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# How Much Do Farmers Expect to Implement for Traceability? Evidence from a Double-Bound Choices Experiment of Vietnamese Shrimp Aquaculture

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## Abstract

Traceability is considered the most important requirement for shrimp products exported to global markets. However, implementing traceability in shrimp-exporting countries is challenging because of limited production at the local supply chain and lack of awareness of financial welfare. This study aims to investigate the expected farm-gate price for traceability implementation using a double-bound dichotomous choice experiment. The censored regression model is used to estimate the factors influencing the anticipated farm-gate price of shrimp farmers. The survey was conducted in Ca Mau Province, Vietnam, by interviewing 71 *Penaeus monodon* Fabricius, 1798, and 43 *Penaeus vannamei* Boone, 1931, farmers. To implement traceability, *P. monodon* farmers estimated the farm-gate price at 10.17 USD.kg<sup>-1</sup>, while *P. vannamei* farmers expected 6.18 USD.kg<sup>-1</sup>. Application of international quality assurance certifications, willingness to implement traceability, land used, culture methods, shrimp species, current farm-gate price, and variable costs affected the expected farm-gate price. The attractive anticipated farm-gate price compensated for the negative influence of applying international quality assurance certifications, indicating that the farmers were willing to implement traceability. This suggests that the application of certifications increased the ability to implement traceability in the shrimp supply chain. The attractive farm-gate price for certified shrimp products would enhance their willingness to implement the traceability of shrimp products.

**Keywords:** International quality assurance certificates, Supply chain management, Double-bound dichotomous choice, Global trade of shrimp products, Vietnam

## Introduction

Food incidents are increasing worldwide and have led to a higher demand for global consumers' food safety and traceability issues (Charlebois et al., 2014). Food traceability requirements were recently included in international quality assurance standards, such as global good agriculture/aquaculture practice (GlobalGAP), aquaculture stewards council (ASC), best aquaculture practices, marine stewardship council, and hazard analysis and critical control point certification (HACCP) (Dong et al., 2019a).

In Vietnam, shrimp production is a main source of income for rural areas (Phuong and Oanh, 2010). Most shrimp farming areas are located in Vietnam's Mekong Delta (VMD), accounting for 70 % of the total area of the country (Vietnam GSO, 2017). *Penaeus monodon* Fabricius, 1798 and *Penaeus vannamei* Boone, 1931 are the main species cultivated in the VMD. Vietnamese shrimp production is export-oriented, accounting for 70 %–80 % of total production (Tran et al., 2013; Dong, 2019). Vietnamese shrimp products are exported to over 90 countries. Accordingly, about 47% of shrimp products are exported to the USA, Europe, and Japan. The living standards in these countries are high, and traceability and food safety requirements are stringent (Portley, 2016; Suzuki and Nam, 2018).

The requirements of traceability, quality, and safety in the high-living standard markets have resulted in a decline in the quantity of Vietnamese shrimp exported to these countries because Vietnamese shrimp producers cannot satisfy all the requirements (Dong and Duc, 2012; Suzuki and Nam, 2018). However, the export price of Vietnamese shrimp products to the USA, Europe, and Japan is 20 % higher than that to other countries (FAO, 2018; VASEP, 2018). The higher export price of shrimp products to the USA, Europe, and Japan might induce exporters from other countries such as Thailand, Indonesia, India, Malaysia, and Ecuador to export to these markets (Flaaten, 2018). This will result in a more competitive market and a bigger challenge for Vietnamese shrimp exporters. Thus, the exporters in Vietnam must consider traceability to be eligible for export to crucial markets with stringent requirements to compete with other shrimp-exporting countries. Therefore, implementing traceability for Vietnamese shrimp products will increase prices and boost competitive advantages in the global market (Dong and Duc, 2012).

In 2011, as a general guideline to implement traceability for shrimp products, the Vietnam Directorate of Fisheries issued a national traceability regulation, namely Circular No.03/2011/BNN-PTNT (Cir.03). Accordingly, shrimp producers have to follow the rule of traceability 'one step backwards and one step forwards' along the supply chain. Recording and exchanging information among shrimp agents in the supply chain are required to ensure the ability to identify the source of shrimp products along the supply chain. Subsequently, Vietnamese shrimp processors and exporters have invested in an internal traceability information system, enabling them to follow their product chain flows from the supply source to buyers at their companies (Nga Mai et al., 2010; Dong et al., 2019a).

However, some areas of the supply chain have not implemented traceability systems, especially at the farm level. Approximately 80 % of the total Vietnamese shrimp products from farmers are sold to middlemen and wholesale agents (Dong et al., 2019a). It is convenient for shrimp farmers to sell their products to these agents as they do not have to provide record information or guarantee product safety and quality (Lap et al., 2015; Tran et al., 2013). Hence, the traceability of shrimp products between farmers and wholesale agents is extremely difficult to implement.

On the contrary, shrimp farmers with contract agreements must follow complicated quality and safety compliances (i.e., antibiotic residue level) to reduce market price fluctuations (Dong, 2019; Ha and Bush, 2010). Contract farmers have no choice but to sell their harvested shrimp to the processors, as stated in the contract. Non-contract farmers can choose shrimp buyers and negotiate farm-gate prices during the harvest. Thus, non-contract farmers receive a better price than contract farmers (Suzuki and Nam, 2018). Hence, it is questionable whether shrimp farmers should pay a premium price to enhance traceability implementation. This is because the trade-off between benefits and potential costs may affect their decision-making and the willingness to implement traceability (Wakamatsu and Wakamatsu, 2017).

