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Effects of fertilizer Modification on Maize Production in Nigeria

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The paper studies the effects of the liberalization of the Nigerian fertilizer sector, vis-à-vis the sustenance of the present dual fertilizer distribution arrangement, on maize production in Nigeria. Time series data was collected for the period 1990- 2006. A multiple regression model was specified with aggregate fertilizer use, maize hectarage and a dummy variable designed to capture the effects of the changes induced by fertilizer liberalization measure, as explanatory variables. Aggregate maize output was the dependent variable. Results of this study indicate that a significant decrease in aggregate maize production followed the Federal Government's liberalization of the fertilizer sector in 1997. The statistically significant decrease in Maize production is attributable to the statistically significant decrease in fertilizer use during the fertilizer liberalization period. The paper concluded that the sustenance of the present dual fertilizer distribution arrangement has a negative effect on maize production in Nigeria.

Key words: Effects, fertilizer liberalization, maize production, Nigeria.

INTRODUCTION

Fertilizer is considered a 'lead' practice, which predisposes the farmer to adopt other improved practices, thus, recognized as a major factor in increasing food production. It has become the 'backbone' of agricultural development programmes in many countries. According to Crawford et al. (2006) the improvements in soil fertility needed to stimulate agricultural productivity growth, improved food security, and increases in rural incomes will require substantial increases in fertilizer use in combination with improved land husbandry practices. In every region of the world, the intensification of crop-based agriculture has been associated with a sharp increase in the use of chemical fertilizer (Morris et al., 2007). Because of the strategic role of fertilizer in accelerating agricultural production and productivity, different policies have been put in place to promote efficient fertilizer production, distribution and use. As a result of these policies, there has been rapid growth in fertilizer consumption in Nigeria; rising from 186,000 MT in 1977

to over one million metric tonnes in 1994 (Ogunfowora, 1996).

The motive for government involvement in fertilizer production, procurement and distribution is that fertilizer is seen as vital commodity that should not be left to the care of the private sector which is regarded as exploitative and unreliable (World Bank, 1981). According to Ogunfowora (1996), the justification for government involvement is two fold, namely: (i) to ensure availability of fertilizer on time and at fair prices through out the country, (ii) to promote increased consumption through intensive extension activities by government agencies. A third justification was on the grounds that small-scale resource poor farmers cannot afford to pay high cost of fertilizer (Mwangi, 1997).

As fertilizer consumption in Nigeria increases, the inadequacies of public sector controlled procurement and distribution arrangements began to manifest in leakages and transit losses, cross border trade in fertilizer, late and non-deliveries of fertilizer to designated depots, artificial scarcity, and unsustainable subsidy burden on the government (IFDC, IITA and WARDA, 2000; Isokrari, 1995; Ogunfowora, 1996). The management of the subsidy programme made the 'middlemen' the main

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beneficiaries while farmers pay exorbitant prices for fertilizers when and if they get to buy (Ogunfowora and Odubola, 1994). The distribution policy witnessed a number of major changes since 1976 due to various problems encountered during the implementation of these policies (see Ogunfowora (1996) for a summary). Every change in distribution policy gave rise to other unanticipated problems which tend to negate the anticipated benefits of the new policy. There is, therefore, the temptation to come to the conclusion that, for as long as the fertilizer program remains a statutory monopoly of government, for so long will the inefficiency in the distribution system persist (Ogunfowora, 1996). The persistence of the problems of fertilizer sub sector re-kindled policy makers' interest in the liberalization of the fertilizer sector.

Liberalization generally refers to a relaxation of previous government restriction, usually in areas of social or economic policy. Economic liberalization is a broad term that usually refers to fewer governments' regulations and restrictions in the economy in exchange for greater participation of private entities. The argument for economic liberalization includes greater efficiency and effectiveness that would translate to a bigger pie for everybody (McKinnon, 1993).

