Economic Analysis of White-Leg Shrimp (*Penaeus vannamei)* Production. Case Study: Rudong County of Nantong city, Jiangsu Province, China

Abstract

This paper examines the economic performance of White-leg shrimp (*Penaeus vannamei*) production in Rudong county of Nantong city, Jiangsu province, China. White-leg shrimp (*Penaeus vannamei*) production is an important economic activity in the overall farming system in China. Despite the current achievements witnessed by white-leg shrimp production, there are many challenges (high cost of production, disease, over feeding, effluent discharge, lack of technical knowledge, low educational level, inexperienced managers, among others) continuing to set back the growth of this sector in China. Three seasonal crops data in 2016 were collected from 52 white leg shrimp farmers. Descriptive statistics, profitability and regression analysis were employed in the data analysis. The study revealed that all white-leg shrimp farmers sampled were males. Most farmers (78.9%) belonged to an age group of 41-60 years with 6-10 years farming experience. Operational costs of White-leg shrimp farming accounted for 89.2% out of the total cost with feed, fingerlings and fuel representing 34.3%, 13.1% and 12.7% respectively. Farmers obtained an average revenue of CNY 924,359.74/ha from shrimp sold at an average price of CNY 43/kg and secured a net profit of CNY 378,144.55/ha. The gross margin ratio (0.47), benefit cost ratio (0.69) and return on investment (0.69) revealed that white-leg shrimp is economically viable. Feed cost, cost of fingerling and experience showed negative significant effect on revenue at 5%, 10% and 1% respectively while farm size and average price showed positive effect on revenue at 1% level of significance.

Key Words: Economic Analysis, White-Leg Shrimp (*Penaeus vannamei*), Jiangsu, China

Introduction

Chinese shrimp farms are located along the coastline nearly 18,000km from Hainan province (South) in the tropics to Liaoning province (North) in the temperate region. The main shrimp producing provinces in China are Guangdong, Guangxi, Zhejiang, Jiangsu, Shandong, Fujian, and Hainan [27]. There are about 14,000 shrimp farms in China, [2]. According to [3], in northern province of China, extensive system of shrimp farming is usually practice by farmers, especially for those who have to farm shrimp with seawater. While in the southern province, intensive farming system is common especially for white-leg shrimp (*P. vannamei*) species, which is featured by pond built in supralitoral zone with a central drain and aerating equipment. Presently, green-house pond is used in the south for over-wintering and harvest is done during the early spring. It has been reported that in the southern province, farms generally have 2-3 production cycles per year, while in the northern province, farms normally have one cycles per year due to the winter season [3]. China is the world largest producer of shrimp, follow by Thailand, Vietnam and Indonesia [7].

Shrimp is the most valuable fisheries commodity in the world representing 15% of the total value of international traded fisheries products [7]. China is the second largest exporter in volume of farmed shrimp after Thailand [13] and third largest exporter by value globally. Shrimp stands out as the highest economic value seafood products export from China. As one of the major producers, China is determined to meet the needs of both international and domestic demand for shrimp especially its delicious taste with high protein. It contributes to animal protein intake, employment generation, household incomes, foreign exchange earnings and livelihood of farmers. Many investors and aquaculturists are hopeful about the potential of shrimp farming industry in China because of the vast domestic shrimp markets indicating the confidence and enthusiasm to the future of the industry. The study attempted to investigate the economic analysis of white-leg shrimp production using enterprise budget approach including, revenue, net income, gross margin, gross margin ratio, benefit cost ratio and return on investment among others.

