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MACROECONOMIC VARIABLES AFFECTING FISH PRODUCTION IN NIGERIA

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ABSTRACT

The study is an attempt to examine the influence of macroeconomic variables on the growth of fishery sub-sector in Nigeria. The study covers the period from 1961 and 2017. The results apparently revealed that aquaculture production, artisanal fish production, and total fish production, grew exponentially at the rate of 8.90%, 3.75%, and 4.25% respectively. To be more precise, various other factors like, demand shocks, food imports, and variable exchange rate, affected artisanal fish production in the long-run; while exchange rate and demand shocks were significant in the short-run period. For the aquaculture production, demand shocks, credit potential, inflation, food imports, and exchange rate were some significant policy variables in the long-run; whereas demand shocks and exchange rate were also significant in the short-run period. Finally, as far as the total fish production is concerned, demand shocks, food imports, and exchange rate were significantly trending variables, both in the short and long-run periods. To promote fish production in Nigeria, fish imports should be gradually restricted and the economic system regulated to ensure the stability of naira exchange for the US dollar.

Contribution/ Originality
The study was designed to explore and uncover some key macroeconomic variables and important fundamentals that affect fishery sub-sector in Nigeria, which led us to quite interesting findings which revealed that some macroeconomic variables are critical in achieving adequate prospective and fullest potentials in fishery sub-sector in the country.

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1. INTRODUCTION

Keeping in view the established fact that macroeconomic imperatives undoubtedly, have very effective influence on the directions and magnitude of growth in the agricultural sector. As Muftaudeen and Abdullahi (2014) concluded that an effective macroeconomic policy framework is very much necessary in regulating the economic activities in order to guarantee a well-established and sustained economic growth in developing economies. This assertion is obviously premised on the tenant of Keynesian Theory, which tends to state that public policy has a direct impact on aggregate demand, which would have multiplier effects on the growth of real economic sectors, in the short-run aspect.

Considered as a major agricultural sector in the agrarian economy of the coastal States in Nigeria, 'fishery' is unarguably the most important and critical sub-sector, with respect to income generation, poverty reduction, and dietary requirement. Payne (2000) and Food and Agricultural Organization (2018) noted that fish production helped to strengthen food security and livelihood structure among dwellers of river-line communities. Again, on the assertion of Adekoya and Miller (2004), it is interesting to note that fishery sources provided more than 60% of the total protein intake among adults in Nigeria, especially in the rural areas. Strangely enough, the country is still unable to adequately cater for its requirement of fishery products for the majority of its citizens, in terms of both ample productive capacity and satisfying dietary needs. For instance, the per caput average annual domestic production of fish (i.e. aquaculture output and artisans output) stood at 6.09 kg/annum in 2015 and at 5.67 kg/annum in 2016 in Nigeria. Assuming that if all that is produced is consumed fully, then these figures are obviously, far below the recommended daily protein intake of 0.75 g per kg of lean body weight, as asserted by FAO/WHO (World Health Organization).

This gives much credence for a reliance on imports and inclination towards smuggling for quite an enough proportion of domestic consumption. For instance, Federal Department of Fisheries (2018) reported that the country's national demand in 2012 was 2,000,000 tones, while supply stood at 690,000 tones, showing a resulting deficit of 1,310,000 tones. In 2014, a total of 2,175,000 tons of fish was demanded for the country's national consumption, the supply apex stood at 730,000 tones, leaving behind a deficit of 1,404,000 tones. The total exports of fish from Nigeria was valued at US$ 284 390 million, whereas the imports stood at about US$1.2 billion in 2013. Therefore, Nigeria is being regarded as one of the heavy importers of fishery products in the world (FAO, 2018).

As showed in Table 1, the fishery sub-sector contributed on the average, to about 0.52% and 2.3% of the total GDP and Agricultural GDP respectively in Nigeria, between 1981 and 2017. However, as far as contributions for the sub-units are concerned, the artisanal fish production was about 88.82%, while aquaculture made up of the remaining 11.18% of the total fish production in the country. This is therefore, a clear indication of high dependence on artisanal fishing for domestic consumption, besides an in-depth indication of under-development of aquaculture sub-unit (Osawe, 2007).

The failure of the dismal performance of the fishery sub-sector in Nigeria has been attributed to multifaceted factors, particularly including the debilitated agricultural policy and inadequate policies on the national water resources (Akpan, 2012; Tobor, 1997), besides other issues relevant to oil spillage, crude oil pollution, militant activities along the coastal States and dumping of toxic wastes, as well as natural phenomenon like, global climatic change (Moyle, 1990; Tobor, 1997; Enabulele, 1999; Ugwumba, 2005; Adeogun *et al.*, 2007; Ugwumba and Nnabuife, 2008; Grema *et al.*, 2011; Issa *et al.*, 2014; Adewumi, 2015; Paulina and Hammed, 2018).

