International Journal of Food and Agricultural Economics
ISSN 2147-8988, E-ISSN: 2149-3766
Vol. 4 No. 2, 2016, pp. 69-85

A MODEL FOR THE PALM OIL MARKET IN NIGERIA: AN ECONOMETRICS APPROACH

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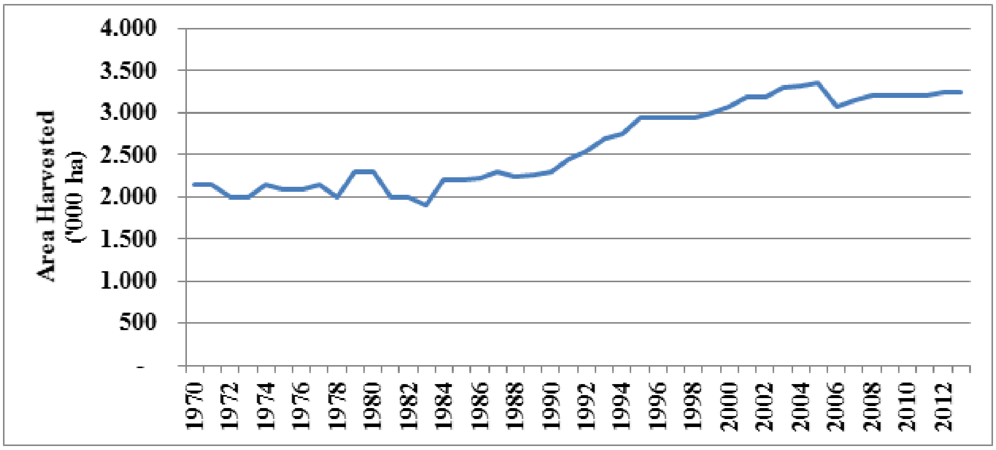
Abstract

The aim of this study is to formulate and estimate a model for the palm oil market in Nigeria with a view to identifying principal factors that shape the Nigerian palm oil industry. Four structural equation models comprising palm oil production, import demand, domestic demand and producer price have been estimated using the autoregressive distributed lag (ARDL) cointegration approach over the 1970 to 2011 period. The results reveal that significant factors that influence the Nigerian palm oil industry include the own price, technological improvements, and income level. Government expenditure on agricultural development is also an important determinant, which underscores the need for government support in agriculture. Our model provides a useful framework for analyzing the effects of changes in major exogenous variables such as income or import tariff on the production, demand, and price of palm oil.
Keywords: *Palm oil, production, demand, cointegration, error-correction model, speed of adjustment*
JEL Codes: C01, C51, Q02, Q18

1. Introduction

Palm oil is an important commodity in the Nigerian economy with reference to its role as a source of farm income and food requirement. In addition to providing direct and indirect employment for about 4 million people, palm oil and palm kernel oil together contribute around 70% of the country's national consumption requirement of vegetable oils (Olagunju, 2008; Nzeka, 2014). Over the past 40 years, however, the Nigerian palm oil industry has undergone dramatic changes, recording slow growth in domestic production and losing its export share in the world market. Additionally, there has been a growing competition from imports in the face of rising domestic demand. These factors have heightened concerns with regards to the survival of the palm oil industry in Nigeria.

Currently, oil palm is cultivated in 26 out of 36 states of Nigeria over a land area a little over 3 million hectares[1]. However, the total land available and ideal for oil palm cultivation is 24 million hectares. Also, about 80% of production is attributed to scattered smallholdings spread over an estimated 1.6 million to 2.4 million hectares of land (Dada, 2007; Kajisa, Maredia & Boughton, 1997). In contrast, estate plantations occupy only about 169,000 to 360,000 hectares, most of it coming up over the last decade with private sector investment. In 2013, palm oil area harvested stood at about 3.2 million hectares while production was only 930 thousand metric tons (Figure 1). On the other hand, the trend in Figure 2 shows that total palm oil consumption has increased sharply to about 1.4 million metric tons in 2013 thus creating a gap between domestic supply and demand. To reconcile the supply-demand imbalance, Nigeria has increased its import of palm oil over the years. In 2013, imports stood within the vicinity of 518 thousand metric tons. Furthermore, Nigeria's exports of palm oil to the world market account for a minuscule and insignificant portion of world export of palm oil (Figure 2).