Overview of White-leg Shrimp Production in China

Shrimp production in China has been increasing over the past years especially the white-leg

shrimp (*Penaeus vannamei*) which has followed a general trend of increasing output [8]. Total white-leg shrimp production increased from 60,5259mt (2002) to 1,672246mt (2016 with a growth rate of 0.053% (Fig. 1). The year 2014 saw a sharp decline of freshwater white-leg shrimp production of 140,606mt (2014) 81,2545mt (2013) [4]. [20] and [3] have also reported that this increase in white-leg shrimp production has been achieved with intensification of farming systems by large commercial companies. White-leg shrimp (*P vannamei)* output surpassed 1.37mt and accounted for 40% of farmed shellfish production nationwide [12]. In spite of the growing trend in white-leg shrimp (*P. vannamei*) output, increase in the number of farm sites have occurred only in more recent years from provinces such as; Guangdong, Jiangsu, Zhejiang, Hainan, Guanxi and also to lesser extend in Shandong, Fujian and other provinces [11]. In 2016, annual production of white-leg shrimp in China has recorded of about 1.67 million mt (Fig. 1**)** [4]**.**

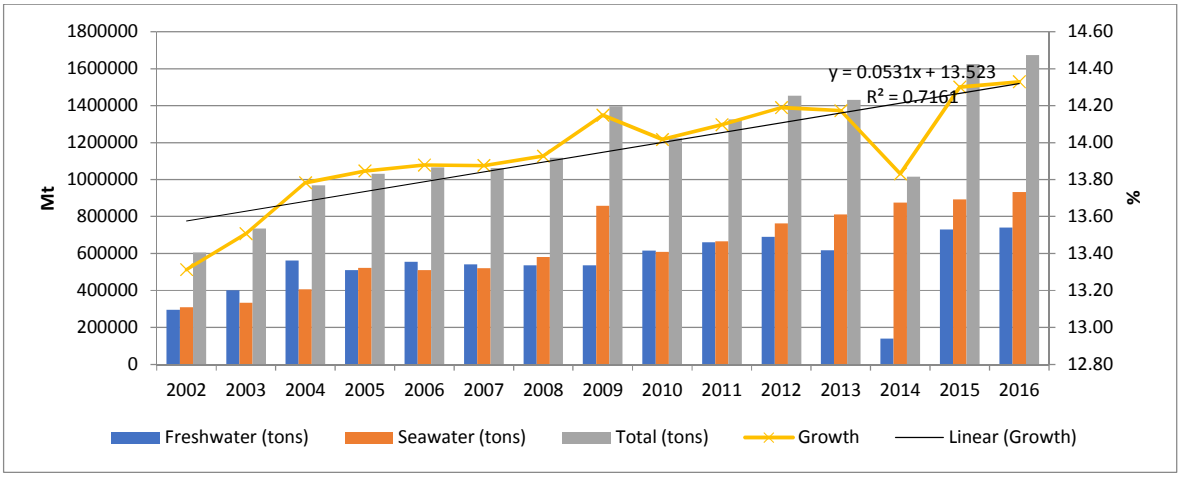


Fig.1: Production of white leg shrimp (*P. vannamei)* in China, 2002-2016.

[**Data source:** 5].

White-Leg Shrimp Production in Jiangsu Province, China

The production of shrimp has been increasing primarily in Guangdong, Jiangsu, Hubei, Zhejiang and Guangxi provinces. Jiangsu province has been regarded as one of the leading producers of aquatic products. In 2012, total aquatic production in Jiangsu province for seawater and freshwater were estimated at, 1,421 tons and 3,339 tons respectively totaling to 4,760 tons. Hubei, Guangdong, and Jiangsu provinces are the largest producers of freshwater cultured shrimp [12]. Annual white-leg shrimp (*P. vannamei*) production in Jiangsu province reached a record of 179,750mt in 2015 of which freshwater and seawater accounted for 152,111 tons (84.62%) and 27,639mt (15.38%) respectively and a total decline in 2016

(179,587mt) as a result of a decline in seawater white-leg shrimp production (20,904mt) (Fig. 2).

