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INDIGENOUS MEAT AND MILK GROSS PRODUCTION INDEXES AND THE DYNAMIC MACROECONOMIC FUNDAMENTALS IN NIGERIA: ARDL MODEL APPROACH

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Abstract

The study established the empirical relationship between some key macroeconomic variables and meat as well as the milk gross production indices in Nigeria. Data were source from the World Bank, Food and Agricultural Organization and the Central Bank of Nigeria and it covers the period from 1961 to 2020. The properties of the series were tested with the Augmented Dickey-Fuller unit root test and ADF-GLS unit root test. The Autoregressive Distributed Lag Model (ARDL) was used to establish the existence of the cointegration among the specified series. The empirical results revealed that, real GDP per capita, nominal exchange rate, land density are the determinants of meat gross production gross index in the long run, whereas, per capita income, credit to the economy and land density are the short run determinants. Also, the per capita income, nominal exchange rate, export and inflation rate influence the milk gross production index in the long run; while the per capita income, land density, credit to the economy, value of export and nominal exchange rate had short run impact. Based on the findings, it is recommended that, specific policy to focus on the improvement of the per capita income, foreign trade control policy and reduction and or stabilization of inflation rate in the country are inevitable.

Key words*: a*griculture, production, macroeconomic, crop, Nigeria

INTRODUCTION

Meat and milk are popular animal derivatives and among the major sources of animal based protein and calorie available to man [33, 39, 2]. In Nigeria, the meat from cattle, goat, sheep, pig and poultry constitute the main sources of daily per capita consumption of animal protein; whereas, the cattle are the primary source of milk, providing more than 90% of the total animal domestic milk output [41, 22, 18]. The bulk of the cow milk produced in the country is derived from the nomadic pastoralists [20]. The dairy sub sector is characterized by small scale production and low average yields/cow/year of 213 litres which is less than one tenth of the World average production [29]. FAO, [19] reported a cattle population of 20.7 million heads, including 2.2 million dairy animals, goat population of 80.1 heads, pig population of 8.0 heads and 46.8 heads for sheep for the year 2019. In 2018, the total production of milk, meat and eggs amounted to 0.5 billion litres, 1.4 and 0.6 million tonnes per year, respectively [19]. The consumption of adequate quantity of animal protein is essential in reducing malnutrition and increasing household food security.

In the last three decades, the demand for meat and milk based products have increased in the Sub Saharan Africa and Nigeria in particular [19]. The upsurge in the demand for meat and milk based products is stemming from several causation factors, including increasing urbanization, educational status, rising personal income and socialization among others. Following the report of FAO, [21, 23], about 40 percent of households in Nigeria are responsible for producing the bulk of the meat and local milk consumed, with the exception of the poultry meat.

With the population growth rate of 2.57% per annum and an estimated population of around 400 million in 2050; the Nigerian government has a serious challenge in meeting the protein requirement of its citizen now and in the future. Cities are expanding, rural areas are turning into semi-urban areas, culminating in an unprecedented increase in overall demand for meat and milk products. The majority of the population is rapidly adopting the consumption model that has greatly enhanced diets rich in meat and milk additives. Following the reports of Popkin, [36] and de Halen *et al.*, [14], urbanization has induced a dietary shift towards more processed foods, partially in response to longer working hours. The increase consumers' preference for meat and milk based products have upshot demand and created short and long run incentives for livestock farmers to increase production. Hence, the livestock sub sector has potentials for job creation, reducing poverty, increase the socio-economic benefits of farmers, and guaranteed availability of affordable priced animal source foods now and in the future.

The recent statistics have shown that, Nigeria's per capita meat and milk consumption are approximately 9.0kg and 8 litres per person per year respectively [20, 22, 19]. This is far less than the continental averages that are 44 litres and 19kg respectively and World Health Organization (WHO) stipulated minimum standard of 0.83g/kg per day consumption of protein for an adult [22]. To address the issue of protein deficiency among Nigerians, the government has implemented several agricultural promotion policies and the national livestock transformation plan programs aimed at increasing output of animal based protein sources as well as guiding the anticipated transformation of the livestock sub sector till 2027. Looking at the retrospective performances of the cow milk, beef and chicken (meat) production with an annual growth rate of 2.11%, 1.18% and 3.42% respectively, there is an overwhelming need for a holistic policy intervention to upshot production. Figures 1 and 2 show the production trend in cow milk and beef in Nigeria. The production performances have been unpredictable and inconsistence across the various policy regimes in the country. Given the current level of poverty among resource poor and vulnerable groups in the country [10, 8, 13, 12], malnutrition could be aggravated if proactive actions are undertaken both in the short and long run periods to upsurge animal protein production.

Observing the trend and given the annual growth rate of individual commodity and the population growth rate of 2.57%, it is obvious that livestock farmers in the country, despite the huge market potentials have not been able to drive production of animal protein adequately. The untapped market opportunities have induced food imports amounted up to 3-5 billion USD per year, out of which milk accounts for 1.3 billion USD [32].