Table 1: Contribution of the fishery sub-sector to the agricultural and total gross domestic product accounts for the period of 1981 and 2017

Year	% share of fishery sub-sector in Total GDP	% share of fishery sub-sector in Agric. GDP	% share of Aquaculture in total Fishery output	% share of Artisanal fish in total Fishery output	Year	% share of fishery sub-sector in Total GDP	% share of fishery sub-sector in Agric. GDP	% share of Aquaculture in total Fishery output	% share of Artisanal fish in total Fishery output
1981	0.380	3.228	2.415	97.585	2000	0.596	2.724	5.506	94.494
1982	0.435	3.346	2.432	97.568	2001	0.703	2.838	5.120	94.880
1983	0.606	4.149	2.513	97.487	2002	0.607	1.618	5.992	94.008
1984	0.509	2.859	2.470	97.530	2003	0.609	1.766	6.065	93.935
1985	0.281	1.579	3.217	96.783	2004	0.572	2.006	8.631	91.369
1986	0.380	2.154	2.009	97.991	2005	0.580	2.143	9.724	90.276
1987	0.267	1.322	2.301	97.699	2006	0.522	1.992	13.280	86.720
1988	0.364	1.581	3.803	96.197	2007	0.497	1.918	13.824	86.176
1989	0.576	2.736	8.600	91.400	2008	0.495	1.918	19.233	80.767
1990	0.642	3.009	2.323	97.677	2009	0.499	1.903	20.346	79.654
1991	0.600	2.903	5.740	94.260	2010	0.457	1.914	24.530	75.470
1992	0.518	2.562	5.367	94.633	2011	0.451	2.025	25.814	74.186
1993	0.444	1.892	6.689	93.311	2012	0.450	2.040	27.518	72.482
1994	0.436	1.724	5.344	94.656	2013	0.458	2.181	27.869	72.131
1995	0.501	1.836	4.539	95.461	2014	0.478	2.360	29.190	70.810
1996	0.604	2.134	5.452	94.548	2015	0.506	2.425	30.838	69.162
1997	0.671	2.277	5.894	94.106	2016	0.521	2.455	29.996	70.004
1998	0.729	2.495	4.231	95.769	2017	0.549	2.608	30.413	69.587
1999	0.727	2.704	4.554	95.446	Av.	0.519	2.306	11.183	88.817

Source: Computed by authors using data from CBN
Note: GDP at the current basic price

Although it is an interesting matter to ponder that fishing (including artisans and aquaculture production) is considered as an economic activity and included as an important parts of the entire economic system, it is ought to be affected by economic variables both at the micro and macro levels (Akpan *et al.*, 2012). Therefore, a need to develop a dynamic and comprehensive study necessarily arises. It must focus on the roles of basic macroeconomic variables on fish production in Nigeria, and should be precisely premised on the need to empirically establish this relationship. In order to enrich the relevant literature with related information, the study should be empirically designed to estimate a system of coefficients in both the short and long run, so as to show the explicit relationship between fish production and key macroeconomic variables in our country of research.

2. METHODOLOGY

An *ex-post facto design* had been employed in this study to establish the comprehensive relationships between fishery output and macroeconomic variables, developed during short and long-run periods. The data for the study had been obtained from three different sources, viz., the Central Bank of Nigeria, Food and Agricultural Organization, and the World Bank. The data sets acquired for 56 years (from 1961 to 2017) had been utilized therein to achieve the requisite results accordingly.

2.1. Analytical framework and model specifications

When we precisely understand the nexus of the relationships and review the flow of agricultural inputs and outputs within the framework of an open economy, wherein enhancers and inhibitors of aggregate demand and aggregate supply work constantly at a brisk pace. Therefore, such an acceleration of growth in total factor productivity or otherwise, experienced well in any real sector of an economy is known to follow certain economic theories and various hypotheses. Within the circles of economic parley, theorists proposed different schools of thoughts so as to conceptualize and materialize them as a model to create causal relationships between the growth of real sectors and some endogenous and exogenous macroeconomic variables. Essentially for this purpose, efforts had been directed accordingly to show the relevance, direction, and magnitude of various macroeconomic policy instruments to regulate the structural behavior of economic growth fundamentals.

Following the neoclassical theorists and citing the works of Fischer (1993) and Lachaal (1994), as well as the results of Muftaudeen and Abdullahi (2014), some macroeconomic variables such as; inflation rate; real interest rate; fiscal policies, real exchange rate, besides the balance of payments, have been identified as potential obstructing blocks to achieve the millennium goals leading towards food security, poverty reduction, and rural development, obviously through positive and precise growth in the agricultural sector. In more specific terms, our work is modelled on the Keynesian IS-LM framework, which according to Fasanya *et al.* (2013), had originally captured liquidity, price, and exchange rate puzzles and problems as drivers of economic growth. These puzzles, have been well defined by both augmented Solow growth and endogenous growth theories, stressing emphasized that investment in human capital and technological process are the major factors, which enhance the capital accumulation. However, the endogenous growth model had been built on economic growth, arising from the influence of significant changes in investment, capital stock, human capacity stock, etc. (Romer, 1994).

