0.01*
Total production costs [(1) + (2)]	**10.86**	**8.18**	**2.67**	**4.63**	**4.24**	**0.39**
Total production costs (exclude family-labor cost)	**3.60**	**2.75**	**0.85**	**3.49**	**3.67**	**-0.18**
Unit Price	**8.98**	**10.39**	**-1.41**	**5.44**	**6.18**	**-0.74***
Profit	**-1.87**	**2.21**	**-4.08**	**0.81**	**1.94**	**-1.13**
Productivity	**369.11**	**346.04**	**23.01**	**847.17**	**943.16**	**-93.99**

Note: *indicates statistical significance at the 0.05 level using T-tests to compare means.

Table 4. Factors influencing to the willingness to implement (WTI) traceability of shrimp farmers

X_i	Std. Err.	Z	Coefficient β_j
Intercept (β_0)	2.66	0.56	1.48
ASC (X_1)	1.40	3.05	4.28***
QApercep (X_2)	1.12	-2.20	-2.46***
Cooperatives (X_3)	1.41	1.94	2.74**
Age (X_4)	0.04	-1.97	-0.07**
Shrimp (X_5)	1.38	2.27	3.13**
Experience (X_6)	0.08	0.87	0.07
Price (X_7)	0.18	1.78	0.31*
Scale (X_8)	0.98	-0.68	-0.67
Variable costs (X_9)	0.04	-1.98	-0.09**
Log likelihood			-29.01
N			108
Pseudo R2			0.40
LR chi2			39.31

Note: The estimated results of Binary logistics regression model with the including of 108 observations of the sampling and its coefficient of determination Pseudo R2, and the results of LR chi2 test statistical present the relationship between explanatory variables and WTI at significant level $p < 0.01$. The β_j is the parameter of the first (1) to the nineth (9) explanatory variables (X_j) in the regression as described in the text, β_0 is the intercept of Binary logistics regression model. The asterisks "***, **, *" denote the statistical significance of the relationship between explanatory variables and WTI in the regression model at 1%, 5% and 10%. The N is the included number of observations in the model. "Std. Err" is the abbreviation of "Standard Error".

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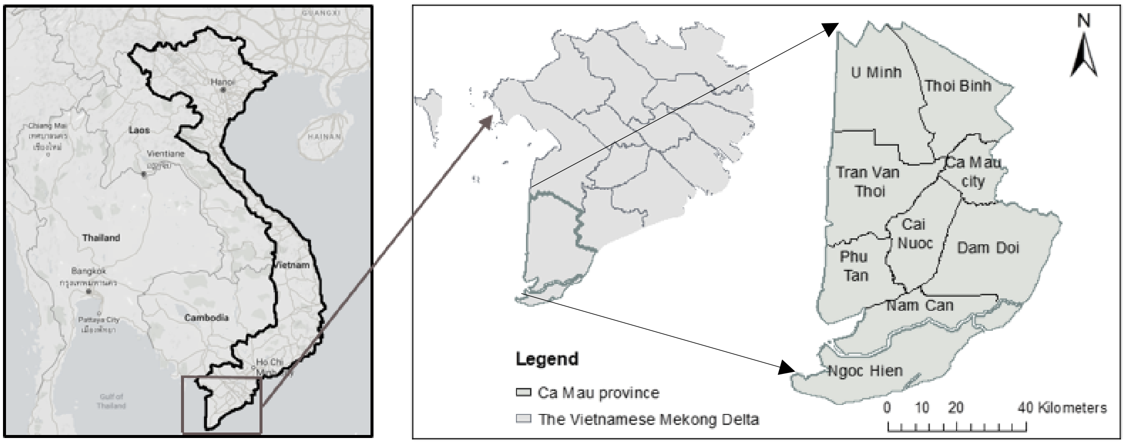


Figure 1. Study area in Ca Mau Province, Vietnam (adapted from Google maps).

