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TRENDS IN MAJOR RUMINANT MEATS PRODUCTION AND THE ROLES OF THE MACROECONOMIC ENVIRONMENT IN NIGERIA

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Abstract

This study analyzed the trends in major ruminant meats (beef, chevon, mutton, and total ruminant meat) and provided empirical evidence on the relationship between ruminant meats production and key macroeconomics fundamentals in Nigeria. The study employed the time-series data that were sourced from the Food and Agricultural Organization (FAO), Central Bank of Nigeria,and the World Bank and ranging from 1961 to 2021. The descriptive analyses, trend equation, and multivariate autoregressive model were used to analyze the data. The result of the data analyses revealed an annual exponential growth rate of 1.156%, 6.694%, 6.032%, and 2.747% for beef, chevon, mutton, and total ruminant meat respectively. The empirical outcomes showed that the annual inflation rate has a significant negative inelastic association with the ruminant meats production in Nigeria; while the per capita income had a significant positive inelastic relationship. Moreover, the annual nominal exchange rate exhibited a mixed effect on ruminant meat production. To improve ruminant meat production in the country, it is strongly suggested that the inflation rate should be moderated and the country should develop sound and efficient policies to increase the per capita income.

Key words: *meat, ruminant, trend, macroeconomic, Nigeria*

INTRODUCTION

Ruminants are even-toed, hoofed, four-legged herbivorous animals that chew the cud and have complex stomach systems [22, 32]. Examples of widely domesticated and economic ruminants in Nigeria include cows, sheep, and goats. In Nigeria, apart from fish, ruminants are the major sources of animal protein available [35, 37, 2]. They are basically reared for meat, milk, and other by-products. They played intermediary and important functions in the food chain and sustainable agricultural system respectively [32]. They are the major constituent of the country's livestock. In 2020, there were about 83.7 million goats; 47.7 million sheep; and 20.7 million cattle heads in Nigeria [24]. Ruminant meats in 2020 make up 57.02% of the total meat produced in the country [24]. Excluding chicken meat, it constituted about 66.15% of the total meat produced in 2020. In 2020, the total meat produced in Nigeria was 1.72 million tonnes. Total production of meat in Nigeria declined from 1.75 million tonnes in 2018 to 1.74 in 2019 and 1.72 million tonnes in 2020 and deaccelerated at an average annual rate of 0.86% [24]. Nigeria's meat production is challenged by low-value addition attributed to poor processing infrastructures and an unregulated market system characterized by price volatility in the spatial markets [12].

Available records revealed that in the last three decades, the consumption of meats in Sub-Saharan Africa and Nigeria, in particular, has witnessed an upsurge [24].

The surge in consumption of meats emanated from several factors, such as increasing urbanization, youthful population, improved educational status, rising personal income, and socialization among others. Irrespective of the growing demand for meats in the country, its production is still majorly small scale and is characterized by declining annual output growth [24, 9] (Figure 1).

According to the report of FAO, [26] and FAO, [28], about 40 percent of households in Nigeria are responsible for producing the bulk of the meat consumed, with the exception of poultry meat.