In this study, the model specified considers macroeconomic variables that have an influence on domestic production and restriction on import. The model is expressed implicitly as thus:

$$\mathrm{LnARS_t} = \gamma_0 + \gamma_1 \sum_{i=1}^{n} \mathrm{LnEXC_t} + \gamma_2 \sum_{i=1}^{n} \mathrm{LnCRE_t} + \gamma_3 \sum_{i=1}^{n} \mathrm{LnINF_t} + \gamma_4 \sum_{i=1}^{n} \mathrm{LnGDI_t} + \gamma_5 \sum_{i=1}^{n} \mathrm{LnFIM_t} + \mathrm{U_t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The variables are defined below:
ARS_t = Annual artisanal or captured fish measured in metric tonnes
EXC_t = Annual average nominal exchange rate (₦/$)
CRE_t = Domestic credit to private sector (% of GDP)
INF_t = Annual Inflation rate to proxy input prices (%)
GDI_t = Per capita GDP representing purchasing power
FIMt = Annual value of import of goods and services in naira
Ln = Representing natural log
U_t = Random error term that is $U_t \sim$ IID $(0, \delta^2_U)$

Note: Equation 1 was estimated for the three major variables representing the fishery sub-sector as specified above. These major variables consist of artisanal fish output/captured fish output, aquaculture output and total or sub-sectoral output.

In order to examine and test for the existence of stable long-run empirical relationship between the fishery sub-sector output and macroeconomic variables in Nigeria's economy, the Engle and Granger two-step method of testing co-integration was applied and conducted for this purpose. According to the Granger representation theorem, error correction models for the co-integrating series were estimated in the simplest form. Therefore, the general form for the error correction specification for the fishery sub-sector is shown in equation 2, as follows:

$$\Delta\mathrm{LnARS}_t = \theta_0 + \theta_1 \sum_{i=1}^{n} \Delta LnARS_{t-1} + \theta_2 \sum_{i=1}^{n} LnINF_t + \theta_3 \sum_{i=1}^{n} LnEXC_t + \theta_4 \sum_{i=1}^{n} LGDI_t + \theta_5 \sum_{i=1}^{n} LnCRE_t + \theta_6 \sum_{i=1}^{n} LnFIM_t + \beta_7 ECM_{t-1} + U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Variable specified are as defined previously in equation 1, and coefficients (β_7) of the ECM ($-1<\beta_3<0$) captured the deviation of the fishery outputs from the long-run equilibrium in period ($_{t-1}$).

Based on the result of the root unit test and the need to capture the dynamic relationship appropriately while avoiding spurious regression, a time series multivariate Cobb Douglas model representing the long-run relationship was specified at the level of variables.

Further, to study the nature and rate of growth in the artisans fish/captured fish, aquaculture and entire fishery sub-sector; an exponential growth equation is fitted into the data. The exponential equation is defined as thus:

$$\mathrm{ARS_t} = \mathrm{b_o e^{bt} e^{ut}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$log_e ARS_t = log_e b_0 + b_1 t + U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\text{Where exponential growth rate is (r)} = (e^{b1} - 1) * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

The trend analysis was defined for the following variables:
ARS_t = Annual artisanal/captured fish measured in metric tonnes

AQC_t = Annual aquaculture fish measured in metric tonnes
TFS_t = Annual total output in fishery sub-sector measured in metric tonnes

Note: Equation 4 was also specified for aquaculture and total fishery sub-sector. The exponential trend equation was adopted because it is expected that the fishery sub-sector should be increasing exponentially given increase in population and food demand in the country

3. RESULTS AND DISCUSSION

The descriptive characteristics of variables presented in the study are shown in Table 2. Since the Jarque-Bera test reveals that most of the specified variables are not normally distributed, the coefficient of variability measures the degree of significant variation in each specified variable.

3.1. Descriptive statistics of specified variables

The statistics of our estimated results showed that output of captured fish, credit and total production in the sub-sector simply exhibited the least degree of variations. However, variations were apparently more pronounced in imports, per capita income, aquaculture output, and nominal exchange rate. The statistics for skewness showed that all specified variables are positively skewed, implying that there is a right-tailed distribution. This means that the fishery sub-sector's productivity increases with the passage of time.

Table 2: Summary of the descriptive statistics of the variables

Variable	Mean	Median	Min.	Max.	Std. dev.	C.V.	Skewness	Jarque-Bera
ARS	3.49e+05	2.66e+05	52837.	7.59e+05	1.96e+05	0.562	0.549	3.990
AQC	56646	10631.	2173.0	3.17e+05	96076.	1.696	1.871	42.607
TFS	4.05e+05	2.72e+05	55010.	1.07e+06	2.83e+05	0.697	1.056	10.605
GDI	87604.	2460.6	69.273	6.02e+05	1.68e+05	1.915	1.975	51.079
CRE	12.286	12.350	3.7043	38.387	6.269	0.510	1.962	113.029
INF	16.377	11.600	0.50000	72.800	15.459	0.944	1.996	65.712
FIM	2.05e+012	1.84e+010	4.76e+008	1.37e+013	3.70e+012	1.804	1.761	36.243
EXC	53.896	7.3647	0.54678	305.79	75.547	1.402	1.301	18.164
Obs.	57	57	57	57	57	57	57	57

Note: ARS = Artisanal fish output; AQC = aquaculture fish output; TFS = Total fish output; EXC = nominal exchange rate; INF = inflation rate; CRE = credit to private sector; GDI = GDP per capita; FIM = food import; Units are as defined in equations 2 and 4

3.2. Exponential trend analysis of outputs of captured fish, aquaculture and the entire fishery sub-sector in Nigeria

Estimates of the exponential trend equation for each of the major areas of the fishery sub-sector are presented in Table 3. The result reveals a positive relationship between the trend in output of captured fish, aquaculture and the entire fishery sub-sector and time in Nigeria.

