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Shrimp Cultivators' Willingness to Pay for Index Based Aquaculture Insurance in the South-Western Region of Bangladesh

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Abstract

Shrimp farming has important implications for the socio-economic development of the south-western region of Bangladesh due to its conducive climate, high salinity, and available labor forces. But, shrimp farming is associated with several risk factors, such as virus attack, bank damages, market failure, mangrove degradation, disease outbreak, saltwater intrusion, and sedimentation. Lack of risk management tools such as, an insurance facility further compounds the issue. Given this context, the current study attempts to estimate the Willingness to Pay (WTP) for index based shrimp insurance packages of shrimp production in Paikgacha upazila, Shamnagar upazila and Koyra upazila. A double-bounded dichotomous choice model is applied to the dataset of 120 randomly selected respondents. The empirical results reveal that shrimp farmers' WTP is significantly dominated by a host of determinants, like age, education, monthly household income, farm size, food type, field monitoring, service point distance, and training. The findings also enumerate the mean WTP of around BDT 1,000 (USD 11.8) per quarter, whereas the economically optimal tariff and the socially optimal tariff are BDT 1,200 (USD 14.2) and BDT 200 (USD 2.4) per quarter, respectively. The study assists policymakers and insurers in redesigning insurance policies, as well as providing accurate information about the supply-demand chain and equilibrium premium. It also suggests ways to maintain coordination between insured and insurer while reducing shrimp farmers' vulnerabilities.

Keywords: Shrimp Risk, Willingness to Pay, Index-based Insurance, Double Bounded Dichotomous Choice Model, Bangladesh

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1. Introduction

Agriculture has a significant role in the economy of Bangladesh, contributing to Gross Domestic Product (GDP), food security, poverty alleviation, and employment generation (Rahman, 2017). In the agriculture sector, shrimp cultivation plays a leading role in fulfilling the protein demand of the country and earning foreign currency (Paul &Vogl, 2011). Also, shrimp farming has important consequences for poverty alleviation, particularly for the rural people of the south-western region of Bangladesh (Rahman & Hossain, 2009). The urban people also benefit from participating in shrimp processing, marketing and other export-oriented activities (Islam et al., 2014).

In the south-western region of Bangladesh, the main source of livelihood is shrimp cultivation in rural areas due to favorable climatic conditions, high salinity in the soil, and adequate labor forces (Swapan & Gavin, 2011). However, some challenges are encircling shrimp farming. For example, virus attack, price fluctuations, floods, soil acidity, frequent breakouts of diseases and moss in the '*Gher*' are the major risk factors associated with shrimp cultivation (Ahmed et al., 2010; Nupur, 2010). Paul &Vogl (2011) disclose that both socio-economic and environmental challenges such as social unrest, market failure, livelihood displacement, mangrove degradation, pollution and disease outbursts, intrusion of saltwater, and sedimentation hinder the path of sustainable shrimp production in Bangladesh. In addition, unplanned and seaside territories' shrimp production culture has a great impact on the coastline ecosystem that hinders further shrimp production in the future (Barua & Hossain, 2019).

However, shrimp farmers do not have the ability to mitigate the large number of production losses due to several risk factors. In agriculture research, shrimp farmers' risk perceptions, as well as management plans, have received little attention from policymakers. Hence, there is a need to make proper provision for the risk factors. To manage the risk factors, there should be a risk taker such as an insurance facility. At the same time, the insurance facility is considered as one of the crucial financial constraints of the shrimp farmers despite its contribution to the economy. The main reason for establishing the insurance facility is that shrimp production is limited by various weather conditions as well as large-scale harms caused by socioeconomic and environmental risks, and shrimp insurance can play an important role in the sector's long-term growth. If the insurance provider ensures to take the risk by charging a premium amount, then the farmers are more willing to invest in this risky but profitable sector (Cervantes-Godoy et al., 2013).

Farmers in Vietnam being one of the leading shrimp producers in the world have a positive willingness to pay for shrimp insurance premiums. Farmers completing at least one training program with low income and high chemical costs are more willing to pay for risk management insurance premiums. In contrast, the conventional scandals of insurance companies in the market make farmers less eager to pay for insurance (Nguyen et al., 2021). A study on Pakistan by Ali (2013), reports that income of the farmers, land, asset holdings, credit access, and extension services are the significant determinats of the WTP for insurance program. Authors also claim that the index-based insurance system has great appeal and a significant impact on purchasing insurance premiums. Index-based insurance in the agriculture sector is also known as index-linked or index insurance. In an index-based insurance system, payouts are associated with an "index" that is closely linked to the agricultural production damage due to some specific risk factors such as, floods, wind flows, and hail, which are ordinarily documented at native weather stations. Payouts are considered when the index surpasses the predefined threshold level, usually denoted as "trigger". Therefore, an index-based insurance facility is not designed to provide shelter for farmers against every risk, but the risk which can significantly influence farmers' livelihood (Muamba & Ulimwengu, 2010).