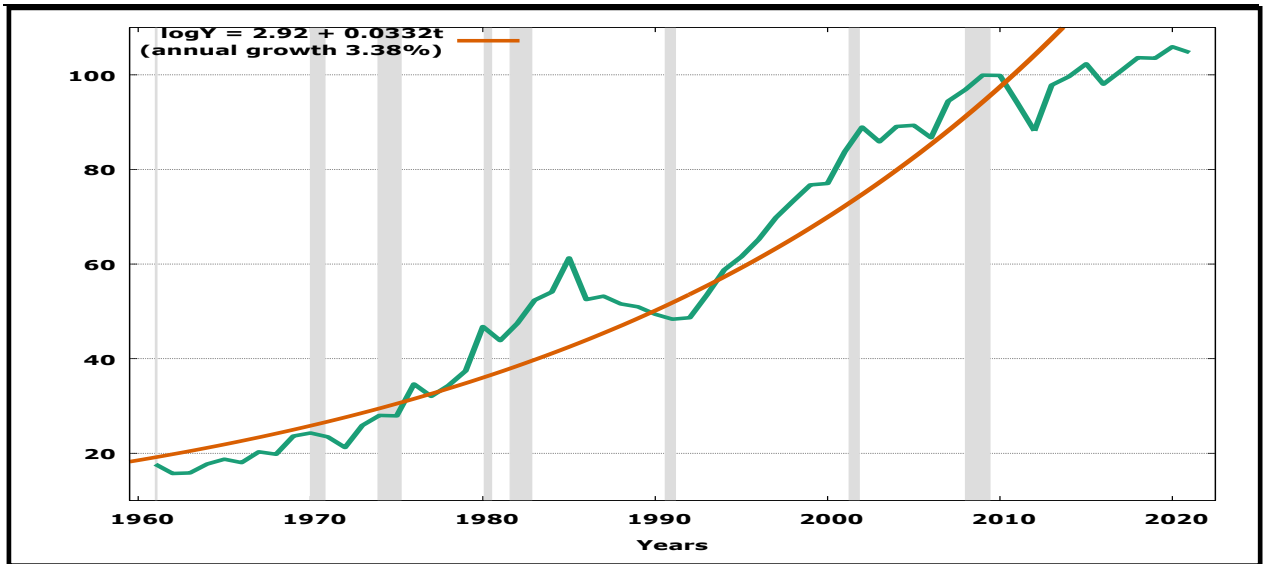

Fig.2. Trend in Total Meat Production Index in Nigeria (2001 - 2016) = 100.
Source: Data from FAO, 2022.

Following Agboola & Balcilar [1], Babatunde & Qaim [19], the country's livestock industry is small and slow-growing relative to the population relying on it for meat. As shown in Figure 1, the total meat production index assumed undulated growth rate from 1960 to 2021 with sharp depressions in 1991 and 2012.

Given the country's annual population growth rate of 2.57% and the current population of over 200 million [34, 10] in addition to the 3.38% annual growth rate (Figure 1) in total meat production, there are serious issues in meeting the protein demand of the majority of Nigerians now and in the future. The majority of the animal farmers in the country are resource-poor; lack adequate veterinary services and are affected by changing climatic and environmental conditions among others [6, 16]. In the country, both population and infrastructures are expanding, culminating in an unprecedented increase in overall demand capacity for protein sources especially meats, but without a corresponding increase in meat production [8]. The majority of the population (being youthful) is rapidly adopting the consumption pattern that is anchored on diets rich in meat and other animal derivatives [13, 18]. Following these occurrences, there is an unprecedented increase in the demand for meat and their derivatives with the urgent need to augment domestic production if the minimum protein requirement of Nigerians is prioritized. To bridge the shortfall in domestic production of meats in the country, issues related to poor infrastructures, farmers' poverty alleviation, improved breeding programs, and genetic engineering as well as ranch development among others are required [32, 5]. Since, the ruminants' production is done mostly by nomadic and semi-nomadic pastoralists, implementing sustainable policies is a serious challenge to Nigeria's government. Currently, there are several nomadic pastoralists – farmers' conflicts which many analysts believe is one of the major causes of the declining ruminant production trend in the country [22, 32].

Available statistics have shown that Nigeria's average per capita meat consumption is approximated at 9.0kg per person per year [25, 27, 24]. The index is less than the continental average of 19.0kg and the World Health Organization (WHO) minimum standard of protein consumption (0.83g/kg of body weight per day of protein) for an adult [27]. The federal government of Nigeria has enunciated several policies and programs to tackle the problems of protein deficiency among Nigerians. For instance, the national livestock transformation plan programs was set up with the aim to increase the output of animal-based protein sources and provide a roadmap through which a holistic transformation of the livestock sub-sector will be achieved till 2027 [39, 34, 15].

However, the anticipated transformation of the livestock sub-sector through the adequate supply of meats and generating effective demand depends, among other things, on previewing and understanding the trends in production as well as the efficient, and stable macroeconomic environment [14]. Hence, this calls for a concerted effort to relate the trends in meats production and the macroeconomic fundamentals that are critical in influencing activities in the real sector of the economy. For instance, improving per capita income is a prerequisite for driving effective demand for agricultural products including meats in developing countries [17, 4, 27, 23, 28]. Furthermore, as noted by Simo-Kengne*et al.*, [36], the price of meat, gross domestic product (GDP), inflation rate, exports, imports, and urbanization are the major variables that affect meat consumption. Besides, Akpan *et al.*, [14], opined that an increase in the per capita income, total exports, external reserves, inflation rate, and external debt influence agricultural production negatively in both short and long-run periods; whereas the industry's capacity utilization rate and nominal exchange rate relate positively in both long and short-run periods. Also, Akpan et al., [11] showed that the rate of inflation, external reserves, per capita income, industrial production, and energy consumption affect agricultural intensification adversely. The findings also noted that the annual inflation rate, industrial output, and external reserves reduce agricultural intensification in the short-run period. Additionally, Akpan and Umoren [9] established the empirical relationship between some key macroeconomic variables and meat as well as the milk gross production indices in Nigeria. The empirical results showed that the per capita income, nominal exchange rate, and land density were the determinants of meat gross production index in the long run, whereas, per capita income, credit to the economy, and land density were identified as the short-run determinants. Furthermore, Betru and Kawashima [21] submitted the determinants of meat consumption in Ethiopia. The result showed that urbanization and per capita income were positive and significant determinants of meat consumption in Ethiopia.

