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Testing for Asymmetric Cotton Lint Supply Response to Price in Nigeria: Evidence from Nonlinear Autoregressive Distributed Lag (NARDL) Model

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ABSTRACT

The study tests for supply response of cotton lint to price changes in Nigeria over the period 1966-2018. To achieve this objective, both linear and Nonlinear Autoregressive Distributed Lag Model (NARDL) were employed to assess which of the models performs better. The study found that nonlinear model performs better than the linear model in analyzing cotton lint supply response. Implying from the result obtained, there is an ample opportunity for price-support programs to improve cotton lint supply if policy makers such as the CBN and the Federal Ministry of Agriculture and Rural Development (FMARD) take into account the differential response of cotton lint supply to positive and negative price changes. Based on this finding, the study concludes that the theoretical relationship between cotton lint supply and its price is best captured in a nonlinear model specification. Therefore, it recommends that CBN and Ministry of Agriculture policy designs should incorporate the differential response of cotton lint supply to price changes.

INTRODUCTION

Nigerian economy, despite its dependence on oil as the major export commodity, has continued to be agrarian since 1960s. Due to this significance, the sector to a large extent, dictated the pace of growth and development of the Nigerian economy until the oil-boom period of the 1970s when its share to the Gross Domestic Product (GDP) fall to less than 15%. However, the continued significance of agricultural sector to the Nigerian economy manifested itself through its contribution to the recovery from the 2016 recession. For example, it contributed about 3.5% - 4.3% percent growth leading to the economy's exit from the recession in 2017 [1].
In view of these, agricultural policy interventions aimed at ensuring food security and improving foreign exchange earnings for the economy. However, Devadoss and Luckstead (2020) observed that most of the instituted policy

measures have negative effects on the welfare of the cotton farmers in both within and outside the economies involved. This is because the policies induced a significant growth in the output which consequently crashed the market price. Cotton is one of such commodities that have witnessed such distortions globally but has begun to attract the attention of policy makers and researchers alike due to its spill-over effect on less-cotton producing economies like Nigeria.

In response to this spill-over, the federal government initiated policies and programs such as Agricultural Transformation Action (ATA, 2012) whereN54 billion was injected to improve cotton production to 325,000 bales but output declined dramatically to 260,000 in 2013 and 200,000 bales in 2014 and it remains below that target since then (USDA, 2019). However, despite all these efforts, cotton production has continued to experience a consistent decline in Nigeria. More recently, it was observed that cotton farmers in Zamfara state are gradually shifting to the production of competing crops such as soybeans. Consequently, the cotton lint supplied was only 30,000 bales while the quantity demanded by Textile mills was about 100,000 bales in 2017. This leaves a gap of about 70,000 bales which consequently, forced textile mills to either import to cover the deficit in local supply or operate below capacity. These negative developments are of great concern given the current high domestic demand for cotton lint which leads to more foreign exchange being devoted to the importation of the commodity to meet local demand (Aminu, 2019). To encourage its domestic production, the Central Bank Nigeria in 2019 ban access to foreign exchange at official rate for the importation of textile and other cotton-allied materials into the country, citing high import bill and a plan to revive the local cotton industry (Emiefele, 2019).

MATERIALS AND METHODS

There are ample empirical studies on cotton supply response and these studies can be broadly classified into two main categories. The first category use linear models and, except Sial, Shafique and Zakir (2007), produce evidence that the long run supply response to changes in price is inelastic. These studies include Mahofa, (2007); Vitale et al., (2009); Sial, et al, (2007); Ozkan and Karaman(2011); Ammani (2012); Ebi and Ape (2014); Haile, Kalkuhl, and Braun (2015); Dupdal, and Patil (2018). They used estimation techniques such as Ordinary Least Squares (OLS), Autoregressive Distributed Lag Model (ARDL), Error Correction Model (ECM), Two-Staged Least Square method, and System Generalised Method of Moments (system GMM) [2].