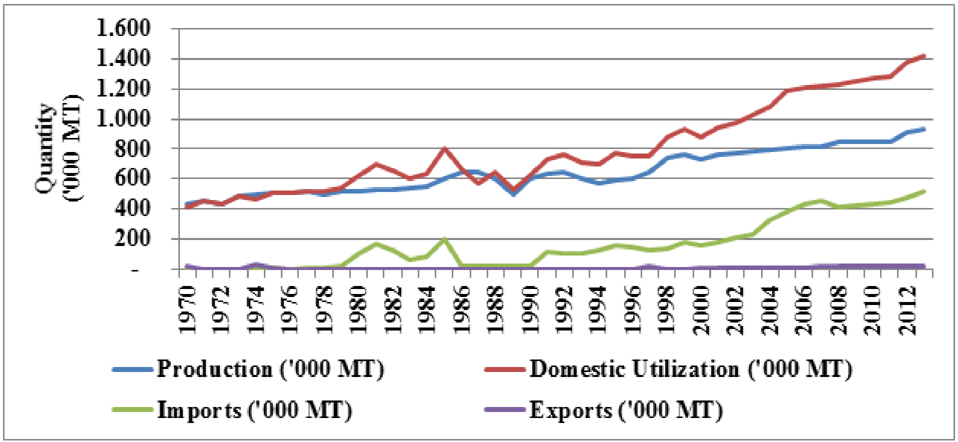
Source: FAOSTAT (2015), USDA (2015), CBN (Various issues)

Figure 1. Oil Palm Area Harvested (Ha) in Nigeria, 1970-2013

Against the backdrop of declining production, the government of Nigeria initiated a number of programs and policies with the aim of reviving the palm oil industry. For example, the Presidential Initiative on tree Crops (PITC) was set up in 1999 to stimulate vegetable oil production through: the cultivation of one million hectares of oil palm capable of producing 2.25 tons of palm oil; the production of five million tons of groundnuts per annum; the production of one million tons of cottonseed per year; and the production of 0.68 million tons of soybean oil per annum (Dada, 2007). Also, in 2012, the government unveiled a number of initiatives under the Agricultural Transformation Agenda (ATA) including the

[1] Most of these states are located in Southern Nigeria where rainfall is relatively stable.

launching of an oil palm value chain to recapitalize the oil palm plantation. The government also approved 4 million sprouted nuts of high-yielding oil palm seedlings to be distributed to farmers across the oil palm growing states in the country; about 1.3 million of these seedlings capable of establishing 9,300 hectares were distributed to 18 private estates at no cost to the farmers. In addition, a number of oil press machines were distributed to farmers to enhance the harvesting of fresh fruit bunches (FFB).



Source: FAOSTAT (2015), USDA (2015), CBN (Various issues)

Figure 2. Palm Oil Production, Utilization, Imports and Exports (Metric Tons) in Nigeria, 1970-2013

Despite governments' attempt to revamp the palm oil industry, there is yet to be seen any significant improvement. Thus, it is vital to investigate the interdependence between the critical market variables in the palm oil sector. In this study, we develop an econometric model of the Nigerian palm oil industry which may provide useful information concerning dynamic adjustments within the supply and demand components of the industry. Such insight on the behavioral relationships of the industry will serve as a tool for appropriate policy formulation. In the 1960s and up to the early 1970s, the Federal Government of Nigeria (FGN) set up commodity marketing boards with the aim of organizing the buying and selling of selected export crops including palm oil and palm kernel (Olagunju, 2008). Under this system, producers of agricultural commodities received predetermined prices for their products regardless of the costs of production. Through these boards the government envisaged the stability of producer prices by paying farmers guaranteed prices for their products, thus shielding domestic farmers from competition in the international market and fluctuations in world prices. In addition, it was designed to encourage farmers to increase production by cultivating marginal lands since they had full knowledge of the price they would receive for their products at the start of every production season. However, the operation of these boards was marred by irregularities and inefficiencies prompting their dissolution and replacement with seven National Commodity Boards in 1977 (Akanni, Adeokun & Akintola, 2005).

The new commodity boards, including the palm produce board, were also abolished in 1986 owing to inefficiencies and failure to provide the needed incentives to farmers to expand production. The pricing policies adopted by the marketing boards were not consistent which further aggravated the fluctuation in the prices of palm oil and also reduced the prices producers received relative to the world prices. This was because producers were heavily taxed by the commodity boards through the exercise of monopoly power in the buying and selling of export crops (Dada, 2007; Olayide, 1972). By abolishing these boards, the pricing system became market-based and domestic prices were influenced by the international markets. In recent years, however, there has been a growing clamor by different stakeholders for the re-introduction of commodity boards (Ibrahim & Yusuf, 2014; Iroegbu-Chikezie, 2015).

The paper is organized as follows. In section 2, we present a review of the literature on past studies on palm oil industry. Section 3 describes the model framework and also presents the specification of the various relationships in the model. Section 4 reports and discusses the empirical results while section 5 concludes the paper.

2. Literature Review

Econometric market models are the most extensively applied type of commodity modeling methodology and are used to quantify the relationships between key market variables by specifying a set of equations (Christ, 1994; Hallam, 1990; Labys, & Pollak, 1984). Generally, agricultural commodity market models find application in understanding structural relationships, policy impact analysis and forecasting of future market prices and quantities (Shamsudin, 2008). Empirical studies on agricultural commodity market models have appeared in the literature focusing on different types of agricultural commodities. For example, Bateman (1965) developed and applied an econometric model to Ghanaian cocoa production and found that prices of cocoa and coffee, rainfall and humidity were important determinants of output response. Dowling (1979) developed a model for Thailand rubber supply which relates rubber output to lagged price of rubber and lagged output of rubber and found that the output of rubber was significantly influenced by the explanatory variables in the model.