Since there was no structured agricultural insurance base in Bangladesh, insurance facilities for crop production were introduced in 1977 by the state-owned insurance company, namely "*Shadharan Bima Corporation (SBC)*" to motivate the production decisions of farmers (Ahmed et al., 2010). But the service had been closed since 1996 because of persevering difficulties such as, lack of grass root level monitoring and adequate evaluation, too much peril coverage, weak and unscientific visual estimation, and moral hazard. However, as mentioned earlier, shrimp farmers face a number of socioeconomic and environmental risks associated with shrimp production. To take the lead in risk management for shrimp farming, it is necessary to first determine the level of interest among shrimp farmers in aquaculture insurance. Therefore, the purpose of the study is to explore the demand for shrimp farmers' index-based aquaculture insurance through estimating their willingness to pay for an insurance program to assess risks.

2. Literature Review

Willingness to pay denotes the amount paid by the beneficiary against any service provided by an authorized party based on the utility of that service (Ali, 2013). The risk management framework by Abebe & Bogale (2014) postulated risk as the amount paid by the insured to the insurer against any impairment of the insured matter under the risk management facility through a policy containing all the terms and conditions of the insurance contract. Likewise, the risk factors in the agricultural sector show the way to huge losses with severe impacts. Consequently, the risks bring about abnormal dynamism in the production chain, the income of the farmers, and result in welfare losses (Assan et al., 2009). Because of an inadequate risk management system, shrimp farmers try to manage the risk through their own capabilities (Cervantes-Godoy et al., 2013).

There are different types of agricultural insurance for the management of risk. Indemnity based insurance is one of those referring to the traditional insurance system, where the contract focuses on the actual loss of the farmers and claim payments are provided with respect to the loss. Several challenges are observed in the case of traditional insurance, such as adverse selection, moral hazard, and high transaction and administration costs, which can be addressed by index based insurance (Aidoo et al., 2014; Binswanger-Mkhize, 2012; Barnett & Mahul, 2007). Additionally, index based insurance mainly depends on using elicits as a reference for concrete damage assessments. An elicit is an index edge below or above, which outlays a twitch (Cole et al., 2012). Elicits can be prepared in several ways, either by using data on rainfall amounts or by using crop yield data, livestock mortality rate in a neighborhood area or district, or the level of vegetation (ILO, 2011). Index-based insurance contracts are structured on the basis of some specific risk factors such as floods, wind flows, and hail, which are ordinarily documented at native weather stations. Muamba & Ulimwengu (2010) describe that index based insurance, covering shrimp production risk that initiates outgoings when the production is 30 kg per ‘Bigha’ or less. The procedure of calculating the payment rate is followed by the ratio where actual value and lower level are deducted from the threshold level in the numerator and denominator, respectively. The threshold level indicates the accrued volume of the production according to the insurance contract.

In Philippines, there is multi-peril crop insurance (rice and corn) subsidized by the government. The Land Bank of the Philippines delivers the schemes through agricultural credit, which is mandatory for the borrowers (Bangsal & Mamhot, 2012). In India, a nation-wide agriculture scheme has been launched to provide coverage for crop production. The program is mandatory for loan takers but voluntary for others. Furthermore, a number of states have a weather-based insurance program that has been in place since 2003 and is subsidized by the government (Shashi & Umesh, 2012). In Mexico, the Ministry of Agriculture program initiated a successful index-based insurance facility (Cole et al., 2012).

Different studies are conducted in order to measure the ‘Willingness to pay’ for agricultural insurance also. Employing a panel data series, Hill et al. (2013) measured the WTP for weather-based insurance in Ethiopia. The authors find that farmers with education, high income, and preemptive and young ages are more willing to purchase the insurance premium and people who are less risk averse are less eager to pay. Liu et al. (2015) find that in China, the past experience of the farmers’ awareness programs about flood, farmers’ assets, experience, education, and credit amount significantly and positively influence the willingness to pay for index-based insurance.

Long et al. (2013) claim that total assets, farm size and ability to borrow are substantially associated with farmers’ WTP. In that study, the author also points out that expenditure per capita has a negative relationship with the willingness to pay for the insurance premium. In context of 200 Turkish farmers, Gulseven (2020) finds that education and income have a strong correlation with the willingness to pay for insurance and points out that the demand is declining sharply with the lower insurance coverage.

3. Methodology

3.1 Study Area, Data Collection and Sampling Strategies

This study is conducted in three south-western sub-districts (*upazila*) of Bangladesh, namely, Paikgacha, Shamnagar and Koyra . The first two upazilas are located in Khulna district and the last one is in Sathkhira district. The majority of residents of these areas earn their livelihood by shrimp farming. A field survey is conducted in these areas to gather information for estimating the willingness to pay of the farmers for shrimp insurance. The selected study areas constitute the primary sampling units of the study. A total of 120 households have been selected from those primary sampling units following a purposive sampling strategy. The study also purposively selects 40 respondents from each upazila. A structured questionnaire is used to conduct the survey of the selected households. The questionnaire frames the issues related to the objectives of the study, such as problems, risk management systems, and risk management costs. This study prominently relies on primary data. Data about socio-demographic features like age, gender, educational qualification, designation, land ownership, farm size, etc. are collected from a questionnaire survey through face-to-face interviews with shrimp farmers.