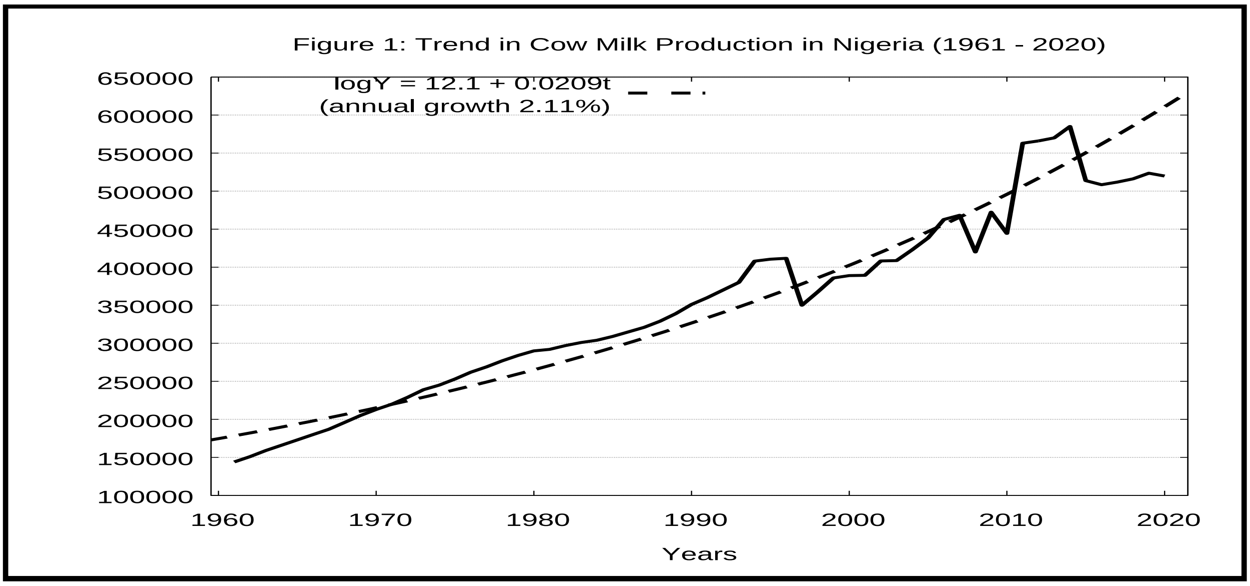

Fig. 1. Trend in Cow Milk Production in Nigeria (1961-2020)
Source: Plotted by authors using gretl, and time series data from the FAO.

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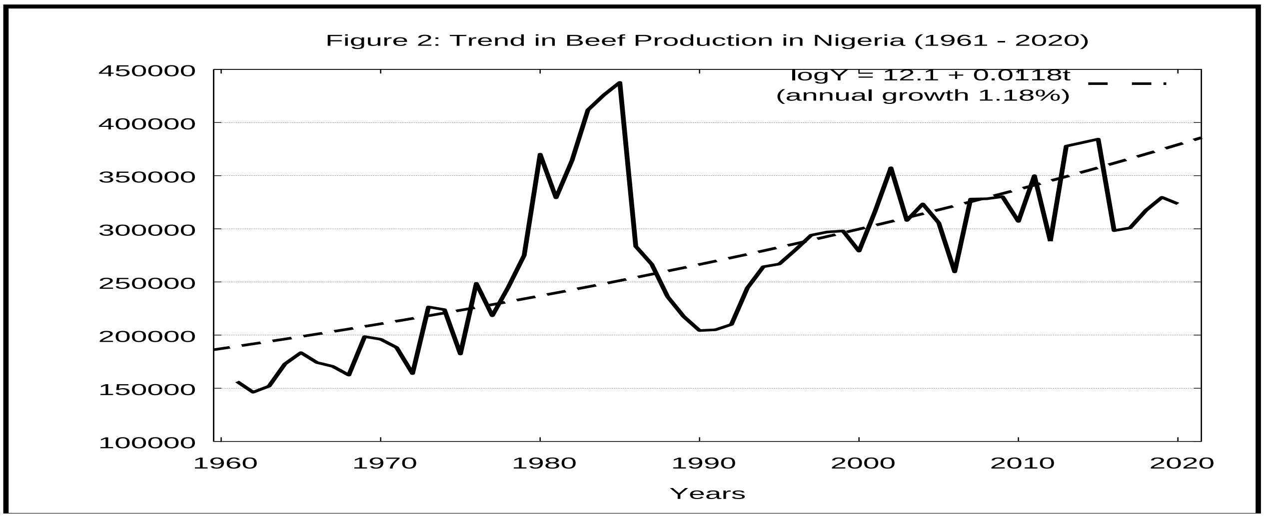

Fig. 2. Trend in Beef Production in Nigeria (1961-2020)
Source: Plotted by authors using gretl, and time series data from the FAO.