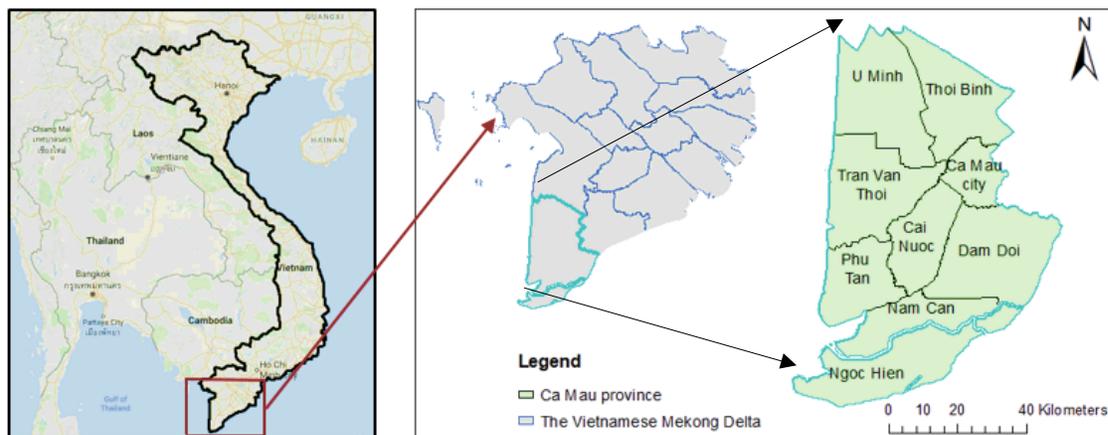
Economic concerns regarding traceability implementation have not been examined scientifically. Thus, current literature may not provide a cogent argument on the benefits and costs of increasing farmers' willingness to implement traceability. This study examines the expected farm-gate price to determine whether Vietnamese shrimp farmers will implement traceability based on the double-bounded dichotomous choice experiment. The factors influencing the anticipated farm-gate price of shrimp farmers are investigated. The results of this study support the rationale for economic incentives to enhance the implementation of traceability for Vietnamese shrimp products. The study is also expected to provide empirical evidence for shrimp-exporting countries, where traceability systems are under consideration to export their products to global markets.

## Materials and Methods

### Data collection

#### Study area

A survey involving interviews with shrimp farmers was conducted in July 2017 in the Ca Mau Province, which represents 44% of shrimp production areas in VMD and 31% of the whole of Vietnam. The geographical location of the Ca Mau Province is shown in Fig 1.



**Fig 1.** Map of Ca Mau Province where the study on the traceability of shrimp products was conducted. Adapted from Google maps.

A total of 114 shrimp farmers were interviewed during the survey, including 71 *P. monodon* and 43 *P. vannamei* shrimp farmers (see **Table 1**). Extensive and intensive culture systems have been practised for both shrimp species. Extensive shrimp farming systems are typically used to

produce large and high-quality *P. monodon*. In this system, the shrimp pond is not standardised, and the pond size varies from 1 to 15 hectares. In the past, shrimp were stocked naturally with the seawater intake during high tide as the shrimp were trapped in the ponds. However, farmers now stock hatchery-produced seeds (Postlarvae-PL) monthly throughout the year. Shrimps are not fed in extensive systems as the shrimp rely mainly on natural food grown in ponds such as plants, copepods, nematodes, insect larvae, and snails. Shrimps are harvested partially using a fyke net during the new moon and full moon cycle.

**Table 1.** The shrimp production characteristics observed during farm visits in Ca Mau Province.

Categories		<i>P. monodon</i> shrimp		<i>P. vannamei</i> shrimp		Whole samples	
		(N = 71)		(N = 43)		(N = 114)	
		Obs.	%	Obs.	%	Obs.	%
International QA certified farms	No	62	87.3	20	46.5	82	71.9
	Yes	9	12.7	23	53.5	32	28.1
Culture systems	Extensive	44	62.0	4	9.3	48	42.1
	Intensive	27	38.0	39	90.7	66	57.9
Land for shrimp culture per farm	Less than 2 hectares	54	76.1	36	83.7	90	78.9
	2 hectares and above	17	23.9	7	16.3	24	21.1

Note: QA = Quality Assurance Certification. Obs = Observation.

In contrast, an intensive system requires advanced technology and high capital investment compared to an extensive system. Complete crop harvest is performed after 6 months of culture for *P. monodon* or 3-4 months for *P. vannamei*. A steady stream of organic waste, chemicals, and antibiotics from shrimp farms can pollute groundwater or coastal estuaries. Salt from the ponds can also seep into the groundwater and agricultural land. Consequently, in concentrated aquaculture areas, especially in intensive shrimp farming areas, the quality of soil, water, and ecosystems has drastically changed because of pollution. To prevent further damage to the environment, intensive shrimp pond construction sites are required to comply with the aquaculture development planning in accordance with the land use plan approved by the local authorities. The pond size ranges from 0.5 to 1 ha for intensive culture. Shrimp were stocked once for each crop at stocking densities varying from 25-40 PLs.m<sup>-2</sup> for *P. monodon*, or 80-200 PLs.m<sup>-2</sup> for *P. vannamei*. High-quality commercial feed is used to feed shrimp throughout the culture period.

Total land use is a good indicator of the production scale of shrimp farmers. A farming area of under 2 hectares represents a small-scale shrimp culture. The characteristics of the sample in this study corresponded to those of scholars such as Loc (2006) and Tran et al. (2013) since approximately 78% of shrimp farming was on small-scale farms in the sample. The survey revealed that 28% of shrimp farmers were applying international quality assurance certification, such as ASC, Nature Land, and GlobalGAP.

