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AN ECONOMETRIC ANALYSIS OF FACTORS FROM THE FARMERS' PERSPECTIVE THAT AFFECT PROFITABILITY OF TILAPIA PRODUCTION IN TRINIDAD

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ABSTRACT: Aquaculture has been identified by the Government of Trinidad and Tobago as a competitive industry with the potential of reducing high fish imports. The purpose of this study was to provide an economic analysis of the factors affecting overall profitability of tilapia production in Trinidad. Thirty farmers selected for the survey were actively involved in a semi intensive or extensive grow out systems production. Data collection was via a structured questionnaire and semi structured interviews. An econometric regression model for the study tested the effects of output (O), selling price (SP), cost of feed (FD), fingerlings (FNG), labour (LAB), and operational costs (OC), with dummy variables tank culture (CT), sex culture (SC), and production system (PS) on the profitability of tilapia production. The Ordinary Least Squares (OLS) method was used and included appropriate tests for multicollinearity. Furthermore, the model provided relevant OLS information on the R-Squared and Durbin-Watson statistics for profitability. The OLS best fit equation derived for PROFIT = -13759.950 + 12.048O + 1492.922SP + 0.144FD - 2.621FNG –1.338LAB + 1.120OC – 4147.623CT - 1552.083SC - 4191.806PS Output and labour cost ($P< 0.0001$) followed by operational costs ($P < 0.01$), selling price and cost of fingerlings ($P< 0.05$) were the main determinants affecting the profitability of these farmers. Two models comparing medium and large farm sizes showed that large farm sizes had higher Net Present Value (NPV's) and Internal Rates of Return (IRR). For farmers to improve profitability, focus should be placed on increasing output and controlling labour costs which are high in comparison to the low levels of output produced under these systems of management. In order for output to increase there will also be a need for better farm management, and better training in aquaculture farming techniques.

Keywords: Tilapia, profitability, econometric model, output, labour costs.

Introduction

Tilapia is a prolific fish capable of providing a good source of food and as such has become the focus for food production in many developed and developing countries with the support of the Food and Agriculture Organisation of the United Nations (FAO 2006, 2010). Tilapia production in Trinidad and Tobago continues to have mixed results at best and minimal full time farming activity is currently conducted. According to Ramnarine and Ramnarine (1999), although there are 1,105 fish farmers registered with the Ministry of Agriculture, only 562 are believed to be active and most of the holdings are extremely small, averaging a pond area of 0.07 ha. In spite of this, tilapia is described as the most important aquaculture species of the 21st century (Shelton 2002).

Current annual tilapia production in Trinidad and Tobago is estimated to be between 9 and 11 tonnes while current consumption is about 112 tonnes per annum [Ministry of Food Production, Land and Marine affairs (MAFPLMA) The National Food Production Action Plan 2012-2015]. The MAFPLMA five-year transformational plan for the sector includes a projected substantial increase of annual production, establishment of processing and value added facilities and the development and implementation of business plans for small, medium and large farms of the sector. However, research focusing on the economics of tilapia production, a contributing requirement for business plan development, is limited (Rampersad and Ashing 2007). Most aquaculture research and development projects address technical issues of feasibility such as breeding, larval rearing and grow-out, but very little time or effort is invested in accompanying economic or marketing issues (Manwaring et al. 1993).

A review of the local scientific literature and interviews with aquaculture extension officers and research professionals have pointed to the wide gap between actual and potential yields as the major constraint to farmers operating within the industry. To address these concerns and to make recommendations pertinent to having a profitable enterprise, research efforts must also be focused to explore the factors affecting profitable production systems, from the farmers' perceptive. These perceived economic factors affecting Tilapia profitability must be adequately addressed before tilapia can be developed and exploited as a locally competitive industry to reduce the heavy importation of tilapia and other fish products into Trinidad and Tobago.

The purpose of this study is (1) to investigate economic factors affecting overall aquaculture profitability, based on aquaculture farmers' perceptions from Trinidad. These factors will be fitted into an econometric estimation of profitability which can lead to the identification of the significant variables affecting production. (2) Using reliable technical coefficients, a Net Present Value (NPV) and Internal Rates of Return (IRR) will also be calculated for medium and large sized aquaculture farms from Trinidad. From these findings, recommendations can be made to foster the development of a profitable tilapia farming industry in Trinidad.

