

Effect of Fertilizer Consumption in Nigeria and Rate of Naira Exchange to the US Dollar on Sorghum Acreage between 1960 and 2006

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ABSTRACT The effect of aggregate fertilizer consumption ('000 metric tons) and the rate of Naira exchange to the US dollar on sorghum acreage between 1960 and 2006 were investigated. Various secondary data used were analysed using cointegration techniques and error correction modelling. Results indicate that fertilizer consumption and US dollar rate were well cointegrated with sorghum acreage although fertilizer consumption did not exhibit any strong relationship with sorghum acreage when US dollar rate was included in the cointegrating model. There was no associated error correction model and there was no indication of any kind of granger causality. This means that long-term neutrality of change does not exist, only short term dynamics is observed. It really shows that policy instruments with respect to the variables under study were not effective during the period under study. It also indicates that policy instrument alone cannot adequately correct for the temporary shocks to sorghum acreage. Therefore, an integrated approach and networking between agencies and participants in the commodities market is advocated and this will ensure food sustainability and the achievement of millennium development goals.

INTRODUCTION

Sorghum is a native of Africa and has much untapped potentials (NRC 1996; Chantreau and Nicou 1994) which can be used to enhance food security of the farm family, bring about self-sufficiency in agriculture and helping to conserve funds that are used to import food to Nigeria. This will ultimately reduce poverty thus achieving one of the key Millennium Development Goals (MDGs). However, in addition to other numerous problems, sorghum productivity in Nigeria is low compared to other countries of the world. For example, while yield in kg/ha in Nigeria is around 1000, it is about 3000 in China, 6000 in US and 2000 in Mexico (NRC 1996). Among the factors affecting sorghum productivity are lack of acreage expansion, availability of land and capital. Farmers are not able to expand acreage in order to increase output since land is a limiting factor for several social, cultural, religious and economic reasons. In addition, many farm families are not landowners hence the freedom to expand farm size is restricted and many times landowners

only rent out low productivity areas while high productivity areas are reserved for the owners.

Alternatively, sorghum farmers could still maintain high productivity without expansion by using improved seeds, chemical fertilizers and other improved technologies. However, the farmers are not able to adopt these improved production practices due to shortage of capital. For example, farmers are unable to apply the recommended dosage of fertilizer because of their low purchasing power and its prohibitive cost. The price of 50 kilogramme bag of fertilizer rose from less than ₦10 in the 70s and early 80s to more than ₦2000 in year 2000 (Nmadu, 2002). Part of the reason for the high cost is the falling value of the Naira against the US dollar as imports are denominated in dollars and more than 50% of the total fertilizer consumption in Nigeria is imported. According to EarthTrend (2006), the cumulative fertilizer consumption in Nigeria from 1961 to 2001 was 6,469,200 metric tons while production was 2,810,700 metric tons leaving a balance of 3,658,500 metric tons to importation. EarthTrend also indicated that since 2000, Nigeria's fertilizer

needs are met only from export as the two government-owned fertilizer companies are shut down due to corruption and mismanagement. Therefore, the objective of this study is to investigate the long-term relationship between sorghum acreage and fertilizer consumption and investigate whether the relationship is accentuated by the Naira exchange rate to the US dollar. The major assumption here is that sorghum acreage is positively related to fertilizer consumption and inversely related to US dollar rate.

METHODS

The data utilised in this research was sourced from CBN (2006), EarthTrend (2006) and FAO (1972-1997). A number of steps were taken to establish the relationship between sorghum acreage and aggregate fertiliser consumption. The first step was to determine the order of the integration of the data respectively. Both the Dickey-Fuller (DF) test (Dickey and Fuller, 1979) and Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1981) were carried out to find out if the data is trend stationary or not. The DF is expressed as:

$$\Delta A_{s,t} = \alpha + \alpha_1 t + \alpha_2 A_{s,t-1} + \lambda_t \quad (1)$$

while ADF was specified as:

$$\Delta A_{s,t} = \alpha + \alpha_1 t + \alpha_2 A_{s,t-1} + \sum_{i=1}^p b_i \Delta S_{s,t-i} + \lambda_t \quad (2)$$

(Greene, 2003)

Where

$A_{s,t}$ = Sorghum acreage in '000 hectares. These operations were also carried out on aggregate fertiliser consumption ('000 metric tons) and US dollar rate against Nigerian Naira

Δ = differencing operator i.e) $\Delta A_{s,t} = A_{s,t} - A_{s,t-1}$
 t = trend, 1961-2006

p = number of differencing required to make the data trend stationary

The number of differencing required was determined using the four branch decision tree adopted by Clark and Youngblood (1992) as follows:

- Test 1: for 2 versus 1 unit root by testing the significance of β in the model:

$$\Delta^2 A_{s,t} = \alpha + \beta \Delta A_{s,t-1} \quad (3)$$

A non-significant estimate of β in equation (3) indicates 2 unit roots i.e. the data are trend stationary if differencing is carried out twice. However, if the coefficient is significant, then a lower than two unit roots is suspected.