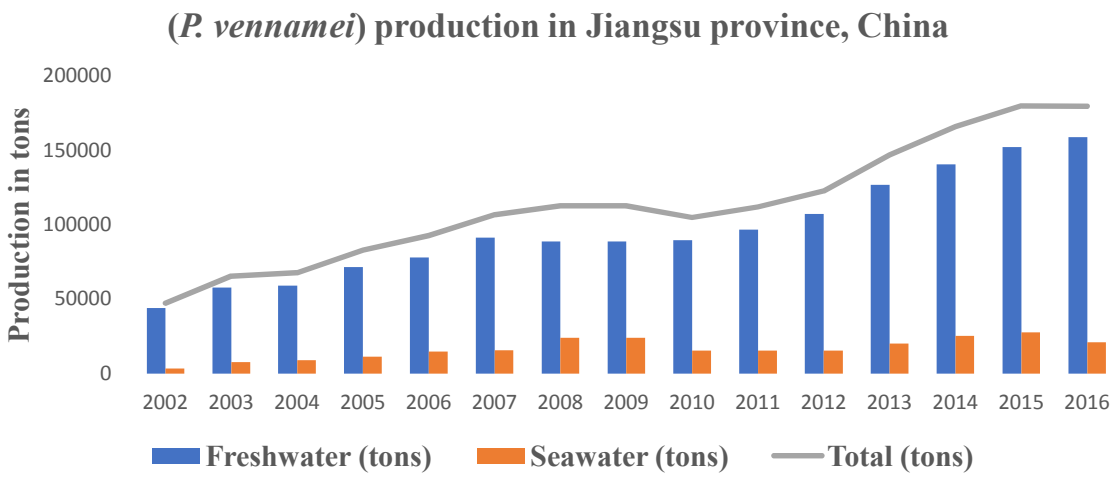


Fig.2: White leg shrimp (*Penaeus vannamei*) production in Jiangsu province, China [**Data source:** 4].

Problem Statements

Production of white-leg shrimp (*Penaeus vannamei*) is a very important economic activity in the farming system in China. The practice of white-leg shrimp farming is gaining popularity in most areas in China. In spite of the present successes witnessed by white-leg shrimp farming, there are many challenges continuing to set back the growth of this sector in Jiangsu province, China. The risk of disease outbreak has a significant negative effect on farm economy and this is a major concern in the shrimp industry. The outbreak of disease can cause massive crop failure, which can largely challenge sustaining production and affect profitability of the sector [3]. Moreover, over feeding and effluent discharges have created challenges for policy makers and threaten the sustainable development of shrimp aquaculture. In addition, lack of technical knowledge, low educational level, inexperienced managers, high cost of production, inefficiencies, differences in socio-economic characteristic and management practice are some of the problems that are hampering the success of shrimp farming in the study areas.

Objectives of the study

The aim of this study is to assess the economic performance of White-Leg Shrimp (*P. vannamei*) production in Jiangsu Province and examine the factors affecting revenue generation.

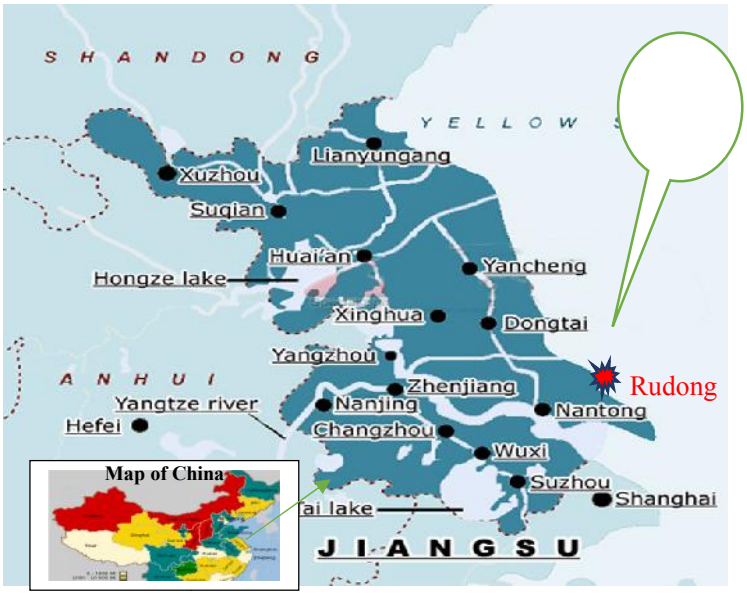
Hypotheses

1. **H_0:** High costs of feed and fingerling does not lead to less revenue;
2. **H_0:** There is no significant relationship between the farm size, average price of the white-leg shrimp products and the revenue.

