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Improving Catfish Production by Utilizing Business Environment Remote Control Theory

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Key words: *Business environment, catfish production, immediate control, remote control*

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1. Introduction

The Business environment of agribusiness from the broader, all inclusive perspective accommodates both the internal and external components (Ogidi and Umeh, 2015). The internal environment presents enterprise *strengths* and enterprises *weaknesses*; while the external environment presents environmental *opportunities* and environmental *threats* – SWOT analysis (Ogidi, 2016). This implies that the environment factor plays a decisive role in determining the success, failure and even continued existence of the business organization (Ottih, 2006). Business environment is seen to contain factors that influence policy decisions and activities of catfish enterprise production units – also referred to as the technical core of the enterprise (Ogidi, 2016). However, the environment of agribusiness can be defined as those factors, institutions and infrastructures that exist outside the agribusiness firm that affects decisions, objectives and activities of the business (Ogidi, 2016). Under the business environment concept, three forces that constitute threat or opportunity to the catfish enterprise were examined in this study. These forces are: physical, social and institutional factors.

2. Theoretical Framework

2.1. Business environment complexity theory

Complexity theory offers a conceptual framework that incorporates the essential unpredictability of economic and environmental systems with the emergence of distinctive and contingently stable patterns (Ormerod, 1998; Anderson, 1999). Complexity was originally developed through advances in non-linear mathematics (Thom, 1975), thermodynamics (Prigogine and Glansdorf, 1971), and computational sciences (Simon, 1962). These ideas were quickly adapted to social systems (Ulrich and Probtst, 1984) and during the 1990s interest exploded in relation to management and organizations (Ashmos and Huber, 1987; Levy, 1994; Merry, 1995). Complexity theory goes beyond systems perspectives through advances in deterministic chaos theory (Lorenz, 1963; Kiel and Elliott, 1996), power-law phenomena (Andriani and McKelvey, 2009) and computational methodologies (Kauff man, 1993; Davis, Eisenhardt and Bingham, 2007). Complexity theory recognizes that economic and environmental systems comprise a multitude of agents, from individuals to large organizations, with distinctive properties at each level. The economy, for example, comprises individual consumers and workers, firms, markets, industries, and national economies. While all these levels are interdependent, higher-level aggregations exhibit “emergent” properties that cannot easily be reduced to the interaction of lower levels (Holland, 1998). Macroeconomics, for example, relies on constructs and theories that differ from those relating to individual firms and consumers.

Understanding business environment complexity has been a long-standing concern of organization theory (Simon, 1962). It offers insights into the emergence of patterned structure and order in higher-level systems, such as the Earth’s climate, economic organizations and social institutions, but also provides methods for finding fundamental relationships and simplicity behind complex phenomena. Complexity helps explain how systems can evolve in unexpected ways, exhibiting dramatic instability (Rudolph and Repenning, 2002) and even collapse (McKelvey, 1999). The weather, the global climate, and the economy are complex systems that exhibit such chaotic behavior (Brock, Hsieh and LeBaron, 1991).

2.2. Chaos theory

This is a core science of complexity. It explores systems in which the recursive application of non-linear functions gives rise to highly complex yet patterned behavior. Chaotic systems have several notable characteristics. First, they are unpredictable in the longer term, even though they are driven by deterministic rules. Weather conditions, for example, evolve due to well-understood interactions among variables such as humidity, air pressure, and temperature; however, the non-linear nature of these interactions makes it impossible to predict the long-term evolution of the weather system. The trajectory of chaotic systems such as these is highly dependent on initial starting conditions: the proverbial butterfly could theoretically cause perturbations that are amplified through successive interactions and reverberate throughout the entire weather system.

An important corollary is that, although chaotic systems never return to the same precise state, the outcomes have predictable boundaries that generate well-known patterns (Dooley and Van De Ven, 1999). Hurricanes emerge in late summer, though we never know their exact timing, path, or strength. Industries exhibit typical patterns of growth and maturity, yet evolve in unpredictable ways. These patterns are shaped by “strange attractors,” structural features of systems that constrain and mold their evolution. The patterns reflect macro-level emergent properties: hurricanes, economic recessions, and social movements exhibit system-wide patterns that are distinct from the properties of the components from which these systems emerge.