Similarly, econometric market models have been employed to quantify relationships between critical variables in the palm oil industry in different countries. In the case of Malaysian palm oil industry, Shamsudin, Mohamed and Arshad (1988) used an econometric market modeling approach to analyze the factors affecting the price of crude palm oil. They developed a market model comprising of production, demand, and price of palm oil and a closing identity was used to complete the system. Their results indicated that palm oil production was significantly influenced by the price of palm oil and palm oil production all lagged one year. Shamsudin et al. (1988) also found that domestic demand for palm oil was determined by current income and palm oil domestic demand lagged one year while the previous years' export demand and world income level were the major influencing factors for palm oil export demand. Furthermore, the result showed that the change in the stock level, the previous years' price of palm oil and the world price of palm oil were the factors that influenced the price of palm oil in Malaysia. In their study on the Malaysian palm oil industry, Talib and Darawi (2002) employed both the Ordinary Least Squares (OLS) and 2SLS methods to estimate behavioral equations reflecting supply and demand blocks of the palm oil market. They found that industrial production index, own and substitute prices, world population, exchange rate, technological advancement and palm oil stock levels have a significant influence on Malaysian palm oil industry.

For the case of Nigeria, there are relatively few studies which focus on the Nigerian palm oil industry and most of the existing studies are largely descriptive in nature (Ayodele, 2010; Dada, 2007; Gourichon, 2013; Olagunju, 2008; Nzeka, 2014). However, there are a few studies that have attempted to model aspects of the palm oil industry in Nigeria. For example, Oni (1969) utilized the Nerlovian partial adjustment model to examine short-run and long-run supply responses of palm produce. Annual data from 1949 to 1966 was used for the analysis and the results showed that output is price inelastic, with short-run and long-run price elasticities of 0.23 and 0.28, respectively. However, the study included only output and input prices as explanatory variables without considering other non-price variables.

Lukonga (1994) specified an export supply function for some selected agricultural export commodities in Nigeria. The study incorporated the effect of domestic demand in the export supply equations for cocoa, palm kernel, and rubber. The Ordinary Least Squares (OLS) estimation technique was adopted to analyze data covering the period from 1970 to 1990. The author found that the price elasticities of cocoa and rubber were statistically significant and with the expected positive signs. On the other hand, palm kernel yielded insignificant price elasticity with a wrong sign. By contrast, however, Ebi and Ape (2014) used palm oil rather than palm kernel in their study on supply response of agricultural export commodities in Nigeria. Using time series data for 1970 to 2010, the error correction model (ECM) approach was used to estimate export supply equations for seven agricultural commodities, including palm oil. Ebi and Ape (2014) found that the response of palm oil export supply to changes in relative price was significant and with the expected positive sign. The findings also indicated that exchange rate, output growth, credit, and rainfall have a significant influence on palm oil export supply.

The foregoing discussion suggests that while there are several studies on the palm oil industries in Nigeria and other countries, no empirical work could be found in the literature that examines the complete model of the Nigerian palm oil market. Additionally, it should be noted that developing and updating market models is a continuous process as economic models are subject to changes in economic phenomena. This study is an attempt to fill this gap.

3. Methodology

3.1. Model Framework

In this study we follow the classic market model advanced by Labys (1973) which has been used by other researchers such as Shamsudin and Arshad (1993), Shamsudin (2008), Shri Dewi, Arshad, Shamsudin, and Hameed (2011) and Wong, Shamsudin, Mohamed and Shariffudin (2014). In its compact form, the structural model consists of four equations that explain supply, demand, price, and inventory. Mathematically, the model can be expressed as follows:

$$S_t = s(S_{t-1}, P_{t-i}, N_t, Z_t) \quad (1)$$
$$D_t = d(D_{t-1}, P_t, P_t^c, A_t, T_t) \quad (2)$$
$$P_t = p(P_{t-1}, W_t, \Delta I_t) \quad (3)$$
$$I_t = I_{t-1} + S_t - D_t \quad (4)$$

where,
S_t = supply of commodity
D_t = demand for commodity
P_t = price of commodity
I_t = inventories or stocks
P_t^c = price of other commodities
P_{t-i} = price with lag i $(i = 1,2,3, \dots)$
N_t = natural factors
Z_t = policy variables influencing supply
A_t = income or economic activity level
T_t = technical factors

ΔI_t = change in inventory
W_t= shift factors

Equations (1) and (2) are respectively the supply and demand equations while equation (3) is the price equation postulated to be a function of excess supply (demand) and other shift variables (W_t). The inventory equation (4) is an identity that represents the market clearing condition. Although the basic market model framework consists of four equations, in practice a more complex and extended structure can be conceived and refined to reflect the particular features of the commodity and market of interest (Ghaffar, 1986; Hallam, 1990). For example, the inventory equation could be extended to incorporate international trade by admitting the addition of imports and the subtraction of exports. Also, the demand equation might be segregated into several parts explaining, for example, consumption, stocks and exports. In this study, we include a relation explaining imports in the model to reflect international trade. However, exports are excluded since the volume of Nigeria's palm oil exports is insignificant in the world market. In view of the above discussion, the structural econometric model of the Nigerian palm oil industry is specified and consists of four behavioral equations explaining production, imports, domestic demand and producer price of palm oil and two identities that determine domestic price and stocks. All variables in the behavioral equations are expressed in their logarithmic form in order to obtain direct measures of elasticities from the estimated coefficients.