The Federal Government of Nigeria (FGN) discontinued the fertilizer subsidy and adopted a complete liberalization of the fertilizer procurement and distribution process in Nigeria in 1997. As reported by Nagy and Edun (2002), The FGN reintroduced a fertilizer subsidy of 25% in May 1999; it then discontinued the subsidy in August 2000 and abolished the import fertilizer tariff. And again, it procured and subsidized a portion of Nigeria's fertilizer in 2001. The problem was further compounded by the procurement and subsidization of the fertilizer commodity by some states, such fertilizer are usually distributed through political channels and are easily diverted. To date, the Federal Government and the various states and local governments are directly involved in the fertilizer procurement and distribution process. Schultz (1976), while delivering the first Leonard Elmhirst Lecture, challenged agricultural economists to evaluate the economic effects of what governments 'do to agriculture'; arguing that much of the difference in the economic performance of the agricultural sector is a consequence of what governments 'do to agriculture'. This study intends to take on this challenge, as the liberalization of the Nigerian fertilizer sector does have an impact on agricultural crop production; therefore, there is the need to conduct an investigation into its effects. Many developing countries, including sub-Saharan Africa have reduced or eliminated subsidies and liberalize their agricultural input markets as part of the reform process that began in the 1980s (Ahmed, 1995; Dimethe et al., 1998; Kempkes, 1997; Minot et al., 2000). Therefore, the findings of this study are expected to contribute to the literature on the effects of government policy reforms on

agricultural crop production. The question that arises for this paper is: after more than a decade of liberalization, did the liberalization of the Nigerian fertilizer sub-sector translate to improvements in agricultural crop production? This paper attempted to assess the direct impact of fertilizer liberalization on aggregate maize production in Nigeria. Specifically, the objectives of the study are to determine the effects of fertilizer liberalization on (i) Maize Production (ii) Fertilizer Use, and (iii) the total area devoted to maize cultivation in Nigeria.

The following hypotheses were formulated and tested in this study:

1. There is no significant difference in the quantity of maize production in Nigerian before and during the liberalization of the fertilizer sector.
2. There is no significant difference in the quantity of fertilizer use in Nigerian before and during the liberalization of the fertilizer sector.
3. There is no significant difference in the total area devoted to maize cultivation in Nigeria before and during the liberalization of the fertilizer sector.

METHODOLOGY

Time series data on aggregate fertilizer use, quantity of maize production and total area under cultivation with the maize crop in Nigeria for the period 1990 - 2006 were collected and used (Appendix Table A1).

The selection of maize as the fertilizer intensive crop used in this study is informed by reports that more fertilizer are used on cereal crops; and that more than 70% of fertilizer devoted to cereals in Nigeria are used for maize crop production (NAERLS, 2002). According to Kelly et al. (2005), maize exhibited the best overall response to fertilizer among cereal crops.

The impact of fertilizer liberalization is assumed as direct impact on level of agricultural crop production resulting from change in the level of fertilizer use. Consider a typical farm with a production function

$$Y=f(X_1...X_m; Z_1...Z_n) \quad (1)$$

Where Y is output, x represent variable inputs and z represent fixed and other shifter variables of the function. Ignoring the fixed costs, the production function becomes

$$Y=f(X_1...X_m) \quad (2)$$

Based on the economics of production outlined above, an empirical aggregate model is developed for maize production in Nigeria, leaving out variables of less interest to this study, as follows

$$Y_t = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_{2t} + D \quad (3)$$

Where Y_t is maize production in year t (measured in MT), X_{1t} is fertilizer use in year t (measured in MT), X_{2t} is total area under maize cultivation in year t (measured in thousand of hectares), and D is the dummy variable that takes a value of 0 for the years 1990 - 1996 and 1 for the years 1997 - 2006.