- Test 2: 1 versus 0 unit root by testing the

significance of β_1 in the model:

$$\Delta^2 A_{s,t} = \alpha + \beta_1 A_{s,t-1} + \beta_2 \Delta A_{s,t-1} \quad (4)$$

if null is rejected in the test in equation (4), then 1 unit root is indicated, otherwise 0 unit root is indicated.

- Test 3: for random walk versus random walk with drift by testing the significance of α in the model:

$$\Delta A_{s,t} = \alpha + \beta \Delta A_{s,t-1} \quad (5)$$

if α is non-significant in equation (5), then a random walk is indicated otherwise it is a random walk with drift

- Test 4: for the joint significance of α_2 and α_3 in equation (6) for random walk with drift versus linear time trend

$$\Delta A_{s,t} = \alpha + \alpha_1 t + \alpha_2 A_{s,t-1} + \alpha_3 \Delta A_{s,t-1} + \lambda_t \quad (6)$$

As was noted earlier, two series can only cointegrate if they are of the same order of integration. The cointegration model was specified as follows:

$$A_{s,t} = \alpha + \beta F_t + \lambda_t \quad (7)$$

Where

$A_{s,t}$ = sorghum hectareage in '000 acres in time t

F_t = aggregate fertilizer consumption in '000 metric tons in time t

λ_t = stochastic term $\text{nid}(0, \sigma^2)$

If γ in equation (8) is zero, then λ_t is non-stationary and the two series, even if they are of the same order of integration, are not cointegrated.

$$\Delta \lambda_t = -\gamma \lambda_{t-1} + \theta_t \quad (8)$$

where θ_t = white noise

If the test for cointegration in equations (7) and (8) above prove positive, then there is an associated Error Correction Model (ECM) specified as follows (Komolafe, 1996; Greene, 2003, Dolado et al. 1999):

$$\Delta A_{s,t} = -\rho \lambda_{t-1} + \sum_{i=1}^p \beta_i \Delta F_{t-i} + \sum_{i=1}^p \eta_i \Delta A_{s,t-i} + V_t \quad (9)$$

Where

$-\rho \lambda_{t-1}$ = disequilibrium term

P = number of differencing required to make the data stationary

V_t = random error term

Granger causality (Granger 1969; Granger and Newbold 1974) can also be inferred from equation (9) if β and η are non-zero.

However, the possibility of other explanatory variables improving the long-run relationship between sorghum and fertilizer consumption was also tested as follows:

$$A_{s,t} = \alpha + \beta F_t + \beta_1 USD_t + \beta_3 t + \lambda_t \quad (10)$$

Where

USD_t = US dollar exchange rate against the Nigerian Naira in time t

t = trend capturing innovations or technical change not immediately measurable like improvement of yield per hectare, new management techniques etc.

All other variables as previously defined.

After equation (10) was estimated, the tests of equation (8) and (9) were carried out to determine if there is cointegration and associated ECM.

RESULT AND DISCUSSION

The DF and ADF tests seeking to determine if the data were trend stationary are presented in Table 1 while the results of the four branch decision tree seeking to find out the number of times the data are differenced to make them stationary is presented in Table 2. Table 3 show the cointegrating statistics while Table 4 shows the results obtained from the error correction modelling of the data. The results in Tables 1 and 2 shows that the data are not trend stationary and are $I(1)$ exhibiting a random walk without drift. This means that the data are differenced once in order to make them

stationary. Since the data exhibited the same order of integration, it is possible to have a cointegrating model between them.

The results in Table 3 indicate that fertilizer consumption and US dollar rate were well cointegrated (Dolado et al. 1999) with sorghum acreage although fertilizer consumption did not exhibit any strong relationship with sorghum acreage when US dollar rate was included in the cointegrating model. This kind of behaviour is possible probably because in Nigeria, sorghum grain is not an international commodity while fertilizer is. That means that the input market for sorghum production is affected directly by the rate of Naira exchange to the dollar while the output market can only be said to be affected by the exchange rate intuitively since Nigerian commodities markets are very sensitive to the exchange rate. The implication of this is that sorghum farmers pay higher prices for sorghum input and other services while receiving less for their output, which in this case is sorghum grain. In this circumstance, what is needed urgently is building the capacity for internal production of the fertilizer needed by sorghum farmers instead of the present situation whereby almost all the fertilizer needs are met by importation.

Table 1: Determination of trend stationarity of the economic time series data

		Intercept	Δ_1	Δ_2	b_i
Sorghum	DF	-87222.2*** (30340.61)	44.81092** (15.51969)	-0.32007** (0.115325)	
	ADF	-75987.4*** (31146.89)	38.98257** (15.94806)	-0.24797** (0.125834)	-0.21084 ^{ns} (0.154732)
Fertilizer	DF	-369.056 ^{ns} (1239.337)	0.193781 ^{ns} (0.62818)	-0.07137 ^{ns} (0.062426)	
	ADF	-993.293 ^{ns} (1259.299)	0.510494 ^{ns} (0.638108)	-0.1055 ^{ns} (0.062279)	0.333453** (0.149904)
US dollar rate	DF	-1441.34** (738.8777)	0.727923** (0.372297)	-0.11357 ^{ns} (0.088964)	
	ADF	-1455.65** (750.8527)	0.735139** (0.378331)	-0.12426 ^{ns} (0.09635)	0.059844 ^{ns} (0.189054)