In addition, James et al., [31] analyzed beef demand drivers and enhancement opportunities in the United States of America. They found a positive significant relationship between U.S. consumer total expenditures and the quantity of beef demanded. The results further revealed that the consumer demand for beef was negative and inelastic with respect to changes in beef price. Also, Baskhron et al. [20] examined the trends in the production and consumption of red and white meats in Egypt. The findings revealed a 1.40% and 2.87% annual growth rate in meat production and consumption respectively.Another study by Fatimah *et al.*, [29] assessed the relationship between domestic consumption of red meat and its macroeconomics determinants in the Kingdom of Saudi Arabia. The results revealed a negative significant relationship between domestic consumption of red meat and meat price index; and a positive significant relationship with consumer price index in the long run. The results also portrayed a positive significant correlation between domestic consumption of red meat and GDP in the short run. In an attempt to understand the trend in meat production in Nigeria, Udom [38] analyzed trends for chicken meat, beef, goat meat (chevon), mutton and lamb, pig meat, and total meat from 1961 to 2004 period. With the exception of pig meat, annual growth rates derived from the exponential trend equations drastically declined from 4.50% during the 1961 – 1986 period to 2.26% during the 1986 – 2004 period. Also, Ojiako and Olayode [34] analyzed the livestock production trends from 1970 to 2005 in Nigeria. The results revealed an exponential growth rate of 4.83% per annum which assumes a significant acceleration in the long-run period.

As revealed from the reviewed literature, none of the research work has specifically focused on ruminant meat production despite the important role it plays in the dietary requirement of Nigerians. Therefore, the meat sub-sector needs specific policy recommendations to be able to tackle the current consumption deficiency gap in the

country. Also, for the last two decades, a lot has happened in Nigeria's macroeconomic environment including the recent COVID 19 pandemic. Hence, there is a need to update the available information on the major meat trends and their relationships with key macroeconomic variables in the country. In line with this assertion, the study sought to examine the trends in the major ruminant meats in the country and establish the empirical correlations between key macroeconomic variables and ruminant meats production in Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted in Nigeria. The country is situated on the Gulf of Guinea in 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 Greenwich. Nigeria's land area is about 923,769km^2 and 853 km of coastline with a population of overtwo hundred (200) million [33]. The country has enormous agricultural, mineral, marine, and forest resources. The multiple vegetation, plenteous rain, surface water resources, and moderate climatic extremes, allow for the production of diverse foods, trees, and cash crops. Over 60 percent of the population is involved in the production of food crops such as cassava, maize, rice, yams, various beans and legumes, sorghum, ginger, onions, tomatoes, melons, and vegetables. Also, fishery, aquaculture and livestock production such as poultry, goat, sheep, pigs, and cattle flourished very well in all regions of the country. The main cash crops are cocoa, cotton, groundnuts, palm oil, and rubber [30].

Data source

The study used secondary data sourced from the World Bank and Food and Agricultural Organization (FAO) as well as the Central Bank of Nigeria. Data used in the study covered the period from 1961 to 2021.

Model Specification

To examine the trend in ruminant meat production in Nigeria:

An exponential trend equation was specified as presented in equation 1.

$$log_e MET_t = \varphi_0 + \varphi_1 T + U_t \dots\dots\dots\dots (1)$$

where 'T' is the time period measured in years. The exponential or compound growth rate is expressed as in equation 2.

$$(r) = (e^{\varphi_1} - 1) * 100 \dots\dots\dots\dots\dots\dots (2)$$

To ascertain whether the growth in specific ruminant meat production assumes an accelerated or decelerated pattern during the period under consideration, a quadratic trend equation was specified as shown in equation 3:

$$log_e MET_t = \beta_o + \beta_1 T_1 + \beta_2 T_1^2 + u_t \dots\dots (3)$$

If the coefficient *β2* is positive and statistically significant at a conventional level, there is an annual acceleration in the growth of the ruminant meat; if the coefficient of *β2* is negative and statistically significant at the conventional level, there is a significant deceleration; however, if *β2* is not statistically significant it implies stagnation in the growth of ruminant meat production in the country [34, 7, 3].

The determinants of ruminant meat

The relationship between annual meat production and macroeconomics variables was explicitly captured in a Cobb-Douglas form and is expressed as:

$$\text{Meat}_t = f(\text{INF}_t, \text{PCI}_t, \text{EXC}_t, \text{CRE}_t) \dots\dots\dots (4)$$

where:

MET = Growth rate in total ruminant meat production (%) (either Beef, Mutton, Chevon, orcombined)

PCI_t = Growth rate in the per capita income as a proxy of demand capacity (i.e. per capita GDP) (%)

INF_t= Growth rate in the annual inflation rate as a proxy of meat price (%)

EXC_t= Growth rate in the annual exchange rate as a proxy of import effect (naira/dollar) (%)

CREt = Growth rate in annual domestic credit to agriculture/GDP as a proxy of infrastructuralavailability (%).