Materials and Methods

Data Sources and Collection

The process of data collection was via the use of primary and secondary data collected during the period to effectively address the research question and meet the conditions of the research framework. Most of the primary information was collected from farmers via the survey method with the use of a questionnaire. The secondary data originated from information compiled by local agencies and organizations from past researchers, as well as, a review of the relevant literature. The survey was also supported by semi-structured interviews using a combination of informal and questionnaire styled interview techniques to assist in further defining the parameters of the analysis. The latter provided a reasonable measure of quantitative and qualitative supporting data for the analysis.

Both primary and secondary data questions revolved around (1) Farm operations and management, nine questions; (2) Revenue, five questions; (3) Production output, two questions; (4) Fingerling costs, seven questions; (5) Feed costs, six questions; (6) Labour costs, three questions; (7) Operational costs, six questions; (8) Disease prevention and control, seven questions; (9) Harvesting of stock, six questions; (10) Capital costs, eight questions; (11) Transportation costs, two questions; and (12) Formal training.

Sample Population

The actual sample population of farmers were derived from three main sources. The first source of potential farmers came from government agencies, and research institutions such as the Seafood Industry Development Company, The Ministry of Agriculture, Land and Marine Resources (MALMR), Fisheries Division, The Ministry of Science, Technology and Tertiary Education (MSTTE), Retraining Programme and the Sugar Cane Feeds (SFC) Centre. These institutions were either able to provide a list of persons which participated in part training programs or developmental activities. The second source came from Non-Governmental Organizations (NGO's) like the Aquaculture Association of Trinidad and Tobago (Aqua TT) which was able to provide a list of its membership involved in the farming of tilapia or persons they provided development support to in the past. Finally, referrals provided by existing farmers yield information on the locations and operating status of other potentials farmers to be included in the data set.

For inclusion on the sample, farmers had to satisfy two criteria or they would be judged unsuitable for inclusion. First, the farmers had to be active in the grow-out of tilapia. Many persons contacted were either no longer involved or were in the process of starting operations which resulted in a smaller sample population. Second, the venture had to be of a semi intensive or extensive nature. Operations of an intensive nature were ignored from the sample size because intensive farming practice has limited industry application locally; the practice only being observed at research facilities like Institute of Marine Affairs (IMA) and Seafood Industry Development Company (SIDC). Finally, the enterprise had to be of commercial nature of some sought. This resulted in the elimination of farmers that cultivated tilapia for the sole purpose of irrigation farming or as part of their other livestock operation as they yield little or no revenue from such a venture.

The above criteria led to the identification of 30 farmers that fit the parameters for the final sample. The sample size of 30 farmers is considered a judgement sample as the exact number of tilapia farmers is unknown due to the unavailability of information regarding the total population size. Most of the agencies and institutions previously mentioned are unable to give an exact number or an estimate of the population size since there is very little recording of information on farmers in the industry at present.

It is expected that the sample size will be reflective of the characteristics featured by the local tilapia farming community. The characteristics of the population were collected by the quantitative and qualitative data with regard to the cost of inputs, the quantities used, and the yields derived, pricing of the tilapia and other production activities as projected by each farmer.

Economic Variables Tested

The basis of this model was to assess certain economic input and output variables affecting the profitability of tilapia farming (Derbetin, 1986; Chambers, 1986; Beardshaw, 1992). The economic model tested the effects of Output, Selling Price, Feed, Fingerlings, Labour, and Operational Costs on profitability on 30 intensive and semi intensive aquaculture farms in Trinidad. Culture Technique and Sex Culture have been recognized as significant factors but based on the advice of development professionals were characterised as dummy variables to account for their qualitative nature. These variables and their related a priori expectations are explained below as follows:

Profit: Profit was defined as the difference in total revenue, TR, and total cost, TC. A farming enterprise maximizes profit by operating at the point where the distance between the total revenue curve and total cost curve is at its maximum. If this holds true then it can be assumed that variables of a cost nature will have an inverse relationship with profitability, that is, the higher these production cost the lower the level of profitability to the farmer, *ceteris paribus* (Derbetin, 1986; Chambers, 1986; Beardshaw, 1992).

