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Determinants of traditional agricultural exports in Nigeria: an application of cointegration and correction model

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Abstract

The study aimed to derive estimates of factors influencing Nigeria's agricultural exports to five principal countries - United States, The Netherlands, United Kingdom, Germany, and France, with the aid of error correction representation procedures. The analysis was carried out with the data collected on Nigeria primary exports - cocoa, palm kernel, and rubber, over 38 years (1960 - 1997).

Agricultural commodity exports to the selected countries were influenced by the domestic output, population growth, quantity supplied by competing countries, index of industrial production of importing countries, and time trend. However, the domestic output and population growth rate were the most significant factors influencing agricultural exports in the importing countries. In addition, there is high feedback captured by the coefficients of the error correction mechanism. There seems to be an instantaneous change in the short-run equilibrium to long-run equilibrium values of agricultural exports as a result of policy changes in the regressors.

Efforts to boost agricultural exports from Nigeria will need to incorporate policy measures to improve producer prices, enhance the quality of the products, and ensure timely exports of the commodities, especially those with a positive relationship between the index of industrial production of importing countries and Nigeria's exports. With short-run policy changes by the importing countries, the rate of response by Nigerian producers through exports will be almost spontaneous, as indicated by the coefficient of the error correction mechanism ECM (-1).

Keywords: cocoa, palm kernel, rubber, Nigeria, cointegration and error correction mechanism

1. Introduction

In Nigeria, agricultural exports have played a prominent role in economic development by providing the needed foreign exchange for other capital development projects. From the initial trade in palm oil, Nigeria's agricultural exports have enlarged to

include cocoa beans, palm produce (oil and kernel), cotton, coffee, groundnut, groundnut cake, copra, cassava, rubber, and timber. Available statistics indicate that agricultural export commodities contributed well over 75% to total annual merchandise exports (EKPO and EGWAIKHIDE, 1994; OLAYIDE et al., 1980; OYEJIDE, 1998). Nigeria also ranked very high in the production and exportation of some major crops in the world in the 1940s and 1950s. For instance, Nigeria was the largest export of palm oil and palm kernel, ranked second to Ghana in cocoa and occupied a third position in groundnut. OLAYIDE and ESSANG (1976) observed that Nigeria's export earnings from major agricultural crops contributed significantly to the Gross Domestic Product (GDP). Similarly, EKPO and EGWAIKHIDE (1994) observed a long-term relationship between agricultural exports and economic growth in Nigeria.

However, the introduction of petroleum in the mid-1960s into the nation's export scene changed the composition and structure of the export trade. In 1960, oil contributed just 2.6% to the foreign exchange earnings. This geometrically increased to 58.1% in 1970, 87.2% in 1972, and 1975. Revenue generated from oil thus increased from ₦4,565.1 million (about $7,412 million) in 1975 to ₦728,265.3 million (97.4% increase, about $33,275 million) in 1995. On the other hand the relative share of the agricultural sector in foreign earnings steadily declined. From an average of 9.11% in the 1970-1975 period, agricultural export earnings declined to 1.76% between 1995 and 1997. OLOMOLA (1995) and YUSUF (2000) attributed this decline in Nigeria's agricultural export earnings to the discovery of crude oil and rural-urban migration.

At present, Nigeria has lost its role as one of the world's leading exporters of agricultural commodities. In addition, the country is currently suffering from a declining as well as fluctuating income from its heavy dependence on oil exports. With the present situation in the oil market, it has become necessary for the country to reconsider its agricultural commodity export position. This study therefore aims to examine the current position of agricultural commodity exports in Nigeria, with a view to identifying the determinant factors that influence its growth, and discovering the role of some important external variables in determining the nation's competitiveness in the world market for agricultural commodities.