3.1.1. Palm Oil Production

The specification of the supply response of Nigerian palm oil derives from the model employed by Alias and Tang (2005) and Shri Dewi et al. (2011). The supply of palm oil is postulated to depend on the producer price of palm oil, producer price of cocoa (a competing crop), interest rate, government expenditure on agricultural development, and a linear time trend. The linear trend is incorporated as a proxy for technological advancement. The lagged palm oil production is included to reflect the stock adjustment process (Bateman, 1969; Behrman, 1968; French & Matthews, 1971). Further, due to the long gestation period which characterizes perennial crops, palm oil supply in any given year depends on lagged prices (Hallam, 1990). Accordingly, we can write the palm oil supply function as follows:

$$NGPCQP_t = f(NGPCQP_{t-1}, NGPCFP_{t-i}, NGPPC_{t-i}, IR_{t-i}, GOVEX_{t-i}, Trend) \tag{5}$$

where,
$NGPCQP$ = Palm Oil Production in tons
$NGPCFP$ = Producer Price of Crude Palm Oil in ₦/ton
$NGPPC$ = Producer Price of Cocoa in ₦/ton
IR = Nigerian Average Lending Rate in percentage
$GOVEX$ = Nigerian Government Expenditure in Agricultural Development in Naira (₦)
$TREND$ = Time Trend as a Proxy of Technological Change
t = Time Period
i = Time Lag

In the above function, palm oil production is expected to be positively related to $NGPCQP_{t-1}$, $NGPCFP_{t-i}$, $GOVEX_{t-i}$, and $TREND$ and negatively related to $NGPPC_{t-i}$ and IR_{t-i}.

3.1.2. Import Demand

Nigeria is a net importer of palm oil and total palm oil supply consists of domestic production, beginning stocks, and imports. Conceptually, the import equation is similar to any other demand model (Carone, 1996; Goldstein & Khan, 1985; Mayes, 1981; Murray & Ginman, 1976). Based on microeconomic theory, the appropriate parameters that influence the demand for a commodity are derived from the maximization of a utility function with respect to prices and income (Nicholson, & Snyder, 2011). The relative price of imports, which is the ratio of import prices to domestic prices, is often used in the import equation in order to account for substitutability between imports and domestic products (Tang, 2008). Accordingly, the Nigerian demand for imports of palm oil is postulated to be a function of the relative import price of palm oil, gross domestic product, and price of a substitute vegetable oil (soybean oil). Also, the quantity of imports lagged one period is included in the model to explain the adjustments of import to price and income changes over time. This demand function is expressed as follows:

$$NGPCQM_t = f(NGPCQM_{t-1}, MRP_t, GDP_t, SYWP_t) \tag{6}$$

where,
$NGPCQM$ = Crude Palm Oil Import Demand in tons
MRP = Relative Price Ratio
GDP = Nigerian Gross Domestic Product in ₦
$SYWP$ = World Price of Soybean Oil in US$/ton

The a priori expected sign of the coefficients of $NGPCQM_{t-i}$, GDP_t, and $SYWP$ is positive while the coefficients of MRP_t is expected to be negative.

3.1.3 Domestic Demand

Palm oil domestic demand equation is based on the theory of derived demand because palm oil is used as input in the production of final food and non-food items such as cooking oil, soaps, pharmaceuticals, and other products. The domestic demand equation is adopted from Shamsudin and Arshad (1993) and Wong et al. (2014) and relates the quantity of palm oil demanded to its own price, Nigerian gross domestic product, the world price of soybean oil (price of a substitute), and lagged domestic demand. The domestic demand function can be written as follows:

$$NGPCQC_t = f(NGPCQC_{t-1}, PCDP_t, GDP_t, SYWP_t) \tag{7}$$

where,
$NGPCQC$ = Nigerian Crude Palm Oil Domestic Demand in Tons
$PCDP$ = Domestic Price of Palm Oil in ₦/ton
$SYWP$ = World Price of Soybean Oil in US$/ton

The quantity demanded is expected to have a positive relationship with $NGPCQC_{t-1}$, GDP_t, and $SYWP_t$. By contrast, $PCDP_t$ is expected to have a negative effect on domestic demand.