3.2 Theoretical Framework for Estimating Willingness to Pay

The elicitation of WTP in the Contingent Valuation Method (CVM) survey deployed in a Dichotomous Choice (DC) model has been popularized by Hanemann (1984). DC model-based CVM assumes that choices are based on utility between the available alternatives, and the alternative that provides the highest utility will be the preferred, which is based on random utility theory (Louviere et al., 2000; McFadden, 1980). This study follows the approach to modeling Contingent Valuation data by Cameron & James (1987) and Cameron (1988), which bypasses the underlying utility model and estimates the parameters of the latent WTP distribution directly. This approach is easy to interpret as it permits the straightforward calculation of marginal values for all arguments in the WTP function. Cameron's approach is derived from the expenditure function as follows:

$$WTP\ (r^0, r^1, u^0; h) = e\ (r^0, u^0; h) - e\ (r^1, u^0; h) \qquad (1)$$

Where, r^1, the situation with risk management by insurance; r^0, the current risk management situation; h, a vector of socioeconomic variables; and u^0, the utility level before the introduction of improved risk management system. The econometric model is as follows (Assuming a linear functional form for the WTP):

$$Z_i = p_i \Upsilon + \varepsilon_i \qquad (2)$$

Where, Z_i, the unobserved true individual WTP for risk management in shrimp production; $p_i \Upsilon$, individual socioeconomic characteristics; and ε_i, an unobservable random component. Z_i is considered a latent continuous censored variable: the observed variable is z^*_i which takes the answer "yes" or "no" regarding whether the individual would be willing to pay a given amount b_i. The individual will state that he is willing to pay the offered amount (B_i=1) if $z^*_i \geq b_i$ and unwilling to pay the offered amount (B_i=0) if $z^*_i < b_i$. The discrete response indicator variable B_i is the single endogenous variable in this framework. It assumes P_1, probability that $Z^*_i > b_i$; P_0, complementary probability.

3.3 Attributes for Risk Management

To manage the risks associated with shrimp cultivation, shrimp insurance can play the role of a catalyst. Because of non-existence of such insurance facility in Bangladesh, market investigation through some attributes is the first obligation. Those attributes indicate the compensation amount and the premium charged against the provided compensation amount. It helps to know the willingness to pay of the farmers for the provided services. According to this framework, the study conducts three procedures, namely Focus Group Discussion (FGD), survey instrument presentation, and cheap talk regarding the designation of the contingent valuation survey, to reduce the hypothetical biasness of the respondents. The team working on this study arranged three FGDs in each of the three *upazilas*. Five respondents from each *upazila* attended this program to share their opinions. The study draws up the outline of the contingent valuation survey along with the inclusion of the initial bid and follow-up bid on the basis of FGD findings. The upper bid is set at 2 times the initial bid, and the lower bid is set at half of the initial bid. Then, the outline schedule is delivered to 10 respondents for modifying further and finalizing the contingent valuation schedule which is presented in table 2.

Table 2: Attributes for Improved Risk Management System (per *bigha*)

Attributes	**Scenario 1**	**Scenario 2**	**Scenario 3**
Field Monitoring	Less Frequent	Frequent	Frequent
Water & Soil Test	No	No	Yes
Emergency Prescription and Treatment	No	Yes	Yes
Service Point	Greater than 5 km.	Less than 3 km.	Less than 1 km.
Shrimp fry Supply (if damage occurs)	500 shrimp fry/bigha	1000 shrimp fry/bigha	1500 shrimp fry/bigha
Mobile Network Service	No	SMS	Call and SMS
Training Facilities	No	1 day	7 days
Compensation Type	Indemnity based	Index based	Index based
Lower Bid	300	600	900
Initial Bid *	600	1200	1800
Higher Bid	1200	2400	3600

Source: Fieldwork, 2019

Note: Signature Features: 3 months coverage for all scenario

The study develops three scenarios in the contingent valuation survey, which are improved versions of the existing situation. The study also organized a meeting with an officer working for an NGO along with an agriculture expansion officer to get an idea about the viability of these scenarios.