2. Methodology

2.1 Data source

The empirical analysis covers the period between 1960 and 1997. Three main agricultural export crops of the country were selected, cocoa, rubber, and palm kernel. The study also looks at the exportation of these commodities to five major importing countries: United Kingdom (UK), United States of America (USA), The Netherlands,

West Germany, and France. Cocoa, rubber, and palm kernel were the main primary exports of Nigeria. Even with the advent of oil, these three commodities still constitute the bulk of agricultural exports. Similarly, five countries have been chosen because they account for most of Nigeria's exports. For instance, these countries combined accounted for about 84% of the total exports from Nigeria in the 1980 and 1984 period and about 72.3% in 1995 and 1996 period. Secondary data used for the analysis were obtained from Central Bank of Nigeria (CBN) publications, such as Annual Reports and Statement of Accounts, Economic and Financial Review, and the Statistical Bulletin. Other sources were Federal Office of Statistics (FOS) Annual Abstract of Statistics and Trade Survey, United Nations Trade Year Book, International Financial Statistics Year Book (IFS) and the Food and Agriculture Organization (FAO) Trade Year Book of various issues. However, for each of the variables used, data were obtained from the most consistent and up-to-date source(s).

2.2 Analytical techniques

The analysis of the data for this study is based on the recent development in cointegration analysis otherwise referred to as Error Correction Models (ECM). The choice of the estimation procedure is to examine the time series characteristics of data used so as to overcome the problems of spurious correlation often associated with non-stationary time series data. At the same time, it becomes possible to generate long-run valuable relationships (ENGEL and GRANGER, 1987; HENDRY, 1986). TAMBI (1999) notes that cointegration has assumed increased importance in analyses that attempt to describe long-run equilibrium relationships. An equilibrium relationship exists when variables in the model area cointegrated (TAMBI, 1999). A pre-condition for integration, however, is that the data for each variable involved exhibit similar statistical properties, that is, are integrated to the same order with evidence of some linear combination of the integrated series.

The starting point of ECM modelling is to assess the order of integration of both the dependent and independent variables in the model. The order of integration ascertains the number of times a variable will be differentiated to arrive at stationarity. A stationary series has a mean, variance, and auto-correlation that are constant over time. ENGEL and GRANGER (1987) provide appropriate tests for the stationarity of individual series such as the Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) statistics (DICKEY and FULLER, 1981). These tests are based on t-statistics and α_1 obtained from the estimates of static ordinary least square (OLS) regressions applied to each of the series. In this study, the ADF test has been chosen because it captures additional dynamic left out by the DF and ensures that the error term is white noise through the inclusion of additional lag length. The test procedure is given by

$$(1) \qquad \Delta X_t = \alpha_o + \alpha_1 X_{t-1} + \sum_{t-1} b_i \Delta X_{t-1} + e_t$$

The decision rule states that the t-statistic on the coefficient of the variable α_1, which is expected to be negative, must be significantly different from the critical values for a given sample size, if the null hypothesis is to be rejected. The null hypothesis is that the variable of interest is non-stationary (i.e., it is integrated of order one I [1]).

After the order of integration of the variables in the model has been ascertained, the next stage is to test for cointegration. Cointegration is a test of stationarity of the residuals generated from running a static regression in levels of one or more of the regressor variables on the dependent variable. The test in this study was carried out by testing the residual from the bivariate cointegration regression for stationarity using the maximum likelihood (eigen value and trace) tests of JOHANSEN and JUSELIUS (1990). ECM is accepted when the residuals from the linear combination of non-stationary I (1) series are themselves stationary. The acceptance of ECM implies that the model is best specified in the first differences of its variables. In this context, the application of the cointegration paradigm will guard against the loss of information from long-term relationships in the first differences.

The lag length used in the vector auto-regressive representation (VAR) of the test was selected using the Likelihood Ratio Test procedure, which compares a larger VAR against a restricted one until the restriction is rejected. The information in the error term of the long-run relationship is used to create a dynamic error correction model. The ECM is then used to analyze the impulse response of exports to a stimulus in the explanatory variables in a dynamic setting. The estimated equation is given as follows:

$$(2) \qquad a(L)\Delta QX_t = a_o + a_1 (L)\, \Delta PDX_t + a_2 (L)\, \Delta PPRX_{t-1} + a_3(L)\, \Delta WLPX_t + a_4 (L)\, \Delta EXC_t + a_5 (L)\, \Delta POP_t + a_6 (L)\, \Delta OTHERS_t + a_7 (L)\, \Delta GDP_t + a_8 (L)\, \Delta INDEX_t + T - a_9 ECM_{t-1} + U_t$$

where:

QX_t = Quantity of agricultural crop exported to a particular country in time t ('000 tonnes)
PDX_t = Quantity of agricultural crop produced in Nigeria in time t ('000 tonnes)
$PPRX_{t-1}$ = Average producer price of the previous year, i.e., year t- 1
WLP_t = Average world price of the agricultural produce in time t
EXC_t = Official exchange rate in time t
POP_t = Population of Nigeria in time t
$OTHERS_t$ = Quantity exported to the importing countries by competing countries in time t
GDP_t = The GDP of the importing countries in time t
$INDEX_t$ = Index of industrial production in the importing country in time t
T = Time or trend factor measured in years
ECM(-1) = The error correction factor
U_t = Stochastic error term assumed to be independently and normally distributed with zero mean and constant variance

In terms of a priori expectation, a direct relationship is expected between the quantity of agricultural exports (QX_t) and the following independent variables: quantity of agricultural crop produced by Nigeria (PDX_t); average producer price of the crop in the previous year ($PPRX_{t-1}$); average world price of the crop in time t (WLP_t) and official exchange rate in time t (EXC_t). Other variables with positive effect on the export commodities from the country include the gross domestic product (GDP_t) of the importing countries; index of industrial production in the importing country in time t ($INDEX_t$) and the time trend (T). Conversely, the population of Nigeria in any year (POP_t), quantity exported by competing countries ($OTHERS_t$) and ECM [-1] are expected to have negative signs.

The coefficient of the ECM when it is statistically significant gives credence to the existence of cointegration. Its magnitude defines the feedback mechanism amongst the cointegrating variables.

3. Empirical analysis and results

3.1 Stationarity tests

Table 1 presents the result of the ADF classes of unit root tests. The tests were applied to the first difference of the natural logarithm of each variable over the period 1960 to 1997 without a time trend.

The ADF test strongly supports the hypothesis at the 5% level that all variables with the exception of palm kernel exported to Germany (GEMPAMK) and UK (UKPAMK) are 1(1) or non-stationary. Following from this is the need to difference the variables once to arrive at stationarity with the exception of the palm kernel export to Germany and UK, respectively. In essence, any attempt to use the non-stationary variables at their level could lead to spurious results.

Table 1. Augmented Dickey-Fuller unit root tests (variables in natural logarithm)

Variable	ADF test statistics	Number of lags (optimal lag)	Remark
GEMCO	-2.9014	1	Non stationary
NTHCO	-1.3555	5	Non stationary
USACO	-2.3359	5	Non stationary
UKCO	-2.3307	0	Non stationary
FRNCO	-1.7831	4	Non stationary
PROCO	-0.85802	4	Non stationary
PRODPRCO	2.7547	0	Non stationary
WLDPRCO	2.8400	0	Non stationary
EXCNIG	1.2878	0	Non stationary
POPING	-0.74204	4	Non stationary
OTHERSCO	0.68044	5	Non stationary
GDPGER	-0.06103	0	Non stationary
GDPNTH	-1.7237	5	Non stationary
GDPUSA	2.1350	3	Non stationary
GDPUK	0.69525	3	Non stationary
GDPFRN	-0.11212	0	Non stationary
INDEX GEM	-1.3229	5	Non stationary
INDEX NTH	-1.0696	5	Non stationary
INDEX USA	0.73832	5	Non stationary
INDEXUK	-0.24777	5	Non stationary
INDEXFRN	-2.0861	3	Non stationary
GEMPAMK	-3.1995*	2	stationary
NTHPAMK	-1.0156	5	Non stationary
UKPAMK	-4.3942*	5	stationary
PRODPRAMK	-1.7074	5	Non stationary
PRODPRPAMK	-0.94852	1	Non stationary
WLDPLPAMK	1.1231	1	Non stationary
OTHERSPAMK	-0.87161	5	Non stationary
GEMRUBB	-2.4994	5	Non stationary
NTHRUBB	-2.7469	5	Non stationary
USARUBB	-1.3427	5	Non stationary
UKRUBB	-0.74517	5	Non stationary
FRNRUBB	-0.84857	5	Non stationary
PRODRUBB	0.6213	5	Non stationary
PRODPRRUBB	3.1642	1	Non stationary
WLDPRRUBB	-1.08954	0	Non stationary
OTHERSRUBB	-1.4913	5	Non stationary

Critical value is -2.9558 at the 95% confidence level. Significant at 5%.