Total Revenue: Total Revenue (TR) was the total sales receipts in a market at a particular price (Beardshaw, 1992). Thus, total revenue can be derived as follows:

Equation 1 Total Revenue (TR) = Selling Price (SP) x Output (O)

Total Costs: Total Costs (TC) was the cost of all the resources necessary to produce any particular level of output. Total cost always rises with output, as obtaining more output must always require more input. Thus no matter what the scale of production, obtainig another unit of output must involve the input of some raw materials, no matter how small the amount, so that a greater ouptut must always involve a greater total cost (Derbetin, 1986; Chambers, 1986; Beardshaw, 1992).

Output: Output (O) for this study can be defined as the total harvest weight of live fish per square feet of pond area in a given grow-out period.

Selling Price: Selling Price (SP) was the price attained from the final selling price of the fish harvested and ready for the market during the period. It is sometimes influenced by seasonal factors but has been estimated by farmers for the study.

Feed Costs: Feed Costs (FC) is essential for increasing tilapia production and output. The quantity and type of feeds varied from farm to farm and the degree of supplemental feeding also varied due to the production system used on particular farms such as mixed sexed versus mono sexed and tank versus pond culture. However, most famers used commercially manufactured pelleted feed for their grow-out operations. The feed cost were estimated or measured as dollar per pound on a yearly production basis.

Fingerlings Costs: Fingerlings are also an important component to the production process. Most fingerlings were purchased from local hatcheries, while some farmers opted to produce their own fingerlings to ensure an availability of supply. For this study, fingerlings was defined as the total number of new recruits introduced to the pond area in the given year. The Fingerlings Costs (FNG) was calculated per fingerling and determined by the purchase price or producer's cost.

Labour Costs: Labour is also an essential to the production process and Labour Costs (LAB) was defined as total cost for the number of man hours used per year.

Operational Costs: The operational costs (OC) included all costs incurred in the production process which was aggregated into utilities, harvesting, fertilizer cost and other overheads attributed by farmers. This was measured on a yearly basis and aggregated to reduce the likelihood of multicollinearity.

Culture Technique Dummy Variable

It is believed that the culture technique (CT) –dummy variable had some degree of influence on the production process since differing results and costs have been known to be associated with particular techniques as supported by many relevant authors. The two main techniques are pond and tank culture. They are represented by the dummy variable as follows:

C = 1 if culture technique is pond: 0 otherwise.

Sex Culture Dummy Variable

The sex culture (SC) identified on farms were either mixed-sexed or mono sex culture of the tilapia for grow-out. It is believed and also supported by literature that both methods differ in the potential growth yields and the productivity of the farm's potential. As such, the dummy variable SC was created to represent the production methods as follows:

SC = 1 if ponds/ tanks stocked with mono sex fingerlings; 0 otherwise.

Production System Dummy Variable

The choice of production system (PS) is expected to have a considerable impact on the economic viability or profitability of the farming project and it is expected to influence the extent of production and is defined as:

PS = 1 if semi intensive; 0 otherwise.

Based on the above mentioned theoretical framework the following initial empirical model using profitability as a function of the above variables can be derived with the below a *priori expectations.*

The Model

$Profit = \beta_0 + \beta_1 O + \beta_2 SP + \beta_3 FD + \beta_4 FNG + \beta_5 LAB + \beta_6 OC + \beta_7 CT + \beta_8 SC + \beta_9 PS + u$

Equation 2: Profitability Model 1

Statistical Analysis

The primary data attained from the farmers was firstly compiled for the various farmers into one Excel based format. The data is of a cross sectional nature. The resulting single equation econometric model was analyzed with regards to the data collected. The model assumed profitability as its endogenous variable and the respective factors in the production process as all exogenous variables. The Ordinary Least Squares (OLS) method was used and included appropriate tests for multicollinearity and heteroskedasticity. Ordinary Least Squares defines the best linear trend as one that minimises the sum of the squares residual error. EViews enterprise software (EViews.com) was used to make the econometric estimation. Confidence intervals were constructed and used to test the individual and joint hypotheses for the significance of the estimated coefficients.