Scenario 1 is the improved version of the insurance program compared to the current situation and less improved than scenarios 2 and 3. This scenario includes some facilities for shrimp farmers under the insurance scheme, such as monitoring fields, supplying shrimp fry, and compensating the loss of the farmers through indemnity based compensation. But there are a few limitations also. Although field monitoring is held under this program, it is less frequent. Besides, there are no facilities for water and soil testing, emergency prescription and treatment, mobile network service, and training programs. Another limitation is that the service point is located more than 5 kilometers away from the site. The service charge is set at BDT 600 per quarter to access this package considering all the facilities and limitations. Scenario 2 is a more improved version of the insurance program than scenario 1 because it includes some additional facilities along with the facilities in scenario 1. The additional facilities are 1) more frequent field monitoring, 2) arrangement of emergency prescription and treatment, 3) within 3 km service point, 4) 1000 shrimp fry/bigha supply, 5) SMS service, 6) 1-day training facilities, 7) index based compensation. So, the service charge of scenario 2 is set at BDT 1200 per quarter, which is 2 times higher than that of scenario 1. The study designs scenario 3 such that the farmers can get the maximum facilities from the insurance program. There are some exclusive facilities along with the facilities, including in scenarios 2 and 3. The exclusive facilities are 1) water and soil testing, 2) 1 km service point, 3) 1500 shrimp fry/bigha supply, 4) call service, and 5) 7 day training program. The service charge is determined at BDT 1800 per quarter, which is higher than in scenarios 1 and 2 by 3 times and 1.5 times respectively.

Since the willingness to pay is directly associated with their farmers' income and consumption, thus they are informed that the improvement is going to reduce their disposable income. They are asked directly about their willingness to pay for the improved scenarios or not. After this, if the farmers' response is negative, then they are asked to select any one of the reasons listed in the questionnaire. This procedure assists the study to distinguish the valid zeros from the protest bids.

3.4 Econometric Specification

As mentioned, Double Bounded Dichotomous Contingent (DBDC) valuation method is deployed to estimate WTP for index based aquaculture insurance. In double-bounded framework, each respondent is approached by two bids i.e. initial bid ($b_{\mathrm{l}}^{\mathrm{i}}$) and follow-up bid dependent on the initial bid. If the respondents say "yes" to the initial bid ($b_{\mathrm{l}}^{\mathrm{i}}$), then presented with a second bid (b^H_i) greater than initial bid ($b_i^l < b^H_i$). Conversely, if the individual responds with a "no" to the initial bid ($b_{\mathrm{l}}^{\mathrm{i}}$) offered a bid ($b^L_i$) smaller than the initial bid ($b^I_i > b^L_i$). The responsiveness of the respondents assorted into four distinguished WTP intervals:

1. Yes-Yes WTP interval: Respondent's positive responses on both initial bid and higher follow-up bid; $b^H_i \leq WTP < \infty$.
2. Yes-No WTP interval: Respondent's positive responses only on initial bid; $b^I_i \leq WTP < b^H_i$.
3. No-Yes WTP interval: Respondent's positive responses only on lower follow-up bid; $b^L_i \leq WTP < b^I_i$.
4. No-No WTP interval: Respondent's negative responses on both initial bid and lower follow-up bid; $0 \leq WTP < b^L_i$.

With the initial preference decision, the follow-up bid permits either an upper or a lower bound to be placed on the respondent's unobservable true WTP. If the second decision is in the same direction as the first ("yes, yes"; "no, no"), it raises the lower bound or lowers the upper bound, respectively. We therefore have the following response probabilities:

$$\Pr(yes, yes) = \Pr\left(Z_i \geq b_i^H \geq b_i^I\right) = 1 - F\left(b_i^H\right) \quad (3)$$

$$\Pr(yes, no) = \Pr\left(b_i^I \leq Z_i \leq b_i^H\right) = F(b_i^H) - F(b_i^I) \quad (4)$$

$$\Pr(no, yes) = \Pr\left(b_i^L \leq Z_i \leq b_i^I\right) = F\left(b_i^I\right) - F(b_i^L) \quad (5)$$

$$\Pr(no, no) = \Pr\left(Z_i \leq b_i^L \leq b_i^I\right) = F(b_i^L) \quad (6)$$

Given this data, a log-likelihood formulation of the double-bounded model is applicable.

$$LogL = \sum_{i=1}^{n}\{(B_i B_i^H)\log[F((t_i^H - x_i^{'}\beta)/\sigma)] + B_i(1 - B_i^H)\log[F((b_i^H - x_i^{'}\beta)/\sigma] - F((b_i^I - x_i^{'}\beta)/\sigma)] + B_i^L(1 - B_i)\log[F((b_i^I - x_i^{'}\beta)/\sigma)] - F((b_i^L - x_i^{'}\beta)/\sigma)] + (1 - B_i)(1 - B_i^L)\log[F((b_i^L - x_i^{'}\beta)/\sigma)]\} \quad (7)$$

Where responsiveness of the initial bid is expressed by dichotomous variable denotes as B_i and B_i =1 if the answer to the initial bid is positive, and 0 otherwise. In addition, the higher follow-up bid and lower follow-up bid are symbolized by B_H^i and B_i^L respectively. When the individual accepts the higher follow-up bid, then *B_i^H* =1 and similarly, when the individual accepts the lower follow-up bid, then *B_i^H* =1. Maximization of the log likelihood will yield the following linear equation:

$$lnw_i = \propto + \gamma x_i \quad (8)$$

Where, the dependent variable w_i for each household is 1 or 0 according to whether the WTP is greater or equal to zero. Equation 8 separately estimates β and σ and their individual asymptotic standard errors. The interpretation of the estimated parameters of Cameron's approach is same as that of the Ordinary Least Squares (OLS) results. More specifically, the γs shows the marginal change in dependent variable (WTP) resulting from one unit change in the explanatory variable (Cameron, 1988).