Hence, Nigeria is a net importer of dairy products and cereals: currently, the country imports about 60 percent of dairy products consumed to satisfy excessive demands of about 1.3 billion tonnes of milk annually [20, 22, 5]. However, the expected transformation of the agricultural sector especially the livestock sub-sector through the adequate supply of meat and milk and its by-products depends, among other things, on the efficiency of the macroeconomic environment [7, 4, 11, 40]. As noted by FAO, [22, 18, 23], the increase in the real per capita GDP is considered as a major driver of demand for meat and milk in Nigeria. Moreover, as observed by Akpan *et al.,* [3], the surge in inflation and persistent poverty among the majority of Nigerians are factors that hamper optimal protein consumption in the country. Likewise, Simo-Kengne *et al.,* [38] opined that price of meat, inflation, GDP, exports, import and urbanization are the major factors that influence meat consumption. Still on the related literature, Saleh *et al.,* [37] identified GDP, exchange rate and country's land area as the significant factors affecting the Chinese pork export flows. According to Akpan *et al.*, [11], the per capita real GDP, real total exports, external reserves, inflation rate and external debt influence agricultural production negatively in the short and long run periods; whereas industry's capacity utilization rate and nominal exchange rate relate positively in both long and short run periods. Also, Akpan *et al.,* [9] examined the relationship between the agricultural intensification and some macroeconomic variables in Nigeria. The findings identified the rate of inflation, external reserves, industrial production, per capita income and energy consumption as long-term negative factors in agricultural intensification. On the other hand, the crude oil prices, foreign capital in agriculture, lending rate of Bank and non-oil import were identified as the positive long run drivers. Also, the finding revealed that the inflation, external reserves and industrial output, reduce agricultural intensification in the short run period. Besides lending rate of commercial Banks and crude oil price were identified as stimulants of agricultural intensification in the short run. Also, Muftaudeen and Hussainatu [30], investigated the impact of macroeconomic policies on crop production in Nigeria. They found that in the long run, agricultural production reacted to changes in government spending, farm credit, inflation rate, interest rate and the exchange rate. Besides, Akpan and Patrick [6] modelled palm oil, palm kernel and rubber annual output equations from 1962 to 2013 in Nigeria. The results identified the per capita GDP, lending interest rate, industrial capacity utilization and kilowatts per capita of electricity consumed as significant factors that affect the outputs of palm oil, palm kernel and rubber; whereas, the per capita GDP was identified as significant variable in the short run period. As well, Adekunle and Ndukwe [1] using data set from 1981 to 2016 showed that, there was no significant long-run relationship between the real exchange rate and agricultural output in Nigeria. Their findings however, revealed significant drivers of agricultural output in Nigeria to include; industrial capacity utilization rate and government expenditure on agriculture. In a related research, Ewubare and Iyabode [17], established a positive relationship between agricultural output and agricultural credit as well as exchange rate in Nigeria. In Ghana, Enu & Attah-Obeng, [16] found real exchange rate, labour force and real GDP per capita as significant determinants of agricultural production. In Malaysia, Kadir and Tunggal [27] employed the Autoregressive-Distributed Lag (ARDL) approach to investigate the impact of macroeconomic variables on agricultural productivity from the period 1980 to 2014. The empirical findings revealed that, in the long run the nominal exchange rate had a significant negative relationship with agricultural productivity. In the short run, the country's net export and government expenditure showed negative correlations with agricultural productivity while interest rate responded positively. From the available literature, it is observed that none has focused specifically on meat and milk production despite the important roles the duo played in the daily dietary requirement of man. Hence, the meat and milk sub sectors need specific policy recommendations given the current consumption deficiency gap in the country. Also, for the last two decades a lot has happened in the Nigeria's macroeconomic environment, therefore there is need to update the available information on its impact on agricultural production.

The study therefore, sought to establish the empirical relationship between macroeconomic variables and meat gross production index as well as milk gross production index in Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted in Nigeria located in the sub-Saharan Africa. It lies between 4^0 and 14^0 north of the equator and between longitude 3^0 and 15^0 east of the Greenwich. Nigeria has a total land area of about 98.3 million hectares or 923,769km^2 with an extended 853km of coastline and an estimated population of 200 million [31]. The country is gifted with significant agricultural, mineral, marine and forest resources. Its multiple vegetation zones, plentiful rain, surface water and underground water resources and moderate climatic extremes, allow for production of diverse food, tree and cash crops. Recent records have provided evidence of over 60 per cent of the population actively engaged in agricultural activities [24].

Data source

Secondary data were used in the study. These data were sourced from the World Bank and Food and Agricultural Organization (FAO) as well as the Central Bank of Nigeria. Data covered the period from 1961 to 2020. The choice of the period was based on the availability of data.

Analytical Technique

The macroeconomic variables and land specific variable were factored as explanatory variables in the indigenous meat and milk gross production indexes equation in Nigeria. The explanatory variables were selected based on the related works in the literature and availability of trusted data sources. The indigenous meat gross production index equation adopted assumes the following implicit Cobb-Douglas form:

$$MET_t = f(PCI_t, EXC_t, EXP_t, CRE_t, LAS_t, CPI_t) \ldots\ldots (1)$$

where:

MET_t = Indigenous gross meat production index (%) 2014 – 2016 = 100

PCI_t = Gross domestic product per capita (Naira/person) to capture demand shock

EXC_t = Nominal exchange rate (%) to capture the effect of external World

EXP_t = Value of total export of goods and services as a % of GDP

CRE_t = Domestic credit to private sector (% of GDP) as a proxy of credit availability

LAS_t = Land density measures as size of arable land per rural dweller (ha/person)

CPI_t = Consumer price index (%) (2010 = 100) to capture effect of price variability.

