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CO-INTEGRATION AND ERROR-CORRECTION MODELLING (ECM) OF LIVESTOCK POPULATION IN NIGERIA

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Target audience: Livestock economists and policy makers

ABSTRACT

Time series of data on livestock population that span two decades were used to study the performance of Nigerian ruminant livestock. Co-integration and error correction modeling (EMC) was employed to establish a long-run relationship between livestock population (cattle, sheep and goat) and factors affecting their livestock population. Analysis reveals that all the dependent variables –cattle, sheep and goat population and the independent variables – government expenditure, wage rate, rainfall (proxy for vegetation availability) and prices of livestock were non –stationary but become stationary after first differencing and are co-integrated. ECM results further reveal that all independent variables complied with the apriori expectation for cattle and sheep and are all statistically significant for goat. Results show that all the considered independent variables are major determinants of Nigeria livestock population. Therefore, it is recommended that appropriate policy packages that will ensure sustainable availability of pastures and forages through the establishment of grazing reserves, disease control campaigns, improved breeding stock and provision of infrastructural facilities and credits to the producers be embarked upon.

DESCRIPTION OF PROBLEM

In spite of the pre-eminent position of the petroleum sub-sector, especially in the areas of income generation, the agricultural sector still plays a major and significant role in the over all economic growth and development of Nigeria. This important role is clearly observable in the areas of employment generation, provision of food and fibre for the generality of the people and agro-allied industries as well as contribution to the gross domestic products among others. The livestock sub-sector, covering all domesticated and edible livestock in any predominantly agricultural economy like Nigeria is very important. In Nigeria, just as it is all over the world, livestock production is an integral part of the farming systems. Stock raising have been described to offer greater economic stability wherever variable annual rainfall reduces income security from cropping; In favourable locations it is a "saving's bank" and a security for the household. Despite high losses and low rearing efficiency, sheep farmers in West Africa, for example, can achieve returns in livestock of between 28% and 40%. A better capital investment that would be hard to find.

However studies in Nigeria have shown that the growth rate in livestock production has considerably decreased when compared with the population growth. (Bincan, J.N. (1990)) consequently, there is a disturbing and noticeable shortage of animal protein in the diet of the average Nigerian. This arises from the short fall in the supply of meat in the country to meet the demand of the ever-increasing population.

Nigerian livestock sub-sector has not fully realised its potentials. The contributory factors include: lack of credit, and low productivity of local herd, low investment and problem of disease infestations. The past and present scenario of the disturbing performance of the livestock sub-sector despite its potentials is brought under focus in this paper by employing recent analytical technique: co-integration analysis.

Co-integration theory (Felix R.A. and Welch J.H. (1998); Godwin, B.K. and Schroeder, T.C. (1991)) examines the time series characteristics of data with a view to overcome the problems of spurious correlation often associated with non-stationary time series data and simultaneously generate long-run equilibrium relationships (Hendry 1986: Engle and Granger (1987).

According to Coe and Mogladar (1993), co-integration means that time series variables (one, two or more) may be regarded as defining a long-run equilibrium relationship if they move closely together in the long-run, even though they may drift apart in the short-run. This long-run relationship is referred to as a co-integrating vector. Because there is a long-run relationship between the variables, regression containing all the variables of a co-integrating vector will have a stationary error term, even if none of the variables, taken alone, is stationary. (Campell, J.Y. and Shiller, R.F. (1988).

Theoretical /Conceptual Frame Work: Co-Integration and Error Correction Modelling

A prerequisite of the ECM estimation is the determination of the characteristics of the time series variable in the model as to whether they are stationary or non-stationary. The use of the ECM is facilitated when variables are first –differenced stationary and co -integrated.