4. Results and Discussions

This section deals with the willingness to pay for an improved risk management system for shrimp cultivation, with the overall socioeconomic characteristics of the respondents. It also searches for the factors associated with the willingness to pay as well as the social optimal tariff rate with necessary policy measures for an improved risk management system.

4.1 Socioeconomic Characteristics

Table 3 summarizes the socioeconomic features of shrimp cultivators regarding their willingness to pay for index-based aquaculture insurance in the South-west zone of Bangladesh. All the respondents are male and middle-aged, with a mean age of around 40 years. The average schooling year is 4 years and the range of years of schooling varies from 0 to 12 years. They perceive that they do not need any institutional qualifications for such types of activities. From the early age, the respondents usually start working with their parents on shrimp cultivation, and they realized that it is going to be their future profession. The average household size is around 5, while only 2 persons from each household earn. Having more than one earning member does not show their well-being status. To maintain a required level of livelihood, the respondent is forced to engage their children in different activities.

The monthly average income of the respondent is almost BDT 24,000, with the earnings vary from BDT 10,000 to BDT 80,000. At the same time, monthly average household expenditure is around BDT 15,500 where lower expenditure is BDT 10,000 and higher is BDT 22,000. Besides, they have to invest their land for the shrimp cultivation process from the gap between their monthly income and expenditure amounts because farming costs are not included in the monthly expenditure amounts. Generally, three types of food are used in shrimp firms, such as conventional, organic, and chemical food. Most of the respondents don't use any type of food between organic and chemical food; rather, they go for conventional food to farm shrimp. But, organic and chemical food have become more popular because usages of these food-stuffs have made shrimp exportable. That is why the shrimp cultivators are participating in training on the use of chemical and organic food.

Table 3: Socioeconomic Characteristics of the Respondent

Variable	Measurement Unit	Mean	S. D.	Min	Max
Age	Number of Years	39.41	10.2	23	59
Education	Year of Schooling	4.28	2.66	0	12
Number of Family Member	Number	4.93	0.41	3	11
Number of Earning Person	Number	1.51	1.44	1	4
Monthly Income	In BDT	23975	7489	10000	80000
Household Expenditure	In BDT	15365	6530	10000	22000
Food Type	0= Conventional, 1= Organic, 2= Chemical, 3= Both	1.03	0.82	0	3
Firm Size	In *Bigha*	7.83	2.66	1	43
Number of Plots	Number	1.55	0.43	1	3
Farming Experience	Number of Years	14.61	6.72	2	40
Training Duration	Number of Days	0.83	0.64	0	7
Problem Extremity	1= Complete Damages, 2= Moderate Damages, 3=Little Damage	2.1	1.2	1	3
Credit Access	0= Others, 1= Relatives, 2= Banks, 3= NGO	1.48	0.6	0	3
Shrimp fry Source	1=River, 2= Hatchery, 3=Both	1.94	0.56	1	3
Field Monitoring	Number	1.68	0.32	1	2
Service Point Distance	In Kilometer	8	2	0	14
Total Cost	BDT/*Bigha*	44500	3500	5000	300000

Source: Fieldwork, 2019

The average firm size is around 8 *bighas* which regulates the monthly income and expenditure of the respondents. Additionally, the average number of plots is 1.5 and the maximum number of plots is 3. The reason behind the fragmentation of land differs from individual to individual. The shrimp farmers usually separate their plot so that they can save their plot from damage. If damage occurs in one plot, another plot can be saved due to the separation. Sometimes the plotting may occur due to systematic defaults, such as the location of land in different places. The farming experience of the respondents is measured through how many years they have been engaged in shrimp cultivation. The average years of farming experiences are almost 15 and it implies that most of the respondents are experienced and their given information will help us to draw a conclusion on this study. Here, the average training durability of the respondents is around 1 day for shrimp cultivation and the highest range is 7 days. Different types of problems, as indicated elsewhere, have been faced by the respondents like virus attacks, floods, and bank damage mainly. The mean value of the problem extremity illustrates that most of the respondents went through moderate damage due to virus attack and bank damage. When they realize the problem, the farmers start to harvest the shrimp for sale. Basically, if the respondents required any financial help during their cultivation period, they tried to get it from their relatives. They are reluctant to take financial facilities from any formal financial institutions like banks or NGOs because of complex documentation, extensive paper works and weekly or monthly installments.

Basically, there are two sources of shrimp fry, namely the river and the hatchery. The shrimp farmers collect shrimp fry from the hatchery because river shrimp fry has a higher price than hatchery shrimp fry. The reason for this is that the productivity and growth of the river shrimp fry are higher than the hatchery shrimp fry. Field monitoring refers to the frequency of expert field visits. Here, per 2 months, an expert visits the shrimp firm of the respondents during the seasonal time. The average service point distance is 8 kilometers and the highest distance is 14 kilometers within the study area. In this study, the average cost of shrimp cultivation is BDT 44,500 per *bigha*, but the lowest and highest range of costs differ from BDT 5,000 to BDT 3,00,000 depending on farm size and shrimp fry sources. Therefore, for improved and risk minimizing shrimp farming, they need index based aquaculture insurance.