#### *Descriptions of the double-bounded dichotomous choice experiments*

From a scientific perspective, contingent valuation methods (CVMs) have been widely used to examine consumers' willingness to pay (WTP) for certified/traceable products (van Rijswijk and Frewer, 2012; Zhang et al., 2012; Huynh et al., 2017). Among CVMs, the dichotomous choice

experiments, including single-bounded dichotomous choice and double-bounded dichotomous choice (DBC) methods, are widely used because of the simplicity in data collection that can reduce the potential bias of self-analysing as occurring in other methods (i.e. open-ended and bidding games). Therefore, these methods are practical for evaluating consumers' WTP and the pricing of goods with high incentives (Hanemann et al., 1991; Calia and Strazzera, 2000).

In a single-bounded choices experiment, the respondent is required to answer 'yes' or 'no' for the question: 'is she/he willing to pay a given amount (bid) for the experimental product?', whereas, in the DBC experiment, the interval bids are enclosed within two given values that the respondent is required to answer 'yes' or 'no' for this elicitation of WTP. If the answer to the first given bid is 'yes', the specifying of the higher value (upper) bid will be followed. Otherwise, the following bid has a lower value (Hanemann et al., 1991).

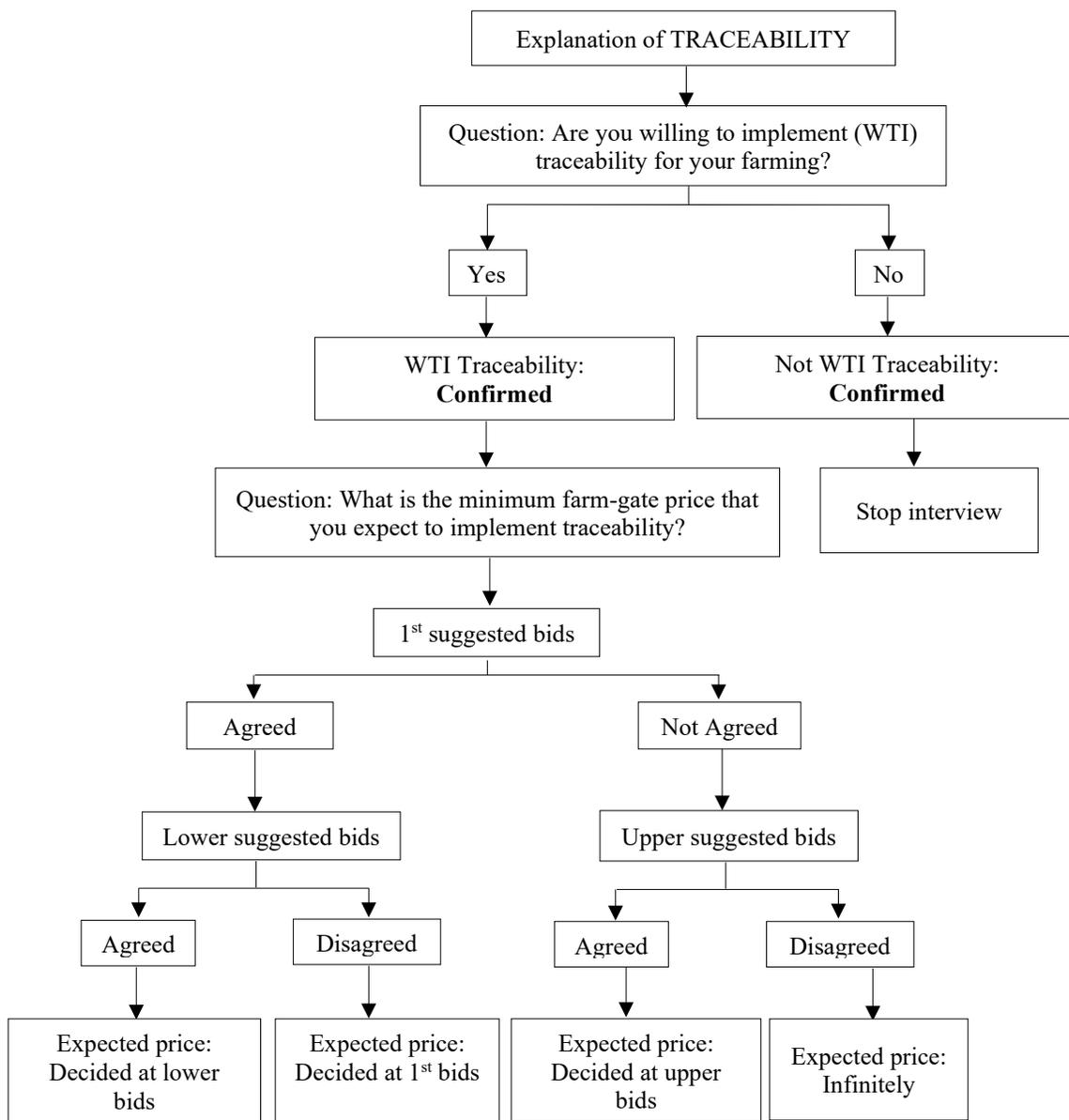


Fig 2. The framework of double-bounded dichotomous choice experiment. Note: WTI = Willingness to implement.

Shrimp farmers are uncertain about the farm-gate price of shrimp products until they sell their products. However, they can address their expectations of what the farm-gate price is likely to be. In this study, DBC experiments were designed to investigate the expected farm-gate price for shrimp products with the traceability implementation, as presented in **Fig 2**. The explanation of traceability implementation, which focused on the information recording, keeping, and exchanging activities from shrimp farmers to shrimp farming inputs buyers, was presented prior to beginning the DBC experiment. Additionally, the potential benefits and costs of these activities are also clearly explained.