An implicit autoregressive version of equation 4 was specified and is expressed as shown:

$$MET_t = \beta_0 + +\delta_1 PCI_t + \delta_2 INF_t + \delta_3 EXC_t + \delta_4 CRE_t + \delta_5 MET_{t-1} + U_t \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Equation 5 was adopted in the study to solve the problem of autocorrelation that existed in equation 4. The variables were expressed in growth rates to ensure their stabilities at the level of the variables and reduce the tendency of producing a spurious regression.

RESULTS AND DISCUSSIONS

The results in Table 1 show the major descriptive statistics of the variables used in the study. The coefficients of variability in beef, chevon, and mutton were 27.14%, 73.22%, and 79.56% respectively. This implies that there was minimal variation in the annual tonnage of beef, while chevon and mutton production witnessed significant fluctuations in production over the specified period. The indices of skewness (being positive) revealed that the production of the individual ruminant meat in the country grew steadily as they concentrated more on the right-hand side of the normal distribution curve. However, the statistic for the combined meats (beef, mutton, and chevon) indicates an average coefficient of variability at 43.74% per annum and negative skewness. The result revealed that the combined ruminant meat production (or total ruminant meat) had moderate variability characterized by a marginal decline in annual production. The descriptive statistics of the macroeconomic variables showed explosive variabilities in per capita income (PCI) and exchange rate (EXC). This implies that these variables were so unstable during the period specified in the study.

Table 1. The Descriptive Tests of Variables Used in the Estimated Models

Variable	Mean	Minimum	Maximum	Std. dev.	CV	Skewness
Beef (tons)	2.7396e+005	1.4624e+005	4.3772e+005	74353.	0.2714	0.0964
Chevon (tons)	1.3779e+005	5715.0	2.8766e+005	1.009e+005	0.7322	0.0711
Mutton (tons)	72540.	6820.0	1.7160e+005	57711	0.7956	0.3453
INF	16.160	0.47606	72.836	14.975	0.9267	2.0959
PCI	1.4062e+005	69.272	7.4829e+005	2.262e+005	1.6085	1.5160
EXC	72.924	0.54678	403.58	103.33	1.4169	1.4855
CRE	8.5579	3.7043	19.626	3.2404	0.3787	1.3268
Total meat (tons)	4.8429e+005	1.5974e+005	7.7806e+005	2.119e+005	0.4374	-0.0810

Source: The tests are computed by the author's data from the FAO [23- 28] and World Bank, 2022 [40].

The inflation rate also showed a high degree of variability of about 92.67% per annum. The coefficient of variability was lowest in the amount of credit disbursed to the agricultural sector. This implies that the amount of credit allotted to the agricultural sector over the years skewed positively but did not change significantly. The skewness indices for the macroeconomic variables were positive and imply that their volatilities and annual production were progressive or continuous over the period considered.

The Trend in ruminant meats production in Nigeria

The estimates of the exponential and quadratic trend equations for beef and chevon production are presented in Table 2, while Table 3 contains estimates for the mutton and combined meat (beef, chevon, and mutton) production. The findings revealed that the beef and chevon production in Nigeria has apositive significant relationship with time. This implies that beef and chevon annual production increases on average over time within the period used in the study. An average positive exponential growth rate of about 1.16% and 6.69% per year were obtained in beef and chevon production from 1961 to 2021 respectively in Nigeria.

Table 2. The exponential and quadratic trend estimates of beef and chevon production in Nigeria

	Beef			**Chevon**		
Equation 1	**Exponential Trend Equation**					
Variable	Coefficient	Std. error	t-value	Coefficient	Std. error	t-value
Constant	12.1245	0.0812	149.4***	9.3218	0.2019	46.18***
Time	0.0115	0.0017	6.875***	0.0648	0.0059	10.96***
R-square	0.51			0.88		
F- cal. (1, 59)	47.26***			120.12***		
Exp. GR (%)	**1.156**			**6.694**		
Equation 3	**Quadratic trend Equation estimates**					
Variable	Coefficient	Std. error	t-value	Coefficient	Std. error	t-value
Constant	11.9322	0.0479	249.3***	8.3657	0.0452	185.0***
Time	0.0299	0.0070	4.261***	0.1559	0.0030	51.29***
Time Square	−0.0003	0.0001	−2.456**	−0.0015	4.798e-05	−30.61***
R-squared	0.60			0.69		
F- cal.(2, 58)	106.64***			29.12***		

Source: computed by the author.
Note: ***, ** and * indicate 1%, 5% and 1% significance levels respectively.

The quadratic trend estimates for beef and chevon revealed for each equation respectively, a time-squared coefficient that is negative and statistically significant at the conventional probability levels. This implies that theproduction of beef and chevon over an increased period of time experienced deteriorating growth rates in annual production in the country. The results indicated a significant deceleration in annual growth of outputs of beef and chevon over an increased period of time. Though the compound growth rates for beef and chevon revealed a positive annual growth rate, the estimates of the quadratic trend equation showed an unsustainable annual growth rate in production. Alternatively, the result of the quadratic trend equation revealed that the exponential or compound growth rate of beef and chevon grew positively at a decreasing rate in the long-run period. This implies that several policies and programs that were implemented by the various tiers of governments to boost beef and chevon production in the country yielded significant short-run positive impacts that seem to depreciate in the long run.