4.2 Household Preference towards Shrimp Insurance Packages

Table 4 illustrates three households' preferences toward index based shrimp insurance packages which are distributed from 21percent to 47 percent. Most of the respondents, around 47 percent, prefer moderate service packages including frequent field monitoring services, training facilities, service points within 3 kilometers and index-based compensation for food and other damages. In contrast, around 22percent of respondents prefer a high service package with the addition of water and soil testing, frequent awareness messages through phone, and service point distance within 1 kilometer. Despite the fact that the high service package is very appealing, the respondent cannot afford it due to increased spending. Another service package is the low service package, which is preferred by around 32 percent of respondents without having any convincing facilities.

Table 4 also highlights the household's willingness to pay for index-based shrimp insurance packages. Almost 48 percent (36.84+10.53) of respondents agreed to accept the lowest initial bid of BDT 200 per month (BDT 600 per quarter) for a low service package. Of these 48 percent of respondents, around 11 percent agree to spend the upper follow-up bid amount of BDT 300 per month. Similarly, around 58 percent and 62 percent of respondents are ready to accept an initial bid, respectively, for moderate and high service packages. On the other hand, rejecting the initial bid but ready to accept lower follow-up for the shrimp insurance packages is around 52 percent (15.79+36.84), 42 percent (8.93+33.93) and 38 percent (11.54+26.92) respectively for low, moderate and high service packages. Therefore, respondents generally prefer the maximum service packages with the lowest possible installment amount.

Table 4: Households' Preference for the index based shrimp insurance package

Packages	Initial Bid	Accepting lower bid or no bid				Accepting at least initial bid					
		Rejecting both initial and lower bid		Rejecting initial bid but accepting lower bid		Accepting initial bid but rejecting higher bid		Accepting both initial and higher bid			
		No-No		No-Yes		Yes-No		Yes-Yes		Total	
		Freq	percent	Freq	percent	Freq	percent	Freq	percent	Freq	percent
Low service package	600	6	15.79	14	36.84	14	36.84	4	10.53	38	31.67
Moderate service package	1200	5	8.93	19	33.93	15	26.79	17	30.36	56	46.67
High service package	1800	3	11.54	7	26.92	8	30.77	8	30.77	26	21.66
	Total	14	11.67	40	33.33	37	30.83	29	24.17	120	100

Source: Fieldwork, 2019

4.3 Determinants of Willingness to Pay

The estimated result of the DBDC model on WTP for index-based shrimp insurance is presented here. The result of WTP is impartial when the model is free from the starting point bias problem (Alberini, 1995). To avoid this major problem, the authors did not expose the initial bid inconsistently; instead, four scenarios were presented, including the introductory bid. Then their preference was asked by the authors for index based shrimp insurance packages. If there is no starting point bias, the DBDC model will provide an accurate result for WTP, and this study design is free from this bias issue.

Table 5: Estimation Double Bounded Dichotomous Choice Model

Model Covariates	Coefficient	Std. Err.
Age	0.223*	0.243
Education	0.920**	0.761
Farm ownership	-0.825	0.579
Farm size	0.043***	8.163
Production cost	-0.822	0.482
Ln income	0.117***	4.492
Food type	0.121*	6.166
Farming experience	0.473	6.543
Field monitoring	0.213***	5.463
Problem extremity	0.632	2.956
Credit access	-0.223	9.765
Shrimp fry source	0.498	2.938
Number of plots	0.009	2.639
Service point distance	4.23**	20.39
Training	-0.747***	0.711
Constant	-72.80	47.03
Sigma	14.92***	2.276
Observations	120	

Source: Fieldwork, 2019

Note:*, ** and *** denote significance at 10percent, 5 percent and 1% levels, respectively.

Table 5 postulates that there is a positive relationship between age and WTP for index-based shrimp insurance packages. Older respondents are significantly (at 10percent level of significant) more willing to pay for using the insurance facilities than younger ones. The result in regards to of the education shows that increasing the number of years of schooling significantly (at a 5 percent level of significant) affects the WTP for having institutional knowledge for shrimp cultivation. Educated respondents want to reduce their risk during the cultivation period by having knowledge regarding shrimp cultivation compared to illiterate respondents.

In the case of farm size, the coefficient has a positive association with WTP. The result seems to be that large farm holders are significantly (at 1percent level of significant) more willing to pay for taking insurance facilities than small farm holders, as they have a higher risk of managing their farm compared to others. As expected, the respondents who have higher incomes are more willing to pay compared to those who have an insufficient amount of income. At the 1percent level of significance, respondents' WTP is positively influenced by around BDT 12 more for index-based shrimp insurance package. This may reflect a security aspect of respondents, where the higher income holders think that some premium can save them from huge damages.