Materials and Methods

Study Location

The study was conducted in Rudong county in the Nantong city of Jiangsu province, east coast of China. Rudong is a municipal government area with 14 towns and 5 districts with an area of 1,872 Km^2 and a total population of 1.08 million people.



Map.1: Study Area

(**Source:** 25)

It is located on the bank of the Yellow Sea [26]. Nantong city is located in Jiangsu province on the northern bank of the Yangtze River, near the river mouth. It has an area of 8,544 Km^2 with a population of about 7.3million people of 2010 census. Nantong is a vital river port bordering Yancheng to the north, Taizhou to the west, Suzhou and Shanghai to the south across the river and the East China Sea to the east [25]. The author chose Jiangsu for the study because is among the three largest producers of White-leg shrimp (*Penaeus vannamei*)

in China. Nantong city is the largest shrimp producer in Jiangsu province of which Rudong county stands out as the largest contributor [26].

Data collection and sampling method

The primary data used for carrying out this study was a cross-sectional data for three crop seasons in 2016. Each of the crop seasons is made up of three months hence the three cop seasons total 9 months. Data collection commenced in October 2017, and with the final field work completed in November 2017. Information and data were collected from 52 white-leg shrimp farmers in the study areas using structured questionnaires. The questionnaires were first tested among 10 white-leg shrimp farmers in Rudong County, before it was finally administered.

Data analysis

All the data collected were coded and entered into a statistical package for social sciences (SPSS). SPSS version 20 and Microsoft Excel 2007 spreadsheets were used in the analysis. Descriptive statistics, enterprise budget and regression (ordinary least square) analysis were used in analysis. All the calculations in this study were based on (1 mu=667 m^2) for average shrimp production area.

Analysis of profitability

[23] described profitability analysis model as deterministic assumption, where random variables reflected by uncertain factors of production can be easily added. The budgetary analysis of profitability was obtained using Equation 1 to Equation 6:

Net Farm Income (NFI) = TR – TC

Eqn.1

Benefit Cost Ratio (BCR) =TR/TC

Eqn.2

Gross Margins Ratios (GMR) = (TR – TVC)/TR

Eqn.3

Return on Investment (ROI) = NFI/TC

Eqn.4

Percentage Profitability (PP) = NFI/TCx100

Eqn.5

Where:

TR = Total revenues, TC = Total cos, TVC = Total Variable cost, NFI = Net farm income, TC = Total cost.

The break-even point rules

To conduct breakeven analysis, the fixed costs was divided by the price minus the variable costs as shown in Equation 6:

Breakeven Point = Fixed Costs/ (Unit Selling Price - Variable Costs)

Eqn.6

Regression Analysis

This was used in this research to examine the factors that affect shrimp production. All the functional forms were tested before selecting the double log which was best fit for Cobb-Douglas production function model [22]. To estimate the factors affecting revenue (output), ten inputs variables were included in the analysis. The output is the revenue of the white-leg shrimp production while the inputs used were cost of feed [9], cost of fingerlings, fuel cost, labor cost, cost of chemicals, and fixed cost [19]. In addition, household size, experience, average price [24] and farm size [1] were included in the model. This model shows the relationship between dependent variable (Y) and independent variables. (X_1, X_2, X_3, X_4, X_5, X_6, ...X_{10}). The production function used is specified as follows (Equation 7).

$$\ln Y = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + b_9 \ln X_9 + b_{10} \ln X_{10} + E$$

Eqn.7

Where:

Y = Dependent variable (Revenue) **X_1**, = Cost of feed **X_2 =** Cost of fingerling

X_3 = Cost of fuel/electricity **X_4** = Cost of labor **X_5** = Cost of chemical