Table 3: Exponential growth rates in outputs of capture fish, aquaculture and total fishery output in Nigeria

Variable	Capture fish	Aquaculture	Entire Fishery
Constant	11.489 (181.5)***	7.107 (57.24)***	11.435 (185.7)***
Time	0.0375 (19.74)***	0.0890 (23.91)***	0.0425 (23.0)***
Exp. Growth (%)	3.75	8.90	4.25
F (1, 55).	389.59***	571.756***	528.83***

Note: *, ** and *** represents 10%, 5%, and 1% level of significance respectively. t-values are in parentheses

The average exponential growth rates obtained for the captured fish, aquaculture production, and the entire sub-sector production showed the percentage figures of 3.75%, 8.90%, and 4.25%, respectively. The findings further revealed that the turnout of fishery sub-sector in Nigeria had shown considerable and consistent improvement during the past few years. This trend obviously means that output of captured or artisans fishing and aquaculture production has shown the rise, on annual basis. The growth rate has been particularly impressive in aquaculture output as compared to artisans fishing. Many significant factors could be attributed for the growth in the two major sources of fish production in Nigeria. One of the most credible reasons or a plausible explanation for the upsurge in fish production therein could be the increasing demand verily conditioned by the increase in population.

To further elaborate and substantiate the relationship between fishery sub-sector output and time, a graphical representation of the linear trend of fishery sub-sector output in Nigeria is presented in Figure 1. The result indicates a conspicuous gap between artisanal production and aquaculture output in Nigeria. In the early 1960s, the country's domestic source of fish was mainly attached to captured fish, and aquaculture was under-developed but was gradually becoming an emerging source of fish production. However, artisanal fish production continued to dominate larger part of domestic production until early 2000.

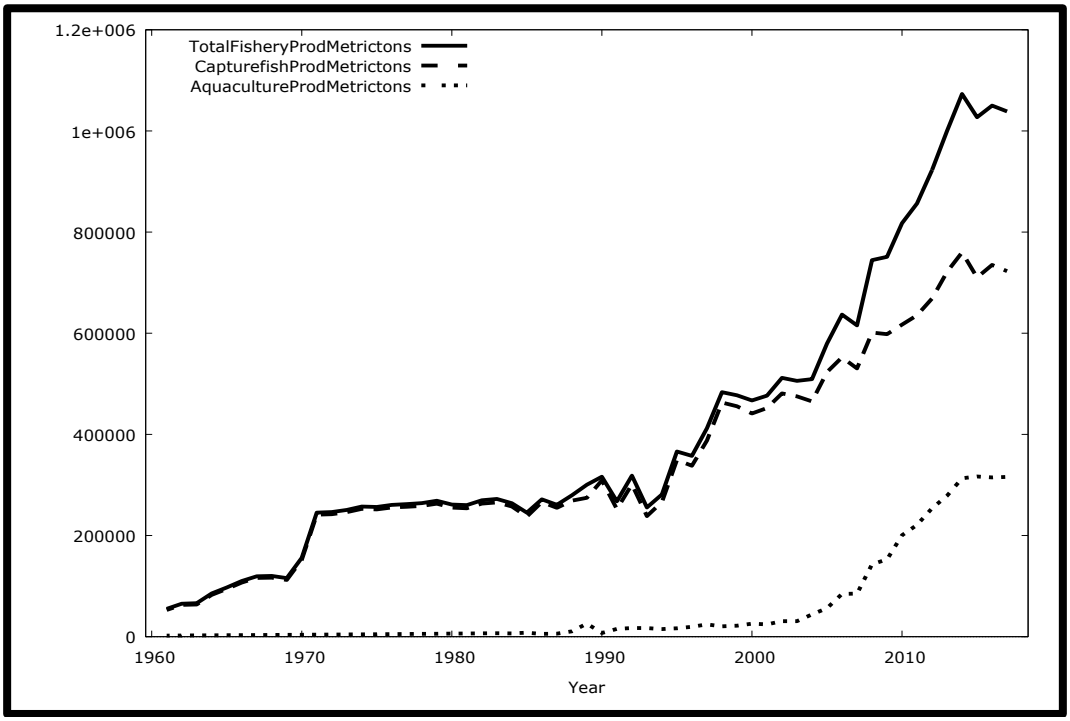

Figure 1: Trends in output of captured fish, aquaculture and total fish output in Nigeria (1961-2017)

It is quite interesting to note that from the 1960s to early 2000, the fishery sub-sector witnessed a marginal growth in production, but due to the country's civil war, a sharp break incurred to slow down the pace of progress from 1968 to 1970. After the civil war, the country once again recorded a steady growth in the production of artisanal fish till 1993, which was the year to mark the end of the structural adjustment program (SAP) in Nigeria. Over the years, since then there have been peaks and troughs in the trends of fish production, most likely due to some unchecked issues like

importation, smuggling, etc. But unexpectedly, there has been exponential growth in both artisanal and aquaculture production in the country, from 1995 onwards till 2017, This growing trend could perhaps be attributed partly to various incentives made available to stakeholders in the sub-sector and partly due to the establishment of adequate and formal institutions by the Nigerian government, to expand the frontier of research activities in various aspects of the fishery sub-sector. Moreover, collaborations in the form of public-private partnership with established agencies/companies involved in fish production also created a progressive atmosphere in the fishery sub-sector. For instance, Akwa Ibom State government on several occasions distributed fishing gears and engine boats to fish cooperative societies within the state (AKSG, 2008).