Another important feature of complex systems is that change can be endogenous; under certain conditions interactions can cascade into system transformation (Cheng and Van De Ven, 1996). Similarly, a stock market collapse can be caused by positive feedback mechanisms affecting investor confidence, liquidity constraints, and computer driven trading. Moreover, systems do not necessarily recover their original pattern after a collapse; rather, they can shit to a new pattern around a different attractor.

The economy can become mired in a self-perpetuating depression, and the climate can become locked in an ice age. Crucially, these critical thresholds are hard to predict. Some relatively large perturbations might peter out while smaller ones can propagate into larger-scale shit s. Despite this unpredictability, however, the pattern of sudden shits, from earthquakes to stock market crashes, tends to follow a power law (Andriani and McKelvey, 2009), such that the frequency of large-scale events is inversely related to their magnitude. These features of chaotic systems provide an important basis for understanding the links between the economy and the environment.

2.3. A theory of change in turbulent environments

Within the resource-based view, resources are the basic units of analysis. A firm’s resources are often classified as financial, human, intangible, organizational, physical, and technological (Bogner, Mahoney and Thomas, 1998). Resources are the stocks of available productive factors owned or controlled by the firm (Madhok, 1996). Often what makes resources economically valuable is the way in which these resources are deployed and developed (Kor and Leblebici, 2005). For resources to be utilized in production and to provide a firm’s distinctive productive services (Penrose, 1959), certain organizational processes must be developed. Capabilities represent the organizational processes by which resources are assimilated and productively deployed. These information-based organizational processes tend to be firm specific and are developed over substantial time periods through complex interactions among the firm’s resources (Amit and Schoemaker, 1993). Capabilities are high-level routines that provide an organization’s management a set of decision options for producing an array of outputs (Nelson and Winter, 1982). They are also typically substantial in scale, representing a large number of activities that produce outputs that increase the likelihood of the firm’s survival and prosperity (Winter, 2000). Further, *dynamic capabilities* involve the organizational processes by which resources are utilized to *create growth and adaptation within changing environments* (Eisenhardt and Martin, 2000; Lado, Boyd, Wright and Kroll, 2006; Teece, Pisano and Shuen, 1997). Dynamic capabilities pertain to the organization's competencies to integrate, build, and reconfigure resource positions in rapidly changing environments. They also reflect organizational competencies to achieve new and innovative forms of competitive advantage despite constraints of path dependencies and previous market positions (Arthur, 1994; Gruca and Nath, 1994; Leonard-Barton, 1992). Dynamic capabilities result from complicated organizational and strategic routines (Zollo and Winter, 2002) through which managers reconfigure and renew a firm's resource base to generate economically value-creating strategies (Foss, 1996; Pisano, 1994). Thus, these capabilities are the fundamental drivers of the creation, evolution, and recombination of other resources to provide new sources of growth (Henderson, 1994; Henderson and Cockburn, 1994; Zander and Kogut, 1995). Dynamic capabilities evolve in important ways that we have only begun to explain. Following Helfat and Peteraf (2003), the current paper's analysis describes the pattern of capability development using the resource-based view (Penrose, 1959; Wernerfelt, 1984) and the dynamic capabilities approach (Eisenhardt and Martin, 2000; Teece, Pisano, and Shuen, 1997).

2.4. Contingency theory

According to contingency theory, the characteristics of the environment affect an organization's ability to obtain resources (Burns and Stalker, 1961). Managers must allow an organization's department to organize and control their activities in ways most likely to allow them obtain resources; given the constraints of the particular environment they face (Lawrence and Lorsch, 1969).

2.5. Production theory

The unit of analysis is the firm. This firm attempts to maximize output with given cost outlay and given quantum of resources; the production function is a mathematical method for the description of relationship between resources and output which is the basis for theory of production (Umeh *et al.* 2013). Implicitly we express it as follows: $Y=f(X_1, X_2 \ldots X_n)$. Within the firm, there are three basic physical relationships that form the basis for theory of production; these are: 1) factor-product relationship, 2) factor-factor relationship and 3) product-product relationship. However, this study is a factor-product relationship study.

