Co-integration and Error-Correction Modeling of Agricultural Output. A Case of Groundnut

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Abstract: Co-integration and error correction modeling tend to solve spurious regression result noticed from the analysis of macroeconomic data and also to establish an equilibrium long-run relationship which enables one to carry out a valid inferences about the explanatory variable that affect the output of such crop. First and foremost, stationarity test was carried out and it reveals that at level form output was stationary while the various variables (producer price, rainfall, hectarage and fertilizer) became stationary only at first-differencing applying the unit root test. Furthermore estimates of factor affecting the output of groundnut were derived using Johansen co-integration and error-correction representation procedures. The result indicated the existence of the one co-integrating vector at 5 percent significance's level, thus rejecting the null hypothesis of no co-integrating vector. As a result a parsimonious error-correction model was set-up. The statistical significance of the error correction model for groundnut validates the existence of an equilibrium relationship among the variables. The result therefore shows that the combine effect of producers price, hectarages, rainfall and fertilizer jointly affect the output of groundnut. [Researcher, 2009; 1(6):27-32]. (ISSN: 1553-9865).

Key words: Johansen co-integration; error-correction modeling; equilibrium relation; stationary; groundnut.

1. Introduction

In the history of Nigeria, agriculture used to be the mainstay of the economy. Nigeria is mainly an agrarian state. The emphasis on agriculture was so great that we had tremendous output in the production of groundnut in the North, cocoa in the West and palm oil in the East. As a result we had groundnut pyramids in 1970's, but this laudable measure could not be sustained due to the advert of petroleum in the early1970's, which subsequently became the major foreign earner for the country leading to the neglect of the agricultural sector. In recent times, revenue from oil hasn't been encouraging, thus, the government as a policy is diversifying the economy such that revenues can also be derived from other sectors of the economy. The agricultural sector to an extent has gained from these policies, which has witness a gradual emphasis being accorded it. This in no small way has lead to a significant but gradual increase in agricultural output of which groundnut is one them. As a result of all these, groundnut output has been fluctuating. In 11965 – 1970 it's output level was 7680 thousand tones, 1971 – 1975 it was 6004 thousand tones, 1976 – 1980 it recorded 9072 thousand tones, 1981 – 1985 it dropped to 2484 thousand tones but resumed a gradual increase in 1986 – 1990 with 3806 thousand tones and in 1991 – 1995 it's value was 7338 thousand tones. Groundnuts witness a total growth rate of 40.93 percent for the period 1965 – 1995.

This paper tends to examine whether producer's price, hectarage cultivated to groundnut, fertilizer applied and rainfall have an important effect on groundnut production. Reliable estimates of the determinations of output level are essential for policy decision to foster groundnut production. Due to the fluctuation in groundnut output, the regression of its statistical data will be spurious, which invalidate the result and interpretation. To adequately cater for this problem necessitate the use of co-integration and error-correction model in this study. During the last decade co-integration analysis has become a widely used technique for the analysis of economic time series. In recent past, co-integration analysis has been used by several authors: Ardeni, 1989; Goodwin and Schroeder, 1991; Alexander and Wyeth, 1992, to study market integration, Moss (1992) applied it to the cost-price squeeze in agriculture in U. S: Hallaam et al (1992) used it to determine the determinant of land prices. Adams (1992) applied the concept of co-integration to estimate the demand for money in Kenya. Tambi (1999) applied it to agricultural export supply in Cameroon. Tijani et al (1999) applied co-integration analysis to Nigeria Cocoa export supply.

2. Co-integration and Error-correction representation

Co-integration has assumed increased importance in analysis that purports to describe long-run or equilibrium relationships. An equilibrium relationship exists when variables in the model are co-integrated. A necessa 1 condition for integration, however, is that the data series for each variable involved exhibit similar statistical properties, that is, be integrated to the same order with evidence of some linear combination of the integrated series.

A stationary series X_t, for example, has a mean, variance and auto-correlation that are constant over time. However, most economic series tend to exhibit non-stationarity.

Stochastic process of the form

$X_t = \alpha + \beta X_{t-1} + e_t$………… (1)

Where α is a constant drift, β =1, and e_1 is an error term. The series X_t is integrated because it is the sum of its base value X_t and the difference in X up to time t. since β is unity, X is said to have 'unit root'. If X_t is non-stationary, the variance may become infinite and any stochastic shock may not return to a proper mean level. As shown by Engle and Granger (1987), such a non-stationary series has no error-correction representation.