Values in parenthesis are standard errors ***p<0.05 **p<0.1 ns not significant

Table 2: Order of integration of the various economic time series data

	Test 1	Test 2	Test 3	Test 4	Order of integration	
Sorghum	-1.31031*** (0.145387)	0.002294 ^{ns} (0.077148)	154.3327 ^{ns} (125.1535)	-0.24797 ^{ns} (0.125834)	-0.21084 ^{ns} (0.154732)	Random walk
Fertilizer	-0.72089*** (0.146422)	-0.07029 ^{ns} (0.043874)	3.222477 ^{ns} (5.94592)	-0.1055 ^{ns} (0.062279)	0.333453 ^{ns} (0.149904)	Random walk
US dollar rate	-0.95177*** (0.174236)	0.008643 ^{ns} (0.070748)	3.50332 ^{ns} (2.72874)	-0.12426 ^{ns} (0.09635)	0.059844 ^{ns} (0.189054)	Random walk

Values in parenthesis are standard errors ***p<0.05 **p<0.1 ns not significant

Table 3: Cointegration statistics of the economic time series data

<i>Intercept</i>	<i>Fertilizer consumption</i>	<i>US dollar rate</i>	<i>Cointegration</i>
4185.401*** (392.0682)	4.995406** (1.927614)		-0.19289** (0.086972)
3808.742*** (384.6921)	2.766757 ^{ns} (1.630816)	33.77316*** (4.401801)	-0.41159*** (0.134649)

Values in parenthesis are standard errors ***p<0.05 **p<0.1 ns not significant

Table 4: Error correction model of the economic time series data

<i>Intercept</i>	<i>Sorghum</i>	<i>Fertilizer</i>	<i>US dollar rate</i>	<i>Trend</i>
168.2349 ^{ns} (125.9375)	-0.31421 (0.145311)**	-3.06572 (3.075607) ^{ns}		
-24646.5 (19087.96) ^{ns}	-0.3407 (0.145564)**	-2.66083 (3.066502) ^{ns}		12.51434 ^{ns} (9.626046)
226.6158 (156.3014) ^{ns}	-0.31795 (0.164023)**	-3.44112 (3.291382) ^{ns}	3.63816 (9.894618) ^{ns}	
-21489.6 (32328.89) ^{ns}	-0.33479 (0.167382)**	-2.87595 (3.425829) ^{ns}	1.39579 (10.52669) ^{ns}	10.92751 ^{ns} (16.26758)

Values in parenthesis are standard errors ***p<0.05 **p<0.1 ns not significant

The result in Table 4 indicates that there was no associated ECM and there was no indication of any kind of granger causality (Dolado et al. 1999). This means that long-term neutrality of change does not exist, only short term dynamics is observed (i.e. cointegration). This is an indication that the relationship between sorghum acreage and the variables under study did not have a defined long-term pattern thus a prospect of general equilibrium between the supply and demand of sorghum grain on the one hand and between inputs market and the sorghum supply on the other, for example Maingwa et al. (2004) has highlighted the challenges facing staple food crops subsector in Nigeria. The results are also indicative of the nature of the foreign exchange market in Nigeria. Except for some time now (2005 till date), the rate of exchange has been some unstable, rising from about N21 to the USD in 1993 to about N150 to USD in 2001 (CBN 2006, Maingwa et al 2004a). It really shows that previous policy instruments (Nagy and Edun 2002) with respect to the variables under study were not effective in stabilising sorghum markets and maintaining stable prices during the period under study. It also indicates that policy instrument alone cannot adequately correct for the temporary shocks to sorghum acreage (Maingwa et al. 2004b). Therefore, an integrated approach and networking between agencies and participants in the commodities market is advocated. Particularly, there is need to have a complete overhaul of the policy environment around fertilizer economy in Nigeria especially

with respect to pricing regime. There has been a very wide margin between the officially-published prices and the actual prices that the commodity is accessed by farmers. In addition, the policy and politics of subsidy on fertilizer, which has generated a lot of debates and concern overtime needs to be properly addressed. Home-grown policies involving all the stakeholders rather than internationally-accepted policies will help to bring stability to the markets. These changes with changes in associated policy regimes will ensure food sustainability and the achievement of millennium development goals.

CONCLUSION AND RECOMMENDATION

The long-term relationship between sorghum acreage; fertilizer consumption and US dollar rate from 1961 to 2006 was investigated. The results revealed that even though the variables were well cointegrated, there was neither ECM nor any kind of granger causality. These results are indication that all policy prescriptions with regards to the variables under study were not effective. The assumption that sorghum acreage is positively related to fertilizer consumption and inversely related to US dollar rate is therefore not supported by this study. This paper advocated a complete overhaul of the policy environment around fertilizer production, pricing and subsidy. An integrated approach and networking of the stakeholders in both the supply side and demand side of sorghum economy is a key to achieving food security, sustainability and MDGs.

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