3. Methodology

3.1. Population and Sampling Procedure

The sampled population of the study is basically of catfish farmers in Benue State. A first attempt at a comprehensive, nationwide inventory of inland water resources was made by the Aquaculture and Inland Fisheries Project (AIFP) of the National Special Program for Food Security (NSPFS). According to this inventory, Benue State has 198 Catfish farms – the highest compared to other Northern States in Nigeria (FAO, 2007). Since the population of catfish farmers in Benue State is not more than 198, the study deemed it adequate to use the population as the sample size. Therefore, the sample size for this study remains 198 catfish farmers. The list of catfish farmers in Benue State obtained from FAO (2007) and Benue State Ministry of Agriculture was distributed across the zones as follows: 36 catfish farmers from

Zone A, 119 catfish farmers from Zone B, and 43 catfish farmers from Zone C.

3.2. Data Collection Techniques

Primary data were utilized in this study, through the use of structured questionnaire. The primary data used in this study come from a questionnaire survey of 198 catfish producers in Benue State for the production year 2013/2014. The questionnaire set was carefully structured by taking into consideration factors critical to the quality of instrument developed. Secondary data from literature (FAO, 2007) were used to determine the population size for this study.

3.3. Data Analytical Techniques

The stochastic frontier model was originally proposed for the analysis of the panel data by Battese and Coelli (1995). However, a general (full specification) stochastic frontier production function for the cross-sectional data, which is considered in this paper, is defined by

$$Y_i = exp(X_i\beta + V_i - U_i)$$

Where:

Y_i = denotes the output for the i_{th} sample farm (kg)

X_i = represents a vector whose values are functions of inputs and other explanatory variables for the i_{th} farm

β = is a vector of unknown parameters to be estimated are assumed to be independent and identically distributed random

V_is = are assumed to be independent and identically distributed random errors which have normal distribution with mean zero and unknown variance σ_v^2 and

U_is = are non-negative unobservable random variables associated with the technical inefficiency of production, such that for a given technology and levels of inputs, the observed output falls short of its potential.

Technical inefficiency effect model proposed by Battese and Coelli (1995) is described by

$$U_{it} = \delta_0 + \delta_i Z_{it}$$

Where:

Z_{it}= is a vector of explanatory variables associated with the technical inefficiency effects of the t^{th} farmer

δ = is an vector of unknown parameters to be estimated

Battese and Coelli (1988) considered the maximum likelihood estimator which involves specification of the distribution of V_i and U_i. The random variables V_i and U_i are assumed to be mutually independent and independent of the input variables in the model. If U_i = 0, the assumed distribution is half-normal. Where outputs are expressed in logarithms, the technical efficiency of the i^{th} farm is estimated as a ratio of the observed to maximum feasible output, where the latter is provided by the stochastic frontier production. The measure of technical efficiency is given by

$$TE_i = exp(X_i\beta + V_i - \mu_i)/exp(X_i\beta + V_i)$$
$$TE_i = exp(-\mu_i)$$

If $U_i = 0$, the farm were 100 percent efficient. Maximum-likelihood estimates of the parameters in the model were obtained. The parametric model is estimated in terms of the variance parameters, $\sigma_s^2 = \sigma^2 + \sigma_v^2$ and $\gamma = \sigma^2/(\sigma^2 + \sigma_v^2)$ (Umeh *et al.* 2013). In case of cross-sectional data, the technical inefficiency model can only be estimated if the inefficiency effects U_i's are stochastic and have particular distributional properties (Battese and Coelli, 1995). Therefore it is of interest to test the null hypotheses that technical inefficiency effects, γ, are non-stochastic. The parameter, γ, has a value between zero and one, in such a way that it is desirable to test the null hypothesis of Ho: γ = 0 whether traditional production function is an adequate representation of the sample data. If so, the non-negative random variable μ_i is absent from the model. The generalized likelihood-ratio test statistic can be calculated from the logarithms of the likelihood function associated with the unrestricted and restricted maximum likelihood estimates for the special case in which the appropriate parameter is zero.