Likewise, the milk gross production index equation was specified implicitly in the Cobb-Douglas form as thus:

$$QLSK_t = f(PCI_t, EXC_t, EXP_t, CRE_t, LAS_t, INF_t) \ldots (2)$$

where:

MIK_t = Milk gross production index (%) 2014 – 2016 = 100

INF_t = Inflation rate (%) proxy of input price changes

Testing for the short and long runs relationships among series in equation 1 and 2

The Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran and Shin [34] and Pesaran *et al.* [35] was used to investigate the long and the short run relationships among variables specified. The ARDL bound model has three advantages when compared with the Engle and Granger [15] two step method and Johansen and Juselius [26] cointegration method. The ARDL method is applied to deal with series having mixed stationary issues (i.e. mixture of 1(0) and 1(1)). Hence, it relaxes the assumption that all series must be integrated of the same order. The second merit associated with ARDL model is that of being relatively more efficient in the cases involving small and finite sample data sizes. The method produced unbiased estimates of the long-run model [25]. The ARDL model for equation (1) and 2 is expressed as follows:

$$\Delta MET_t = \beta_0 + \beta_1 \sum_{i=1}^{n_1} \Delta MET_{t-1} + \beta_2 \sum_{i=1}^{n_2} \Delta PCI_{t-i} + \beta_3 \sum_{i=1}^{n_3} \Delta EXC_{t-i} + \beta_4 \sum_{i=1}^{n_4} \Delta EXP_{t-i} + \beta_5 \sum_{i=1}^{n_5} \Delta CRE_{t-i} + \beta_6 \sum_{i=1}^{n_6} \Delta LAS_{t-i} + \beta_7 \sum_{i=1}^{n_7} \Delta CPI_{t-i} + \delta_1 MET_{t-i} + \delta_2 PCI_{t-i} + \delta_3 EXC_{t-i} + \delta_4 EXP_{t-i} + \delta_5 CRE_{t-i} + \delta_6 LAS_{t-i} + \delta_7 CPI_{t-i} + U_t \ldots\ldots\ldots\ldots..\ldots..(3)$$

For equation 2

$$\Delta MIK_t = \beta_0 + \beta_1 \sum_{i=1}^{n_1} \Delta MIK_{t-1} + \beta_2 \sum_{i=1}^{n_2} \Delta PCI_{t-i} + \beta_3 \sum_{i=1}^{n_3} \Delta EXC_{t-i} + \beta_4 \sum_{i=1}^{n_4} \Delta EXP_{t-i} + \beta_5 \sum_{i=1}^{n_5} \Delta CRE_{t-i} + \beta_6 \sum_{i=1}^{n_6} \Delta LAS_{t-i} + \beta_7 \sum_{i=1}^{n_7} \Delta INF_{t-i} + \delta_1 MIK_{t-i} + \delta_2 PCI_{t-i} + \delta_3 EXC_{t-i} + \delta_4 EXP_{t-i} + \delta_5 CRE_{t-i} + \delta_6 LAS_{t-i} + \delta_7 INF_{t-i} + U_t \ldots\ldots\ldots\ldots..\ldots..(4)$$

The specification of the ARDL model was also done for the rest of the variables in equation (1) and (2). The coefficients from β_1 to β_8 represent the short-run coefficients whereas the coefficients from δ_1 to δ_8 represent the long-run coefficients of the ARDL model. Also, β_0 is the drift component, "n" is the maximum lag length while U_t is the stochastic error term. The bounded F-statistic test was used to check the existence of a stable long-run relationship among the variables in the models. For instance, if the calculated F-statistic in equation (3) and (4) are greater than the upper bound critical values, the null hypotheses are rejected implying the existence of co-integration relationship. But if the value of the F-statistic is below the lower bound, the null cannot be rejected, indicating the absence of co-integration. Besides, if the F-statistic value lies within the lower and upper bounds, the results is considered inconclusive [35]. If the bound test shows evidence of co-integration among variables specified, the long and short run (an error correction model (ECM)) equations of the ARDL model are specified as follows;

The ARDL long run model for equation 3:

$$\mathrm{MET_t} = \delta_0 + +\delta_1\mathrm{MET_{t-i}} + \delta_2\mathrm{PCI_{t-i}} + \delta_3\mathrm{EXC_{t-i}} + \delta_4\mathrm{EXP_{t-i}} + \delta_5\mathrm{CRE_{t-i}} + \delta_6\mathrm{LAS_{t-i}} + \delta_7\mathrm{CPI_{t-i}} + \mathrm{U_t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Then the ARDL short run model (ECM model) for equation 3 is stated as thus:

$$\Delta MET_t = \beta_0 + \beta_1\sum_{i=1}^{n_1}\Delta MET_{t-1} + \beta_2\sum_{i=1}^{n_2}\Delta PCI_{t-i} + \beta_3\sum_{i=1}^{n_3}\Delta EXC_{t-i} + \beta_4\sum_{i=1}^{n_4}\Delta EXP_{t-i} + \beta_5\sum_{i=1}^{n_5}\Delta CRE_{t-i} + \beta_6\sum_{i=1}^{n_6}\Delta LAS_{t-i} + \beta_7\sum_{i=1}^{n_7}\Delta CPI_{t-i} + +\emptyset ECM_{t-1} + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where: Ø is the error correction term and its measures the speed of adjustment towards the long-run equilibrium, and the remaining coefficients provide the short-run dynamics. To access the performance of the estimated model, RESET test, Serial correlation and normality of the residuals tests were conducted, whereas the cumulative sum squared (CUSUM) test was conducted to verify the stability nature of the model.