Source: results pront out from the EVIEWS software

Table 2. Number of cointegrating vectors for the exported crops (1960-1997)

	No. of cointegrating vectors (r) 1	Test statistics 2	95% critical value 3	No. of cointegrating vectors (r) 4	Test statistics 5	99% critical value 6
GEMCO	7	24.48	24.31	5	71.36	66.25
NTHCO	6	44.20	39.89	5	72.48	66.52
USACO	7	29.101	24.31	6	49.36	45.58
UKCO	5	63.96	59.46	4	104.80	90.45
FRNCO	6	54.80	39.89	6	54.80	45.58
GEMPAMK	7	26.91	24.31	6	49.50	45.58
UKPAMK	5	77.22	59.46	5	77.22	66.52
GEMRUBB	6	40.59	39.89	5	76.85	66.52
NTHRUBB	6	41.27	39.89	5	73.23	66.52
USARUBB	8	18.76	12.53	8	18.76	16.31
UKRUBB	6	41.72	39.89	5	69.62	66.52
FRNRUBB	7	27.18	24.31	6	29.18	29.75

Columns 2-4 show the number of cointegrating vectors, the value of test statistics and the critical value at 95% level. On the other hand, columns 5-7 show the number of cointegrating vectors, the value of test statistics, and the critical value at 99% level.

Source: computed from survey data.

3.2 The error correction model

The analysis concentrated on the long-run parsimonious export determinant models estimated. In proceeding from the general error correction model to the parsimonious model, variables that had low t statistics and were not significant were eliminated. The final and parsimonious model is presented in tables 3, 4, and 5 for each export commodity. The Schwartz criterion for all the regression is reduced in the parsimonious model, meaning that it carries more information and that model parsimony is achieved.

In table 3 the coefficient of determination (R^2) of exports of cocoa to Germany is 0.667, thus the independent variables explain 66.7% of the variations in the dependent variables. Also, the R^2 was 0.517 for The Netherlands, 0.663 for USA, 0.629 for UK, and 0.429 for France. The information criterion (Schwartz criterion) improved from –4.343 to –3.7382 for exports of cocoa to Germany, implying that the model carried more information. This can also be said for the others. Besides, the coefficient estimates had expected signs. The total output (PDX) was significant at 1% for Germany and USA, and 10% for The Netherlands, UK, and France while the population growth (POP) was significant at 10% for Germany, The Netherlands, and USA. Furthermore, the quantity of cocoa supplied by other competing countries (OTHERS) was significant at 10% for Germany, 1% for The Netherlands, and 5% for USA, but was not significant for the other two countries (UK and France). There is a

high feedback adjustment mechanism as indicated by the ECM, varying from 0.720 in The Netherlands cocoa equation to 1.228 in USA cocoa equation, thus implying a spontaneous adjustment to short-run change in any of the independent variables.

The coefficient of determination R^2 of exports of palm kernel to Germany is 0.3809 (table 4), thus indicating that 38% of the variations in palm kernel export to Germany can be explained by the independent variables. For The Netherlands it was 0.5384, and for the UK it was 0.5384 and 0.1577, respectively. The information criterion (Sc) also improved. In the model, total output (PDX), population growth (POP), the index of industrial production (INDEX) and time trend (T) were significant at 10% level, while quantity supplied by competing countries (OTHERS) was significant at 5%.