X_6 = Household size **X_7=** Farm Size **X_8=** Average price

X_9 = Fixed cost **X_{10}** = Experience

193 $\mathbf{b_0}$ = Constant term $\mathbf{b_1 - b_2}$ = Parameters that were estimated **E** = Error term

194

195 # Results

196 ## Socio-economic features of the white-leg shrimp farmers

197 The result of the socio-economic features of the respondents are summarized in Table 1.

198 **Table 1:** Socio-economic characteristics of the white-leg shrimp farm owners

Variables	Classification/Range	Frequency	Percentage
Gender	Female	5	9.6
	Male (farm owners)	47	90.4
	Total	52	100.0
Age of farmers/ respondents	21-30	1	1.9
	31-40	7	13.5
	41-50	24	46.2
	51-60	17	32.7
	>60	3	5.8
	Total	52	100.0
Educational level	Primary school	4	7.7
	Junior high school	13	25.0
	Senior high school	27	51.9
	College/university	8	15.4
	Total	52	100.0
Shrimp farming experience	<= 5	14	26.9
	6-10	31	59.6
	11-15	5	9.6
	> 20	2	3.8
	Total	52	100.0
Household size (person)	< 3	2	3.8
	3-5	41	78.8
	> 5	9	17.3
	Total	52	100.0
Farming as a Primary occupation	Yes	48	94.2
	No	3	5.8
	Total	52	100.0
Secondary occupation	Driver	1	1.9
	Factory worker	1	1.9
	Shop seller	2	3.8
	Shrimp farming	48	92.3
	Total	52	100.0
Having technical training	Yes	49	94.2
	No	3	5.8
	Total	52	100.0
Buy fishery insurance	Yes	23	44.2
	No	29	55.8
	Total	52	100.0

199 **Source:** Field survey

200 Majority (90.4%) of the white-leg shrimp farm owners sampled were male while female
201 (mostly family members) represent 9.6%. Most (46.2%) of the respondents fall within the age

group of 41-50 years, 32.7% fall within the age bracket of 51-60. The minimum and maximum age of farmers ranges from 22 to 75 years (48.9±8.25). Regarding the educational level, the result showed that 32.7% of the respondents had one form of educational (Primary and junior high school) exposure while 51.9% and 15.4% had senior high school and college education respectively. The Table 1 also shows that 59.6% of the farmers have 6-10 years of experience in white-leg shrimp farming. Experience ranges from 2 to 24 years with average experience of 8.2 years and standard deviation of 4.2 years. Based on household size, the result indicated that most of respondents have 3-5 persons per family, representing 78.8%. Household size is between 2 to 8 people (4.6±1.3). Finally, 94.2% of the respondents had secured technical training.

Sources of Input Employed

Table 2 shows different types of sources of inputs employed by the white-leg shrimp farmers in the study area.

Table 2: Percentage distribution of Inputs employed in white-leg shrimp production

Variables	Classification/Range	Frequency	Percentage (%)
Sources of seed/feed	Self-breeding/self-made feed	8	15.4
	Buy from local enterprise	40	76.9
	Buy from non-local enterprise	4	7.7
	Total	**52**	**100.0**
Weight of seed	(5-8g)	6	11.5
	(10-12g)	46	88.5
	Total	**52**	**100.0**
Type of feed used	Sinking pellet	49	94.2
	Floating pellet	3	5.8
	Total	**52**	**100.0**
Financial sources	Individual savings	47	90.38
	Loan from relative	21	40.38
	Loan from bank	17	32.69
	Loan from relatives	3	5.77
	Total		**171.15***

*Total percentage greater than 100 as a result of multiple responses

Source: Field survey, 2017

Most (76.9%) of the respondents sourced shrimp seed, feed and medicine from local enterprise, 15.4% of the farmers make their own feed and breed their own fingerlings while 7.7% sourced feed and seed from non-local enterprise. Majority (94.2%) of the farmers used sinking pellet while 5.8% used floating pellet. The results further showed that most (90.38%

showing multiple responses) of the respondents sourced their working capital from personal savings. 40.38% of the farmers used loan from relative, 32.69% accessed loans from the bank while 5.77% sourced funding from cooperatives.