RESULTS AND DISCUSSIONS

Descriptive Statistics

The summary of the descriptive statistics of the variables used in the study are presented in Table 1. The coefficient of variability and skewness in the indigenous meat gross production index and milk gross production index are 51% and 35% respectively. This means that, there was more fluctuations in annual meat production compared to annual milk production in the country. Both variables showed positive insignificant skewness and marginal exponential growth rates in the specified period.

The average land density per rural dweller stood at 0.46ha with a 26.00% coefficient of variability and exponential growth rate of 0.93% per annum. The finding revealed that agricultural land expansion grew at a rate below unity per annum. This means that the continuous increase of the rural population will restricts agricultural land expansion in the future. The descriptive statistics for the nominal exchange rate (EXC), per capita income (PCI) and consumer price index (CPI) showed explosive coefficients of variability and exponential growth rates respectively.

Table 1. Descriptive Statistics of Variables Used in the Estimated Models

Variables	Mean	Std. deviation	CV	Skewness	Exponential growth rate (%)
MET	58.34	29.72	0.51	0.079	0.11
MIK	65.18	22.72	0.35	0.152	0.06
PCI	1.3+05	2.1+05	1.63	1.554	18.46
EXC	66.54	92.21	1.39	1.316	13.51
EXP	17.60	7.85	0.45	0.246	1.25
CRE	8.53	3.26	0.38	1.353	1.35
LAS	0.46	0.12	0.26	0.944	0.93
CPI	44.22	70.93	1.60	1.779	16.67
INF	16.16	15.10	0.93	2.078	1.51

Source: Computed by authors, data from the FAO and World Bank, 2020.

This means that, these variables were so unstable during the period specified in the study. The inflation rate also showed a high degree of variability, but grew exponentially at the rate of 1.51% per annum. The value of export (EXP) skewed to the right hand side and has a variability rate of about 45% and the annual exponential growth rate of 1.25%.

Unit root test

The study employed ADF and ADF-GLS unit root tests to confirm the unit root of the specified variables. The results are presented in Table 2. The results revealed that, inflation rate (INF) and domestic credit (CRE) were stationary at levels; while the rest of the variables were stationary at the first difference. Since we have a mixture of variables that are 1(0) and 1(1), it implies that the ARDL model is most appropriate to test the co-integration in the specified models. Before estimating the ARDL model, the optimal lag lengths for the series were determined by using the Akaike Information Criterion (AIC), Schwarz and Bayesian Criterion (SBC). The F-statistics computed for the selected equations are presented at the upper portion of Table 3.

Table 2. ADF and ADF-GLS unit root tests on variables used in the specified equations

Variable	ADF (constant and trend)			ADF-GLS (constant and trend)		
	Level	**1st Diff.**	**Decision**	**Level**	**1st Diff.**	**Decision**
MET	-1.478	-9.524***	1(1)	-1.631	-9.524***	1(1)
MIK	-2.785	-9.924***	1(1)	-1.892	-9.027***	1(1)
PCI	-2.041	-6.271***	1(1)	-1.588	-6.299***	1(1)
EXC	-1.883	-5.950***	1(1)	-1.248	-6.039***	1(1)
EXP	-3.014	-9.269***	1(1)	-2.412	-9.099***	1(1)
CRE	-3.431*	-	1(0)	-1.432	-4.544***	1(1)
LAS	-1.636	-7.770***	1(1)	-1.653	-7.850***	1(1)
CPI	-1.976	-3.541**	1(1)	-1.084	-3.551**	1(1)
INF	-4.261***	-	1(0)	-4.333***	-	1(0)
	Critical values					
1%	-4.124	-4.127		-3.58	-3.739	
5%	-3.489	-3.490		-3.03	-3.164	
10%	-3.173	-3.174		-2.74	-2.866	

Source: computed by authors. Note: ***, ** and * indicate 1%, 5% and 1% significance levels respectively. Note, the variables are stated in natural logarithm form.

The Results of the F-statistics for equation 3 and 4 revealed that cointegration exist among the variables specified. The F-statistics calculated for these equations were greater than the tabulate upper bound critical value at 10% and 5% levels of significance. The findings imply that, the long run equilibrium equations exist for equations 3 and 4 and the short run models can be generated from these equations.

Table 3. ARDL Bound Test

Equations	F-Statistic		Decision
F_{MET}(MET │PCI, EXC, EXP, CRE, LAS, CPI)	9.4819		Co-integration
F_{MIK}(MIK │PCI, EXC, EXP, CRE, LAS, INF)	4.2457		Co-integration
Critical Values Bound (at K = 6 and n = 60)			
	Lower	Upper	
10%	2.114	3.153	
5%	2.456	3.598	
1%	3.293	4.615	

Source: computed by authors using Eviews 10 and data as described in equation 1 and 2. Critical values are derived from Narayan, (2005). Note, variables are stated in natural logarithm form.

Following the establishment of the co-integration for the specified equations, Table 4 presents the long run coefficients for the ARDL model for equation 3 (indigenous meat gross production Index equation).

The Long- run Coefficients of ARDL for Indigenous meat gross production Index equation

The results revealed that, the per capita income (PCI) has a positive and significant (at 1%) impact on the indigenous meat gross production index. This means that, one percent increase in the per capita income will lead to 0.236 percent increase in the indigenous meat gross production index. The result satisfies *a priori* expectation, because increase in the PCI increases the purchasing power of the citizen thereby stimulating aggregate demand. When demand increases, farmers would have incentives to produce more meat resulting in the increased in the total meat production. The result is similar to the reports submitted by Akpan *et al.,* [11], Enu & Attah-Obeng, [16], Akpan *et al.,* [9], Akpan and Patrick [6], and recently by FAO, [22, 18, 23].