Test For Unit Root

A variable is said to be integrated of order d, written I(d), if it must be differenced d times to be made stationary. Thus, a stationary variable is integrated of order zero, written I(0), a variable which must be differenced once to become stationary is said to be I(1), integrated of order 1 e.t.c . Economic variables are seldom integrated of order greater than two, and if non-stationary are usually I(1)

The statistical tests to determine whether each of the economic variables is I(0) or I(1) are:

1. The Dickey-Fuller (DF)
2. The Argumented Dickey-Fuller (ADF). The DF test (Fuller, 1976, Dickey and Fuller (1979) is carried out by applying a regression such as:

$$X_t = C_t + \square X_{t-1} + e_t \qquad \text{.......(1)}$$

The t- value is then compared with Fuller (1976) distribution table.

In the ADF test, a regression such as:

$$\Delta X_t = C_t + \square X_{t-1} + \sum_{i=1} b_i \Delta X_{t-1} + e_t \qquad \text{.......... (2)}$$

Is run and the t-test is carried out

Test For Co-Integration – Johansen's Approach

Johansen (1998) and Johansen and Juselius (1990) presented a co-integration estimation methodology that overcomes most of the problems of the two-step approach. This is based on maximum likelihood estimates of all the co-integrating vectors in a given set of variables and provides two likelihood ratio tests for the number of co-integrating vectors.

The general model is given as:

$$X_t = C_t + \square_1 X_{t-1} + \dots + \square_k X_{t-k} + e_t \qquad \text{..........(3)}$$

For t=1,..................T

and the first-difference form is given by:

$$\Delta X_t = C_t + \square_{k-1} X_{t-k-1} + \square_1 X_{t-k} + e_t \qquad \text{..........(4)}$$

Where:

X_t is vector of n variables

e_t is the error term.

It therefore follows that the only level term in equation (4) is $\square\, x_{t-1}$. Thus, only the matrix of $\square$ contains information about the long-run relationships between the variables in the data. There are three cases that are considered:

(1) Matrix of $\square$ has rank zero, then all variables in X_t are integrated of order 1 or higher and the vector autoregression has no long-run properties.

(2) If $\square$ has a rank n (it is of full rank) the variables in X_t are stationary.

(3) If $\square$ has a rank m where m lies between O and n (0< m< n). $\square$ can be decomposed into two distinct (m x n) matrices α and β^1 such

That $= \alpha\beta^1$. This implies that there are m co-integrating variables.

To determine the number of co-integrating vectors, m, Johansen and Juselius describe two likelihood ratio tests by setting hypothesis thus:

(1) Based on the maximal Eigen value;

H_0: there are at most m co-integrating vectors

H_1: there are m +1 co-integrating vectors

(2) Based on the trace of the stochastic matrix

H_a: there are at most m co-integrating vectors

H_1: there are m or more co-integrating vectors

The first test is generally considered to be more powerful because the alternative hypothesis is equality.

MATERIALS AND METHODS

Sources Of Data

The data for the study came from secondary sources. Major sources were the two main data compiling agencies in the country: namely: the Federal Office of Statistics (FOS) and the Central Bank of Nigeria (CBN). Supplementary information were also obtained from FAO various National Livestock Production Division of the Federal Ministry of Agriculture and the International Livestock Research Institute (ILRI) publications.

Estimation Procedure

The relationship investigated in the study using ECM is implicitly expressed as follows:

Y_t = f (P_{t-1}. $GEXP_{t-j}$. $WAGER_{t-k}$. R_{t-1})

Where:

Y_t = Livestock population

P_{t-1} = Average unit price of livestock concerned

$GEXP_{t-j}$ = Government expenditure

$WAGER_{t-k}$ = Real farm wage rate in livestock producing areas of the country

R_{t-1} = Weather variable, using rainfall as proxy for feed availability in extensive production system for ruminant livestock concerned.

i. j. k. and l are number of periods to which each variable is lagged and can be a maximum of four. Ordinary Least Square regression technique was then used for the estimation of the relationship.

Apriori Expectation

All the variables except the real farm wage rate are expected to carry positive signs. meaning that an increase in any of the variables with positive signs would lead to an increase in livestock population. The farm wage rate is expected to have negative sign. meaning that its decrease would favour an increase in production of livestock.