The above studies show that the long run cotton supply response is inelastic which implies that price support policies will have very little or no impacts on cotton supply response. All the studies are based on the assumption that agricultural supply response is symmetric or reversible. But agricultural producers' reaction to positive and negative price changes is asymmetric (Surekha, 2005). This kind of behavior is quite different from the situation where the variables of interest move together and any deviation from equilibrium is adjusted in a symmetric manner (Goshray, 2008).

The second category use nonlinear models and find that supply response to price changes is nonlinear and also elastic in the long run. These studies include; Jaforullah, (1993); Surekha, (2005). These studies employed nonlinear Least Squares methods and produced evidence that supply response is elastic in the long run. Their finding (that supply response is elastic) implies that price-support policies will have an important role to play in changing cotton farmers' supply response decisions. But this can only be observed if the differential effects of changes in price on cotton supply is taken into account [3].

In summary, the literature based on linear models indicated evidence of mixed findings. All the studies, except Sial et al, (2007) ; Ebi and Ape (2014), have shown that cotton supply response is inelastic in both the short run and long run. On the contrary, the second category (those based nonlinear models) produced positive and elastic long run cotton supply response estimates. This is in line with Surekha (2005) who concluded that supply response estimates are often sensitive to the model specification used.

This section presents the theoretical framework of analysis, estimation techniques and data description used in the study.

Theoretical Framework

The study used the Nerlovian model which allows analysing both the speed and the process of adjustment from actual towards the desired output level (Haile, et al., 2015; Magrini et al., 2016). Hence the following specification:

$$Q_t^* = \alpha_1 + \alpha_2 P_t^* + \alpha_3 Z_t + U_t \quad \text{.......} (3.1a)$$

Where Qt* is the desired area to be cultivated in period t; Pt* is expected own and competing crops' real prices; Zt represents a set of input price, rainfall etc and ut represents random factors affecting acreage under cultivation. In the literature, three variables are used as proxies for output: Acreage allocation to crop, production quantity, and yield (Magrini et al. 2016; Haile et al, 2015). The former is however, preferred to the latter two because it is not subject to the vagaries of nature that occur after planting, hence it is fully under the farmers' control (Askari and

Cummings, 1977). This study therefore, used acreage allocation as a proxy for cotton output supply as in Magrini et al., (2015).

$$Q_t = \lambda\ Q_t^* + (1-\lambda)\ Q_{t-1} + \ell_t \ = \quad + \qquad \text{..(3.1b)}$$

Where ( ) is the desired change in output, and λ is the adjustment coefficient. Equation (3.1b) states that actual change in output in period t is a fraction of the desired change for that period. The farmers' price expectation formation is based on adaptive expectation hypothesis expressed as:

$$p_t^* = \delta P_{t-1} + (1-\delta)P_{t-1}^* + \ell_t \qquad \text{..(3.1c)}$$

Where Pt* and Pt-1* are the current and previous period cotton lint expected price, pt-1 is the actual price in the previous period, and is the expectation coefficient. The unobservable variables P* and Q* are eliminated in the reduced form below from equation (3.1.a), (3.1.b) and (3.1.c) and expressed in log form so as to interpret the parameters as elasticity coefficients (Leaver, R. 2003 and Magrini et al, 2016):

$$InQ_t = b_0 + b_1 InP_{t-1} + b_2 InZ_t + b_3 InQ_{t-1} + V_t \qquad \text{..(3.2.a)}$$

Testing for Co integration under Linear ARDL Specification

We follow the lead of Ozkan and Karaman (2011) to use Autoregressive Distributed Lag model to estimate the bound test using the linear ARDL specification in order to check for the possibility of linear co-integration among the variables under study. Furthermore, because our sample size is relatively small (53 observations), we used Narayan's critical values for F-statistics. Hence, we specify the Autoregressive Distributed Lag model as follows;

$$A_t = \sum_{j=1}^{p} \rho A_{t-j} + \sum_{j=0}^{q} \alpha_2 Inp_{t-j} + \sum_{j=0}^{q} \alpha_3 Inpcs_{t-j} + \sum_{j=0}^{q} \alpha_4 Inpsb_{t-j} + \alpha_5 R_t + \varepsilon_t \quad \dots \quad \dots\dots\dots\dots\dots \quad 3.1$$