The structure of the General Model is imbedded in the equation linking catfish output to resources (inputs) on one hand (Model 1) and inefficiency model (Model 2) on the other. In the inefficiency model, inefficiency effect is linked with the business environment. Business environment factors are captured, through variables that influence the welfare or performance of the catfish production in the study area. This study will focus on the following business environment factors, i.e. physical, social and institutional factors.

$$LogY_i = \beta_0 + \sum_{j=1}^{4} \beta_j \, LogX_{ij} + (V_i - U_i)$$

$$\boldsymbol{lnY = \beta_0 + \beta_1 lnFING + \beta_2 lnFEED + \beta_3 lnLABO + \beta_4 lnPOSI + (V_i - U_i)}$$

………………………………………………………………………………………… (Model 1)

Where:

Log or ln = natural logarithm;

I = sample of catfish enterprises

j = number of inputs and farm-specific variables

Y = represents yield of the catfish enterprises in kg

$FING$ = fingerlings used in production (kg); *a priori* expectation is positive

$FEED$ = quantity of standard feeds used (kg); *a priori* expectation is positive

$LABO$ = labor requirements (man-days); *a priori* expectation is positive

$POSI$ = pond size of fish enterprise (m^2); *a priori* expectation is positive

β_js = parameters of linear terms; j = 0, 1... 4 are parameters to be estimated

ln = Log of estimated values of inputs, output and error term

v_is = statistical errors and random shocks such as faulty equipments, low quality fish feed, errors in measurement; are assumed to be independent and identically distributed N (0, σ^2) random variables

u_is = error term measuring the level of inefficiency in production; are assumed to be independent and identically distributed non-negative truncations of the N (μ, σ^2) distribution.

The **inefficiency model** for the study is shown below;

$$U_i = \delta_0 + \sum_{j=1}^{9} \delta_j \, LogZ_{ji}$$

$$\boldsymbol{U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \cdots + \delta_9 Z_9} \quad \text{.................... (Model 2)}$$

Where:

U_i = inefficiency effect

Z_{ji}= Explanatory variables for the technical inefficiency effects for the ith farmer,

δ_js = parameters of demographic and environment of business variables

Z_1= Accessible roads to production unit [AROADS] (Dummy: accessible roads to production unit =1, bad roads to production unit=0); *a priori* expectation is positive

Z_2= Cost of energy [COSTPF] (₦); *a priori* expectation is negative

Z_3= Cost of water storage [COSTSF] (₦); *a priori* expectation is negative

Z_4= Number of years spent acquiring formal education [EDUCAT] (yrs); *a priori* expectation is negative

Z_5= Years of experience in catfish production business [EXPERI] (yrs); *a priori* expectation is negative

Z_6= Collaboration with model catfish farmers [COLLABO] (Dummy: access to consultants/vets=1, No access to consultants/vets=0); *a priori* expectation is positive

Z_7= Credit obtained from financial institutions [CREDIT] (₦); *a priori* expectation is negative

Z_8= Cost of innovation/technology in fish production from research institutions [COSTIN] (₦); *a priori* expectation is negative

Z_9= Availability of market intermediaries for catfish output [AVLMKT] (Dummy: access to market institution/intermediaries = 1, scarce markets = 0); *a priori* expectation is positive

The generalized likelihood ratio statistic is computed as $\lambda = -2log[L(H_0)/L(H_1)]$, where, $L(H_0)$ and $L(H_1)$ are the likelihood functions evaluated at the restricted and unrestricted maximum likelihood estimator for the parameters. If the null hypothesis, H_0, is true, then the statistics has approximately a chi-squared distribution with parameter equal to the number of restriction imposed by H_0 and with the degree of freedom equal to the difference between the parameter estimated under H_1 and H_0 respectively. The value of the γ indicates the relative magnitude of the variance associated, with the distribution of inefficiency effects, U_i. If U_i in the stochastic frontier are not present or alternatively, if the variance parameter, γ, associated with the distribution of, U_i, has zero value, then, σ_u^2, in (model1) – (model 2) is zero and the model reduces to a traditional function with the variables, fingerlings, feeds, labor and pond size, all included in the production function meaning that inefficiency effects are not stochastic.