A non-stationary series required differencing to become stationary. X_t is integrated of order D_x or X_t – (D_x) if it is differences D_x times to achieve stationarity. Engle and Granger (1987) provide appropriate tests for stationarity of individual series as the Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) statistics. These tests are based on t-statistics on 'σ' obtained from estimates of the following respective static OLS regressions applied to each of the series:

$\Delta X_t = \alpha + \sigma X_{t-1}$ (for DF test)…………….. (2)

$\Delta X_t = \alpha_0 + \sigma X_{t-1} + \Sigma\beta\Delta X_t{-}_1 1 \div e_t$ (for ADF test)……….... (3)

Where the lag length K chosen for ADF ensures e_t is empirical white noise. The null hypothesis that X is 1(1) against the alternative of 1(0). The null is rejected if the t-statistic on σ is negative and statistically significant when compared to appropriate critical values established for stationarity tests. These critical values have been established by a number of studies from Monte Carlo simulations (Fuller, 1976: Dickey and Fuller, 1981: Engle and Granger, 1987: Perron, 1988: Blangiewiez and Charemza, 1990: Mackinnon, 1990).

Once the stationarity properties of the individual series are established, linear combinations of the integrated series are tested for co-integration. Should a linear combination of individual non-stationary series produce a stationary data series, then the variables are co-integrated and unless they integrates, they cannot describe equilibrium relationships. It they do not co-integrate, regressions of one 1(1) variables to another become spurious. As shown by Granger and Newbold (1974), such regressions produce high $R^{2's}$ and t-ratios that are biased towards rejecting the hypothesis of no relationship even when there is no relationship between the variables. Estimates of a linear combination of individual series tend to be reliable and constant and are fit for describing the steady-state relationships.

A number of studies have provided exposition of the co-integration methodology along with explicit tests for evaluating the co-integrating properties of a pair of non-stationary series (Hendry, 1960: Engle and Granger. 1987: Johansen, 1988: Johansen and Jusselius, 1990; Goodwin and Schroeder, 1991: Hallaam et al, 1994). The procedure consists of two steps. First, standard OLS is applied to the levels of the variables to establish the order of integration for particular combinations of co-integrating variables. Estimates of the residual error e_t are obtained as follows:

$E_t = X_t - \alpha - \beta y_t$………… (4)

The null hypothesis that e has a unit root and therefore is a random walk, is tested against the alternative that, it is stationary using the DF and ADF tests.

The Johansen procedure which is the most recent method 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-integration vectors. This technique is important when testing for co-integration between more than two variables. The first test is based on the maximal eigen-value, the null hypothesis is that there are at most r co-integrating vectors against the alternatives of r + 1 co-integrating vectors. The second test, is based on the trace of the stochastic matrix, the null hypothesis is that there are at most r co-integrating vectors against the alternative hypothesis that there are r or more co -integrating vectors.

In order to achieve along-run equilibrium relationship the second step of Engle-Granger is applied by estimating an error-correcting model in which residual from the equilibrium co-integrating regression are used as an error-correcting regressor (Ec_t lagged one period) in a dynamic model.

2.1. EMPIRICAL ESTIMATION

The general form of the equation specified in the double log form as follows:

$$\ln \Delta Q_t = a_0 + a_1 \ln \Delta A_{t-j} + a_2 \ln \Delta P_{t-1} + a_3 \ln f_{t-p} + a_4 \ln \Delta W_{t-k} + Ecm_{t-1} + U_t$$

Where;

$\ln\Delta Q_t$ = the quantity of groundnut output produced in thousand tonnes

$\ln\Delta A_{t-j}$ = the hectarage under cultivation for groundnut in hectare

$\ln\Delta P_{t-1}$ = the producers price for groundnut in N/tonnes

$\ln\Delta F_{t-p}$ = the quantity of fertilizer available in thousand MT

$\ln\Delta W_{t-k}$ = the weather variable

Ecm_{t-1} = error correction variable

U_t = error trem

On a prior basis all the variables are expected to have a positive effect on output of groundnut. But there could be deviation due to one reason or the other.