Similarly, the result for mutton and combined meat (beef, chevon, mutton) production revealed a positive significant relationship with the time coefficient. This implies that mutton and total ruminant meat annual production increase on average with time. Precisely, an average positive exponential growth rate of about 6.03% and 2.75% per annum were obtained in mutton and aggregate ruminant meat production from 1961 to 2021 respectively in Nigeria. Further investigation on the nature of the exponential growth in mutton and total meat revealed significant deceleration over an extended period of time. This implies that the exponential growth rate in mutton and combined ruminant meat production was increasing at a decreasing rate. Following the history of Nigeria's economy, many phenomena could likely help to explain the short and long period trends in major ruminant meats production in Nigeria. Similar studies have estimated a single-digit exponential growth rate for agricultural commodities. They include; Udom [39]; Ojiako and Olayode [34], andBaskhron et al. [20].

The pictorial representation of the estimated trend lines for beef, mutton, chevon, and combined ruminant meat annual production is shown in Figure 2. The trend in meat production assumed an upward progressive growth from 1961 to 1985. This period corresponds to the era of the pre-structural adjustment programme (SAP).

Table 3. The exponential and quadratic trend estimates of mutton and combined ruminant meat production in Nigeria

	Mutton			**Combined (beef, chevon and mutton)**		
Equation 1	**Exponential Trend Equation**					
Variable	Coefficient	Std. error	t-value	Coefficient	Std. error	t-value
Constant	8.9228	0.0809	110.2***	12.1332	0.0714	169.9***
Time	0.0586	0.0032	18.25***	0.0271	0.0019	14.28***
R-square	0.95			0.88		
F- cal. (1, 59)	33.00***			23.97***		
Exp. GR (%)	**6.032**			**2.747**		
Equation 3	**Quadratic trend Equation estimates**					
Variable	Coefficient	Std. error	t-value	Coefficient	Std. error	t-value
Constant	8.5074	0.0901	94.38***	11.8750	0.0456	260.7***
Time	0.0981	0.0073	13.41***	0.0517	0.0053	9.676***
Time Square	−0.0006	0.0001	−5.73***	−0.0004	8.847e-05	−4.482***
R-squared	0.68			0.63		
F- cal.(2, 58)	64.39***			60.57***		

Source: computed by the author.
Note: *** indicates 1% significance level.

The agricultural policies and programmes then were majorly targeted at the development of the agricultural sector at the regional levels. For instance, in1962 in northern Nigeria, there was a supplementary feed programme on cattle aimed at increasing the quality of beef produced [30].

In 1965, grazing reserves were introduced in the northern region to improve the quality of feeds and meat correspondingly. In 1979, a smallholder fattening scheme was initiated as a tool to increase ruminant farmers' income through an increase in quality meats [30].