3.1.4. Producer Price

The price linkage block is made up of two equations: one structural equation that links the local producer price to the local consumer price (domestic price) of palm oil; and, an identity equation that associates the domestic price to the world price of palm oil. Thus, the producer price is determined by the domestic price as expressed in the function below:

$$NGPCFP_t = f(NGPCFP_{t-1}, PCDP_t) \tag{8}$$

where all the variables are as defined above. It is expected that the producer price will be positively related to $NGPCFP_{t-1}$ and $PCDP_t$. As a trade policy instrument, the Nigerian government applies a 35% import tariff as a measure to stimulate domestic production. Consequently, this creates a wedge between domestic and world prices of palm oil. Hence, the domestic price of palm oil is determined by an identity which includes the world price of palm oil, import tariff and Nigerian exchange rate. This relation is represented below:

$$PCDP_t = [PCWP_t\ (1 + TARIFF)] * NGXR_t \tag{9}$$

where,
$PCWP$ = World Price of Palm Oil in US$
$TARIFF$ = Import Tariff in percent
$NGXR$ = Nigerian Currency Exchange Rate in Naira/US$

3.1.5. Palm Oil Ending Stocks

A stock identity equation is specified to achieve the completion of the model. The Nigerian palm oil ending stocks are defined to be equal to the previous period's ending stocks plus the amount of palm oil produced plus imports, less the domestic demand. The lagged one-year ending stocks are assumed to be equal to the opening stocks of palm oil in the current year. The ending stocks are determined as follows:

$$NGPCES_t = NGPCES_{t-1} + NGPCQP_t + NGPCQM_t - NGPCQC_t \tag{10}$$

where,
$NGPCES$ = Palm Oil Ending Stocks in tons
$NGPCES_{t-1}$ = Palm Oil Opening Stocks in tons

3.2. Variable Classification and Sources of Data

This study uses secondary data from various sources. Annual data covering 1970 to 2011 are used for the estimation. A summary of the variables and data sources are presented in Table 1.

3.3. Estimation Technique

A major feature of most time series is the presence of trend, either stochastic or deterministic. Estimated regression results from such series are unreliable due to what is popularly known as the "spurious regression" phenomenon. To sidestep this problem, it was initially suggested that time series be differenced sequentially until they become stationary. However, it has been shown that useful long-run information in the data is lost when series are subjected to differencing (Granger & Newbold, 1974; Panik, 2009).

Table 1. Summary of Variables and Sources of Data

Variable Type	Acronym	Variable Definition	Unit of Measurement	Data Sources
Endogenous	NGPCQC	Crude Palm Oil Domestic Demand	Tons	USDA Online Database (2015)
Endogenous	NGPCES	Crude Palm Oil Ending Stock	Tons	USDA Online Database (2015)
Endogenous	NGPCQM	Crude Palm Oil Import	Tons	USDA Online Database (2015)
Exogenous	NGPCOS	Crude Palm Oil Opening Stock	Tons	USDA Online Database (2015)
Endogenous	NGPCQP	Crude Palm Oil Production	Tons	FAOSTAT, USDA Online Database (2015)
Exogenous	GOVEX	Government Expenditure on Agricultural Development	Naira	Central Bank of Nigeria (various issues)
Exogenous	IR	Bank Lending Rates	percentage	Central Bank of Nigeria (various issues)
Exogenous	GDP	Nigerian Gross Domestic Product	Naira	Central Bank of Nigeria (various issues)
Exogenous	NGXR	Nigerian Exchange Rate	Naira/US$	Central Bank of Nigeria (various issues)
Endogenous	NGPCFP	Producer Price of Palm Oil	Naira/Ton	FAOSTAT Online Database (2015), Central Bank of Nigeria, Nigeria Bureau of Statistics (various issues)
Endogenous	PCDP	Domestic Price of Palm Oil	Naira/ton	Nigeria Bureau of Statistics (various issues), Central Bank of Nigeria (various issues)
Exogenous	PCWP	World Price of palm Oil	US$/Ton	Malaysian Palm Oil Board (various issues)
Exogenous	SYWP	World Price of Soybean Oil	US$/Ton	Malaysian Palm Oil Board (various issues)

The concept of cointegration, first established by Granger (1981) and then used by Engle and Granger (1987), provided a major breakthrough in time series econometrics. Cointegration analysis provides a framework that permits the application of nonstationary data in such a way that the spurious regression phenomenon is circumvented. In this study, we use the Autoregressive Distributed Lag (ARDL) method advanced by Pesaran, Shin, and Smith (1996) and Pesaran et al. (2001) to examine the cointegrating characteristics of the estimated equations. A chief advantage of the ARDL technique is that it can be used regardless of whether all the variables are I(0) or I(1) or a mix of I(0) and I(1) variables, but not I(2). The ARDL framework allows for both the testing of long-run relationships as well as estimating the long-run parameters. What is more, it has been found to have good small sample properties relative to conventional cointegration testing techniques.