RESULTS AND DISCUSSION

Results in Table 1 show the unit root test and that after first differencing: three variables each became stationary at 1%. 5% and 10% levels of significance. Output (population) of cattle (CATO). sheep (SHEO) and goat (GOAO). were significant at 10%; cattle price (CATP). government expenditure (GEXP) and wage rate (WAGER) significant were at 5%; while sheep price (SHEP). goat price (GOAP) and rainfall (RAINF) were each significant at 1% level. All variables were non- stationary [(1)] at their levels but attained stationarity at their first level of difference.

Since all the variables in their levels are non-stationary. the variables can then be determined directly as to whether or not they are co-integrated. The results using Johansen test are presented for the three dependent variables (cattle. sheep and goat) in Tables 2.3. and 4 respectively.

The co-integration tests reveal that there is a long-run relationship between the dependent variables and their determinants. To this effect the null hypothesis of no co-integration was rejected for all the dependent variables. For cattle (Table 2), the null hypothesis was rejected at 1% level of significance and the likelihood ratio test indicates two co-integrating equations at 5% level. In Table 3 the null hypothesis was rejected at 5% level for sheep and the likelihood ratio test also indicates 2 co-integrating equations at 5% level. In the case of goat.

Table 1: Result Of The Unit Root Test

VARIABLES	ADF t-STATISTICS	CRITICAL VALUE*	SIGNIFICANCE LEVEL	NO OF LAGS
(LCATO)	-2.696	-2.642	10%	1
(LSHEO)	-2.808	-2.642	10%	1
((LSHEO)	-2.847	-2.624	10%	1
(LCATP)	-3.575	-3.004	5%	1
(LSHEP)	-5.364	-3.767	1%	1
(LGOAP)	-4.407	-3.767	1%	1
(LGEXP)	-3.533	-3.004	5%	1
(LRAINF)	-4.060	-3.767	1%	1
(LWAGER)	-3.398	-3.004	5%	1

**Mackinnon critical values for rejection of hypothesis of unit root.*

Table 4 shows the rejection of the null hypothesis at 5% level but the likelihood ratio test indicates 1 co-integrating equation at 5% level..

The existence of co-integration led to the use of parsimonious error correction model (ECM) to estimate for each of the dependent variables a long-run solution of the dynamic auto-regressive distributed lag- model.

Table 2: Result Of Johansen Co-integration Test For Cattle

LIKELI-HOOD RATIO	EIGEN VALUE	CRITI-CAL VALUE AT 5%	CRITICAL VALUE AT 1%	HYPOTHES-ISED NO OF CE	VARIABLES
107.835	0.8865	68.52	76.07	None**	LCATO LCATP
57.779	0.7762	47.21	54.46	At most 1**	LGEXP
23.344	0.4321	29.68	35.65	At most 2	LRAINF LWAGER
10.332	0.2641	15.41	20.04	At most 3	
3.278	0.1328	3.76	6.65	At most 4	

**(**) denotes rejection of hypothesis at 5% (1%) significant level*

L.R test indicates 2 co-integrating equations at 5% significant level.

Table 3: Result Of Johansen Co-Integration Test For Sheep

EIGEN VALUE	LIKELIHOOD RATIO	CRITICAL VALUE AT 5%	CRITICAL VALUE AT 1%	HYPOTHES-ISED NO OF CE (s)	VARIABLES
0.8359	95.479	68.52	76.07	None**	LSHEO LSHEP
0.82418	53.916	47.21	54.46	At most 1*	LGEXP
0.4186	24.292	29.68	35.65	At most 2	LRAINF
0.2424	11.821	15.41	20.04	At most 3	LWAGER
0.2105	5 431	3.76	6.65	At most 4*	

**(**) connotes rejection of the hypothesis at 5% (1%) significant level.*

L.R test indicate 2 co-integrating equations at 5% significant level.