Mishan and Quah (2007) indicated that the expected farm-gate price depends on their willingness to accept and implement an alternative that can guarantee the farm-gate price to reduce future market uncertainty. The shrimp traceability implementation may not be immediately reflected in the products' farm-gate price. However, shrimp farmers who have implemented traceability can improve their products compared to others (Dong, 2019). Hence, shrimp farmers willing to implement traceability are expected to enable the guarantee of the farm-gate price in the future. In this study, the DBC was explored to obtain the minimum farm-gate price that shrimp farmers anticipated to receive if he/she implements traceability. Therefore, during the experiment, shrimp farmers who agreed to implement traceability at the initial suggested farm-gate price were given lower bids in the following round. Otherwise, the shrimp farmers who did not agree to implement traceability at the first suggested bid were given upper bids in the next round.

As seen in **Table 2**, five scenarios of the expected bids in the experiment were based on the statistics of the historical data of the daily farm-gate price of two different shrimp species reported by the Provincial Department of Fisheries in the VMD from June 2015 to June 2017. During the survey, the  $i^{\text{th}}$  farmer was randomly asked about the 1<sup>st</sup> bid of the  $n^{\text{th}}$  ( $n = 1; 5$ ) scenario, concordant with his/her cultivated species. Then, the lower (or upper) bids of the  $n^{\text{th}}$  ( $n = 1; 5$ ) scenario were continuously asked. Thus, the  $i^{\text{th}}$  farmer probably indicated his/her expected farm-gate price at the 1<sup>st</sup> bid, the upper bid, or the lower bid of the  $n^{\text{th}}$  ( $n = 1; 5$ ) scenario. Hence, in total, there were 15 cases of the expected farm-gate price that might be illustrated by shrimp farmers in the DBC experiment.

**Table 2.** The designs of the scenarios of expected bids of shrimp products, used in double-bounded dichotomous choice experiments

Scenarios	<i>Penaeus monodon</i> shrimp			<i>Penaeus vannamei</i> shrimp		
	1 <sup>st</sup> bid	Down	Upper	1 <sup>st</sup> bid	Down	Upper
1	5.33	4.44	6.22	3.56	3.11	4.00
2	6.67	5.56	7.78	4.44	3.78	5.11
3	8.44	7.11	9.78	5.78	4.89	6.67
4	10.67	8.89	12.44	7.56	6.44	8.67
5	13.33	11.11	15.56	9.78	8.44	11.11

Note: The unit of the expected bids in USD.kg<sup>-1</sup> The exchange rate was 1 USD = 22.500 VND, based on the statistical data of the Vietnam State Bank.

After the DBC experiment, shrimp farmers were interviewed using structured questionnaires to obtain the socioeconomic characteristics of respondents, distribution flows, and information

movement along the supply chain, farm efficiency indicators such as production costs, farm-gate price, and productivity.

### **Data analysis**

Consistent with Bateman et al. (2002), the average expected farm-gate price for shrimp products of the  $i^{\text{th}}$  farmer, conducted by the DBC questions, was calculated as follows:

$$P_E = \sum_{j=1}^{15} \hat{S}(P_{Ej}) [P_{Ej} - P_{Ej-1}]$$

$$\text{where, } \hat{S}(P_{Ej}) = \frac{\hat{m}_j}{N} \text{ and } \hat{m}_j = \sum_{k=j+1}^{15} \hat{h}_k$$

Note that  $P_E$  denotes the mean of the expected price of shrimp farmers from the samples;  $P_{Ej}$  ( $j = 1; 15$ ) is the higher probability associated with the lower expected price  $\hat{S}(P_{Ej})$ , indicated by the shrimp farmers in the DBC experiment;  $N$  is the total number of shrimp farmers who decided the expected price in the DBC experiment;  $\hat{h}_k$  is total shrimp farmers who bid the expected price lower than the boundary value of  $B_j$ .

A censored regression model (CRM) was used to estimate the factors impacting the expected price of shrimp farmers to implement traceability systems (Henningsen, 2011). The cumulative CRM for the expected price of shrimp producers to implement the traceability system is described as follows:

$$P_{Ei} = \begin{cases} \beta X_i + u_i & \text{if } X_i \geq a/\beta \\ \infty & \text{if } X_i < a/\beta \end{cases}$$

where,  $P_{Ei}$  denotes the expected price of the  $i^{\text{th}}$  shrimp farmer in the sampling for application of the traceability system;  $a$  is the lower limit of the expected price chosen by shrimp farmers in the survey;  $X_i$  are explanatory variables;  $\beta$  is the explanatory variable parameter;  $u_i \sim N(0, \sigma^2)$  are error terms.

The likelihood ratio chi-square (LR-chi2) statistic was used to test the statistical significance, and 5% was used for the p-value significance level. The residuals were assumed to be normally distributed, and the error terms  $u_i$  were assumed to have a mean of zero and constant variance. The explanatory variables included in the CRM model are listed in **Table 3**.

Shrimp farmers' application of international quality assurance certifications was included in the CRM model as the one factor influencing the expected farm-gate price for shrimp products with traceability. As discussed in studies by Bailey et al. (2016), Dong et al. (2019a), and Dong et al. (2019b), the application of these certificates was a critical alternative for the traceability system implementation along the supply chain. Moreover, it was assumed that certified shrimp farmers had been trained and updated with related information about the requirements of food quality, safety, and traceability from the global market. They, therefore, would be better aware of the role of implementing shrimp products' traceability compared to non-certified shrimp farmers (Dong et al., 2019c). Thus, the application of quality assurance certifications was expected to have a negative impact on the expected price of shrimp products with traceability implementation.