White leg shrimp farm size (ha) and stocking density

The areas of shrimp farm (ha) owed by the farmers is shown below. Most (57.7%) of the farm size operated by the farmers is less than 7ha. Majority (69.2%) of the farmers stocked between 1,000,000-40,000,000ha fingerlings while 30.8% of the respondents stocked between 41,000,000-200,000,000ha fingerlings. The mean stocking density of fingerlings was 31,618,245.5.

Table 3: Area of Shrimp farming (size/ha) and stocking density (ha)

Variables	Range	Frequency	Percentage	Min	Max	Mean	Std.
Area-2016	**< 7.0**	30	57.7				
	7-27ha	22	42.3	26.7	2000.4	240.75	311.08
	Total	52	100.0				
Stocking density	1,000,000-40,000,000	36	69.2	1,017,297.4	150,030,000.0	31,618,245.5	29,837,494.9
	41,000,000-200,000,000	16	30.8				
	Total	52	100.0				

Source: Field survey**.**

Profitability and Breakeven Analysis of white-leg shrimp production

Table 4a and b show the costs as well as returns and profitability ratios of White-Leg shrimp farming with variable costs (89.2%) representing the largest cost out of total cost of white-leg shrimp production. Feeds alone accounted for the largest proportion (34.3%) of the total cost. This is followed by fingerlings, fuels and labors costs, accounting for 13.1%, 12.7% and 10.4% respectively, of the total costs.

Table 4a: Costs analysis of White-Leg Shrimp Farms.

Cost Items	Amounts (CNY)/ha	Percentage (%) Total Cost
Variable Costs		
Fingerlings	71,407.61	13.1
Shrimp feed	187,173.58	34.3
Chemical	24,798.18	4.5
Labor wage	57,038.40	10.4
Electricity/fuel	69,098.43	12.7
Manger salary	45,673.08	8.4
Others	32,147.39	5.9
Total Variable Cost (TVC)	**487,336.67**	**89.2**
Fixed Costs		
House construction	10,150.64	1.9
Pond construction	24,988.46	4.6
Hatchery construction	3,130.77	0.6
Aerators	4,254.81	0.8
Feeders	2,458.33	0.5
Pump	4,047.12	0.7
Vehicle/Tricycle	7,685.90	1.4
Boats	200.00	0.0
Nets	481.73	0.1
Others	1,480.77	0.3
Total Fixed Cost (TFC)	**58,878.53**	**10.8**
Total Cost	**546,215.20**	**100.0**

Source: Field survey

The fixed cost accounted for 10.8% of the total production cost. Also, the result revealed that the farmers spent a total cost of CNY546,215.20/ha (Table 4a) and secured a total revenue of CNY924,359.74/ha with a net farm profit of CNY378,144.55 from shrimp sold at an average price of CNY43/kg (Table 4b).

Table 4b: Returns and profitability ratios of White-Leg Shrimp Farms

Yield (kg)	21,283
Price of shrimp (kg)	43
Revenue	924,359.74
Net Farm Income (NFI)/Profit	378,144.55
Benefit Cost Ratio (BCR)	1.69
Gross margin	437,023.07
Gross Margin Ratio (GMR)	0.47
Return on Investment (ROI)	0.69
Percentage Profitability (PP)	69.23
Breakeven Price	25.6
Breakeven Yield	2,867

The results of the profitability ratio analysis showed that the white-leg shrimp farmers in the study area had a positive Gross Margin Ratio (GMR) of 0.47, a Benefit Cost Ratio (BCR) of

1.69, Return on Investment (ROI) of 0.69 and Percentage Profitability (PP) of 69.23. From Table 4b, it can be seen that the breakeven yield and the breakeven price were recorded as 2,867 Kg and CNY25.7/kg, respectively.

Regression Results; Factors influencing white-leg shrimp production

Table 5 shows the results of the regression analysis of factors affecting revenue. The independent variables such as input variable (feed, fingerling, labor), socio-economic variables like, farming experience, household size showed negative relationship with revenue. Other independent variables included were farm size and average price both exhibiting positive relationship with revenue.