Results

The regression model as specified in equation 2 was tested and respective statistics obtained by EViews resulted in the below linear regression equation with the relevant coefficients:

The Model is:

$Profit = \beta_0 + \beta_1 O + \beta_2 SP + \beta_3 FD + \beta_4 FNG + \beta_5 LAB + \beta_6 OC + \beta_7 CT + \beta_8 SC + \beta_9 PS + u$

PROFIT = -13759.950 + 12.048*O + 1492.922*SP + 0.144*FD - 2.621*FNG – 1.338*LAB + 1.120*OC – 4147.623*CT - 1552.083*SC - 4191.806*PS

Equation 3: OLS fit 1 Estimate Equation for Profitability

With the application of OLS, the above regression equation can be interpreted as follows:

β_0 – In this output, the value of the intercept coefficient/ constant term is -13759.950.
β_1 – Ceteris Paribus, if Output increases by one unit, then profitability will increase by 12.048.
β_2 – Ceteris Paribus, if the Selling Price increases by one unit, then profitability will increase by 1492.922.
β_3 – Ceteris Paribus, if Feed Costs are changed by one unit, then profitability will increase by 0.144.
β_4 – Ceteris Paribus, if Fingerling Costs are changed by one unit, then profitability will decrease by 2.621.
β_5 – Ceteris Paribus, if Labour Costs are changed by one unit, then profitability will decrease by 1.338.
β_6 – Ceteris Paribus, if Operating Costs are changed by one unit, then profitability will increase by 1.120.
β_7 – Ceteris Paribus, the choice of culture technique negatively affects profitability.
β_8 – Ceteris Paribus, the choice of sex culture negatively affects profitability.
B_9 – Ceteris Paribus, the choice of production system negatively affects profitability.

Furthermore, the model provided relevant OLS information on the R-Squared and Durbin-Watson statistics for profitability. The R-squared statistic measures the success of the regression in predicting the values of the dependent variable within the sample. The R-Squared statistic for this model is 99.73%. The Durbin-Watson (DW) statistic is a measure of serial autocorrelation among the variables within the model. This statistic varies whether valid statistical inferences about coefficients of the equation can be made. The Durbin-Watson statistic in this model is 2.233.

Test of Statistical Significance

Given the estimation output of EViews (EViews.com) for the aforementioned model as in Table 2 the following results have been observed. Firstly, negative coefficients were realised for the constant term, fingerling cost, labour costs and the dummy variables of culture technique, sex culture and production system. While positive coefficients were attained for output, selling price, feed costs, operational costs. Secondly, a p-value of 0.057 was attained for the constant. Thirdly, the variables of output and labour costs had a p-value of < 0.0001. Fourthly, p-values of < 0.05, > 0.05, < 0.05 and < 0.01 were attained for selling price, feed costs, fingerling costs and operational costs, respectively (Table 2). Lastly, the dummy variables of culture technique, sex culture and production system all had p-values > 0.05.

At first glance, the regression results appear to show that feed costs (FD), sex culture (SC) and culture technique (CT) are insignificant to the model based on the high P-values associated with these explanatory variables. The output also generated extremely high R-squared of 99.73% which means that the regression model is 99.73% successful in predicting the values of the dependent variable within the sample.

Additionally, the sign of the coefficients of feed costs, operational costs, culture technique, sex culture, and production system contradicts their *a priori* expectations. Furthermore, the probability value for F-Statistic is equal to zero. Despite the above mentioned good characteristics of the model being observed, the simultaneous occurrence of these factors indicated the presence of multicollinearity. Multicollinearity exists when there is a relationship between two or more exogenous variables (Derbetin 1986).

The existence of multicollinearity sometimes forces the researcher to drop variables from the model so as to test the validity and impact of these variables. To solve the issue of multicollinearity five different models were run and tested at conventional confidence interval for the p-values. The following revised model- OLS fit 5 attempts to solve the multicollinearity issue as experienced in OLS fit 1 to OLS fit 4 as shown below.