**Table 3.** Explanatory variables in the Censored Regression Model

Variables	Description	Mean	SD
Application of QA	1 = yes, 0 = no	0.27	0.45
WTI traceability	1 = yes, 0 = no	0.63	0.48
Gender of household head	1 = male, 0 = female	0.93	0.26
Experiences	Total year worked on farmed shrimp	12.15	5.18
Shrimp species	1 = <i>Penaeus vannamei</i> , 0 = <i>Penaeus monodon</i>	0.38	0.49
Land	Total land used for shrimp farm (1,000 m <sup>2</sup> )	15.46	10.62
Price	Farm-gate price of current crop (USD.kg <sup>-1</sup> )	8.55	2.97
Cultured methods	1 = Intensive systems, 0 = Extensive systems	0.68	0.47
Education of respondents	Total participated school years from elementary <sup>a</sup>	7.76	3.27
Unit costs	Variable costs per unit (USD.kg <sup>-1</sup> )	6.90	6.97

Note: <sup>a</sup>In Vietnam, elementary proficiency is the 1<sup>st</sup>-5<sup>th</sup> grade, junior high school is the 6<sup>th</sup>-9<sup>th</sup> grade, high school education is the 10<sup>th</sup>-12<sup>th</sup> grade, junior college proficiency is 3 years, bachelor's proficiency is 4 years, master's education includes two years, and doctoral programme is four years; SD = standard deviation; WTI = willingness to implement. QA = International quality assurance certifications.

Together with the application of international quality assurance certifications, shrimp farmers' willingness to implement traceability systems was also added to the CRM model to test its influence on the expected price of shrimp producers for traceability shrimp products. Shrimp farmers, who confirmed their willingness to implement traceability in the DBC experiment, were expected to have a lower expected farm-gate price. In addition, the current farm-gate price of shrimp products paid by the buyers, either middlemen or processing companies, to shrimp farmers to buy was included in the model. This current farm-gate price serves as a reference for shrimp farmers to entertain their expected price to implement traceability. The anticipated price of shrimp farmers is expected to increase if they receive a higher price for shrimp products in the current crop.

Farming conditions, such as shrimp species and cultured systems, were added to examine the impact of these factors on the anticipated farm-gate price of shrimp farmers, as suggested by Duc (2010). In addition, the production scale might reflect the differences in the decision-making for farm investments, choosing buyers, and distribution flows of the harvested shrimp products. Large-scale farmers might have greater price negotiability over buyers than small-scale farmers do (Suzuki and Nam, 2018). During the interview survey, the important role of land in the decision-making process of shrimp farmers was determined. The land is not only a direct resource for farming activities but is also shrimp farmers' most valuable asset. Farmers use the land as collateral to acquire secured loans from the banking system. Hence, shrimp farmers who own more land might take advantage of expansion and/or an approach to improve production procedures (i.e. application of quality assurance certificates; implementation of traceability). In this study, large shrimp farms were assumed to reduce the expected farm-gate price of shrimp products for traceability implementation.

The total production cost per kilogram of shrimp produced comprises a fixed cost of 5 % and a variable cost of 95 % (Ling et al., 1999; Hasan, 2007; DANIDA, 2010). Variable cost changes may, therefore, lead to a significant change in total production costs, affecting decision-making in shrimp farm activities. Shrimp farmers who pay more for the variable cost may expect a higher farm-gate

price for their products. Thus, an increase in total variable costs was estimated to raise the expected farm-gate price of shrimp farmers to implement traceability.

Socio-demographic characteristics, including gender, education proficiency levels, and the experiences of shrimp farmers, were added to the model because these factors play a vital role in decision-making for shrimp farm activities, such as the traceability systems implementation (Coughenour and Swanson, 1992; Frey and Stutzer, 2002; Duc, 2010). Furthermore, this study also found a significant interactive influence of the amount of land used for shrimp farming and farming conditions (including cultured methods and shrimp species) on-farm investment decision-making. Therefore, the effects of these interaction variables, including total land used for shrimp farming and culture methods, shrimp species, and willingness to implement traceability on the expected farm-gate price, were examined in the CRM model.

However, most of the recently certified shrimp farms in the samples cultured *P. vannamei* shrimp. The farm-gate price of *P. monodon* shrimp is higher than that of *P. vannamei* shrimp. Therefore, the farm-gate price of shrimp products might be different between certified and non-certified farms. This study also tested the interactive impact of current farm-gate price and the application of international quality assurance certifications on the anticipated farm-gate price to implement traceability.

## Results

### *The expected price of shrimp farmers to implement traceability*

Among the 96 shrimp farmers who confirmed their willingness to implement the traceability system in the DBC experiment, 54 farmed *P. monodon*, and 42 *P. vannamei*. The expected farm-gate prices for each shrimp species are presented as follows:

**Table 4.** The expected price of *Penaeus monodon* shrimp farmers confirmed in the DBC experiment

Scenarios	1 <sup>st</sup> Bid*	Lower*	Upper*	Answers in DBC				Confirmation of Expected price				
				(Number of farmers)				(Number of farmers)				
				YY	YN	NY	NN	At 1 <sup>st</sup> Bid	At Lower	At Upper	Infinite	Total
1	5.33	4.44	6.22	2	0	1	14	0	2	1	14	17
2	6.67	5.56	7.78	2	1	1	4	1	2	1	4	8
3	8.44	7.11	9.78	0	2	5	3	2	0	5	3	10
4	10.67	8.89	12.44	1	2	3	1	2	1	3	1	7
5	13.33	11.11	15.56	7	4	2	0	4	7	2	0	13
<b>Numbers of farmers</b>				<b>12</b>	<b>9</b>	<b>12</b>	<b>21</b>	<b>9</b>	<b>12</b>	<b>12</b>	<b>21</b>	<b>54</b>