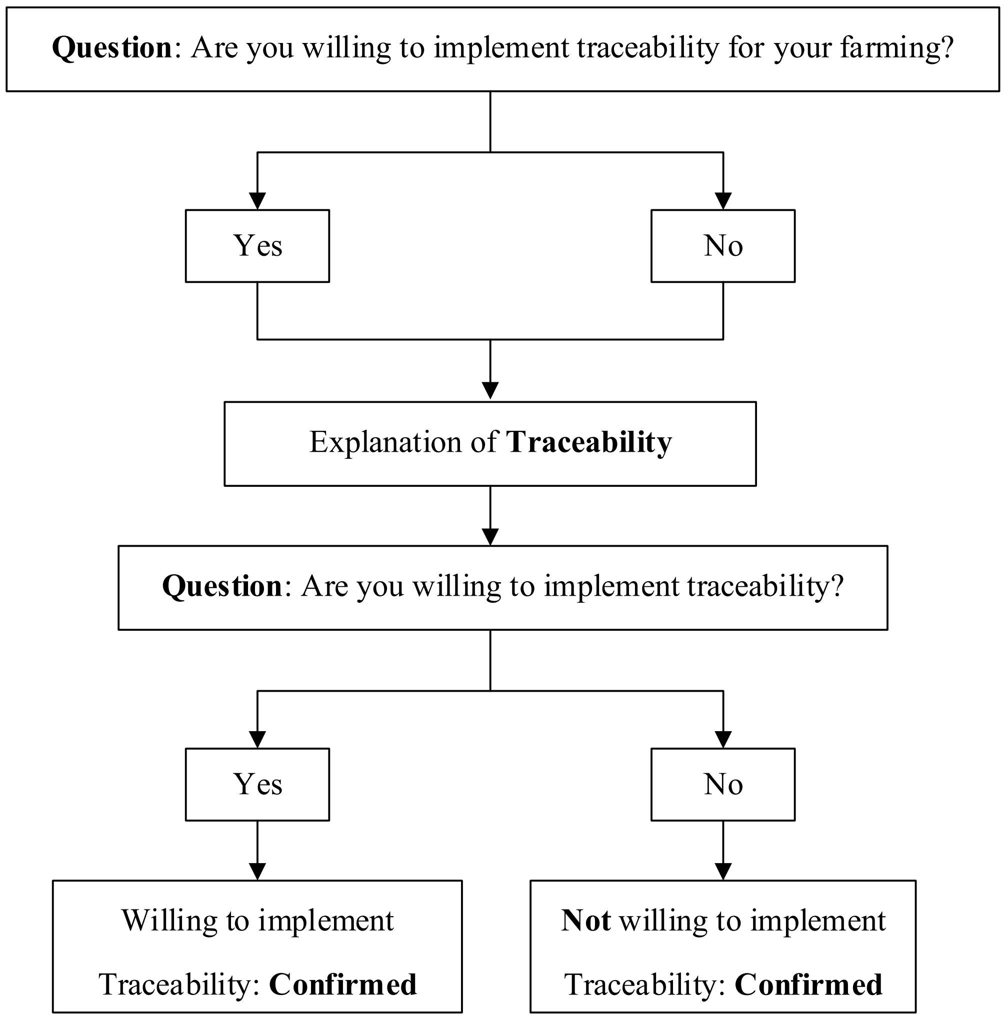


Figure 2. Procedure to investigate shrimp farmers' willingness to implement traceability systems.

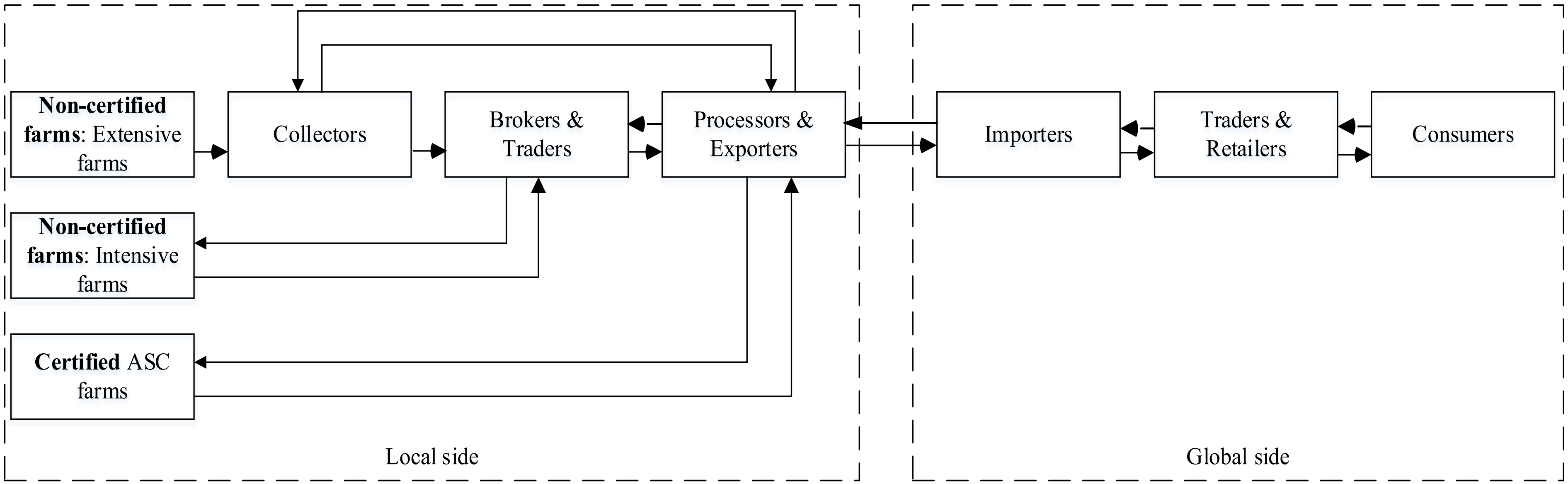
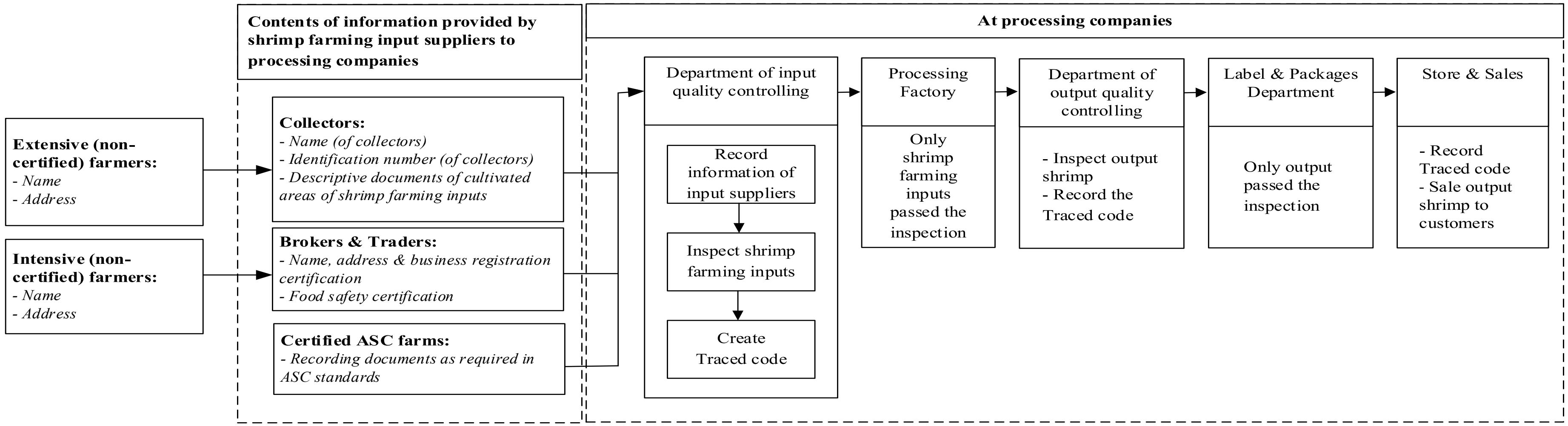