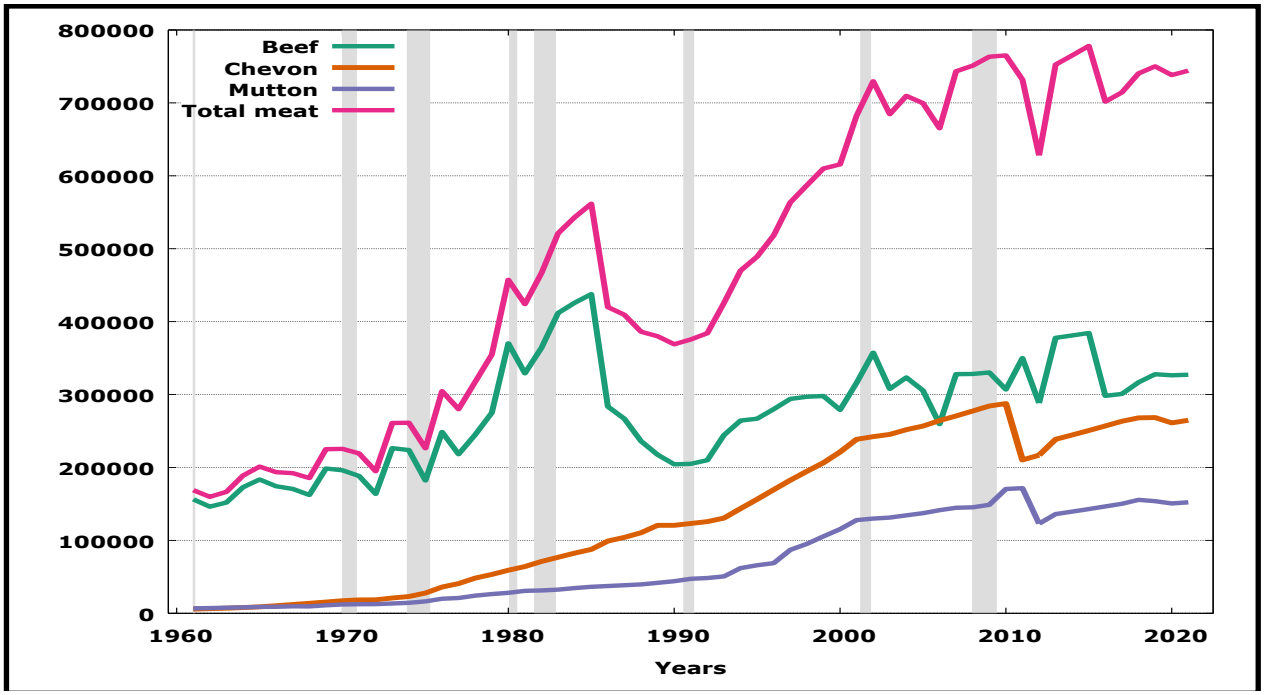

Fig. 3. Trends in Beef, Chevon, Mutton and Combined Meat (tons) in Nigeria.
Source: Plotted by authors and data from FAO [23-28].

Within this period, trade policies were instituted to protect domestic ruminant meat producers. From 1971 and 1973, the beef import was banned while supplementary feeding programmes for livestock which served as incentives continued from 1971 to 1974 in the country [39]. The Nigerian Livestock Production Company (NLPC) was

established in 1976 to provide credit and technical services to farmers. Ruminant meat producers within the period had several incentives to leverage, and these resulted in the corresponding increase in meat production in this era.

The trend in ruminant meat production witnessed a sharp depression from 1986 to 1993. The trend in beef, mutton and chevon production in this period was mainly dictated by the policies and programs of the structural adjustment program era.

The remarkable characteristic of this era was the privatization and commercialization of government-owned agro-enterprises. During this time, private investment in meat production witnessed a remarkable increase, but improvement in the sub-sector was hampered by increasing volatility in the macroeconomic fundamentals. In 1988, a ban on imports of fresh, chilled, or frozen meat was enforced to protect domestic producers, but the intention was defeated due to an unfavourable macroeconomic environment.

The post-SAP era which spanned from 1993 to 2021 saw the introduction of new agricultural policies including a ban on the importation of frozen poultry meat, the national currency was devaluated and private roles in meat production, processing and marketing increased tremendously. These and several incentives upsurge meat production although in undulating pattern until 2020 when COVID-19 pandemic and persistent increase in feed prices stalled the production capacity of meat producers and resulted in a reduction in annual output.

Unit root test

To test the stability of the variables used in the study, the ADF-GLS test was used to confirm the unit root of the specified variables. The results are presented in Table 4. The findings revealed that all the specified variables were stationary at their levels. This denotes that the specified regression model can be estimated at the level of these variables with little or no risk of obtaining spurious estimates.

Table 4. ADF-GLS unit root tests

Variables	ADF-GLS (constant and trend)		
	Level	**1st Diff.**	**Decision**
Total meat (tons)	-9.3369***	–	1(0)
INF	-7.6647***	–	1(0)
PCI	-6.5589***	–	1(0)
EXC	-8.5682***	–	1(0)
CRE	-8.3414***	–	1(0)

Source: computed by the author.

Note: ***, ** and * indicate 1%, 5% and 1% significance levels respectively. Note that, variables were expressed as natural logarithm growth rate.

Determinants of ruminant meats production in Nigeria

The result in Table 5 presents the estimates of the autoregressive models for the beef equation while Table 7 contains the estimates for chevon and total ruminant equations. The R-squared is estimated at 0.19 and 0.39 for beef and chevon respectively. The F- statistics of 9.01 and 22.47 are significant at the conventional probability levels for the beef and chevon equation respectively. This means that the estimated R-squared for both equations are significant and thus indicate that both equations have goodness of fits. The estimated value of Durbin-Watson which is 2.19 for the beef equation and 2.33 for chevon were not statistically significant, implying that there is an absence of serious autocorrelation in the estimated equations. Also, the null hypotheses were not rejected for the RESET test, Breusch-Pagan test, normality test, and CUSUM test for both equations. This means that the estimated autoregressive models have structural rigidity, absent of heteroscedasticity, normally distributed error terms and is stable within the time frame specified.