Note: \* Unit = USD USD.kg<sup>-1</sup>. YY = ‘Yes-Yes’ respondents who agreed with both the 1<sup>st</sup> bid and lower bid orders. YN = ‘Yes-No’ respondents, who agreed with the 1<sup>st</sup> bid order but did not agree with the lower bid order. NY = ‘No-Yes’ respondents, who did not agree with the 1<sup>st</sup> bid order but agreed with the upper bid order. NN = ‘No-No’ respondents who did not agree with either the 1<sup>st</sup> bid or upper bid orders. DBC = double-bounded dichotomous choice

Regarding *P. monodon* shrimp, during the DBC experiment, 33 of 54 (~61%) shrimp farmers accepted the expected price for shrimp products aiming to implement traceability, meaning that 21 of 54 (~39%) shrimp farmers did not agree with the bids ordered (see **Table 4**).

On average, the expected farm-gate price for *P. monodon* shrimp products of farmers was calculated at 10.17 USD.kg<sup>-1</sup>, suggesting that shrimp farmers might pay attention to the implementation of traceability if they received the farm-gate price for *P. monodon* shrimp products at 10.17 USD.kg<sup>-1</sup>.

**Table 5.** The confirmation of *Penaeus vannamei* shrimp farmers for the expected price in the survey

Choices	1 <sup>st</sup> Bid*	Lower*	Upper*	Answers in DBC (Number of farmers)				Confirmation of Expected price (Number of farmers)				
				YY	YN	NY	NN	At 1 <sup>st</sup> Bid	At Lower	At Upper	Infinitely	Total
1 <sup>st</sup>	3.56	3.11	4.00	0	1	3	4	1	0	3	4	8
2 <sup>nd</sup>	4.44	3.78	5.11	1	3	3	4	3	1	3	4	11
3 <sup>rd</sup>	5.78	4.89	6.67	3	2	3	1	2	3	3	1	9
4 <sup>th</sup>	7.56	6.44	8.67	3	4	1	0	4	3	1	0	8
5 <sup>th</sup>	9.78	8.44	11.11	6	0	0	0	0	6	0	0	6
<b>Numbers of farmers</b>				<b>13</b>	<b>10</b>	<b>10</b>	<b>9</b>	<b>10</b>	<b>13</b>	<b>10</b>	<b>9</b>	<b>42</b>

Note: \* Unit of expected bids is USD USD.kg<sup>-1</sup>. YY = ‘Yes-Yes’ respondents who agreed with both the 1<sup>st</sup> bid and lower bid orders. YN = ‘Yes-No’ respondents who agreed with the 1<sup>st</sup> bid order but did not agree with the lower bid order. NY = ‘No-Yes’ respondents who did not agree with the 1<sup>st</sup> bid order but agreed with the upper bid order. NN = ‘No-No’ respondents who did not agree with either the 1<sup>st</sup> bid and upper bid orders. DBC = double-bounded dichotomous choice.

The same procedures were applied to *P. vannamei* shrimp farmers to obtain the expected farm-gate price. The DBC experiment results indicate that 33 of 42 (~74%) shrimp farmers accepted the expected farm-gate price in the survey, while 9 of 42 (~26%) shrimp farmers did not agree with the bids ordered (see **Table 5**). The expected farm-gate price for *P. vannamei* shrimp products was proposed at an average 6.15 USD.kg<sup>-1</sup>, indicating that the *P. vannamei* shrimp farmers might be interested in implementing traceability if the price was at least 6.15 USD.kg<sup>-1</sup>.

### ***Factors influencing the expected price of shrimp farmers to implement traceability in Ca Mau Province, Mekong Delta, Vietnam***

**Table 6** presents the estimated factors affecting the anticipated price of shrimp farmers in implementing traceability. The LR chi2 test value of the result of CRM was at 35.52 ( $P < 0.01$ ), suggesting that the explanatory variables included in CRM are statistically significant. The log-likelihood ratio of the fitted model was found to be -230.35.

**Table 6.** Factor influencing the expected price of shrimp farmers

Variables	Description	Coefficient
Intercept		-6.35
$X_1$	Application of QA certification	-5.84***
$X_2$	WTI traceability	7.00***
$X_3$	Gender of the household head	-1.94
$X_4$	Experiences	0.13
$X_5$	Shrimp species	2.10
$X_6$	Land	0.28**
$X_7$	Price	-0.41
$X_8$	Cultured methods	6.33**
$X_9$	Education	-0.11
$X_{10}$	Unit variable costs	0.22**
$X_{11}$	Land × Cultured methods	-0.29**
$X_{12}$	Shrimp species × WTI traceability	-5.74**
$X_{13}$	Price × Application of QA certificates	-1.54***
Number of observations		108
Prob.>F		0.00
LR chi2		35.52
Log-likelihood		-230.35

Note: \*\*\*, \*\*, and \* indicate statistical significance at 0.01, 0.05, and 0.1, respectively; WTI = Willingness to implement; QA = international quality assurance certifications.