Table 5: Multiple regression analysis result of the determinant of shrimp revenue.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-1.924	4.703		-2.842	.007***
Feed	-1.468	5.235	-.083	-2.191	.034**
Seed/fingerlings	-8.546	6.218	-.061	-1.760	.086*
Fuel	6.585	5.389	.015	.428	.671
Labor	-3.940	9.484	-.014	-.415	.680
Chemical	9.874	5.335	.014	.390	.699
Fixed cost	11.371	0.445	.020	.556	.581
Experience	-6.538	0.393	-.081	-2.351	.024***
Household size	-5.025	0.712	-.033	-.974	.336
Farm size	3.375	9.910	.974	25.268	.000***
Average price	1.961	0.814	.235	6.611	.000***
F -Statistics	97.95				.000***
R^2 Adjusted	0.950				
R^2	0.960				

Dependent Variable: Revenue, ***Variables significant @1%, *Variables significant @10%

Data source: Field survey.

Test for Hypothesis 1: H_0: High cost of feed and fingerling does not lead to less revenue

Based on the result in Table 5, it was revealed that the costs of feed and fingerlings showed negative relationship with revenue. This negative sign indicated that feed and fingerlings moved in opposite direction to revenue. In addition, feed and fingerlings were statistically significant at 5% and 10% respectively. Which means, high cost of these input variables affect revenue negatively. This explanation does not agree with the null hypothesis that states that high cost of feed and fingerlings does not lead less revenue but rather in favour with the alternative.

Test for Hypothesis 2: H_0: There is no significant relationship between the farm size, average price of the white-leg shrimp products and the revenue

With regards to the results, farm size and average price of white-leg shrimp product exhibited positive relationship at 1% level of significant to revenue. It means that 1% increase in the average price of shrimp products would result to 23.5% increase in revenue. The larger the farm size the more revenue generation ceteris paribus. Based on this strong statistically significant level of 1% for farm size and average price with revenue, the null hypothesis which states that there is no significant relationship between farm size, average price and revenue is rejected and the alternative is accepted. That is, there is significant relationship between farm size, average price and revenue.

Constraints encountered by shrimp farmers

Table 6 summarized the constraints encountered by farmers in White-leg shrimp production. Total percentage is greater than 100% indicating multiple responses. The major constraints highlighted by the farmers are; Quality of shrimp seed (80.8%), Water quality (63.5%) and shrimp disease (32.7%) while minor constraints were low shrimp price (13.5%). frequent natural disaster (5.8%) and technology request (3.8%).

Table 6: Percentage distribution of constraints encountered by shrimp farmers

Variables	Frequency	%*
Quality of shrimp seed	42	80.8
Shrimp disease	17	32.7
Water quality	33	63.5
Low shrimp price	7	13.5
Frequent natural disaster	3	5.8
Technology request is high	2	3.8
Total		200.0*

(*) Total percentage greater than 100% due to multiple responses

Data Source: Field survey.

Discussion

Farmer's socio-economic characteristics

Gender is an important socio-economic factor that plays significant role in aquaculture, in terms of assets acquisition, for example, land and machines. Majority (90.4%) of the White-leg shrimp farmer sampled for this study were males. With regards to age, it has been

revealed that most White-leg shrimp farmers' fall within the ages of 41 to 60 years representing 78.9%. These are within the productive and economically active ages which indicate better future for shrimp production. This assertion is in agreement with [17] that these age brackets are considered as economically active ages. In term of the household size, it was discovered that 78 percent of the respondents have family size ranging from 3-5 persons per household. It means that increase in household size can lead to an increase in white-leg shrimp production. This result is in line with [10] that large family size supports productivity in fish farming. The research further discovered that the respondents usually get technical training from fellow farmers and organizations. Majority (90.38%) of the respondents depended on their own personal savings source of funding. This result is in agreement with the findings of [5] which stated that most fish farmers in Cross River and Ogun States, Nigeria sourced working capital from personal savings. The study also revealed that very few shrimp farmers access loans from bank (32.69%). This could be as a result of high interest rate. This assertion is in line with the suggestion given by [19] who said that the inability of fish farmers to assess bank might be connected to its high rate of interest.