Figure 3. Traceability along Vietnamese shrimp supply chain: empirical study of Ca Mau Province, Vietnam.

Note: The black arrowed lines indicated the traceable information flows of shrimp products in the entire supply chain.



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753 Figure 4. Information flows from shrimp farmers to processing companies of Vietnamese shrimp supply chain

754 Note: The italic text in the shapes indicated for the contents of information provided by backward agents to downward agents along shrimp supply chain

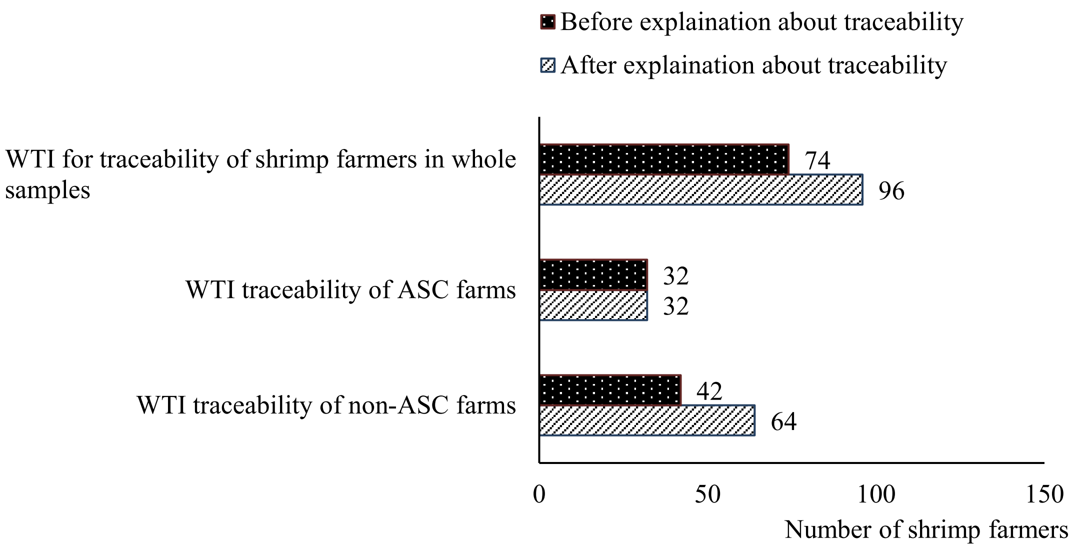

Figure 5. Shrimp farmers' willingness to implement traceability systems before and after the explanation of the traceability process.

Note: WTI is the abbreviation of willing to implement traceability.

Figure captions

Figure 1. Study area in Ca Mau Province, Vietnam (adapted from Google maps).

Figure 2. Procedure used to identify shrimp farmers' willingness to implement traceability systems.

Figure 3. Traceability along the shrimp supply chain in Ca Mau Province, Vietnam.

Figure 4. Information flows from shrimp farmers to processing companies of Vietnamese shrimp supply chain.

Figure 5. Shrimp farmers' willingness to implement traceability systems before and after the explanation of the traceability process.