In addition, planned trade policies and tariff systems were gradually proposed for implementation in recent years, led to the reduction of importation of fish into the country. Although the security had been intensified at the borders so as to cope with excessive smuggling attempts, but in vain. From the trending conditions, it is also apparently observed that production gaps between aquaculture production and artisanal fish product increased persistently along the years. Moreover, the issues leading to aquaculture production, which had been playing a sluggish role in domestic fish production/supply, had to be dealt with sincere and important plans with various effective determinants like, input prices, economic environment, and demand preferences, among other factors.

Osawe (2007) reported that constraints in investment in aquaculture production in Nigeria emerge in different facets and dimensions, and specifically pointed out the following major obstacles faced in aquaculture development in the country: (i) scarcity of fingerlings, high costs of fish feeds and labor force supply; (ii) poor water supply, land fragmentation for fish ponds development; (iii) insufficient capital availability and lack of up-to-date technology in fish production, and obsolete storage facilities; (iv) poor roads infrastructure and miserable conditions, leading to higher hike in transport costs; and, (v) stormy and surging morbidity and mortality rates.

The poor National Fisheries Development plans and policies of the country in past few years mainly focused on the development of industrial fisheries to the detriment and risk of aquaculture production (Tobor, 1997). Likewise, many other researchers have also attempted to trace down the causes of low productivity in aquaculture to be closely linked with several factors, including (i) inadequate quality of fish seeds for stocking ponds, (ii) dearth of information on and usage of modern technologies in aquaculture, due to poor extension in services, (iii) poorly trained personnel, pathetic social capital formation, negligible support infrastructures, and (iv) capital injection by the government and high costs of fish feeds (Tobor, 1997; Ugwumba, 2005; Adeogun *et al.,* 2007; Ugwumba and Nnabuife, 2008).

3.3. Unit root test for specified economic variables

In a bit to investigate the impact of major economic variables on fish production in Nigeria, the stationarity test for the specified economic variables was conducted. This is necessary to avoid the tendency of having nonsense regression estimates. The Augmented Dickey-Fuller root unit test and Phillip Peron root unit tests were used to ascertain the degree of stationarity of specified variables used in the analysis. The result of the Augmented Dickey-Fuller unit root tests are presented in Table 4, while Phillip Peron unit root test is shown in Table 5. Unit roots equations specified were those without constant and trend and those containing constant and trend. Variables were tested at level and first difference and their order of integration determined. Critical values were set at 1%, 5%, and 10% probability levels. Result of ADF and Phillip Peron unit-roots show that for equation without constant and trend, all specified variables were integrated of order 1. Also, inflation and credit were stationary at a level for an equation containing a constant and trend for ADF and inflation alone for Phillip Peron unit root test equation.

Table 4: Presentation of the result of the augmented Dickey-Fuller root unit test

	ADF equation without Constant& trend			ADF equation with constant and Trend		
Variable	**Level**	**1st Diff.**	**OT**	**Level**	**1st Diff.**	**OT**
ARS	2.620	-6.635***	1(1)	-2.866	-7.791***	1(1)
AQC	2.382	-2.029**	1(1)	-1.386	-3.411*	1(1)
TFS	2.946	-3.061***	1(1)	-2.792	-7.403***	1(1)
EXC	1.505	-5.127***	1(1)	-2.038	-5.897***	1(1)
INF	0.029	-8.547***	1(1)	-4.332***	—	1(0)
CRE	0.428	-5.962***	1(1)	-3.227*	—	1(0)
GDI	6.285	-4.440***	1(1)	-2.457	-6.307***	1(1)
FIM	4.430	-1.630*	1(1)	-2.017	-3.799**	1(1)
			CRITICAL VALUES			
CR (1%)	-2.609	-2.607		-4.133	-4.133	
CR (5%)	-1.947	-1.947		-3.493	-3.493	
CR (10%)	-1.613	-1.613		-3.175	-3.175	

Note: OT stands for order of integration. *, ** and *** represents 10%, 5% and 1% level of significance respectively. Variables are as defined in Equations 6

Table 5: Result of Phillips – Peron root unit test

Variable	**Equation without Constant and trend**			**Equation with constant and Trend**		
	Level	**1st Diff.**	**OT**	**Level**	**1st Diff.**	**OT**
ARS	2.962	-6.683***	1(1)	-3.055	-7.791***	1(1)
AQC	4.950	-9.325***	1(1)	-1.923	-12.286***	1(1)
TFS	3.369	-6.312***	1(1)	-2.793	-7.404***	1(1)
EXC	1.596	-5.209***	1(1)	-2.009	-5.909***	1(1)
INF	-0.858	-14.038***	1(1)	-4.255***	—	1(0)
CRE	0.732	-8.367***	1(1)	-3.089	-11.145***	1(1)
GDI	5.824	-4.002***	1(1)	-2.493	-6.275***	1(1)
FIM	4.119	-4.927***	1(1)	-2.164	-6.215***	1(1)
			CRITICAL VALUES			
CR (1%)	-2.607	-2.607		-4.130	-4.133	
CR (5%)	-1.946	-1.946		-3.492	-3.493	
CR (10%)	-1.613	-1.613		-3.174	-3.175	

Note: *, ** and *** represents 10%, 5% and 1% level of significance respectively. Variables are as defined in Equations 6

Results, as presented, imply that the time series specified are non-stationary at their level. This suggests the verification of the co-integration among the specified variables as proposed by Johansen (1988) and Johansen and Juselius (1990).