Table 4: Result Of Johansen Co-Integration Test For Goat

EIGEN VALUE	LIKELIHOOD RATIO	CRITICAL VALUE AT 5%	CRITICAL VALUE AT 1%	HYPOTHESISED NO OF CE (s)	VARIABLES
0.7896	80.722	68.52	76.07	None**	LGOAO
0.5637	44.870	47.21	54.46	At most 1*	LGOAP
0.4686	25.791	29.68	.65	At most 2	LRAINF
0.3663	11,249	15.41	20.04	At most 3	LWAGER
0.0323	0.756	3.76	6.65	At most 4	

*** (**) denotes rejection of hypothesis at 5% (1%) significant level.***
L.R test indicates 1 co-integrating equations at 5% significant level

Table 5 shows the result of the ECM for livestock population (cattle). All the variables and their corresponding lagged variables were significant at between 1% and 10% levels except one year lagged variable of government expenditure (LGEXP) and wage rate (LWAGER) which were not significant. The coefficient of multiple determination (R^2) of 91% shows that the independent variables can jointly explain 91% of the movement in the dependant variables justifying the fact that they are major determinants of cattle population. The goodness of fit of the model is further confirmed by the F- statistic, which is significant at one percent. Since an auto-regressive distributed lagged model was estimated, Durbin- Watson (DW) statistics is rendered unacceptable for predicting the presence of autocorrelation. Coefficient of the ECM_{-2} of 0.947 and its significance at 1% implied a high feed back mechanism in the value of the dependent variables, meaning that cattle population adjust to correct long-run equilibrium between itself and its determinant at a high speed of about 95%.

Table 5: Ecm Result For The Determinants Of Livestock Population By Ols - Cattle (1975-1994)

INDEPENDENT VARIABLES	COEFFICIENT	STD.ERROR	T-STATISTICS	LEVEL OF SIGNIFICANCE
C	-0.028631	0.049910	-0.573681	59%
[LCATP.2]	1.509575	0.503446	2.998482	2%
[LCATP(-2).2]	-1.831176	0.776568	-2.358037	6%
[LGEXP.2]	-0.164913	0.064600	-2.552820	4%
[LGEXP (-1).2]	0.084346	0.049527	1.703025	14%
[LGEXP (-2).2]	-0.199526	0.078210	-2.551155	4%
[LRAINF(-1).2]	1:479806	0.432938	3.418057	1%
[LRAINF(-2).2]	-2.088144	0.773324	-2.700220	4%
[LRAINF(3).2]	-1.592272	0.490818	-3.244121	2%
[LWAGER. 2]	1.101198	0.315243	3.493170	1%
[LWAGER.(1).2]	0.667250	0.428752	1.556263	17%
[LWAGER.(2).2]	-1.434291	0.456183	-3.144114	2%
ECM (-1)	-1.633282	0.229351	-7.252135	1%
ECM (-2)	0.946756	0.173630	5.452719	1%

R^2=97%, R^2 = 91% DW =1.91, F-STATISTICS =15.32 AT 1% LEVEL
OLS □? Ordinary Least Square

Table 6: Ecm Result For The Determinants Of Livestock Population By Ols 1975-1994 (Sheep)

INDEPENDENT VARIABLES	COEFFICIENT	STD.ERROR	T-STATISTICS	LEVEL OF SIGNIFICACE
C	-0.011019	0.023450	-0.469903	66%
[LSHEP.2]	0.136063	0.072226	1.883861	10%
[LSHEP(-3).2]	-0.868773	0.289318	-3.002831	2%
[LGEXP.2]	-0.061359	0.031312	-1.959639	10%
[LGEXP (-2).2]	-0.049426	0.029145	-1.695838	14%
[LGEXP (-3).2]	0.071670	0.027525	2.603819	4%
[LRAINF.2]	-0.620637	0.196090	-3.165058	2%
[LRAINF(-1).2]	0.336277	0.252982	1.329254	23%
[LRAINF(-2).2]	-0.550143	0.246601	-2.230902	7%
[LWAGER. 2]	0.446844	0.283368	1.579902	17%
[LWAGER.(-2).2]	1.069748	0.443364	2.412800	5%
[LWAGER.(-3).2]	-1.000008	0.456675	-2.189911	7%
ECM (-1)	-1.060463	0.244398	-4.344416	0%
ECM (-2)	0.641186	0.164105	3.907177	1%

R2=97%, R^2= 90% D.W=1.92, F-STATISTICS =14.30, Sig. at 1% level.