4. Results and Discussion

4.1. The Return to Scale

The Return to Scale (RTS) from the general model consisting of both Cobb-Douglass Stochastic

Production Frontier model and the inefficiency model is 0.9797, on the catfish enterprise. This was largely influenced by inefficiency effects from the business environment. Comparing this with the three restricted models (see Table 1, Columns 3, 4 and 5), the RTS values are: 1.0669, 0.9877 and 1.0692. The RTS attained in the pooled data and the Social effects model shows that the catfish farms were producing at stage 2 of the production function also known as the decreasing returns to scale stage (rational stage). Table 2 shows that fingerlings, feeds, labor and pond size are operating in stage 2, i.e. they are increasing at a decreasing rate and are operating in the rational stage of production. This study's result is in tandem with the findings of Ogundari, Ojo and Brummer (2005) in a study of aquaculture in Oyo State with RTS of 0.841. This current study's RTS (0.9797) is also in accordance with the RTS (0.664) of Emokaro and Ekunwe (2009).

Table 1: Elasticities of Production Frontier and Returns to Scale (RTS)

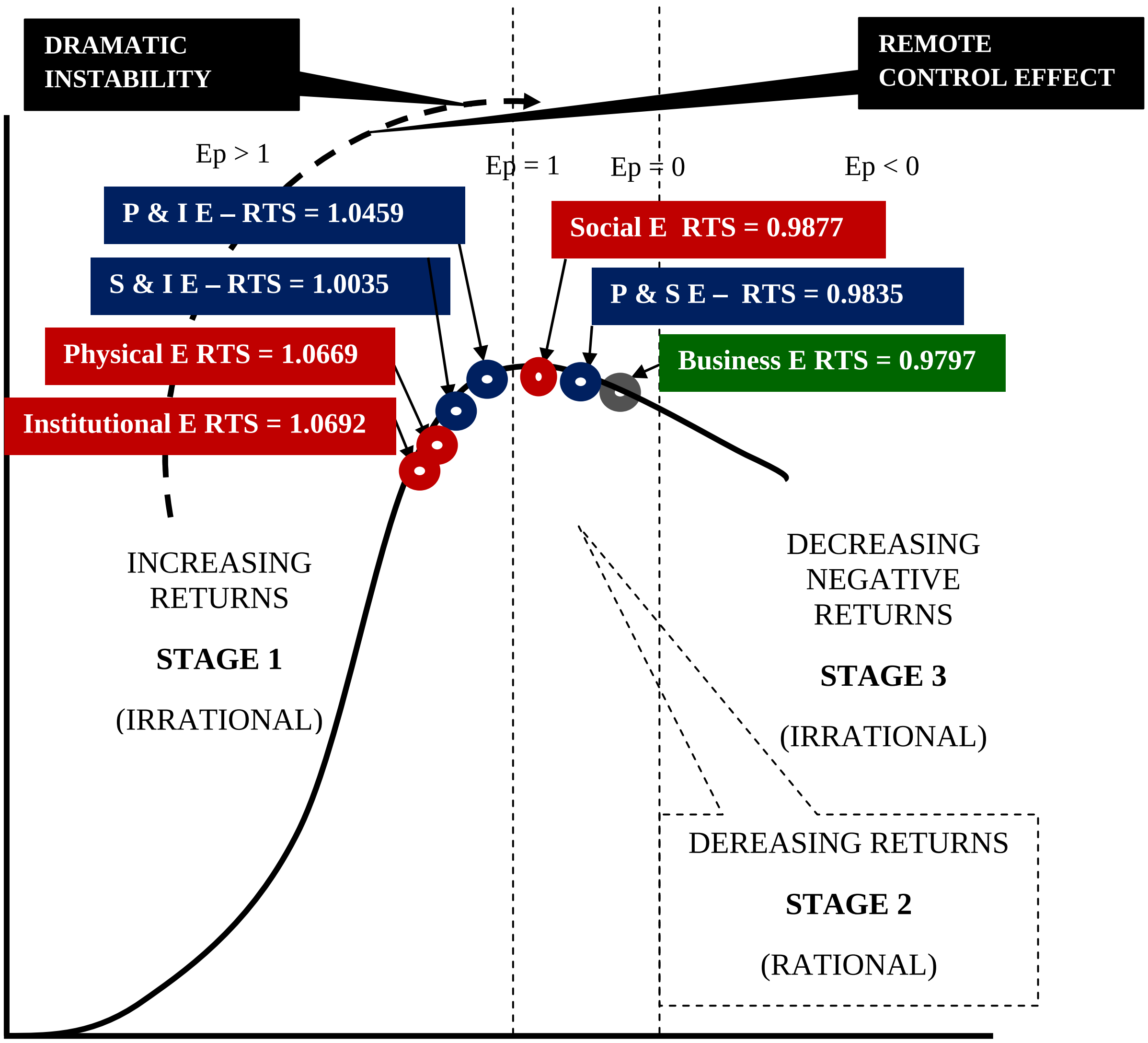
Output Elasticities of the Frontier				
Variables	General Model	Physical Effects Only	Social Effects Only	Institutional Effects Only
FING (kg/m^2)	0.171	0.220	0.176	0.236
FEED (kg/m^2)	0.0534	0.0571	0.0626	0.0636
LABO (man days/m^2)	0.0353	0.0258	0.0361	0.0236
POSI (m^2)	0.720	0.764	0.713	0.746
Returns to Scale (RTS)	**0.9797**	**1.0669**	**0.9877**	**1.0692**

