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Effects of rainfall on rubber yield in Nigeria

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ABSTRACT

The study examined the effects of rainfall and other factors on rubber yield in Nigeria for the period 1970 to 2012. The methods of analysis employed in the study were mainly error-correction model (ECM) within the context of co-integration theory. The results show that all the variables were not stationary at their levels and thus, they were difference once to attain stationary. Statistical significance of the error-correction term validates the existence of an equilibrium relationship among the variables. Rainfall was most significant, indicating that increase in rainfall will affect rubber yield as this will reduce the number of tapping days of rubber stands. Rubber prices were also found to determine rubber yield in Nigeria. The study therefore recommends that rain guard should be attached to rubber stands during the raining season to prevent the washing away of latex by rain.

Key words: rainfall, rubber yield, co-integration, error correction model, Nigeria.

1. INTRODUCTION

Agriculture is vital to livelihoods in Nigeria as it is the main source of employment for over 65 percent of rural dwellers and accounts for 35 percent of Gross Domestic Product (GDP). Agriculture as important as it is to the lives of Nigerians, it is rain fed and as such highly impacted by the vagaries of climatic factors okoh (2015). Generally, there are many factors influencing crop production and these include soil, climate and diseases among others. In relation to climate, rainfall is the dominant controlling variable in tropical agriculture since it supplies soil moisture for crops and grasses for animals (Afunmilayo, 2016; Ale et al. 2016). According to Ayoade (1983), agriculture largely depends on climate to function. Hence, precipitation, solar radiation, wind, temperature, relative humidity and other climatic parameters affect and solely determine the global distribution of crops and livestock as well as their productivity. Rainfall, among other factors, has always dictated how land is used in one way or another and it also affects the humidity condition of the atmosphere. Rainfall determines the vegetation cover of a particular geological zone and crop distribution. Heavy rainfall facilitates the growing of tree crops like cocoa, rubber, oil palm possible in the rainforest. Some of the attributes of rainfall that are important to crop production are the time of onset of the raining season, total amount of rainfall, distribution, number of rainy days and duration of rainfall as well as the time of its cessation (Akintola, 1995). Furthermore, rainfall determines the amount of moisture present in the soil which is ultimately made available to plants. Water plays a vital role in the growth of plant and it provides the medium through which nutrients are carried through the plant. According to Olaoye (1999), regular occurrence of drought as a result of erratic rainfall distribution and/or cessation of rain during the growing season reduce Nigeria's capability for increased crop production. Sdoodee and Rongsawat (2012) concluded that high rainfall tended to decrease tapping days per year. From the results, it was suggested that climate change and climate variability in Songkhla province tends to reduce latex yield because of an increase of rainfall leading to a reduction of tapping days. Mesike and Esekhade (2014) & Mesike et al. (2015), in their work on rainfall variability and rubber production in Nigeria reported an inverse relationship between rubber production and rainfall.

Climate change impact assessments done by the Intergovernmental Panel on Climate Change (IPCC) (2007) and Buddenhagen *et al.* (1992) conclude that rain fed agriculture in Africa risks negative impacts due to climate change. Rain fed agricultural production in Africa in general is projected to be reduced by up to 50% by 2020 (IPCC, 2007). Akintola (1983), studying the effects of agro climatic factors on some selected food crops such as cowpea, yam, rice and maize in Ibadan. Following his correlation and regression analysis, the responsiveness of each crop yield to specific agro climatic variables (rainfall, temperature, sunshine and humidity) was determined. Based on his findings, it was known that rainfall has statistically significant effect on yields of rice, cowpea and yam. Adubi (1986), using methods similar to those used by Akintola, found out that rainfall, rainy days and technology have positive effects on the yield of groundnut and cowpea and accounted for 56% and 52% variations in total yields respectively in Oyo State. Total rainfall was said to have a negative effect on yield of yam in all of Oyo, Ogun, Ondo and Bendel States of Nigeria; and also on the yields of cowpea particularly in the last growing month.