3.4. Johansen's co-integration test on specified variables

The co-integration test as was developed by Granger (1981) involved the determination of long-run associations among non-stationary time-dependent variables. The prerequisite for conducting the test is that the series must be integrated of the same order or non-stationary individually. The study applied the Engle and Granger two-step technique and Johansen approach to conduct the co-integration test on the specified series. Results showed stationary of residual (ECM) generated from the long-run model representing the captured fish output, artisanal and the entire fishery sub-sector outputs. The results are presented in the lower portion of Table 7. The test results showed that at 1% level of probability, the Engle-Granger co-integration tests reject the null hypothesis of no co-integration. This implies that there are long-run equilibrium relationships between fishery sub-sector outputs and major macroeconomic variables in Nigeria. In the same Venn, the Johansen co-

integration approach showed that the trace and maximum Eigen value test statistics were significant at various rank levels. The result is presented in Table 6. The result further indicates at least two (2) co-integration relationships among specified series.

The upper region of Table 7 presents the estimated long run models for outputs of capture fish, aquaculture and the entire sub-sector. The long run coefficients represent the long-run fishery output elasticity with respect to each of the specified macroeconomic series.

Table 6: Johansen's co-integration test results

Hypothesized No. of CE(s)	Eigen Value	Trace Statistic	Critical Value 99%	Critical Value 95%	Max-Eigen Statistic	Critical Value 99%	Critical Value 95%
None *	0.723	153.636***	104.962	95.754	70.669***	45.869	40.077
At most 1 *	0.508	82.967***	77.819	69.819	38.995**	39.370	33.877
At most 2	0.309	43.972	54.682	47.856	20.351	32.715	27.584
At most 3	0.215	23.621	35.458	29.797	13.307	25.861	21.132
At most 4	0.166	10.314	19.937	15.495	10.005	18.520	14.265
At most 5	0.006	0.309	6.635	3.841	0.309	6.635	3.842

Note: Trace test indicates 2 co-integrating equations at the 0.01 level.* denotes rejection of the hypothesis at 5% and 1% level. Max-Eigen value test indicates 1 co-integrating Eqn.(s) at the 0.01 level and 2 equations at 5% level

3.5. Error correction model for Fishery development in Nigeria

The error correction model (ECM) for the co-integrating series in the study was estimated and is presented in Table 8. The main motive for estimating the ECM model was to capture the dynamics in the fishery development equation in the short-run and to determine the speed of adjustment as a response to the departure of the long-run equilibrium. For the purpose of achieving a parsimonious dynamic ECM for the fishery sub-sectors' equations; the study used Hendry's (1995) approach. "This approach estimated an over parameterized model initially and was gradually reduced by eliminating insignificant lagged variables until a more interpretable and parsimonious model was obtained" The slope coefficient of the error correction term in each specified equation (i.e. outputs of capture fish, artisanal fish and entire fishery sub-sector) showed the prerequisite negative sign and was statistically significant at the conventional probability level. The result obtained from the sign of the coefficient of ECM validates the existence of a long-run equilibrium relationship among the series specified in the study, and also indicates that the fishery sub-sector development is sensitive to departure from its equilibrium value in the previous periods. In other words; the estimated equations will be at an appropriate time correct any deviations from the long-run equilibrium. If long-run equilibrium value is too high; the error correction will reduce it, otherwise it will increase it.

The slope coefficient of the error correction term representing the output of captured fish is 0.221. This denotes that, about 22.10% of any past deviations from the long run disequilibrium are corrected in the current period. Thus, it will take more than four (4) years for any disequilibrium, in the long-run, to be totally corrected. The long-run disequilibrium adjustment periods for aquaculture and the entire fishery sub-sector are similar to the captured fish output and will equally require more than four years for a total adjustment.

The validity test for the ECM model revealed R-squared values of 0.226, 0.299 and 0.248 for captured fish, aquaculture and entire fishery sub sector equations respectively. This implies that at 22.6%, 29.9% and 24.8% of the total variations in captured fish, aquaculture and entire fishery sub sector's output respectively are explained by the specified macroeconomic series in the equation. The F-test for each of the fish sources is significant at the conventional level of probability showing that the estimated coefficients of determination are statistically significant. The normality

tests for each of the fish source are significant implying, the residuals are normally distributed and this also justify the used of ordinary least squared method of estimation.