Note: RTS for the following studies are as follows: Emokaro and Ekunme (2009) is 0.664 and Ogundari, Ojo and Brummer (2005) is 0.841

The frontier result has helped to identify the technical efficiency implications arising from the effect of business environment on catfish production in Benue State, Nigeria. The study would explain the business maneuvers and decisions taken by the catfish producer to mimic or reduce business environment perturbations arising from the business environment.

4.2. Business Environment Remote Control Theory

The physical effects only model, the institutional effects only model, social and institutional combinations model, physical and institutional combinations model are operating in stage 1 of the production function also known as the increasing returns stage which is also the irrational stage. In theory, this stage is perceived to under utilize input resources.



Note: S = Social Factors, P = Physical Factors, I = Institutional Factors, RTS = Return to Scale, Es = Environments, Ep = Elasticities of Production

Figure 1: Business Environment Remote Control Effect on Return to Scale (RTS)

The restricted state (that is, social effects only), the combination of physical and social effects model and the entire business environment variables are operating in stage 2 (rational stage) of the production function which is the state of decreasing returns (see Figure 1 above). In practice, the catfish producers in our study area are operating in stage 2 – the rational stage. This is because, the farmers were able to identify business environment variable items and succeeded in strategizing and controlling the environment to avoid producing outside stage 2 of the production function. This finding is in cognizance with Ogundari, Ojo and Brummer (2006) and Emekaro and Ekume (2009). Thus, the more business environment variables that are identified and controlled, the more likelihood of the catfish manager to produce within stage 2.

The catfish farms were able to cushion their catfish enterprises against environmental perturbation. However, *immediate* control of the resources can easily be influenced by the manager, but long term scarcity of inputs within the business environment, which could easily disrupt production in stage 2, can be *remotely* controlled. The study found out that the catfish enterprises were able to remotely control the business environment by strategizing and adjusting to the agribusiness environment. Thus, the phenomenon gives rise to a situation termed *"business environment remote control"* as observed by this study. This term personifies the business environment as a remote, complex entity that can be cajoled so as to reduce the full wrath of the threats from the business environment. Our theory is in line with Rudolph and Repenning (2002)'s Disaster Dynamics or Business Environment Complexity Theory – complexity helps explain how systems can evolve in unexpected ways, exhibiting dramatic instability. This theory is depicted by Figure 1, which indicates that the RTS of the Business Environment is closer to the border line between stage 2 and stage 3. On the other hand, the RTS of the Social, Physical and Institutional Factors and their combinations are either in stage 1 or stage 2, however, they are not close to the border line between stage 2 and stage 3.