White-Leg Shrimp production costs and profitability

Based on the cost and return analysis, it was revealed that the four most important cost items among the production cost are shrimp feed (34.3%), fingerlings (13.1%), fuel/electricity cost (12.7%) and labour (10.4%). [9] conducted a study on White-leg shrimp farming in Song Cau District, Phu Yen Province Vietnam and concluded that the highest variable cost item is feed which accounted for 45.19% of the total cost of production. [15] had also reported that farmers had to spend large sum of money on feeds during production process. The high cost of electricity shows that significant amount of money was spent by white-leg shrimp farmers on electricity to run aerators, pumps and feeders for efficient shrimp production. This may be as a result of the fact that China has expanded electricity even to the most remote rural areas hence contributing to an increase productivity and profitability from aquaculture production.

Revealed from the profitability analysis showed that white-leg shrimp farmers obtained a profit of CNY378,144.55 ($58,176) per hectare. [9] examined the profitability of White-leg shrimp farms and revealed an average profit of 78,883,209 VND ($3,944.16), per hectare for the shrimp farmers. Benefit Cost Ratio (BCR) was found to be 1.69. It means that the white-leg shrimp farming is profitable because the BCR is greater than 1 and farmers can pay for both fixed and operational costs. [14] indicated that as a rule of thumb, project with cost ratio

greater than one, equal to one or less than one, shows profit, break-even or less profit, respectively. White-leg shrimp farming is profitable with positive Gross Margin of 437,023.07. This is in agreement with the finding of [6] that fish farming enterprise were profitable in the short run with gross margin greater than total variable cost. [16] also reported that positive gross margin shows that a fish farming enterprise would make reasonable profit as long as these farms kept overhead costs in control. The research discovered that the Percentage Profitability (PP), Return on Investment (ROI) and Gross profit margin ratio were found to be 69.23%, 0.69 and 0.47 respectively. For every 1.00CYN invested, the farmers were able to gain CYN0.69 at a percentage rate of 69.23%. [18] in their study on fish farming showed that the return on investment was 0.92 which implies that for every one naira invested, 92 kobo was gained. The higher gross profit margin shows the farms are profitable. According to [16], a ratio of 0.35 or higher is more desirable.

Regression analysis of explanatory variables

Multiple regression results revealed that white-leg shrimp revenue is significantly influenced by the cost of inputs. Out of the 10 independent variables, 5 significantly influence revenue at various level of significance. Cost of feed, seed, experience, farm size and average price significantly influence revenue at 5%, 10%, 1%, 1% and 1% level of significance respectively. Farm size and average price met their expected signs of positive while the other three were negative. It shows that an increase in farm size and average price would increase the overall revenue of the farmers and vice versa for the others. According to [19], input costs affect revenue. For the farm size, the study agreed with the finding that large farm sized produced the highest yield [1]. The result further revealed that one unit increase in the average price of white-leg shrimp products resulted to 23.5% increase in revenue. This finding is in agreement with the ideas of [24] which states that an increase in average price of shrimp will lead to an increase in white-leg shrimp production. [21] also stated that selling price was the most significant variable for white-leg shrimp production.

Conclusions

Based on the analysis and the results obtained, it can be concluded that most White-leg shrimp farmers in the study area depend on their own source of savings for farming. A high percentage of farmers bought seeds and feed from local enterprise and operate less than 7ha of pond size. The three major highest production costs are: feed, fingerlings and

electricity/fuel cost. The results further showed that White-leg shrimp farms are profitable based on the percentage profitability, return on investment and gross margin ration obtained. The factors affecting revenue are: cost of feed, cost of seed, experience. Farm size and average price of White-leg shrimp production. The three important challenges faced by the farmers are low quality of seed, water quality and disease.

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