In its generic form, the Unrestricted Error Correction Model (UECM) representation of the ARDL specification is given as:

$$\Delta Y_t = a_0 + \sum_{i=1}^{p} b_i \, \Delta Y_{t-i} + \sum_{j=0}^{q} c_j \, \Delta X_{t-j} + \sum_{k=0}^{r} d_k \, \Delta W_{t-k} + \emptyset_1 Y_{t-1} + \emptyset_2 X_{t-1} + \emptyset_3 W_{t-1} + \varepsilon_t \tag{11}$$

In equation (11) Δ symbolizes the first difference operator, a_0 stands for the drift component, ε_t is the random error term with its classical attributes, and Y, X and W represent the variables in the structural equations.

The first step in the ARDL approach involves testing the existence of a long-run relationship by calculating the F-statistic and using this to perform a joint test of the significance of lagged variables. In mathematical notation, the null hypothesis is expressed as:

$$H_0: \emptyset_1 = \emptyset_2 = \emptyset_3 = 0$$

The null hypothesis of the non-existence of a long-run relationship is tested against the alternative of the existence of a cointegrating relationship, that is, the $\emptyset$'s are jointly different from zero. For large samples, Pesaran et al. (2001) provide two categories of critical values for the F-test: a lower bound and upper bound critical values. The former assumes all variables are I(0) while the latter reckons all variables to be I(1). In this study, however, we make use of the critical values provided by Narayan (2005) which accounts for small sample size. The null hypothesis is rejected if the computed F-statistic is greater than the upper bound, thus, establishing that the variables are cointegrated. In contrast, if the computed F-statistic is less than the lower bound we fail to reject the null hypothesis of no cointegration. The test is inconclusive in the event that the computed F-statistic falls within the band.

4. Empirical Results

4.1. Unit root and Cointegration Tests

In econometrics, the assumption of stationarity underlies statistical inference and thus a key aspect of any time series analysis is to establish the stochastic properties of all variables. Therefore, before we estimate the structural equations, preliminary analysis of the properties of the variables is conducted. The relevant test statistics based on the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests are reported in Table 2. The results from both tests reveal that all the variables, except MRP, are integrated of order one i.e. I(1); which indicates that all the variables, except MRP, are non-stationary in level but become stationary after being transformed to first differences. Meanwhile, MRP is found to be integrated of order zero (that is I(0)) by both tests, implying that it is stationary in level.

Table 2. ADF and PP Unit Root Tests

Variable	ADF		PP		Conclusion
	Level	First Difference	Level	First Difference	
NGPCQP	-0.839	-6.196***	-0.302	-11.543***	I(1)
NGPCFP	-0.938	-5.806***	-0.914	-5.799***	I(1)
NGPPC	-1.064	-4.702***	-0.899	-3.785***	I(1)
IR	-1.965	-6.851***	-2.191	-8.497***	I(1)
PCWP	-1.895	-7.765***	-2.338	-6.613***	I(1)
SYWP	-1.750	-8.029***	-2.288	-9.273***	I(1)
NGXR	-0.214	-5.249***	-0.320	-5.252***	I(1)
PCDP	-0.145	-6.484***	-0.054	-6.542***	I(1)
NGPCQC	-0.773	-6.903***	-0.435	-10.980***	I(1)
NGPCQM	-1.654	-6.510***	-1.792	-5.774***	I(1)
GDP	0.464	-4.894***	0.338	-4.906***	I(1)
MRP	-4.127***	-	-4.184***	-	I(0)
GOVEX	-1.876	-7.796***	-1.791	-7.927***	I(1)

Note: *** denotes significant at 1% significance level

Table 3 provides the ARDL Bound test of cointegration for the 4 structural equations under the null hypothesis of no long-run relationships among variables. This test uses the F-statistic and the computed value is compared with the critical values reported by Narayan (2005). Thus, a rejection of the null hypothesis will imply the existence of a long run relationship between the variables. As reflected in Table 3, the null hypothesis of no cointegration is conclusively rejected in all the equations, thereby suggesting a compelling evidence for the existence of a long run relationship among the regressors.

Table 3. ARDL Bound Test of Cointegration

Equation	K	Calculated F-statistic	Narayan (2005) Critical Values	
			I(0)	I(1)
NGPCQP	5	4.733**	2.962	4.338
NGPCQM	3	4.933**	3.548	4.803
NGPCQC	3	4.203*	2.933	4.020
NGPCFP	1	5.334*	4.235	5.000

Note: ** and * denote significant at 5% and 10% levels, respectively. K is the number of exogenous variables in the equation.

4.2. Estimated Long-run Coefficients

The long-run parameter estimates of the Nigerian palm oil market model along with their t-statistics are displayed in Table 4. Following Narayan (2004), we normalize the coefficients of the explanatory variables in each equation by the coefficient of the lagged-dependent variables to obtain estimated long-run coefficients. Additionally, diagnostic tests were performed to ascertain proper specification and the results are reported at the bottom of the table. The ARDL models were selected in line with Hendry's (2005) general to specific approach with an optimum number of lags selected using the Schwartz-Bayesian Criterion

(SBC). Results obtained are reasonably satisfactory in terms of statistical and economic criteria as reflected by the high R^2 and the significance and signs of the coefficients. Furthermore, the models satisfy all the diagnostic tests at the 5% level and the plots of CUSUMSQ for evaluating model stability are within the critical bands[2].