The error correction term, ECM was significant at 1% for palm kernel exports to Germany and The Netherlands, and at 5% for UK. A feedback of 89.5% was achieved for Germany, 139.7% for The Netherlands, and 33.9% for UK. This confirms that there is a relationship between palm kernel exports and total output, population growth, quantity supplied by other competing countries, and the index of industrial production. Thus, there is high feedback in the value of palm kernel exported to these countries with a shock in any of the independent variables. This is highest for The Netherlands as a unit short-run change in the economy will lead to an instantaneous change in the export of palm kernel, as shown by the ECM value.

The coefficient of determination R^2 of exports of rubber to Germany is 0.3387, thus showing that 33.9% of the variations can be explained by the independent variables. The coefficient estimates have expected signs. The output (PDX) was significant at 10% for UK and France, while the population growth (POP) was significant at 5% only for The Netherlands. The index of industrial production was significant at 10% for Germany, The Netherlands, and UK, while the quantity of rubber supplied by other competing countries was significant at 10% for The Netherlands. The world price of rubber was significant at 5% for USA and the time trend was significant at 10% for exports of rubber to UK.

The outstanding feature of all the models is the well-defined ECM. There, coefficients were significant at 5% level with a feedback effect of 91.2% for Germany and 42.5% for The Netherlands, while USA with a feedback effect of 81.8%, UK, with 59.9%, and France with 86.6% were significant at 1%.

The strong significance of the coefficient on the ECM supports the conclusion that rubber exports are cointegrated with rubber output, population growth, index of industrial production, quantity supplied by other competing countries, time trend, and the world price. The rate of adjustment to policy shocks is also almost instantaneous, with the exception of The Netherlands' rubber export equation.

Table 3. Restricted parameter estimate for cocoa

Country	Constant term	ΔPDX(-1)	ΔPOP(-1)	Δothers(-)	ECM(-1)	R^2	F	DW	Sc
Germany (GEMCO)	1.7419	0.0575* (3.2293)	-0.6052*** (-1.8752)	-0.0228 (-2.6619)	-0.8950* (-5.1767)	0.667	15.5247+	2.0843	3.7382
The Netherlands (NTHCO)	2.0978	0.0479*** (1.6486)	-0.7986*** (-1.5595)	-0.035* (-2.5263)	-0.7203* (-3.9150)	0.5172	8.3016+	1.8397	4.7059
USA (USACO)	279.252	9.5019* (2.8656)	83.8763*** (1.6860)	2.9508** (1.9954)	-1.228* (-4.3149)	0.6626	11.7815+	2.256	13.9831
UK (UKCO)	-1.5091	0.0367*** (1.6109)	-	-	-1.2275* (-7.3613)	0.6287	27.9337+	2.2857	4.1479
France (FRNCO)	0.1818	0.0296*** (1.8787)	-	-	-0.8558* (-4.1995)	0.4294	8.0257+	1.8782	3.4634

The values in parentheses are t values

* t values significant at 1%
** t values significant at 5%
*** t values significant at 10%

\+ F values significant at 1%
DW Durbin Watson statistics
Sc Schwartz information criterion

Source: computed from survey data

Table 4. Restricted parameter estimate for palm kernel

Country	Constant term	ΔPDX(-1)	ΔPOP(-1)	Δothers	Δindex(-)	T	ECM(-1)	R^2	F	DW	Sc
Germany (GEMPAMK)	0.3796	-	-0.4320*** (-1.8535)	-	-	-	-0.8947* (-4.2781)	0.3809	6.5613+	2.1438	4.7280
The Netherlands (NTHPAMK)	-8.8401	-	-	-0.6028** (-2.1612)	2.4617*** (1.6958)	-	-1.3970* (-5.3472)	0.5384	6.7641+	2.2565	6.3139
UK (UKPAMK)	-16.7516	0.0422*** (1.6883)	-	-	-	0.5413*** (1.6548)	-0.3394** (-2.0221)	0.1577	1.9967++	1.9305	6.7097

The values in parentheses are t values

* t values significant at 1%
** t values significant at 5%
*** t values significant at 10%