The coefficient of land density is negative and has a significant (at 10%) effect on the indigenous meat gross production index in the country. A unit increase in the land density would lead to about 0.245 increase in the indigenous meat gross production index in the long run. The result may be partly due to the opportunity cost of land. Farmers may decide to go for alternative land use following the magnitude of returns from competing enterprises. Also, meat production requires special facilities and not really relied on large land size.

Table 4. The Long- run Coefficients for Indigenous meat gross production Index equation

Var.	Coeff.	Std. error	t-value	Prob.
Const.	1.797	0.539	3.33**	0.001
PCI	0.236	0.069	3.38***	0.001
EXC	−0.091	0.045	−2.01**	0.049
EXP	0.032	0.036	0.88	0.385
CRE	−0.042	0.059	−0.69	0.491
LAS	−0.245	0.141	−1.74*	0.087
CPI	0.003	0.086	0.04	0.971

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are specified in natural logarithm form.

The slope coefficient of the nominal exchange rate shows a significant negative effect (at the 5% level of significance) on the indigenous meat gross production index in the long run. This means that, an increase in the nominal exchange rate decreases the indigenous meat gross production index by 0.0907 units in the country. It is a fact that a good proportion of goats, sheep and cattle consumed in Nigeria are imported from the neighbouring countries of Niger, Sudan and Chad. Hence, the international trade on livestock depends on the strength of our local currency. It implies that, the stronger the international currency, the smaller the volume of trade across the boarder and this would have a negative impact on the overall meat production volume in the country. The finding corroborates Muftaudeen and Hussainatu [30] and Saleh *et al.,* [37], but is contrary to Ewubare and Iyabode [17].

The Error Correction Model of the ARDL for Indigenous meat gross production Index equation

The result in Table 5 contains the error correction representation of the ARDL model for equation 3. The coefficient of the error correction term is negative and statistically significant at 1% level, which implies the existence of a stable long run relationship among the variables included in the ARDL model for the indigenous meat gross production index. It indicates that about 20.37% of the short-run disequilibrium is adjusted towards its long-run equilibrium annually. The diagnostic test for the ECM model revealed R^2 value of 0.4913 which means that the specified explanatory time series explained about 49.13% of the adjusted total variations in the indigenous meat gross production index.

Table 5. The short - run coefficients for indigenous meat gross production Index equation

Variable	Coeff.	Std. error	t-value	Prob.
Const.	0.024	0.016	1.567	0.124
ΔMETt -1	−0.061	0.152	−0.401	0.691
ΔPCIt-1	0.174	0.052	3.33***	0.002
ΔEXCt	−0.034	0.035	−0.97	0.339
ΔEXPt-1	0.021	0.021	1.00	0.322
ΔCREt-1	0.169	0.051	3.33***	0.002
ΔCREt-2	0.056	0.029	1.86*	0.070
ΔLASt	0.489	0.130	3.76***	0.001
ΔLASt-2	−0.362	0.124	−2.92***	0.006
ΔCPIt-2	−0.094	0.073	−1.28	0.209
ECMt-1	−0.204	0.064	−3.18***	0.003
Diagnostic Test				
R-Squared	**0.49**	Durbin-Watson		**2.1546**
F(9, 46)	**9.22*** **	Normality of residual		**10.0*** **
RESET test	**3.73***	CUSUM test for parameter stability		**-10.5*** **
Breusch-Pagan test	**17. 8*** **	LM test for autocorrelation (1)		**0.93**

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are stated in natural logarithm form.

The F-statistic of 9.2156 is significant at 1% probability level, indicating that the R^2 is significant and this implies that the equation has goodness of fit. The Durbin-Watson value of 2.154 indicate a mild serial correlation. According to Laurenceson and Chai, [28], it is shown that the presence of autocorrelation does not negatively affected the ECM estimates. Therefore, the presence of autocorrelation does not affect the estimates. Also, the RESET test is significant which confirms the structural rigidity of the estimated model. The residual is normally distributed and this justified the used of OLS estimation method. The CUSUM test is significant, indicating that, the estimated model is stable. As shown in Figure 3, the CUSUM of recursive residuals remains within the 5 per cent critical bounds, which indicate that the model is stable. The Breusch-Pagan test shows no evidence of heteroscedasticity.

The empirical result revealed that, the current value of the per capita income has a significant positive relationship with the indigenous meat agricultural gross production index in the short run period. It means that, a unit increase in the PCI would lead to about 0.1738 units increase in the indigenous meat gross production index in the country. The finding suggests the importance of consumers' income in the aggregate volume of meat produce in the country. The result agrees with Akpan *et al.,* [11], Enu & Attah-Obeng, [16], Akpan *et al.*, [9], Akpan and Patrick [6], FAO, [22, 18, 23].

The short run coefficients of the current and the last two-year value of land density of farmers has a positive and negative significant effect on the indigenous meat gross production index at 1% level respectively. As previously noticed, the result could be linked to the opportunity cost of farmers' land in the short run.