Table 4. Estimated Long-run Coefficients Using the Selected ARDL Model

Regressor	Palm Oil Production	Import Demand	Domestic Demand	Producer Price
Constant	13.924*** (7.570)	-4.807 (-0.773)	7.585*** (5.804)	0.677 (0.503)
$NGPCFP_t$	0.088** (2.707)			
$NGPPC_t$	-0.162 (-0.277)			
IR_t	-0.325 (-0.750)			
$GOVEX_t$	0.018*** (2.943)			
$TREND$	0.031*** (3.283)			
MRP_t		-0.720* (-1.783)		
$PCDP_t$			-0.138* (-1.810)	1.085*** (8.686)
GDP_t		0.468*** (3.127)	0.234*** (3.345)	
$SYWP_t$		0.577 (0.544)	0.128 (1.548)	
Adjusted-R^2	0.940	0.736	0.942	0.989
BG-LM	0.334[0.846]	0.496[0.780]	3.310[0.191]	5.398*[0.067]
JB	2.861[0.239]	2.544[0.280]	2.381[0.304]	4.139[0.126]
RESET	0.113[0.740]	1.534[0.224]	0.749[0.393]	0.438[0.512]
BP-G	10.315[0.112]	9.518*[0.090]	2.692[0.611]	0.585[0.746]

Note: ***, ** and * denote significant at 1%, 5% and 10% levels, respectively. Figures in parenthesis (…) are t-statistics while figures in brackets […] are p-values. The diagnostic test statistics are: BG-LM is the Breusch-Godfrey Lagrange multiplier test for serial correlation; JB is the Jarque-Bera test for normality of residuals; RESET is Ramsey's test for functional form misspecification; and BP-G is the Breusch-Pagan-Godfrey test for heteroscedasticity.

In the palm oil production equation, results indicate that palm oil producer price has a positive and statistically significant effect on palm oil production with a fairly low own price elasticity of 0.088. This indicates that a 1% increase in palm oil price will lead to an increase in the current palm oil production by about 0.088%, holding other factors constant. This small value of the own price elasticity means that Nigerian palm oil producers are predominantly unresponsive to price changes. The results further suggest that the coefficient of the price of cocoa, although having a reasonable sign, is statistically insignificant to influence palm oil production in Nigeria. Thus, cocoa is a substitute crop; an increase in the

[2] The plots of CUSUMSQ are suppressed due to space constraint. They are, however, available upon request.

price of cocoa will induce producers to shift resources away from palm oil production and vice versa.

The inclusion of the interest rate in the palm oil production equation is to account for the cost of borrowing and its coefficient carries a negative sign as expected and implies that the desire of agents to invest in palm oil production declines with an increase in interest rate. In other words, the incentive for firms to invest reduces as the cost of borrowing increases. However, the interest rate was found to be statistically insignificant suggesting that the interest rate is not important in influencing investors' decision on palm oil production in Nigeria. In addition, the results show that the estimated coefficient of government expenditure on agriculture (an indicator of government support) is positive and has a statistically significant effect on palm oil production. Thus, an increase in government expenditure will crowd in private investment in the oil palm sector. As expected, the coefficient of the time trend is positive and significant indicating that the use of technology, such as the use of high-yielding varieties and innovation in cultivation and management, is significant in determining palm oil production.

The results of the import demand equation indicate that palm oil import is negatively related to the relative price of import. Moreover, the coefficient of the relative price of import is statistically significant, indicating the importance of relative price as a determinant of palm oil imports. As expected, the coefficient of GDP, a measure of income, is positive and statistically significant in the long-run. The findings from this study are similar to income elasticity values reported by Wong et al. (2014).

In the domestic demand equation, only the own price and income have statistically significant influence on local palm oil demand. The coefficient of the own price is negative as expected and suggests that a 1% increase in the own price would decrease domestic demand by about 0.138%. This result is close to the elasticity value of 0.16 reported by Shri Dewi et al. (2011) in the case of Malaysia. Also, Talib and Darawi (2002) and Shamsudin, Fatimah and Fauziah (1997) recorded elasticity values of 0.388 and 0.242, respectively. The positive sign for the estimated GDP coefficient is in line with the argument of trade theory and also points to the fact that palm oil is a necessity good. Thus, as their income increase, consumers would consume more palm oil; however, the increase in consumption is less than proportional to the rise in income. The estimated coefficient of the world price of soybean oil is statistically insignificant but has the correct sign with a long-run cross-price elasticity value of 0.128. A similar conclusion was arrived at by Shri Dewi et al. (2011).