Table 5. Determinants of Beef and Chevon production in Nigeria

Variables	Beef estimates				Variables	Chevon estimates			
	Coeff.	Std. error	t-value	VIF		Coeff.	Std. error	t-value	
Constant	0.079	0.1564	0.509	-	Constant	0.171	0.1096	1.564	-
Inflation	−0.001	0.0005	−2.065**	1.017	Inflation	−0.0004	0.0002	−2.000**	1.078
Per capita income	0.028	0.0122	2.295**	1.544	Per capita income	0.035	0.0194	1.804*	1.431
Exchange rate	0.005	0.0009	5.019***	1.052	Exchange rate	−0.0008	0.0002	−3.468***	1.026
Credit to Agric.	0.008	0.0179	0.421	1.386	Credit to Agric.	0.016	0.0116	1.410	1.408
Beef lag 1	−0.198	0.1777	−1.116	1.192	Chevon lag 1	0.534	0.1731	3.086***	1.108
R-squared	0.1917				R-squared	0.3884			
F- cal. (5,53)	9.0122 (0.0011)				F- cal. (5,53)	22.4663 (0.0000)			
Normality test	0.8039 (0.6690)				Normality test	2.1283 (0.3132)			
RESET test	1.3333 (0.1436)				RESET test	1.5450 (0.1064)			
Breush-Pagan	8.3285 (0.1967)				Breush-Pagan	4.3444 (0.3014)			
CUSUM test	0.2527(0.8015)				CUSUM test	2.1254 (0.3833)			
Durbin Watson	2.1855 (0.7608)				Durbin Watson	2.3329 (0.8842)			

Source: computed by the author.

Note: ***, ** and * indicate 1%, 5% and 1% significance levels respectively. Note that, variables are expressed in a natural logarithm.

The diagnostic statistics for the mutton and combined ruminant meat equations are presented in Table 6. The R-squared are 0.11 and 0.18 for mutton and combined meat equation respectively. The F- statistics for both equations are significant at the conventional probability levels and thus indicate the goodness of fit. The Durbin-Watson values of 2.06 for the mutton equation and 2.18 for combined meat were statistically insignificant, implying no serious autocorrelation in the estimated equations. Similarly, the null hypotheses were not rejected for the RESET test, Breusch-Pagan test, normality test, and CUSUM test for both equations.

Determinants of Beef production in Nigeria

The empirical result revealed that the price of beef (proxy by inflation growth rate) has a significant negative inelastic relationship with beef production in Nigeria. A one percent increase in inflation growth rate will cause about a 0.001% decrease in the growth rate of beef production in Nigeria. This means that as the inflation rate upsurge, the quantity of beef produced in the country declines. The result satisfies a priori expectation as the soaring inflation rate has a negative multiplier effect on all sectors of the economy such as transportation, cost of raw materials, and marketing cost among others, resulting in an increase in production cost. An increase in production cost reduces the producer's profit through a reduction in the quantity of goods produced. The result corroborates Simo-Kengne*et al.,* [36], Akpan *et al.,* [14], Akpan et al., [11], James et al., [31], and Fatimah et al., [29].

The result also shows a positive relationship between the per capita income and the quantity of beef produced in the country. For instance, a unit increase in the per capita income would likely result in about a 0.028 unit increase in beef production in the country. An increase in per capita income suggests an increase in the consumers' income (on the assumption that the per capita income is not significantly skewed). This means that as the per capita income increases, both the nominal and the real income of an average consumer will increase thus enhancing the consumer's purchasing power. The finding agrees with the reports of Akpan et al., [17]; Akpan and Patrick [4], FAO, [27], FAO, [23], and FAO, [28], Akpan *et al.,* [14], Akpan et al., [11], Akpan and Umoren [9] and Betru and Kawashima [21].

Similarly, the result revealed a positive inelastic correlation between the nominal exchange rate (i.e. naira/dollar) and beef production capacity in Nigeria. By implication, a unit increase in the annual nominal exchange rate would lead to a 0.005 unit increase in beef production in Nigeria.

Table 6. Determinants of mutton and combined meat production in Nigeria

Variables	Mutton				Variables	Combined meat			
	Coeff.	Std. error	t-value	VIF		Coeff.	Std. error	t-value	
Constant	0.303	0.1024	2.957***	-	Constant	0.183	0.1204	1.517	-
Inflation	−0.0008	0.0004	−2.124**	1.009	Inflation	−0.0009	0.0004	−2.104**	1.023
Per capita income	0.072	0.0273	2.632**	1.493	Per capita income	0.028	0.0144	1.944*	1.645
Exchange rate	0.0004	0.0002	1.510	1.025	Exchange rate	0.003	0.0007	4.834***	1.053
Credit to Agric.	0.015	0.0109	1.335	1.414	Credit to Agric.	0.005	0.0119	0.419	1.387
Mutton lag 1	0.053	0.0893	0.5915	1.093	Total meat lag 1	−0.192	0.1941	−0.991	1.289
R-squared	0.1069				R-squared	0.1813			
F- cal. (5,53)	5.3690				F- cal. (5,53)	9.5682			
Normality test	1.3723 (0.4045)				Normality test	2.7799 (0.1916)			
RESET test	1.0232 (0.5744)				RESET test	1.4965 (0.1924)			
Breush-Pagan	4.7755 (0.3194)				Breush-Pagan	4.7636 (0.3155)			
CUSUM test	-1.2642 (0.2118)				CUSUM test	0.1129 (0.9106)			
Durbin Watson	2.0568 (0.5704)				Durbin Watson	2.1807(0.7529)			

Source: computed by the author.
Note: ***, ** and * indicate 1%, 5% and 1% significance levels respectively. Note that, variables are expressed in a natural logarithm.