Table 7: The Long-run determinants of development in fishery sub-sector in Nigeria

Variable	Captured fish	Aquaculture	Entire Fishery
Constant	9.534 (6.988)***	11.296 (5.201)***	10.438 (8.214)***
GDI_t	0.336 (3.170)***	1.082 (6.411)***	0.473 (4.792)***
CRE_t	0.103 (1.080)	0.010 (3.067)***	0.077 (0.868)
INF_t	─0.043 (-1.201)	─0.141 (-2.503)**	─0.0127 (-0.385)
FIM_t	─0.013 (-2.449)**	─0.404 (-2.805)***	─0.058 (-3.684)***
EXC_t	─0.223 (-4.480)***	─0.150 (-1.898)*	─0.251 (-5.418)***
R- Squared	0.894	0.951	0.926
F(5, 51)	86.179***	196.033***	127.869***
Unit Root of Residual (equation without trend and constant)			
ADF test	-3.516***	-3.998***	-3.517***
Phillip-Perron test	-3.486***	-4.031***	-3.472***
Unit Root of Residual (equation containing trend and constant)			
ADF test	-3.402*	-3.911**	-3.434*
Phillip-Peron test	-4.093**	-3.947**	-4.093**

Note: *, ** and *** represents 10%, 5% and 1% level of significance respectively. t-values are in parentheses

The RESET test of the structural rigidity of the estimated equation is significant for the three sources of fish output. This means that the estimated equations have structural rigidity and are stable. The value of the Durbin-Watson test for the three sources of fish output indicates the presence of minor serial correlation. However, "the ECM model has been shown to be robust against residual autocorrelation; hence, the presence of autocorrelation does not affect the estimates" (Laurenceson and Chai, 2003).

3.6. Long and short runs determinants of fishery development in Nigeria

The long and the short runs impact of macroeconomic variables on output of fishery sub-sector was discussed based on sources of fish as specified in the study. The detail discussion is found below.

3.7. The long and short runs impact of macroeconomic variables on captured fish output

The short-run model reveals that per capita GDP which proxy the purchasing capacity of Nigeria has a significant positive relationship with the captured fish output in Nigeria. The result is also replicated in the long-run period. This implies that, as demand capacity upsurge, the captured fish output increases too in both short and long-run periods. For instance, a 10% increase in the purchasing power of consumers would lead to 2.60% and 3.36% increase in captured fish output in the short and long-run period respectively. Hence any policy that increases the per capita GDP will have a direct impact on captured fish production in Nigeria in both short and long runs. The reason for the result could be attributed to the fact that; captured fish comes in different sizes and quality and are readily affordable to the wide range of consumers. Another possible reason is the necessity of fish protein in the dietary requirement of most Nigerian. Captured fish constitutes one of the affordable sources of animal protein available to the majority of consumers in Nigeria. Being one of the major sources of animal protein hence normal good, its consumption increases with an increase in consumers' income.

The slope coefficient of the nominal exchange rate in short and long run models is negative and significant at the conventional probability level. This implies that as the exchange rate increases (i.e. naira depreciates against the US dollar), the output of captured fish responded negatively and vice versa. However, the magnitude of this response was greater in the long-run compared to the

short-run period. For example, a 10% increase in the nominal exchange rate will lead to 0.75% and 2.23% decrease in the output of captured fish in the short and long run periods respectively. The reason for this result could be seen in two dimensions. Firstly, the increase in the exchange rate would make the importation of fishing inputs and processing facilities difficult and would be very expensive for the resource-poor fisher folks in the country. As a result of this, the efficiency of these fisher folks will reduce and the overall production/catch shrinks. Secondly, the increase in the exchange rate has encouraged many fisher folks to sell off their production in the high sea thereby reducing domestic supply.

In the long run, food import has a negative impact on captured fish output. The result satisfies *a priori* expectation because the increase in food import would result in dumping and this will shrink domestic production. A 10% increase in imports will lead to a 0.13% reduction in the volume of captured fish in the country. Hence, any government policy that discourages massive food import is directly increasing the efficiency of capture fish production in the country.

3.8. The long and short runs impact of macroeconomic variables on aquaculture fish output

The slope coefficient of per capita GDP in both short and long models is significant and positively related to aquaculture output in Nigeria. This means that, as the purchasing power of consumers increases, the aquaculture output increases correspondingly. For example, a 10% increase in the purchasing power of consumers will lead to 2.58% and 10.82% increase in aquaculture output in the short and long-run periods respectively. Based on the magnitude of the elasticity coefficient, it seems purchasing power is the most important macroeconomic factor influencing aquaculture production in Nigeria. The result is in line with the expectation of the study because aquaculture is basically business-oriented and needs financing for sustainability.

Food import has a negative relationship with the output of aquaculture in short and long-run periods in Nigeria. This means that, as the volume of food imports increases, the tendency to increase aquaculture production deteriorates. For instance, a unit increase in food imports would result in 0.002 and 0.013 units declined in aquaculture production in the short and long-run period respectively. As expected, an increase in food import will create unhealthy competition resulting to suppress domestic production.

Similarly, the nominal exchange rate (naira for dollar) relates negatively to the output of aquaculture in short and long-run eras in Nigeria. This suggests that a 10% increase in the nominal exchange rate will reduce aquaculture output by 1.05% and 1.50% in short and long run periods respectively. An increase in the nominal exchange rate of naira for dollar will directly constrain the importation of farm inputs or machinery and will stimulate locally produced substandard input. Since key input used in aquaculture is imported, an increase in the nominal exchange rate will breed inefficiency in production through high morbidity and mortality rates in production, thereby reducing aggregate output.