As noted in various literature, empirical analysis of time series data pose several challenges as empirical work, including causality tests of Granger and Sims based on time series data assumed that

the underlying time series is stationary (Seddighi et al., 2000; Enders, 1995; Patterson, 2000). Mercifully, as Gujarati (2003) noted, by simply establishing stationarity of the residuals from regression equation, if they are stationary, the traditional regression methodology is applicable to data involving non stationary time series. Co-integration was tested on the data collected for this study using the Co-integrating Regression Durbin-Watson (CRDW) Test method as expounded by Gujarati (2003).

Our regression model:

$$Y_t = 1 + 2X_{1t} + 3X_{2t} + D + \mu_t$$

was estimated and the residuals obtained.

The DW d was computed using the following relation

$$d = \frac{\sum_{t=2}^n (e_t - e_{t-1})^2}{\sum_{t=1}^n e_t^2}$$

In CRDW Test, the Durbin-Watson d obtained from the co-integrating regression (4) is used, with a proviso that the null hypothesis is $d = 0$ rather than the standard $d = 2$ in the conventional DW test for autocorrelation.

The computed DW d (0.800) obtained from the co-integrating regression (4) is greater than the critical value of 0.386 at the 5% level, thus it was concluded that the regression residuals are stationary. However, the estimated DW d value of 0.800 is lower than the critical DW dL value of 0.897, indicating an evidence of positive first order serial correlation (Appendix Table A2). However, the first-order difference transformation method was not used to remedy the detected autocorrelation problem because it is not appropriate for our case despite its other advantages. This decision is guided by Maddala (1992) rule of thumb on the appropriateness of using the first-order difference method; use the first difference transformation method whenever $d < R^2$. It will be recalled that our computed d and R^2 from Equation (3) are 0.800 and 0.767 respectively that is, $d > R^2$.

The Praise-Winsten transformation method, as expounded by Gujarati (2003) was used to transform the model, using estimated based on the Durbin-Watson d statistic. This is done, based on the following assumptions: (a) that the error term in Equation (3) follows the AR (1) scheme and (b) that if Equation (3) holds true at time t, it also holds true at time (t-1), thus:

$$Y_{t-1} = 1 + 2X_{1t-1} + 3X_{2t-1} + 4D + \mu_{t-1} \tag{4}$$

Multiplying Equation (4) by

$$Y_{t-1} = 1 + 2X_{1t-1} + 3X_{2t-1} + 4D + \mu_{t-1} \tag{5}$$

Subtracting Equation (5) from Equation (3)

$$(Y_t - Y_{t-1}) = 1(1 -) + 2(X_{1t} - X_{1t-1}) + 3(X_{2t} - X_{2t-1}) + D + \mu_t$$

Where $\mu_t = (\mu_t - \mu_{t-1})$

Equation (6) was then expressed as follows

$$y_t = \beta_1 + \beta_2 x_{1t} + \beta_3 x_{2t} + D + \mu_t \tag{7}$$

Where $\beta_1 = 1(1 -)$, $y_t = (Y_t - Y_{t-1})$, $x_{1t} = (X_{1t} - X_{1t-1})$, $x_{2t} = (X_{2t} - X_{2t-1})$

), $\beta_2 = 2$ and $\beta_3 = 3$.

OLS was then applied to the transformed variables to obtain the usual optimum properties of the OLS coefficients asymptotically.

RESULTS AND DISCUSSION

The aggregate maize production model is estimated using the transformed time series data for the period 1990 - 2006 with SPSS Statistics 17.0. The F value of 6.598 computed for Equation (7) is highly significant at the 5% level. This implies that the included explanatory variables (fertilizer use, maize hectarage and the effects of the liberalization measures as represented by the dummy variable) together significantly explain the variation in aggregate maize production. The R^2 value obtained from the equation is 0.604. This indicates that the explanatory variables included in the model explained, on the average, 60% of the variation in the total aggregate maize production over the study period. The unexplained variation, less than 40%, in the model is attributable to other factors not specified in the model due to difficulties in quantification and for computational ease. Such factors include costs of fertilizer to maize farmers, availability of fertilizer to farmers at the right time and place due to the supposedly competitive fertilizer market resulting from the liberalization process and the peculiar dual nature of the Nigerian fertilizer market since 1999: one fully liberalized and the other partly regulated.