Table 6 shows ECM result for sheep. Again all the variables were significant at between 1% and 10% with the exception of $LGEXP_{-2}$ (14%), LRAINF (23%) and LWAGER (17%). The R^2 was also high at 90% and the fit of the model (F-statistics) was significant at 1% percent level. The ECM_{-2} has a coefficient of 64% and its significant at 1%

Table 7: Ecm Result For The Determinants Of Livestock Population By Ols 1975 –1994 (Goat)

INDEPENDENT. VARIABLES	COEFFICIENT	STD. ERROR	T-STATISTICS	LEVEL OF SIGNIFICANCE
C	-0.037894	0.022894	-1.655164	16%
[LGOAP. 2]	0.793902	0.223761	3.547995	1%
[LGOAP (-2).2]	0.210342	0.143147	1.469418	20%
[LGOAP(-3).2]	-0.761565	0.295570	-2.576597	5%
[LGEXP .2]	-0.089251	0.028424	-3.139985	3%
[LGEXP (-1).2]	-0.103136	0.027742	-3.717722	1%
[LGEXP(-2).2]	-0.058166	0.029315	-1.984185	10%
[LGEXP(-3).2]	-0.077736	0.027211	-2.856737	4%
[LRAINF(-1).2]	-0.730836	0.245573	-2.976043	3%
[LRAINF(-2). 2]	-0.522697	0.283319	-1.844909	12%
[LRAINF.(-3).2]	-1.054781	0.221544	-4.761047	1%
[LWAGER. 2]	-0.370418	0.152818	-2.423908	6%
[LWAGER(-1). 2]	-0.159995	0.113246	-1.412816	22%
[LWAGER. (-2). 2]	-4.77861	0.141640	-3.373769	2%
ECM (-1)	-0.880643	0.185950	-4.735905	1%

R^2 =95% R^2 =80%, DW = 0.98, F-STATISTICS =6.40

Table 7 shows the ECM result for goat. Two variables were not significant; $LRAINF_{-2}$ (12%) and $LWAGER_{-1}$ (22%). All other variables were significant at levels between 1% and 10%. The R^2 was also high enough at 80% while the significance of the F-statistics (6.40) at 5% is a measure of good fit of the model. Coefficient of ECM_{-1} is 88% and it's significant at 1%.

CONCLUSION AND APPLICATION

The general consensus is that the performance of the Nigerian livestock sub-sector has been dismal. Consumption of protein of animal origin has been on the decrease due to the declining rate of animal production consequently, other benefits derivable from the sub-sector has been jeopardised. This unfortunate trend despite the potentials of the sub-sector as a veritable means in agriculture to diversify the economic base of the country calls for a study of this nature.

Analyses have shown that the population of ruminant livestock, which constitutes the larger proportion of animal protein source in the country, has greatly lagged behind particularly the most important of them all, cattle. Co-integration and error correction modelling of the ruminant livestock for a vivid exposition of population determinants revealed the importance of all the variables considered. It is therefore suggested that radical approach towards addressing various issues raised be set in motion. These include the abundant supply of the all-important good quality forages through the establishment of sustainable grazing reserves in the country. This is one of the areas where government expenditure has to be focused to improve ruminant livestock production.

The positive and negative relationship of livestock prices and wage rate, respectively, to livestock output suggest a better return to farmers to further motivate participation in livestock production

With appropriate policy options in these directions as well as focusing on other elements within the economy at large, problems of the under performance of the livestock sub-sector would not only be ameliorated but also be able to play its role both as a means of boosting the economic base of the country as well as fulfil its primary role of providing protein for the teeming population.

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