The long run coefficient of credit to the economy reveals a significant and direct relationship with aquaculture output in Nigeria. A 10% increase in credit disbursement to the economy will trigger a 1.0% increase in aquaculture output in the long-run. Credit has become a serious concern to agricultural development in Nigeria. The impact of credit disbursement on aquaculture output satisfies the a priori expectation. This because the federal government over the years has implemented several credit policies anchored by collaborative institutions such as commercial banks, micro finance Banks and the central bank of Nigeria as well as special arrangement with the State government to release credit to the agricultural sector in the country. The resultant effect has become a massive injection of credit to the sector at the regulated interest rate and the

corresponding increase in agricultural output. However, the impact of credit on aquaculture output was not significant in the short-run periods.

Table 8: The Short-run economic determinants of development in fishery sub-sector in Nigeria

Variable	Captured fish	Aquaculture	Entire Fishery
Constant	0.007 (0.321)	0.101 (1.813)*	0.014 (0.536)
ΔLag-1 (dependent V.),	0.095 (0.465)	-0.239 (-1.667)*	0.119 (0.867)
ΔGDI_t	0.260 (2.210)**	0.258 (2.979)***	0.262 (2.328)**
ΔCRE_t	0.127 (1.504)	0.111 (0.529)	0.092 (1.090)
ΔINF_t	─0.001 (-0.054)	─0.039 (-0.974)	─0.002 (-0.130)
ΔFIM_t	─0.002 (-0.048)	─0.122 (-0.977)	─0.015 (-2.306)**
ΔEXC_t	─0.075 (-2.296)**	─0.105 (-1.783)*	─0.084 (-1.871)*
ECM_{t-1}	─0.221 (-4.256)***	─0.249 (-2.091)**	─0.228(-3.066)***
R- Squared	0.226	0.299	0.247
F(5, 51)	5.194***	2.871**	2.209**
Normality test (Chi-sq.)	27.67***	49.377***	30.485***
RESET Test (F(2, 45))	16.616***	22.217***	12.689***
CUSUM test (Harvey-C)	-2.739***	2.682***	-2.454 **
Durbin Watson test	1.929	2.150	1.969

Note: *, ** and *** represents 10%, 5% and 1% level of significance respectively. t-values are in parentheses

The long run coefficient of inflation indicates a significant negative relationship with aquaculture development. For instance, a 10% increase in the inflation rate will induce a 1.41% reduction in aquaculture production. A rise in the inflation rate will inflate the prices of factors of production and also lower the purchasing power of consumers. Since aquaculture is business-oriented, a rise in inflation will reduce the efficiency of production and brings about higher production uncertainties as well as risks. To cushion the effect of inflation in the long-run, output will decline accordingly. However, the relationship was statistically insignificant in the short-run period.

3.9. Impact of macroeconomic variables in the long- and short-run periods

Throughout the entire discussion on fishery sub-sector in Nigeria, the findings have very clearly shown that in the long run, fish output had been affected by the purchasing power of the consumers, volume of food imports, and fluctuation in the nominal exchange rate of 'naira' as against the US$. In the short run, on the other hand, our study identified previous outputs in the sub-sector, purchasing power of consumers, food import and nominal exchange rate as the major determinants of fishery output in Nigeria. Based on the magnitude of the estimated coefficient, it is also shown that the purchasing power of consumers is the most important factor that affects the output of the fishery sub-sector in the short-run and, as well as in the long run periods in Nigeria. Since the processing and storage system are both expensive and out of the reach of poorly resourced fisher folks, the effective demand is considered to be the most necessarily essential aspect for the survival of fish production.

4. CONCLUSION AND RECOMMENDATIONS

The outcome of the study has precisely revealed empirical relationship between the output of the fishery sub-sector and some macroeconomic variables in both the short-run and long-run periods in Nigeria. The exponential growth rate in various sources of fish production in the subsector revealed quite positive growth within the period considered for the study, i.e. from 1961 and 2017. Surprisingly, the artisanal or captured fish production contributed more than 80% of the total fish production of the country. The empirical results of our study have also revealed the significant role of per capita income, credit, inflation, food import and exchange rate on fish production in Nigeria.

Following the current requirements and necessary promises of the federal government to provide nutritious and sufficient food to its citizens, it is absolutely and needful required mapping out the ways to intensify fish production in the country. The evidence derived from the results of our study, supports well the following recommendations:

a) The growth rate in the sub-sector is positive; and premised on this, the study strongly supports the current policies, programs, and institutions established in Nigeria to fast track the fish production in the country. But call for greater efficiency in the management of the sector's resources, which is still on the slower tracks.
b) The federal government should try to reduce its fish import and rather generate appropriate policies that would upsurge domestic production of fish.
c) Depreciation of 'naira' has always shown a deteriorating effect on fish production in the country. The study strongly upholds the task of the federal government of Nigeria in regulating her economic system to ensure stability of its currency exchange against US$.
d) Just as a way to encourage aquaculture production, more credit channels should be opened for fish farmers in the country. A credit system that guaranteed minimum risk and built on a single-digit interest rate is strongly advocated.
e) Finally, the implementation of economic policies void of inflationary tendencies, is being strongly advocated through the results of this study.

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