The movement of producer price of palm oil in Nigeria is influenced by the domestic price of palm oil as evidenced by the statistically significant coefficient of PCDP. Thus, a 1% increase in the domestic price of palm oil will lead to about 1.085% increase in the producer price in the long-run, holding other factors constant.

4.3. Estimated Error-Correction Models

Following the estimation of the long-run structural equations, we advance our analysis by estimating error correction models for the respective equations. The results of the error correction representation for the models are presented in Table 5.

As shown in Table 5, the lagged error-correction terms (ECT) are statistically significant and carry the expected negative signs. According to the Granger Representation Theorem (Engle and Granger, 1987; Granger, 1983), the existence of a long-run relationship among a set of variables implies that there exist a valid error-correction representation and vice versa. Thus, the estimates of the ECT obtained in this study provide further evidence that the variables are tied together in the long-run. In addition, the magnitude of the ECT reflects the speed of adjustment of any deviation towards the long-run equilibrium path. In particular, the size of the lagged ECT (-0.5) for the palm oil production equation indicates that about 50%

of the previous year's variation between the actual and equilibrium value of palm oil production is corrected for each year. Although this result is consistent with the theoretical prediction of the partial adjustment and adaptive expectation models (Askari & Cummings, 1977; Nerlove, 1958) which suggest that output will adjust but not fully, it should be noted that adjustments in palm oil production are not instantaneous but usually delayed for two or three production cycles. In the same vein, import demand has a modest rate of adjustment of 37% while the rate of adjustment for producer price is very low at about 14% per annum. Domestic demand, on the other hand, records a relatively fast rate of adjustment (57%) to the equilibrium.

Table 5. Short-run Dynamic Error Correction Representation for the Selected ARDL Models

Regressor	Palm Oil Production ($\Delta NGPCQP_t$)	Import Demand ($\Delta NGPCQM_t$)	Domestic Demand ($\Delta NGPCQC_t$)	Producer Price ($\Delta NGPCFP_t$)
Constant	-0.014 (-0.596)	-0.025 (-0.125)	0.002 (0.106)	-0.022 (-0.190)
$\Delta NGPCFP_t$	-0.004 (-0.108)			
$\Delta NGPPC_t$	-0.052 (-1.460)			
ΔIR_t	-0.145 (-0.515)			
$\Delta GOVEX$	-0.016 (-0.334)			
$\Delta TREND$	0.0003 (0.389)			
ΔMRP_t		-0.287** (-2.253)		
$\Delta PCDP_t$			-0.046 (-1.043)	0.286* (1.967)
ΔGDP_t		0.055 (0.067)	0.042 (0.452)	
$\Delta SYWP_t$		0.763* (1.729)	0.057 (0.977)	
ECT_{t-1}	-0.500*** (-3.624)	-0.368*** (-3.164)	-0.570*** (-3.933)	-0.139* (-1.768)

Note: ***, ** and * denote significant at 1%, 5% and 10% levels, respectively. Figures in parenthesis (…) are t-statistics. Δ indicates the first difference of variables and ECT_{t-1} denotes the error correction term.

5. Conclusions

In view of the importance of palm oil in Nigeria, the objective of this paper has been to develop and estimate a market model that will provide useful insight and better understanding of the structure of supply and demand of the Nigerian palm oil industry. The formulated model is made up of important components including a palm oil production equation; an import demand equation; an equation that predicts domestic demand for palm oil; and, a price equation. The empirical analysis based on the ARDL approach to cointegration suggests that our model performs adequately in terms of high R^2, expected signs and statistical significance of critical variables. We find compelling evidence for the existence of long-run relationships among variables in the structural equations.

Our findings reveal that in the long-run, the own price, government expenditure on agricultural development, and technological improvements are the chief determinants of palm oil production. The import demand and domestic demand appear to be shaped by the own price and income level. In addition, there is a correspondence between domestic price and producer price of palm oil. From a policy standpoint, therefore, a number of implications stand out.

The fairly low elasticity of palm oil price suggests that a substantial drop (rise) in palm oil price would only yield marginal effect in decreasing (increasing) output and hence factor use. Thus, incentives schemes that stimulate production and are cost-reducing should be provided to palm oil producers. Incentives schemes such as replanting grants, fertilizer subsidy, credit, storage and processing facilities are likely to stimulate production in the long-run. In addition, the importance of government expenditure in explaining output response of palm oil producers reinforces the need for government support in agriculture through the provision of infrastructures such as roads and electricity in the rural areas. Technological advancement is found to have a significant influence on palm oil production. Therefore, there is a need to increase investment in research and development (R&D) for the development of high-yielding varieties and innovation in palm oil production. Additionally, relevant mechanisms should be put in place to ensure the stability of the macroeconomic environment that will guarantee income growth of consumers and increase demand for palm oil. It is also recommended that counterfactual analysis that incorporates the effects of changes in these variables on the supply-demand components of the Nigerian palm oil industry should be pursued in future research.

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