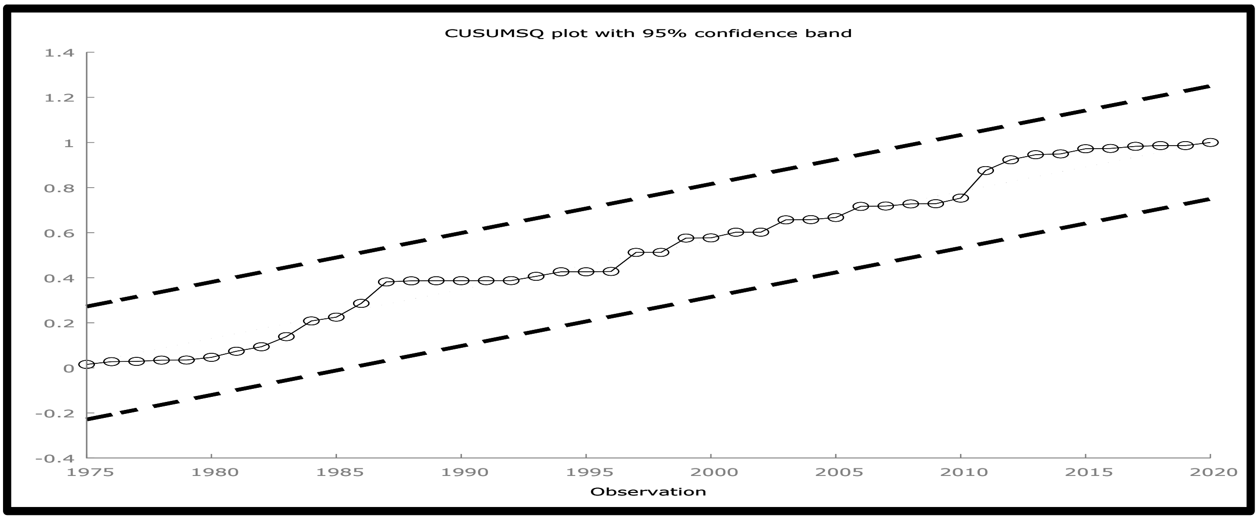

Fig. 3. The Cumulative sum of recursive residuals plot
Source: Plotted by authors using gretl, and data from the result of analysis.

The coefficients of the previous year's credit exhibited significant positive relationships with the indigenous meat gross production index in the country. For instance, about 0.1697 and 0.0555 units' increase would occur in the indigenous meat gross production index for a unit increase in the previous one year and two years' values of credit disbursed to the economy respectively. The finding indicates the importance of credit to the meat processing industry in Nigeria. Credit is always seen a stimulant to production by facilitating the acquisition of other factors of production. The finding upholds the reports of Ewubare and Iyabode [17].

The Long and short runs estimate of ARDL for milk gross production Index equation

The long run model for milk gross production index equation is presented in Table 6. The result revealed that the per capita income (PCI), the volume of exports (EXP) and inflation rate (INF) have positive and significant long run relationship with the milk gross production in the country. A unit increase in (PCI), (EXP) and (INF) would lead to 0.1593 units, 0.0523 units and 0.0294 units increase in the milk gross production index respectively.

The increase in the per capita income implies increase in the purchasing power per capita and the corresponding increase in the market demand of milk. The sustained increase in demand for milk would probably stimulate production, increase farm income and increase the overall well-being of the country's milk producers. The finding is in line with the report of Enu & Attah-Obeng, [17], FAO, [22, 18, 23].

Similarly, increase in export will create alternative opportunities for milk farmers to earn more revenue through stimulation of production. Farmers are rational and will therefore respond to alternative opportunities that yield higher income, such as export market by increasing production.

Table 6. The Long-run Coefficients for milk gross production index equation

Var.	Coeff.	Std. error	t-value	Prob.
Const.	2.602	0.133	19.61***	0.000
PCI	0.159	0.024	6.67***	0.000
EXC	−0.073	0.027	−2.71***	0.009
EXP	0.052	0.026	2.03**	0.047
CRE	0.009	0.043	0.23	0.819
LAS	−0.018	0.098	−0.19	0.853
INF	0.029	0.014	2.07**	0.043

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithm.

The result with respect to the inflation rate could be explained by the fact that, increase in inflation rate is always associated with the increase in prices of goods in the country. Premised on this fact, milk farmers will utilize the opportunity of any price increase to boost meat production in order to increase farm income. The finding verifies the submissions of Akpan *et al.*, [3] and Simo-Kengne *et al.*, [38].

On the other hand, a 10% increase in the nominal exchange rate would lead to 0.729 units decrease in the milk gross production index. The literature as previously stated has provided evidence that about 60% of the milk consumed in the country is imported. Hence the increase in the nominal exchange rate (devaluation of Naira) would constrain importation of dairy cows from the neighbouring countries thereby reducing aggregate milk production in the country. The finding is supported by the empirical results of Muftaudeen and Hussainatu [30], Kadir and Tunggal [27]) and Saleh *et al.*, [37].

The results of the ECM estimates for the milk gross production index are presented in Table 7. The diagnostic statistics revealed that the estimates were best, efficient and adequate. The F-test, Breusch-Pagan test, RESET test and normality test as well as CUSUM test showed that the ECM has goodness of fit, no heteroscedasticity, have structural rigidity, justified the used of the OLS estimation method and is stable within the time horizon of the data set. The coefficient of the error correction term is negative and statistically significant. It indicates that 23.86 per cent of the short-run disequilibrium is adjusted towards its long-run equilibrium annually.