In the model, there are three types of shrimp food, like conventional, organic, and chemical food. Use of organic or chemical food is positively related to the WTP for shrimp insurance facility. The result implies that the respondents who use organic or chemical food compared to conventional food are significantly (at 10 percent level of significant) more willing to pay for insurance. Using organic or chemical food increases the cost of production more than conventional food users. That is why the respondents are highly concerned about the farm and risky issues. For the field monitoring variable, the coefficient result is positive and statistically significant (at 1 percent level of significance). It implies that the physical appearance of the expert in the field raises the motivation of the respondents to spend money on the index-based shrimp insurance package.

Here, the variable service point distance has a positive effect on the willingness to pay for an improved risk management system. The result is statistically significant at the 5 percent level. The respondents agreed to spend around BDT 5 more for improved shrimp insurance facilities. In the case of training facilities, respondents who receive training are significantly (at 1 percent level of significant) less willing to pay compared to those who do not have any sort of training. This result suggests that respondents who are trained are highly aware of the risk factors regarding shrimp cultivation. As a result, the trained respondents are less willing to pay for the improved risk management service for shrimp cultivation. Therefore, in the DBDC model, some important variables are insignificant, such as farm ownership, production cost, farming experience, problem extremity, and number of plots, but these variables exhibit expected signs.

5. Market Optimal and Social Optimal Tariff Rate for Policy Measures

The estimated result of WTP supports policymakers in defining the ideal tariff rate for an index-based shrimp insurance package. The computed average value of WTP is around BDT 1000 with an interval of 988-1024 at a 95 percent confidence interval. This refers to households that are willing to pay an average of BDT 1000 per quarter to adopt the package**.** Figure 1 reveals that almost all of the respondents agreed to pay for index-based aquaculture insurance at BDT 200 per quarter. Approximately 95percent of respondents are willing to pay BDT 300 per quarter to use the service. As a result, it is clear that the preference of households gradually decreases with the progressive tariff rate. It is also observed that only 13 percent of respondents are willing to pay the tariff rate of BDT 3600 per quarter. The study also determined that the median WTP BDT 1200 represents approximately 50 percent of those willing to use the service at this tariff rate. In this backdrop, the formulation of policies regarding index-based insurance by deploying WTP would not be affected by the outlier problem.

Figure 1: Respondent's response towards offer bid for shrimp insurance package

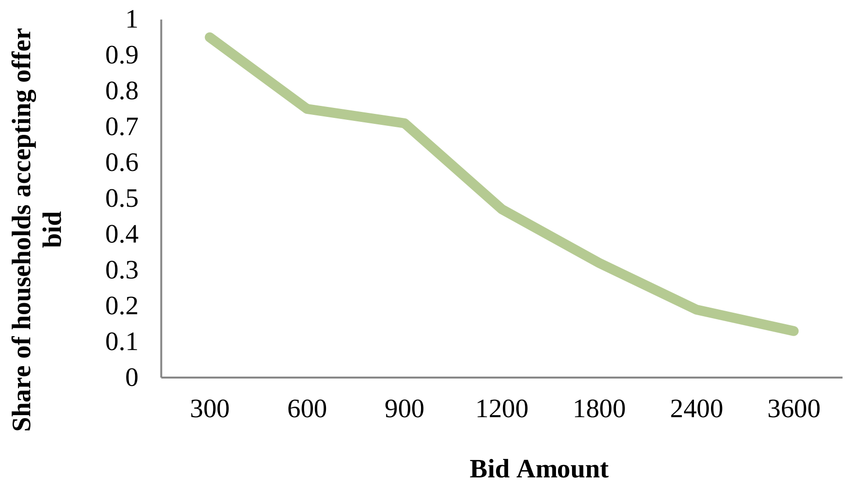
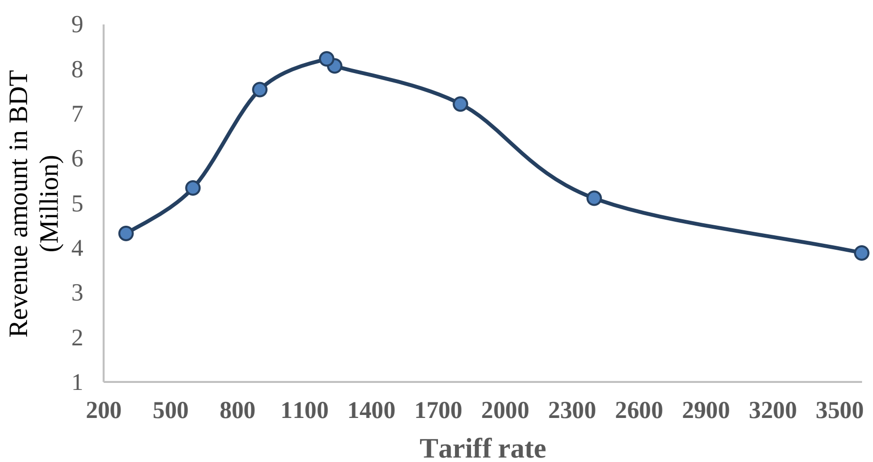