If the F-statistics FPSS / tBDM is greater than the upper bound critical value as tabulated in Narayan (2005), we reject the null hypothesis of no (symmetric) co-integration and accept the alternative of co-integration among the variables under study (Pesaran et al., 2001).

Testing for Cointegration under Nonlinear Specification

We follow the lead of Shin et al. (2014) to specify the non-linear Autoregressive Distributed Lag model (NARDL) (p; q) by disentangling the price variable in to positive and negative price changes so as investigate the existence (or otherwise) of co-integration under asymmetric specification as follows;

$$A_t = \sum_{j=1}^{p} \rho A_{t-j} + \sum_{j=0}^{q} (\alpha^+_2 Inp^+_{t-j} + \alpha_2^- Inp^-_{t-j}) + \sum_{j=0}^{q} \alpha_3 Inpcs_{t-1} + \sum_{j=0}^{q} \alpha_4 Inpsb_{t-1} + \alpha_5 R_t + \varepsilon_t$$

..............3.2

The null hypothesis of no long run relationship among the variables will be tested using Fpss and tBDM bound testing approach of Narayan, (2005) as in the case of the linear ARDL model above.

Data Sources and Description

The study use annual data on the variables of interest; Cotton Acreage, Consumer Price Index (CPI), Cotton lint nominal Price, Soybeans nominal price, cotton seeds nominal price and annual precipitation. Data on Consumer Price Index are drawn from the International Monetary Fund (IMF), cotton acreage are from the United State Department of Agriculture (USDA), cotton lint, cotton seeds and soybeans nominal prices are obtained from Food and Agricultural Organization statistical database (FAOSTAT), while annual precipitation (Rainfall) data are sourced from the World Bank database. All the price data have been transformed into logarithmic form so as to normalize and calculate the coefficients as elasticity [4].

RESULTS AND DISCUSSION

The Stochastic Properties of the Variables

This presents the results obtained from Augmented Dickey-Fuller (ADF) and Phillip-Perron tests. The results show that all the variables, except soybeans and area harvested, are stationary at levels I(0), the soybeans price and area harvested are however, stationary only at first difference, suggesting that they are integrated of order one, I(1). The results from Phillip-Perron test is also in agreement with that of the ADF's (Table 1).

Table 1. Results of ADF and Phillip-Peron tests.

Variable	T-stat at levels	T-stat at first difference	Inference	T-stat at level	T-stat at 1st difference	Inference
$lnAREA_t$	-2.25094	-6.767780*	I(1)	-2.55949	-6.78063*	I(1)
$lnRCLP_t$	-3.71094*	-	I(0)	-3.73345*		I(0)
$lnRCSP_t$	-0.38757*	-	I(0)	-3.92384*		I(0)
$lnRSBP_t$	-0.39108	-3.043501*	I(1)	-0.77488	-9.62719*	I(1)
lnRNF	-5.97876	-	I(0)	-6.02372*	-	I(0)

ADF critical values are -4.15673, -3.50433 and -3.18183. While that of Phillip-Perron are 4.14458, -3.4986, and -3.17857 at 1%, 5%, and 10% respectively.

Because the data cover a relatively long period of time (1966-2018), structural break may have a permanent effect on time series pattern which could be mistaken for unit root when the data is in fact stationary. Ignoring these breaks as argued by Perron (1989) might reduce the power of the rejection of the null hypothesis when the alternative is true. We therefore, follow Ogundari (2016) and used modified Augmented Dickey Fuller test which takes into account the possibility of structural breaks in testing the unit root of variables. This presents the unit root tests with structural break based on modified ADF test statistic. The results show that all the variables have the same order of integration as those earlier obtained from the conventional ADF and Phillip-Perron methods. Hence, we conclude that there is no evidence of structural break in the data (Table 2).