The short run model revealed that the current value of PCI has a significant positive relationship with the milk gross production index in the country. That is, a unit increase in the PCI will result at 0.0381 units increase in the milk gross production index. The reasons are similar to that of the meat gross production index. Enu & Attah-Obeng, [16], FAO, [22, 18, 23], have reported similar result.

The slope coefficient of the exchange rate shows a significant positive effect (at the 10% level of significance) on the milk gross production index in the short run. The likely reason for the result could be that the increase in the nominal exchange rate (N/$) would constrain importation by depreciating the domestic currency (N) against appreciating US dollar. The reduced importation would likely decrease unhealthy competition in the domestic market and instead creates incentives for milk farmers to increase production. The result is supported by the finding of Enu & Attah-Obeng, [16], however it contradicts the report of Ewubare and Iyabode [17].

Credit to the economy has a negative impact on the growth of milk gross production at 10% level of significance in the short run. This means that, credit has not played a significant role in the development of the milk sub sector. The result seems reasonable because the bulk of the domestic milk production is carried out by the nomadic pastoralists who have little or no need for credit and produced mostly in subsistence level using traditional tools. Also, credit to the agricultural sector from the conventional banks has always been a serious issue due to risk inherent in the sector.

The last two-year coefficient of land intensity is negative and significant at 10% probability level. This implies that, as the milk farmers' land holding increase, less output of milk will be produced. We suggest the opportunity cost of land as the major factor inducing this relationship. With increase in land holding, milk farmers may diversify occupation to high yielding ventures.

Table 7. The Short-run Coefficients for milk gross production index equation

Variable	Coeff	Std. error	t-value	Prob.
Constant	0.015	0.011	1.416	0.164
ΔMIKt-1	−0.166	0.137	−1.217	0.229
ΔPCIt	0.038	0.018	2.165**	0.040
ΔEXCt	0.039	0.021	1.845*	0.071
ΔEXPt-1	0.033	0.017	2.022**	0.049
ΔCREt-1	−0.069	0.037	−1.895*	0.064
ΔLANt	0.071	0.049	1.424	0.161
ΔLANt-2	−0.187	0.099	−1.881*	0.066
ΔINFt	0.013	0.010	1.280	0.207
ΔINFt-2	0.011	0.005	1.963*	0.056
ECMt-1	−0.239	0.103	−2.328**	0.024
Diagnostic Test				
R-Squared	0.58	Durbin-Watson		1.86
F(9, 46)	6.02***	Normality of residual		11.19***
RESET test	5.56***	CUSUM test for parameter stability		-10.62***
Breusch-Pagan test	17.04***	LM test for autocorrelation (1)		1.06

Source: computed by authors. Note: ***, and ** indicate 1% and 5% significance level respectively. Note, variables are expressed in natural logarithm.

The short run coefficient of the previous export is positive and significant at 5% significance level. This implies that, as total value of export increases by a unit in a short run, the milk gross production index increases by 0.033 units.

The result satisfies *a priori* expectation, because increase in activities in the export market would induce domestic competition that will lead to increase in production. The finding corroborates Kadir and Tunggal [27] and Simo-Kengne *et al.*, [38].

The result also revealed that the inflation rate has a positive significant relationship with the milk gross production index. A unit increase in the INF would lead to a 0.0106 units increase in the milk gross production index. Akpan *et al.*, [3] and Simo-Kengne *et al.*, [38] have submitted similar results.

CONCLUSIONS

The study has established the relationship between some key macroeconomic variables and meat as well as the milk gross production indicators from the period 1961 to 2020 in Nigeria. The time series data properties were analysed using the Augmented Dickey-Fuller unit root test and improved ADF-GLS unit root test. The result indicated that the specified series have mixed stationarity issue (i.e. I (0) and 1(1)). Grounded on the behaviour of the series, the ARDL model was used to establish the cointegration among series. The existence of cointegrations among series was established and the long and short runs coefficients of the specified meat and milk production indicator equations were generated. The error terms from the short run models have appropriate signs and were statistically significant at the conventional probability levels. This entails that, some key macroeconomic fundamentals in Nigeria's economy interact in each period to re-establish the long-run equilibrium in meat and milk gross production indices equations following the short-run random disturbances.

The empirical findings revealed that real GDP per capita, nominal exchange rate and land density are significant determinants of the long-term gross meat production index. Besides, the per capita income, credit to the economy and land density were identified as the short run determinants of meat gross production index in the country. Also, the per capita income, nominal exchange rate, export and inflation rate influence the milk gross production index in the long run; whereas the per capita income, land density, credit to the economy, the value of export and nominal exchange rate had a short run impact.

The study established the fact that, variations in some key macroeconomic fundamentals transmit mixed effects to the meat and milk sub sector production indicators in the short and long run periods. It is also established that, the per capita income is the most important factor that influence the production of meat and milk in Nigeria. The findings further suggest that, the country needs specific policy intervention in order to help boost meat and milk production in the country. Such policy should target improvement of the per capita income of Nigerians, regulation of trade policy that will favour export driven market or reduction in the excessive importation of foods in order to protect domestic agro-enterprises. Appropriate measures to reduce or stabilize the rate of inflation in the country are inevitable and adequate credit to agriculture is strongly recommended.

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