Table 2: Cobb–Douglas Production Frontier Functions with Log Likelihood Estimates and LR Test of the One Sided Error (n=174)

		Cobb-Douglas Frontier Production Function	**General Model**	**Physical Factors are Excluded**	**Social Factors are Excluded**	**Institutional Factors are Excluded**
Variable						
Frontier Production Function						
Constant	β_0	-42.882 (27.303)	0.391** (0.177)	0.372** (0.161)	0.274*** (0.151)	0.389** (0.170)
FING (kg/m^2)	β_1	25.370** (8.291)	0.171** (0.07661)	0.202 (0.123)	0.215** (0.072)	0.169** (0.0752)
FEED (kg/m^2)	β_2	0.00876 (0.00638)	0.0534* (0.0166)	0.0601* (0.0165)	0.0590* (0.0152)	0.0577* (0.0154)
LABO (man days/m^2)	β_3	0.0113 (0.00638)	0.0353 (0.0207)	0.0304 (0.0262)	0.0319 (0.0208)	0.0398*** (0.0203)

POSI (m^2)	β_4	0.7554* (0.0772)	0.720* (0.0779)	0.711* (0.0714)	0.740* (0.0688)	0.717* (0.0765)
Inefficiency effects model						
Constant	δ_0		0.141*** (0.0713)	0.128 (0.119)	0.0320** (0.0122)	0.174* (0.550)
AROADS (dummy)	δ_1		0.0127 (0.0133)		0.0117 (0.0140)	0.0124 (0.00801)
COSTPF (₦)	δ_2		-0.00216 (0.00344)		0.000207 (0.000921)	0.000362 (0.00247)
COSTSF(₦)	δ_3		-0.00175 (0.00263)		-0.00539 (0.00451)	-0.00292 (0.00193)
EDUCAT (yrs)	δ_4		-0.0506 (0.541)	-0.0416 (0.0809)		-0.0661 (0.0410)
EXPERI (yrs)	δ_5		-0.0127 (0.0263)	-0.0185 (0.0280)		-0.0108 (0.0202)
ACONS (dummy)	δ_6		-0.0631* (0.0182)	-0.0572** (0.0226)		-0.0577* (0.0136)
CREDIT (₦)	δ_7		-0.00207 (0.0031)	-0.00149 (0.361)	-0.00326* (0.000765)	
COSTIN (₦)	δ_8		-0.00315 (0.00252)	-0.00199 (0.00641)	-0.0115* (0.00435)	
AVLMKT (dummy)	δ_9		0.00908 (0.00943)	-0.0218 (0.0617)	-0.0166* (0.00430)	
Variance parameters						
Sigma-squared	σ^2	9181.350* (55.470)	0.00222* (0.000286)	0.00226* (0.000354)	0.00242* (0.000255)	0.00227* (0.000232)
Gamma	γ	0.0258 (0.133)	0.000311** (0.000137)	0.00835 (0.192)	0.0248 (0.000979)	0.00118 (0.0547)
Log Likelihood	LLF	-1038.077	283.723	278.740	279.785	282.634
LR test of the one sided error	LR		30.612	20.647	22.736	28.434

*,** and *** indicate that the parameter is significant at the 1, 5 and 10%, respectively, figures in parenthesis are error values

5. Conclusion and Recommendations

5.1. Conclusion

The study concludes that *immediate* control of resources can easily be influenced by the manager, but additional change in the level of inputs, which will subsequently lead to decreasing return to scale is *remotely* controlled by the business environment. Thus, the study came up with the conclusion that, business environment (i.e. physical, social and institutional) factors do have effect on catfish production in Benue State, Nigeria.

5.2. Recommendations

Based on the findings of this study, the following recommendations are appropriate:

i. However, the agribusiness manager or catfish producer needs to make meaning of the frontier statistics.

ii. Catfish Production Managers should ensure that business maneuvers and decisions should be taken to mimic or reduce business environment perturbations arising from the business environment.

iii. In order to have effective control over the inputs resources within the catfish business environment, efforts should be made by academics and managers to identify other environmental factors such as government/political/legal, economic, natural, suppliers, etc, that could pose serious threats.

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