The data used in this study covered the period 1970 – 1998 data for the entire period were collected from of the federal office of statistics (Abstract of statistics); Central Bank of Nigeria and fertilizer yearbook of food and Agricultural organization.

3. DIAGNOSTIC RESULTS

3.1 Ordinary least square technique

The result of the static model for groundnut is shown in the table 1 below. It shows that the explanatory variable could only explain about 24 percent movement in the dependent variable. The priori sign for hectare and fertilizer are positive while that of rainfall and price are negative. The negative sign for price could be attributed to glut in the market, which pushes the price down while that for rainfall could be due to the drought nature of the northern part of the country. The D. W statistics showed no sign of serious negative auto correlations.

$R^2(R^{-2})$ =0.24 (0.11)
F-Statistics = 1.91
Durbin-Watson statistics = 2.25

Table 1: The result of static model estimate using the ordinary least square technique (1970 -1998) Dependent variable-quantity of groundnut produced

INDEPENDENT VARIABLES	CO-EFFICIENT	STANDARD ERROR	T-STATISTICS	PROBABILITY
CONSTANT ©	4.428	0.409	0.471	0.6421
LOG (G/NUT P)	-0.100	0.250	-0.401	0.6918
LOG (G/NUT HA)	0.480	0.318	1.509	0.1444
FERTILIZER	0.001	0.002	0.532	0.5999
LOG (RAINFALL)	-0.064	1.003	-0.064	0.9499

3.2. Unit root test

Table 2 below; present the ADF test-statistics for unit root for the entire variable used for groundnut. For all variables in their level form except for quantity of groundnut produced, the null hypothesis that each variable is 1(1) cannot be rejected as their ADF statistics are above the critical value of -2.98 at 5 percent significant level. Thus the variable hectare, price, fertilizer and rainfall are non-stationary at their level form. Note; critical value for level form is -2.98 at 5 percent significant level. For first differencing the critical value are -3.71,-2.98 and -2.63 at 1, 5 and 10 percent significant level respectively.

Table 2: Univariate stationary properties of the variable (ADF root test)

VARIABLES	ADF	VARIABLE	ADF	NO OF LAGS
Qty g/nut output	-3.10			1
G/nut price	-0.35	G/nut price	-3.53	1
G/nut ha	-1.94	G/nut hectare	-3.45	1
Fertilizer	-0.28	Fertilizer	-2.75	1
Rainfall	-2.36	Rainfall	-4.25	1

In the first difference form, however we can reject the null hypothesis for all the variables. At their first difference all the variables except fertilizer are stationary at 5 percent significant level while fertilizer is stationary at 10 percent significant level.

3.3. Johansen co- integration test

After stationarizing the variables, the Johansen procedure to test for the existence of more than two co-integrating vectors was applied. The result of test is shown in table 3 below. None denotes rejection of the hypothesis at 5 percent significances level. L.R test indicates 1 co-integrating equation at 5 percent significances level.

Table 3: Johansen Tests for the Number of Co-integrating Vectors for G/Nut Series in the Equation: Qty G, G/Nut P, G/Nut Ha, Fertilizer and Rainfall

HYPOTHESIS					
NULL	ALTERNATIVE	LIKELIHOOD RATIO	5 PERCENT CRITICAL VALUE	EIGEN VALUE	HYPOTHESIS NOS OF CO-INTEGRATING EQUATION
r = 0	r = 1	78.8085	68.52	0.7498	None
r ≤ 1	r = 2	41.4047	67.21	0.5366	At most 1
r ≤ 2	r = 3	20.6400	29.68	0.3218	At most 2
r ≤ 3	r = 4	10.1561	15.41	0.2673	At most 3
r ≤ 4	r = 5	1.7600	3.76	0.0631	At most 4

The result of the Johansen test for groundnut indicates the existence of a single co-integrating vector at 5 percent significant level. Thus rejecting the null hypothesis of no co-integrating vector, but accepting the alternative hypothesis of a single co-integrating vector. The long-run test indicates that one co-integrating equation (vector) exist at 5 percent significant level in the sets of normalized co-integrating equations. This is so because the alternative hypothesis of r = 1 is 78.8085 which is greater than the critical value at 5 percent.