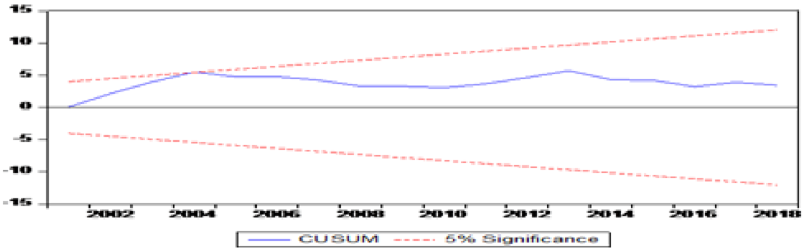
Table 2. Modified ADF Tests.

VARIABLES	LEVEL	1st Difference
AREA	-3.91394	-7.751946***
lnRCLP	-6.4658***	
lnRCSP	-5.8266***	
lnRSBP	-1.9026	-10.26324**
lnRAIN	-6.3165***	

Cointegration Tests under both Linear and Nonlinear Models

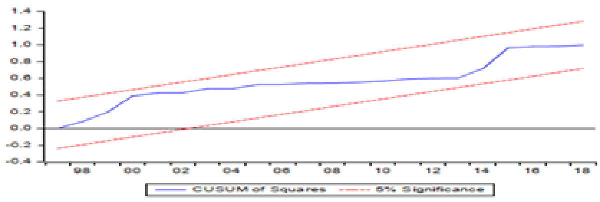
The results from Table 4.3 show that the calculated F-statistics result (4.501847) from the linear model is less than the upper bound F- statistics calculated at 5% level of significance (4.70) (Figure 1).

Figure 1. NARDL CUSUM.



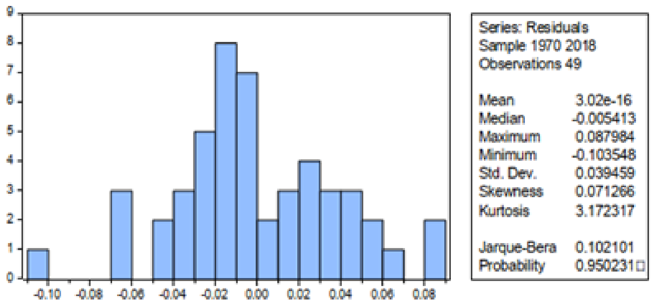
Therefore, we conclude that the symmetric model does not support the presence of long run relationship between cotton lint supply and the explanatory variables. Furthermore, the T-statistics of 3.134 also supports the null hypothesis of no long run relationship among the variables as the estimate is lower than the upper bound critical value of -3.78 (Figure 2).

Figure 2. NARDL CUSUM OF SQUARES.



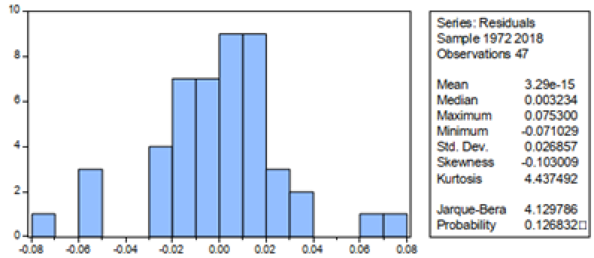
The acceptance of the null hypothesis of no co-integration among the variables suggests that real cotton lint price and the explanatory variables are not linearly cointegrated [5]. This implies that cotton lint supply response may be nonlinear, indicating possible existence of nonlinear cointegrating relation among the variables (Figure 3).

Figure 3. ARDL NORMALITY TEST.