The negative coefficient of application of the international quality certification variable suggested that this factor negatively influenced the farmers and the expected price for shrimp products aimed at implementing traceability ( $P < 0.01$ ). According to this result, the ASC-certified shrimp farmers expected a lower price for shrimp products to implement traceability compared to non-ASC-certified farmers, meaning that certified shrimp farmers were more willing to implement traceability than non-certified farmers. This result is consistent with that of the interview survey. In the observed samples, the shrimp farmers were asked about their willingness to implement traceability after the explanations. The results show that 54 of 71 (~ 76%) *P. monodon* and 42 of 43 (~ 98%) *P. vannamei* shrimp farmers confirmed that they were willing to implement traceability (see **Table 7**). Moreover, recent findings also indicated that, for both shrimp species, *P. monodon*, and *P. vannamei*, all certified farmers in the samples in the samples acceded to implement traceability.

**Table 7.** The willingness to implement traceability of shrimp farmers

Categories	<i>Penaeus monodon</i> shrimp farmers			<i>Penaeus vannamei</i> shrimp farmers		
	Total	Certified	Non-Certified	Total	Certified	Non-Certified
	(N = 71)	(N = 9)	(N = 61)	(N = 43)	(N = 23)	(N = 20)
WTI traceability	54	9	45	42	23	19
Not WTI traceability	17	0	17	1	0	1
<b>Total</b>	<b>71</b>	<b>9</b>	<b>62</b>	<b>43</b>	<b>23</b>	<b>20</b>

Note: WTI = willingness to implement; N = number of observed shrimp farmers in the whole sample.

The willingness to implement a traceability system positively contributed to the expected price of farmers' shrimp products ( $P < 0.01$ ). Also, the statistical significance of the interaction variable between current farm-gate price and application of international quality assurance certification ( $P < 0.01$ ) showed that if the current price paid to certified shrimp farmers was higher, they would expect a lower price for their products to implement traceability.

Positive statistical contributions of total land used ( $P < 0.05$ ) and variable expenses ( $P < 0.05$ ) for shrimp farms to the farmers' expected price to implement traceability were found. These findings emphasise the important role of these two factors in traceability systems implementation. Supposing that intensive shrimp farmers expected a higher price for implementing traceability than extensive farmers, the statistically significant coefficient of cultured methods variable indicated a positive relationship between cultured methods and the expected shrimp price to implement traceability ( $P < 0.05$ ). In addition, the estimated results of the CRM model indicated a considerably negative effect of the interaction variable between the total land used for shrimp farms and cultured methods on the anticipated farm-gate price ( $P < 0.05$ ).

## Discussion

The expected farm-gate price was 10.17 USD.kg<sup>-1</sup> for *P. monodon* and 6.15 USD.kg<sup>-1</sup> for *P. vannamei*, indicated the farmers' willingness to implement traceability. The current farm-gate averaged price for *P. monodon* was 10.2 USD.kg<sup>-1</sup>, and 5.8 USD.kg<sup>-1</sup> for *P. vannamei* (**Table 8**). This implies that the farm-gate price for *P. monodon* was acceptable to the farmers to implement traceability. However, the current price for *P. vannamei* was lower than the farmers' expectation.

**Table 8.** The current farm-gate price received by the interviewed shrimp farmers in the sampling

Categories	<i>Penaeus monodon</i> shrimp farmers			<i>Penaeus vannamei</i> shrimp farmers		
	Total	Certified	Non-Certified	Total	Certified	Non-Certified
	(N = 71)	(N = 9)	(N = 61)	(N = 43)	(N = 23)	(N = 20)
Minimum	5.8	6.7	5.8	3.5	4.0	3.5
Maximum	15.9	11.1	15.9	8.9	7.6	8.9
Mean	10.2	9.0	10.4	5.8	5.4*	6.2*
Standard deviation	2.4	1.8	2.4	1.3	1.0	1.4

Note: \* indicates statistically significant differences in farm-gate price between certified and non-certified farms at 0.05 level, using t-test comparing means.

However, the application of quality assurance certificates and shrimp farmers' awareness of traceability dramatically impacted their willingness to implement traceability. This finding is in line with studies by Tran et al. (2013), Dong et al. (2019a), and Dong et al. (2019c), suggesting that the application of quality assurance certificates might be an alternative to incentivise shrimp farmers to implement traceability. This is a meaningful result because global customers are increasingly aware of food quality and food safety (Uddin, 2009; Lap et al., 2015; Bailey et al., 2018; Suzuki and Nam, 2018; Dong et al., 2019a). The application of quality assurance certificates helps increase the acceptability of Vietnamese shrimp products in the global market. Research findings corresponded with Decision 100/2019/QĐ-TTg, issued by the Vietnamese Government in 2019 to enhance the traceability implementation for Vietnamese products. Hence, the role of the application of quality assurance certification needs to be emphasised in the procedure for implementing traceability.

Nevertheless, it is notable that the estimated coefficient of farmers' perception of operational benefits of traceability in the CRM model showed a negative effect of this factor on the traceability implementation decision-making, contrasting the initial hypothesis and the findings of earlier work of Rahman et al. (2017). This could be because the observed shrimp farmers in this study are unfamiliar with traceability, even after the benefits and costs of implementing traceability were clearly explained to them. The shrimp farmers speculated that information management activities in the traceability implementation procedures might directly increase the quality of shrimp products. Therefore, they expected that the price of these products would be higher.