2. MATERIALS AND METHODS

Sources Data

The empirical analysis covers the period between 1970 and 2012. Secondary data used for the analysis were obtained from Nigeria Meteorological Agency (NIMET), Central Bank of Nigeria (CBN) publications, such as Annual Reports and Statements of Accounts, and the Statistical Bulletin. Rainfall data used for this study were obtained from NIMET and the data related specifically to Delta state where over 70% of Nigeria rubber is produced was used. Data on rubber yield were obtained from Food and Agriculture Organizaton Statistics. Also, data on producer prices and exchange rate were also collected over the period from Central Bank of Nigeria (CBN) Publications and International Financial Statistics Year Book.

Method of Data Analysis

The study employed the Error Correction Model (ECM) within the context of co-integration theory to analyze the data. The estimation procedure was used to overcome the problems of spurious correlation often associated with non-stationary time-series data. Further, the procedure is able to generate long run relationships (Engle and Granger, 1987; Hendry, 1986; Johansen, 1988; Johansen and Juselius, 1990; Goodwin and Schroeder, 1991; Hallam et al., 1994).

In using Error Correction Model (ECM), the first step is to assess the order of integration both the dependent and independent variables in the model. The order of integration ascertains the number of times a variable will be difference to become stationary. Dickey-Fuller statistics (DF) and Augmented Dickey-Fuller statistics (ADF) was used in this study to test the stationary of individual series (Dickey and Fuller 1981). The DF and ADF test procedure is indicated in equations 1 and 2.

$$\Delta X_t = \alpha_o + \delta X_{t-1} \quad (1)$$

$\Delta X_t = \alpha_o + \delta X_{t-1} + \Sigma \beta_j \Delta X_{t-1} + e_t$ (2)

Where t is the time or trend variable, e_t is a pure white noise error and $\Delta X_{t-1} = (X_{t-1}-X_{t-2})$.

The decision rule states that the t-statistics on the coefficient of the variable δ, 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 establishing the stationary properties of the individual series, linear combinations of the integrated series were tested for cointegration. Cointegration is a test of stationarity of the residuals generated from running a static regression at levels of one or more of the regressor variables on the dependent variable.

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 cointegration paradigm will guard against the loss of information from long-term relationships in the first differences. 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 effects of rainfall and prices on rubber yield in Nigeria. The estimated equation is:

$\Delta Y_t = \beta_0 + \beta_1 \Delta RF_t + \beta_2 \Delta P_t + \beta_3 \Delta P_{t-1} + \beta_4 EX_t + \beta_5 GDP_t + \beta_6 ECM_{(-1)} + \delta_t$ (3)

Where Δ is the difference operator, Y_t is rubber Yield, RF_t is rainfall in time t, P_t is the average producer price in time t, P_{t-1} is the average producer price of the previous year, EX_t is the official exchange rate in time t, GDP_t is te Gross Domestic Product in time t, ECM $_{(-1)}$ is the error correction factor and δ_t is the stochastic error term assumed to be independently and normally distributed with zero mean and constant variance. The *a priori* expectation is that rainfall, producer price and exchange rate are expected to have positive relationship with rubber yield. While ECM $_{(-1)}$ is expected to have negative signs. The coefficient of the ECM when it is statistically significant gives credence to the existence of co integration.

3. RESULTS AND DISCUSSIONS

Table 1 presents the results of the Augmented Dickey-Fuller (ADF) classes of unit root tests. The tests were applied to each variable over the period of 1970-2012 without a time trend at the variables level and at their first difference. The ADF tests strongly support the null hypothesis that all the variables are not stationary at their level. This indicates that the variable are I(1) and any attempt to specify the dynamic function of the variable in the level of the series will be inappropriate and may lead to problems of spurious regression. In essence, the econometric results of the model in that level of series may not be ideal for policy making

The Engle Granger two-step procedure was adopted to test for co-integration of rubber yield with the explanatory variables. This was done as a condition for accepting the Error Correction Mechanism (ECM) model. Cointegration would be accepted if the residuals of the series that were I (1) are in fact I (0). The test tries to establish whether there was long-run relationship between the dependent variables and their fundamentals. The result of the cointegration tests conducted shows that the absolute value of the ADF test statistic was greater than its critical value at 1%, so cointegration was not rejected (Table 2). The results indicated that rubber yield

Cointegrate with the explanatory variables. The existence of cointegration implies that there is a long-run equilibrium relationship between the variables used in the model.