\+ F values significant at 1%
++ F values significant at 5%

DW Durbin Watson statistics
Sc Schwartz information criterion

Source: computed from survey data

Table 5. Restricted parameter estimate for rubber

Country	Constant term	ΔPDX(-1)	ΔPOP(-1)	ΔIndex(-1)	ΔOthers (-1)	T	ΔWLP (-1)	ECM(-1)	R^2	F	DW	Sc
Germany (GEMRUBB)	-0.4457	-	-	0.1822*** (1.3539)	-	-	-	-0.9121* (-3.6715)	0.3387	5.4625+	2.1718	1.8816
The Netherlands (NTHRUBB)	-0.3019	-	-0.1818** (-1.7857)	0.2281*** (1.5868)	0.0022*** (1.5115)	-	-	-0.4251** (-1.8541)	0.3455	3.1667++	2.2219	1.6829
USA (USARUBB)	0.5648	-	-	-	-	-	-0.0010*** (-1.7418)	-0.8182* (-2.7059)	0.2437	5.3155+	2.0233	4.3332
UK (UKRUBB)	0.8521	0.0001*** (1.6234)	-	-0.3715*** (-1.4066)	-	-0.0533** (-0.6425)	-	-0.5993* (-3.4921)	0.2984	3.2956+	2.1486	3.26696
France (FRNRUBB)	-0.0734	0.0062*** (0.7903)	-	-	-	-	-	-0.8659* (-2.8568)	0.2007	8.0875+	1.9312	0.7768

The values in parentheses are t values

* t values significant at 1%
** t values significant at 5%
*** t values significant at 10%

\+ F values significant at 1%
++ F values significant at 5%

DW Durbin Watson statistics
Sc Schwartz information criterion

Source: computed from survey data

4. Policy implications and conclusion

The study which was based on the determinants of traditional agricultural exports in Nigeria revealed that the major determinants of exports were lagged producer prices, lagged world prices, population growth, quantity supplied by other competing countries, index of industrial production of importing countries, and the time trend.

A number of policies for increasing agricultural exports, therefore, emerged from the findings of the study. For cocoa, lagged producers prices, and lagged population growth rate were the most important factors determining Nigeria's export to the importing countries. Population growth in Germany and The Netherlands negatively influenced cocoa exports from Nigeria, whereas it positively influenced cocoa exports to USA. In three of the estimated equations for cocoa (Germany, The Netherlands, and USA) it was evident that the quantity of cocoa imported by these countries from countries other than Nigeria has a significant influence on the quantity imported from Nigeria. In particular, Nigeria's cocoa competes in Germany, and The Netherlands with cocoa from other countries while it complements other countries' cocoa exports to USA. Emerging from the above is the need to increase the producer prices of cocoa to match world prices so as to encourage increased maintenance of cocoa farms, and increased output. Also, the replacement of Nigeria's cocoa by cocoa from other exporting countries dictates that there must be a quality improvement so that cocoa from Nigeria can compete favourably with cocoa from other countries. The same recommendation holds for cocoa exports to USA since a better quality cocoa from Nigeria could be used to blend with cocoa from other exporting countries. Nigeria's cocoa during the era of the marketing board used to enjoy some premium over cocoa from other countries due to its high quality. Hence, there must be appropriate post-harvest practices to ensure an improvement in cocoa quality.

In the case of palm kernel, there is no discernible pattern of the influence of the independent variables on exports from Nigeria. In fact, Nigeria is currently not exporting much palm kernel due to the emergence of small scale enterprises (in soap and vegetable oil manufacture and livestock- keeping among others), which are now utilizing palm kernel products. The need for concerted effort to improve output of this product to cater for domestic and external markets cannot be overemphasised. With specific reference to the external market, the lagged producer prices, the import by The Netherlands from countries other than Nigeria, the population growth rate in Germany, and the index of industrial production must be critically considered for enhanced palm kernel exports to these countries.

For rubber, the index of production was consistently significant for all importing countries but carried a negative sign for UK. Producer prices also have positive and significant influence on exports to the UK and France. On the other hand, lagged

world prices of rubber significantly influence rubber exports to USA. Policies are therefore needed that will take into consideration the growth in industrial production in the importing countries. However, Nigeria's exports may have to be increased to Germany and The Netherlands.

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