OLS fit 5 Estimation Output

The regression equation for profitability of tilapia production in Trinidad & Tobago was further specified as:

PROFIT = -14337.898 + 13.178*O + 1330.692*SP - 3.413*FNG - 1.379*LAB + 1.026*OC - 4824.997*PS

Equation 4: OLS fit 5 Estimation Equation for Profitability

The new regression equation was interpreted and explained as follows:

β_0 – In this output, the value of the intercept coefficient/ constant term is -14337.898.
β_1 – Ceteris Paribus, if Output increases by one unit, then profitability will increase by 13.178.
β_2 – Ceteris Paribus, if the Selling Price increases by one unit, then profitability will increase by 1330.692.
β_4 – Ceteris Paribus, if Fingerling Costs are changed by one unit, then profitability will decrease by 3.413.
β_5 – Ceteris Paribus, if Labour Costs are changed by one unit, then profitability will decrease by 1.379.
β_6 – Ceteris Paribus, if Operating Costs are changed by one unit, then profitability will increase by 1.026.
B_9 – Ceteris Paribus, the choice of production system negatively affects profitability.

The coefficient of the first exogenous variable β_1, was positive, as expected. This variable was also significant at all levels as indicated by a p-value of <0. 0001. The coefficient β_2 was positive as anticipated and this variable was also significant at conventional levels of 5% and 10% for a p-value of 0.038. The coefficients of β_4 and β_5 were negative, as expected, and significant at all conventional levels as indicated by their p-values of < 0.001 and < 0.000, respectively.

Initially, in the *a priori* expectation, a negative sign was expected for OC and a positive sign was expected for PS. However, the output generated from EViews by the application of OLS contradicts this initial expectation. Above, β_6 which is the coefficient for OC was positive. This variable appeared to be significant at all conventional levels of significance as indicated by the p-value of 0.008. β_9 which was the coefficient for PS is negative. This variable appears to be significant at 5% and 10% confidence levels as indicated by its p-value of 0.071.

The output also produced an R-squared of 99.69% and an adjusted R-Squared of 99.61%. This indicates an extremely well fit for the model and means that 99.69% of profitability for tilapia production in Trinidad & Tobago is explained by the above six variables. The P value of the F Statistic of 0.001 indicates the simultaneously significance of the independent variables. The Durbin-Watson Statistic, which is a measure of serial autocorrelation among the variables of the model, is 2.213. This high value of the Durbin-Watson statistic is indicative of the presence of no serial correlation in the residuals of the estimated equation. This meant that valid statistical inferences for the coefficients of the equation could have been derived from the model.

The findings of major importance of the model for OLS fit 5 was that feed costs, culture technique and sex culture were not significant in determining the profitability of a farmer. It is generally expected that feed costs are significant for such a farming venture (Manwaring et al., 1993). Contrastingly, in this study the output and labour costs showed the largest impact on the farmers' profits.

Net Present Value (NPV) and Internal rates of Return (IRR)

To the point that output contributes to the level of profitability two farm models have been developed and compared on the basis cost to benefit, net present values (NPV) and the internal rate of return (IRR) at 25 acres and 100 acres of production (not shown).

The two models (Tables 5 and 6) were based on the following assumptions:

- A grow-out period of six months
- Production of Red Hybrid and Silver Tilapia
- Harvest weight of 1 lb
- Stocking densities of 20,000 fingerlings per one acre pond at $2.00 ea
- Mortality rate of 15%
- Feed Conversion Ratio of 1.5:1
- Selling price of $12.00 per lb
- 12% cost of capital

The two models showed that for large farm sizes had higher cost benefit ratios and the achieved NPV's and IRR were also higher.

Discussion

The findings of this study from the farmers' perspectives showed that output and labour cost were highly significant in determining the profitability of their aquaculture enterprises. Next, the factors of feed costs, culture technique and sex culture were deemed not significant in determining the overall profitability of farmers. It was initially assumed that feed costs would be one of the factors with the greatest level of significance in determining profitability of farmers but this was not evident in the final econometric model. This may be attributable to the fact that many farmers did not have a feeding regime, while others depended on the natural vegetation or alga blooms as a food source. Finally, contradictory *a priori* expectations were derived for feed costs, operational costs, culture technique, sex culture and production systems. The discovery of this fact may point to other tilapia production related issues as it was observed that most farmers did not operate under ideal farming conditions, thus possibly affecting output and profitability. These findings from the NPV and IRR values obtained for the 25 acre farm compared with the 100 acre aquaculture farm supported the function that economies of scale in production, and the importance that output play in the profitability of an aquaculture enterprise.