Table 1 Test for order of Integration Using ADF Test

Variable	ADF Test Statistic	Critical Value at 95 %	Critical Value at 99 %	Remarks
RF_t	1.930034	-2.881830	-3.476805	Non Stationary
P_t	-1.897484	-2.882433	-3.478189	Non Stationary
P_{t-1}	-2.692195	-2.881978	-3.477144	Non Stationary
EX_t	1.742532	-2.881685	-3.476472	Non Stationary
GDP_t	-1.934272	-2.881685	-3.476452	Non Stationary
ΔRF_t	-9.343011	-2.882279	-3.477835	Stationary

ΔP_t	-11.96992	-2.882748	-3.478911	Stationary
ΔP_{t-1}	-13.15375	-2.881978	-3.477144	Stationary
ΔEX_t	-9.881112	-2.881830	-3.476805	Stationary
ΔGDP_t	-8.472896	-2.882315	-3.474673	Stationary

Table 2 Cointegration Test for Rubber Yield

Variable	Coefficient	Standard Error	t-statistics	Probability
Constant	77939.99	7789.960	10.00519	0.0000
RF_t	0.312944	0.125372	2.496120	0.0145
P_t	0.070170	0.569369	0.123243	0.9025
P_{t-1}	473.7607	225.2918	2.102876	0.0382
EX_t	221.6078	305.7129	0.724889	0.4728
GDP_t	8.628162	7.217606	1.184181	0.1954
	t-statistics	**Critical value at 1% level**	**Critical value at 5% level**	**Critical value at 10% level**
ADF	-4.421964	-3.8274716	-2.918375	-2.472946

The existence of cointegration among the variables necessitated the specification of ECM for the effect of rainfall and prices on rubber yield in Nigeria. The result of the ECM in Table 3 shows that the error-correction term has the expected negative sign and statistically significant at 1% confirming cointegration of rubber yield with the explanatory variables. The ECM indicates a feedback of about 52.70% of the previous year's disequilibrium from the long-run values of the explanatory variables. The adjusted R^2 of 0.63 indicates that the independent variables explain 63% of the variations in the dependent variable. Rainfall was negatively significant at 1% while average producers price and average producers price of the previous year were positively significant 5%. The Significance of the rainfall indicates that decrease in rainfall will increase rubber yield. This may be due to the fact that rainfall usually affects tapping operation. The positive significance of the prices implies that as the price increases farmers would be encouraged to improve management techniques thereby increasing yield.

However, in proceeding from the general error correction model to the parsimonious model, variables that had low statistics and were not significant were eliminated. This was done in order to detect the most significant variables that mostly influenced rubber yield. The final and parsimonious model is presented in Table 4.

Table 3 General Error Correction Model of Rubber Yield

Variable	Coefficient	Standard Error	t-statistics	Probability
Constant	4.932456*	0.588214	8.385474	0.0000
RF_t	-0.184274*	0.034116	-5.401395	0.0012
P_t	1.287482**	0.546644	2.355248	0.0373
P_{t-1}	1.517175**	0.608712	2.492437	0.0245
EX_t	176.8441	127.3385	1.388772	0.1686
GDP_t	8.426783	7.116126	1.184181	0.4283
$ECM_{(-1)}$	-0.527054*	0.097321	5.415625	0.0000
Adjusted R^2	0.63			
F-statistics	18.56*			
Schwarz Criterion	17.72			
DW	1.81			

*, ** indicate significance at 1%, and 5% probability level. Values in parentheses are the corresponding probability level

Table 4 Parsimonious/Restricted Error Correction Model of Rubber Yield

constant	RF_t	P_t	P_{t-1}	$ECM_{(-1)}$	R^2	F	DW	SC
5.113034	-0.197643	1.289546	1.5362841	-0.572417	0.65	19.62	2.12	19.21
(8.423136)	(-5.863527)*	(2.355482)**	(2. 492345)**	(5.721316)*				

The values in parenthesis are corresponding t values

* Significant at 1%, **significant at 5%, DW = Durbin-Watson statistic, Sc= Schwartz information criterion

4. CONCLUSION

Rainfall was most significant factor affecting rubber yield in Nigeria. Increased rain days will affect rubber yield as this will reduce the number of tapping days of rubber stands. Based on this findings, the study therefore recommend that rain guard should be attached to rubber stands during the raining season to prevent the washing away of latex by rain.

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