An increase in the nominal exchange rate (naira against the dollar) will likely constrict the importation of meat-related products thereby promoting the domestic production of meats. Akpan *et al.,* [14], and Akpan and Umoren [9] have reported similar results.

Determinants of chevon production in Nigeria

The determinants of chevon production are similar to beef production. The empirical results revealed that an increase in the annual inflation rate has a significant adverse inelastic relationship with chevon production. The finding connotes that a unit increase in the annual inflation rate will trigger a 0.0004 unit decrease in the annual chevon production. The result is buttressed by the submissions of Simo-Kengne*et al.,* [36], Akpan *et al.,* [14], Akpan et al., [11], James et al., [31], and Fatimah et al., [29].

Correspondingly, the annual nominal exchange rate correlates negatively to chevon production in Nigeria. Precisely, a unit increase in the nominal exchange rate (naira against the dollar) would likely reduce chevon production by 0.0008 units. The occurrence of this relationship could be linked to the fact that a good proportion of goats slaughtered in Nigeria are imported from neighbouring countries like; Niger, Cameroun, Chad, and Sudan. The country depends heavily on imported goats for the domestic chevon market. Therefore, an increase in the nominal exchange rate (i.e. naira /dollar) would likely increase the cost of importation in the local currency thus resulting in a reduction in the number of goats imported. The reduction in the number of goats imported would likely have a diminishing impact on the quantity of chevon or goat meat supply in the domestic market. Similar reports are presented by Akpan *et al.,* [14], and Akpan and Umoren [9].

Contrary, the coefficient of the per capita income has a significant positive inelastic association with the chevon production in Nigeria. For instance, a 10.0% increase in the per capita income would lead to a 0.35% increase in chevon production. The plausible reasons for the results obtained for beef production are also applied for chevon production. Akpan et al., [17]; Akpan and Patrick [4], FAO, [27], FAO, [23], FAO, [28], and Betru and Kawashima [21] agree with the finding.

Determinants of mutton production in Nigeria

The result indicates that the inflation rate (or the market price) has a significant inelastic negative correlation with the annual production of mutton in Nigeria. Following the law of demand, an increase in the price of a normal commodity has a negative impact on demand. The result showed that a 10.0% increase in the inflation rate will induce about a 0.008% reduction in the production of mutton. The finding is substantiated by Simo-Kengne *et al.,* [36], Akpan *et al.,* [14], Akpan

et al., [11], James et al., [31], and Fatimah et al., [29].

On the opposing side, the slope coefficient of per capita income is positive at a 5.0% probability level indicating a significant positive relationship with mutton production in Nigeria. For instance, a unit increase in the per capita income will cause about a 0.072 unit increase in mutton production. The finding agrees with the reports of Akpan et al., [17]; Akpan and Patrick [4], FAO, [27], FAO, [23], and FAO, [28], Akpan *et al.,* [14], Akpan et al., [11], Akpan and Umoren [9] and Betru and Kawashima [21].

Determinants of total ruminant meat production in Nigeria

The empirical results indicate that the combined ruminant meat (that is, consisting of beef, chevon, and mutton) has a significant negative inelastic relationship with the annual inflation rate and a significant positive inelastic correlation with the per capita income and nominal exchange rate. The following empirical researches support the finding: Simo-Kengne *et al.,* [36], Akpan *et al.,* [14], Akpan et al., [11], James et al., [31],and Fatimah et al., [29], FAO, [27], FAO, [23], and FAO, [28], Akpan and Umoren [9], and Betru and Kawashima [21].

CONCLUSIONS

Ruminant meats constitute more than 50% of the total meat consumption in the country and it is a key component of the livestock system. From the available data, Nigeria is not self-sufficient in animal protein production and consumption. It is obvious that the rate of annual growth in ruminant meat production is insufficient to meet the minimum World Health Organization animal protein requirement in the country. To upsurge animal protein production and consumption in the country, key macroeconomic variables have to be stabilized in addition to other prerequisites.

The study estimated 1.156%, 6.694%, 6.032%, and 2.747% annual exponential or compound growth rates in beef, chevon, mutton, and combined ruminant meats production respectively in Nigeria. In addition, the study establish that changes in the annual inflation rate, per capita income (GDP), and nominal exchange rate were statistically significant in influencing ruminant meats production in the country.

Based on these findings, it is recommended that the country should moderate the rate of annual inflation, improve the per capita income and ensure a favourable exchange rate.

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