The overall findings have provided valuable information from which general recommendations can be made to improve the levels of profitability of many tilapia farmers in Trinidad and Tobago. It is recommended that for farmers to improve profitability the focus should be placed on increasing output and controlling labour costs. Many farmers, especially farmers who rear tilapia under extensive systems, have high labour costs as the labour rates for scarce farm labour is relatively high in comparison to the low levels of output produced under such a system. Farmers could instead choose to utilise less labour hours in their operations if possible or seek out reduced labour cost in the various day to day operations.

Furthermore, for output to increase there will be a need for more astute farm management practices. Aquaculture farmers need better training in farming techniques including the health and management practices necessary to achieve better growth rates and survivability. Many farmers had varying lengths for the grow-out period which when coupled with partial harvesting and mixed sex culture practices resulted in substantially different levels of output. In addition, farmers who purchase fingerlings at high cost may lower this cost by operating a small nursery for the production of the farmer's own brood stock, so improving the farmer's profitability.

Additionally, increasing the selling price through value added products will have the impact of improving profitability once the other variables remain constant. It is also recommended that proper record keeping be encouraged through the intervention of Government extension services which can also serve to improve other factors that impact negatively on the profitability of the enterprise.

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Table 1. Dependent variables of the econometric model with a *priori* expectations

Variables	Symbol	A Priori Expectation	Unit of Measurement
Dependent Variable			
Profitability	Profit		Profitability of the farmer's venture in TTD$
Explanatory Variables			
Output	O	+	Number of pounds harvested in one year
Selling Price	SP	+	Selling price at harvest
Feed	FD	-	Purchase price of feed used during grow-out
Fingerlings	FNG	-	Cost of fingerlings purchased
Labour	LAB	-	Cost of hired labour during the period
Operational Costs	OC	-	Total cost of overheads in production
Culture Technique	CT	+	1-Pond Culture or 0- Tank Culture
Sex Culture	SC	+	1- Mono Sex Culture or 0- Mixed Sex Culture
Production System	PS	+	1-Semi Intensive Culture or 0- Extensive

Table 2: OLS fit 1 Estimation Output

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-13759.950	6808.087	-2.021	0.057
O	12.048	1.070	11.261	0.000
SP	1492.922	662.467	2.254	0.036
FD	0.144	0.156	0.923	0.367
FNG	-2.621	1.198	-2.188	0.041
LAB	-1.338	0.107	-12.461	0.000
OC	1.120	0.362	3.096	0.006
CT	-4147.623	4430.482	-0.936	0.360
SC	-1552.083	4816.871	-0.322	0.751
PS	-4191.806	3752.674	-1.117	0.277

Table 3. Ordinary Least squares to solve multicollinearity

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-14337.898	6760.062	-2.12	0.045
O	13.178	0.427	30.88	0.000
SP	1330.692	605.752	2.20	0.038
FNG	-3.413	0.864	-3.95	0.001
LAB	-1.379	0.0569	-24.25	0.000
OC	1.026	0.350	2.93	0.008
PS	-4824.997	2549.119	-1.89	0.071

Table 4. NPV and IRR values based on a 25 farm acreage.

25 Acre Farm					
Year	Total Output	Total Revenue	Total Cost	Unit Cost	Cost Benefit
1	499800	5997600	6450390	12.91	1.08
2-10	856800	10281600	6450390	7.53	0.63
Average				8.07	0.67

Table 5. NPV and IRR values based on a 100 farm acreage

100 Acre Farm					
Year	Total Output	Total Revenue	Total Cost	Unit Cost	Cost Benefit
1	1987300	23847600	22594140	11.37	0.95
2-10	3406800	40881600	22594140	6.63	0.55
Average				6.69	0.59