Figure 2: Determining Optimal Tariff Rate



The study projects the costs related to the implementation of index-based aquaculture insurance for shrimp farmers are based on establishment and annual operating costs. The installation of this project requires BDT 50,000-60,000 (USD 590-708) along with an operation cost of BDT 10,000 (USD 118) annually (Roberts, 2007). The deep consultation with an agriculture expansion officer provides the apparent idea about the installation cost of scenario 3 for the 60 shrimp farmers, which is around BDT 1,20,000 (USD 1415) along with an annual maintenance cost of around BDT 20000 (USD 236) per year. There are around 15,000 shrimp farmers in Paikgacha , Shamnagar , and Koyra *upazilas* (BBS, 2020). Therefore, around USD

4,12,750 (0.41 million) is required to install and maintain the project in the first year. The establishment cost of the project is around 0.37 million, and the remaining 0.04 million is associated with maintaining the project. The study follows the approach by Palinko & Szabo (2012) to compute the overall cost of the project, where the life span of the project and discount rate are 10 years and 10 percent, respectively. Following the approach, the study computes the implementation cost of scenario 3 along with a 10 year operating and maintenance cost, which is almost USD 0.61 million. Consequently, the study takes into account all the bids regarding WTP to compute the revenue from the project. The present value of the project with a 10 year life span is computed at each tariff rate. And, the study figures out the social optimal tariff rate for the implementation of index based shrimp insurance through the simulation of present value and revenue which is presented in Figure 2.

If a mean tariff rate of BDT 1,000 per quarter (BDT 333 per month) is imposed on the households covering 70 percent of the farmers (almost 10,500), the present value of the revenue with a 10 percent discount rate and a 10 percent life span is around BDT 630 per month (USD 7.75 million), which is 12.9 times higher than the total cost. The imposed median tariff rate of BDT 1,200 per quarter (BDT 400 per month) covers nearly half of the farmers and generates a maximum revenue of BDT 700 per month (USD 8.25 million), which is 13.75 times the cost. As a result, at this tariff rate, approximately 20 percent more people are discarded from this service. Despite the fact that approximately half of the farmers are denied access to the project's services, this tariff rate is considered the economically optimal tariff rate due to the optimization of the authority's financial benefits. As a result, the mean tariff rate and the median tariff rate are not socially optimal tariff rates because approximately 30 percent and 50 percent of farmers, respectively, are discarded from the service. Following the median point of tariff rate, increasing the amount of tariff rates maximizes the authorities' financial position while excluding all farmers from the services. Conversely, before the median point, the revenue decreases and the coverage increases gradually. A drastic reduction in the tariff rate to BDT 300 per quarter (BDT 100 per month) increases coverage to approximately 90 percent and generates revenue of BDT 450 per month (USD 4.2 million), which is 7 times the cost in present value. And, further reduction of the tariff rate to BDT 200 per quarter (BDT 67 per month) ensures coverage for almost all of the farmers along with generating 6.67 times higher revenue of BDT 420 per month (USD 4 million) for the authorities. Since most farmers can get access to the service after the implementation of index-based aquaculture insurance at a tariff rate of BDT 200 per quarter, this is considered the socially optimal tariff rate. And, the revenue from this tariff rate exceeding the cost ensures the sustainability of the project.

6. Conclusion

In the south-western areas of Bangladesh, especially the Paikgacha, Shamnagar, and Koyra areas, the shrimp farming is susceptible to several risks such as natural calamities, virus attacks, and bank damages. The shrimp cultivators are not able to manage the uncertainty, hence the index-oriented shrimp insurance can serve as a risk-control strategy. The cultivators’ willingness to pay for index-based shrimp insurance packages is significantly regulated by numerous factors, such as age, education, monthly household income, farm size, food type, field monitoring, service point distance, and training. Farm ownership, production cost, farming experience, problem extremity, credit access, shrimp fry source, and number of plots have negative associations with WTP for indexed-based insurance packages. About 88 percent of the respondents have a willingness to pay for the improved risk management insurance packages for shrimp cultivation. Respondents' WTP differed between BDT 300 and 3600 per quarter. Around 95 percent of respondents are more willing to pay BDT 300 per quarter, while around 13 percent of respondents are willing to pay BDT 3,600 per quarter for this shrimp insurance package. The computed average value of WTP is around BDT 1,000 per quarter and the median WTP is BDT 1,200 per quarter. The estimated result of WTP can support policymakers in defining the ideal tariff rate for an index-based shrimp insurance package. The total monthly risk assessment of the farmers can be covered by a tariff rate of BDT 200 per quarter (BDT 67 per month), and this rate is the socially optimal tariff. If the mean WTP is higher than the socially accepted amount, the government should come forward to subsidize the sector.

Therefore, to reduce the risks, shrimp cultivators need to insure the production. However, for shrimp farming, there are no specific insurance facilities in Bangladesh. To introduce one, it is critical to utilize the public-private partnership.

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