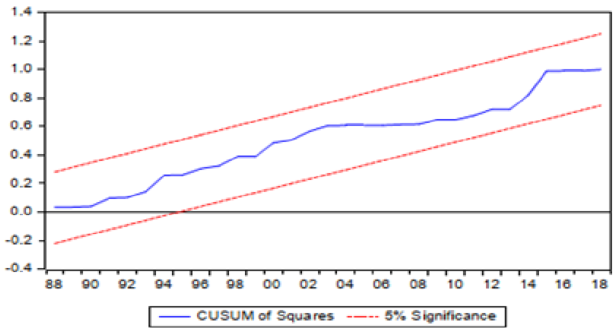
However, it remains an empirical question that section 4.3 will address. The absence of symmetric supply response can be explained by the fact that most of the factors that affect acreage allocation decision (eg Assets specificity) exhibit non-linear behaviour which means that linear specification could be a misspecification of the actual functional form (Figure 4).

Figure 4. NARDL NORMALITY TEST.



However, the F-statistics calculated from the nonlinear ARDL model is greater than both the lower and upper bound critical values at 5% level of significance. This indicates asymmetric long run relationship between cotton lint supply and the explanatory variables in the estimated model (Figure 5).

Figure 5. ARDLCUSUM OF SQUARES.



Hence, the cointegrating relationship is therefore nonlinear. Given this result, we select the nonlinear model. This is because theory of supply predicts a long run relationship between quantity supply, cotton lint price and other explanatory variables. This result supports Kohli (1996) and Jafaroullah (1993) who showed that most agricultural output response to price have tendency to exhibit nonlinear behavior (Tables 3 and 4).

Table3: Cointegration Tests for Linear and Nonlinear Models.

Model specification	**F-statistics**	**CV (5%)** **I(0) I(1)**	**CV -0.01** **I(0) I(1)**	**T-Statistics**	**t-Bound CV (5%)** **I(0) I(1)**	**t-Bound Test CV (1%)** **I(0) I(1)**	
Linear ARDL (2,4,4,3)	FPSS ARDL 4.501847	3.5 4.7	4.86 6.36	-3.13459	2.86 3.78	3.43 4.37	Not Cointegrated
Nonlinear ARDL model	FPSS NARDL 9.393	3.14 4.42	4.31 5.87	-6.2522	2.86 3.99	3.43 4.6	Cointegrated

Table 4. Diagnostic Checks.

	Linear	**Probability**	**Nonlinear**	**Probability**

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LM Test	0.13944	0.7093	0.053	0.9485
Jarque-Bera	0.1021	0.9502	4.1297	0.1268
F_{Reset}	0.0014	0.7904	0.7881	0.3847
Fhet	0.60617	0.8613	0.5712	0.9082
DW	2.29429		2.0646	

Diagnostic tests were also conducted to check the model reliability in terms of its prediction and for policy recommendations, the LM and Breusch-Godfrey tests show that the model are free from serial correlation and heteroscedasticity respectively. Also, the Jaque-Bera normality test indicated that the errors are normally distributed. Furthermore, both CUSUM and CUSUMSQ tests in figure show that the models are stable as both lie within the critical bound at 5% significance level; while Ramsey RESET test shows that the models are correctly specified.

CONCLUSION

This study examined the response of cotton lint supply to price incentive in Nigeria and the paper finds as follows: The theoretical relationship between cotton lint supply and price is better understood within the context of nonlinear model.

Since policy recommendations based on the inappropriately specified cotton lint supply response models could be very costly, there is need for researchers to embrace the use of modern econometric techniques such as nonlinear ARDL in tracing the cotton lint supply response to price in Nigeria. Furthermore, policy makers such as CBN and Ministry of Agriculture's policy designs should incorporate the differential response of cotton lint supply to price changes. Future research should study the level of positive cotton lint price change required to stimulate cotton lint farmers to return from competing crops to cotton lint production.

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