Based on the results of the CRM, the influence of shrimp species and the current farm-gate price of shrimp products on the expected price of shrimp products with traceability were not statistically significant. However, this study found a statistically significant interactive influence of shrimp species and willing to implement traceability on the expected shrimp price. This result indicates that *P. vannamei* shrimp farmers, who were willing to implement traceability, would expect a lower farm-gate price for their products ( $P < 0.05$ ). That is, *P. vannamei* shrimp farmers were more willing to implement traceability if the farm-gate price for shrimp products increased. These results highlight the potential effect of the farm-gate price for certified products on shrimp farmers' willingness to implement traceability. These findings are concordant with the results of studies by Karipidis et al. (2009), Bjornlund et al. (2017), and Dong et al. (2019b), suggesting that economic incentives, especially the differentiation of the farm-gate price paid for the shrimp products with the certification of quality assurance, might call for the willingness to implement traceability. However, as shown in Table 8, the average farm-gate price for certified shrimp products was lower than that for non-certified products for both species. The maximum farm-gate price range for certified shrimp farmers was lower than that for non-certified farmers. These findings demonstrate that non-certified farmers might have greater negotiation power over shrimp farming input buyers. Certified shrimp farmers likely provide harvested shrimp to contracted processors. Non-certified shrimp farmers might freely choose buyers and negotiate for a higher farm-gate price. Hence, an increase in the farm-gate price of certified products should be considered to attract the attention of shrimp farmers towards quality assurance applications and the implementation of traceability.

Furthermore, it was found that an increase in production costs might inhibit shrimp farmers' willingness to implement traceability. Increasing investment in inputs, such as the extent of land used and variable expenses, might cause a decrease in farmers' willingness to implement traceability. The results were consistent with the earlier study of Trienekens and Zuurbier (2008), who suggested the positive impact of production costs on producers' expectations in the traceability

implementation and quality assurance certificates application. Hence, although the important role of the application of quality assurance certificates in enhancing the implementation of traceability was established, the application costs must be carefully considered. Thus, high production costs may discourage Vietnamese shrimp farmers from obtaining quality assurance certificates (Lap et al., 2015; Dong et al., 2019a). This is because the application cost ranges from 5,000 to 10,000 USD per farm or a cultivation area, equivalent to over 130% of Vietnamese household income (Vietnam GSO, 2017).

As specified in Circular No.27/2011/TT-BNNPTNT of Vietnam, small-scale farms in the aquaculture sector are farms that explored less than 2 hectares for cultivating areas. Accordingly, approximately 70% of shrimp farms, not only in the VMD region but also throughout Vietnam, are small-scale farms (Tran et al., 2013; Portley, 2016; Suzuki and Nam, 2018). Individual small-scale farmers lack financial resources and cannot bear these application costs. The results of CRM model show that if intensive shrimp farmers extended the total land used for farming activities, the expected price for shrimp products to implement traceability would decline. This suggests that these farmers were more willing to implement traceability systems. Hence, to overcome the challenges of small-scale production at the farm stage, Verhaegen and Huylenbroec (2001), Jonell and Henriksson (2015), and Dong et al. (2021) suggested that the production scale extension might encourage farmers to apply for quality assurance certifications and other tools related to product quality and safety such as traceability systems. The farm cooperatives establishment, therefore, is probably a practical alternative for the integration of shrimp farmers for sharing the application costs in obtaining quality assurance certificates and participating in the traceability implementation.

### **Conclusion and Policy Implication**

This study investigated the expected farm-gate price of farmers for shrimp products to implement traceability systems and estimate the factors influencing the expected farm-gate price based on the evidence in the Ca Mau Province, Vietnam.

The research results emphasised that shrimp farmers who have applied international quality assurance certificates expected a lower farm-gate price to implement traceability. This means that the application of international quality assurance certificates encourages shrimp farmers to implement traceability. Generally, financial factors play an important role in increasing the probability of implementing traceability at the farm level. However, in Vietnam, small-scale production might make it difficult for shrimp farmers to implement traceability, making it necessary to encourage farmers to collaborate and participate in farm cooperatives establishments.

Various national policies for farm cooperatives establishment, and the development of linkages in production and consumption of agricultural production, including farming, breeding, aquaculture, forestry, and salt production, have been issued in Decree 98/2018/NĐ-CP in 2018 of the Vietnamese Government. Accordingly, shrimp farmers, who are members of the cooperatives and have signed contracted agreements with the processing companies, can receive support in terms of preferential interest rates on long-term, mid-term, and short-term commercial loans with no collateral for expanding farming production scale as specified in Decree 55/2015/NĐ-CP in 2015 and Decree 116/2018/NĐ-CP in 2018, and for buying machinery and equipment serving reduction of agricultural losses as regulated in the Decision 68/2013/QĐ-TTg in 2013. These incentive programmes are valid only for the members of the cooperatives and/or those who take part in the local farmers' associations. The enforcement of these national policies is aimed to provide commercial loans to the stakeholders participating in the supply chain, instead of individual farmers.

This is to encourage collaboration among small-scale farmers, to support the integration of the stakeholders in the supply chain, and to develop vertical linkages from farming to distributing and processing.

However, the number of shrimp farming cooperatives in Vietnam is limited. According to the statistical data of Vietnam GSO (2019), farm cooperatives accounted for only 0.07 % of the total entities in the aquaculture sectors, where more than 99 % are operating as individual farming households because the financial benefits of participation in the cooperatives have not been properly marketed and implemented. Thus, the economic incentives of the traceability implementation, especially the differentiation in the farm-gate price for shrimp products, should be noted in increasing the awareness and willingness of shrimp farmers to collaborate, concerning the implementation of traceability. Additionally, a large database of traceability products should be prepared and published on the web portal of the Vietnamese state, enabling producers and stakeholders in the supply chain to trace relevant information on shrimp products.

**Conflicts of interest:** The authors declare that they have no conflicts of interest.

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