3.4. Error correction model for groundnut

Since the result reveal the existence of co-integrating among the variables of the model a parsimonious error correction model (ECM) was then set-up, it is presented in table 4 below. the result indicated (going by the value of the co-efficient of multiple determinations) that the model has a good fit as the independent variable jointly explain 99 percent of the movement in the dependent variable which is a marked improvement on the 24 percent obtained with static model using OLS.

R^2= 0.999842; Prob (F-statistic) = 0.0015; R^2= 0.998263; D.W= 1.169899; F-statistic = 633.3200

Table 4: Modeling the Determinants of the Output of G/Nut by Ordinary Least Squares (A Dynamic Error Correction Model): Summary of the results of the Estimated Equations (1970 – 1998). Dependent variable = LOG OF G/NUT OUTPUT (LGNUTO)

	INDEPENDENT VARIABLE	CO-EFFICIENT	STANDARD ERROR	t-Statistics
1	C	-0.034793	-0.011438	-3.041833
2	D(LGNUT HA,2)	0.346290	0.048908	7.080441
3	D(LGNUT HA,(-1),2)	-0.059164	0.060049	-0.9852262
4	D(LGNUT HA, (-2),2)	0.354026	0.044498	7.956026
5	D(LGNUT HA (-3),2)	0.905166	0.101154	8.948360
6	D(LGNUT HA (-4),2)	0.747013	0.127464	5.860557
7	D(LGNUT P,2)	-0.740937	0.100189	-7.395414
8	D(LGNUT P(-1),2)	-0.225266	0.078539	-2.868216
9	D(LGNUT P(-2),2)	-0.825961	0.135119	-6.112850
10	D(LGNUT P(-3),2)	-0.757401	0.128746	-5.882915

11	D(LGNUT P(-4),2)	-0.766367	0.121703	-6.112850
12	D(LRAINFALL,2)	-0.909280	0.157490	-5.773563
13	D(LRAINFALL, (-1),2)	-0.683869	0.170690	-4.006492
14	D(LRAINFALL,(-2),2)	-1.449964	0.2502294	-5.793048
15	D(RAINFALL,(-3),2)	-0.137132	0.110911	-1.236415
16	D(FERTILIZER,2)	0.002695	0.000380	7.099002
17	D(FERTILIZER(-1),2)	0.003739	0.000646	5.787657
18	D(FERTILIZER(-2),2)	0.001294	0.000442	2.927222
19	D(FERTILIZER(-3),2)	0.004242	0.000688	6.159390
20	ECMG	0.612802	0.047291	12.95811
21	ECMG(-1)	-1.142107	0.039308	-29.05509

This means that the independent variables used in the model are the major determinant of the output of groundnut in Nigeria. The F-statistics which is significant at zero percent confirmed the goodness of fit of the model. The result shows that the coefficient of the 3rd and 15th explanatory variable is statistically significant at various levels ranging from zero to 10 percent. For instances the coefficient of the explanatory variables (LGNUTHA, 2) and its four years lagged components are significant at 1 and 5 percent respectively. Similarly the explanatory variables (LGNUTP, 2) and its four years lagged component are significant at 1, 5 and 10 percent respectively. While the variable (LRainfall, 2) and its two years lagged component are significant at 5 percent. Furthermore, the variable (Fertilizer, 2) and its various three years lagged component are significant at 1, 5 and 10 percent respectively. The ECM coefficient and that of its one year lag are both significant at zero percent, which is an indication of its high feed back mechanism, thereby ensuring non-less of information and a confirmation of the validity of an equilibrium relationship among the variable in the co-integrating equation. The result therefore reveals that the combine effect of producer's price, hectarage cultivated, fertilizer and rainfall jointly affects the output of groundnut.

4. Conclusion

Estimation of Nigeria's groundnut production was approached through Johansen co-integration and correction model. The unit-root reveals that groundnut output was stationary at level first differencing. The Johansen co-integration reveals the existence of one co-integrating vector, thus a parsimonious error-correction model was set-up. Statistical significance of the error-correction terms validates the existence of an equilibrium relationship among the variables in the co-integrating vector.

The conclusion from this is that the combine effect of producer's price, the hecterage, fertilizer and rainfall jointly affects the production of groundnut in Nigeria. In order to boost production a positive price policy should be put in place, a well defined land use policy should be pursued and an efficient management of available surface and underground water resources should be emphasized.

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