The sign of the coefficient of the dummy variable is positive implying that the socio-economic changes induced by the fertilizer liberalization measures have negative effect on aggregate maize production in Nigeria. The failure of the fertilizer liberalization process to significantly increase aggregate maize production in Nigeria could be attributed to the inconsistent fertilizer policies of the Nigerian government since 1999 which led to the emergence and sustenance of a dual dysfunctional private-public fertilizer market. As reported by Nagy and Edun (2002), the FGN reintroduced a fertilizer subsidy of 25% in May 1999; it then discontinued the subsidy in August 2000 and abolished the import fertilizer tariff. And

again, it procured and subsidized a portion of Nigeria's fertilizer in 2001. The problem is further compounded by the procurement and subsidization of the fertilizer

commodity by some states, such fertilizer are usually distributed through political channels and are easily diverted. To date, the Federal Government and the various states and local governments are directly involved in the fertilizer procurement and distribution process. Table 1 shows the results of the regression analysis with transformed variables (Equation 7).

All estimated parameters, except maize hectarage, are statistically significant at the 5% level. The statistically

significant coefficient of the dummy variable indicates that the observed negative effects of fertilizer liberalization on aggregate maize production resulted into the statistically significant decrease in the level of fertilizer use during the liberalization period. The mean of annual quantity of fertilizer use in Nigeria before liberalization, 1990 - 1996, is 370062.86 MT, while that during the liberalization period is 284857.50 MT resulting in a mean difference of 85205.36 MT. This shows that more fertilizer, statistically

Table 1. Results of regression analysis with transformed variables Equation (7).

Independent variables	Coefficients	t-values	p-values
Constant term	1312.007	2.350 ^a	0.035
Fertilizer use	0.006	2.832 ^a	0.014
Maize hectarage	0.086	0.232	0.820
Dummy	767.154	2.345 ^a	0.036

$R^2 = 0.604$; Adjusted $R^2 = 0.512$; $R = 0.777$; $F(\text{model}) = 6.598$; p-value for $F(\text{model}) = 0.006$; DW $d=1.005$. ^aStatistically significant statistics at = 5%.

significant, was used annually before fertilizer liberalization than during the era of liberalization. Again, this could be attributed to the inconsistent fertilizer policies of the Nigerian governments since 1999 as discussed. There was no significant change in total area devoted to maize crop cultivation between the two periods. The mean annual maize hectarage before fertilizer liberalization, 1990 - 1996, was 5139285.7 Ha which is greater than the mean of 3781300.00 Ha during the liberalization era, 1997-2006. This gives a mean difference of 1357985.71 Ha between the two periods. This shows that more land area, though not statistically significant, was put under maize cultivation before fertilizer liberalization than during the liberalization era. This could be explained as resulting from maize farmers gradually moving away from maize production in favour of sorghum and millet that require less fertilizer than maize because maize crop demands more fertilizer than other cereals and most farmers are resource poor, therefore cannot afford fertilizer.

Conclusion

This paper set out to evaluate the effects of fertilizer liberalization on aggregate maize production in Nigeria. No such study is known to have been conducted in the Nigerian context. To achieve this objective, a multiple regression model was specified with aggregate fertilizer use, maize hectarage and a dummy variable designed to capture the effects of the changes induced by fertilizer liberalization measure as explanatory variables. Aggregate maize output is the dependent variable. Time series data was collected for the period 1990 - 2006. Results of this study indicate that the liberalization of fertilizer procurement and distribution in Nigeria has not significantly increased maize production in Nigeria.

Fertilizer use has significantly decreased; as more fertilizer was used before the fertilizer liberalization period. There was a statistically non-significant decrease in the total area devoted to maize cultivation during the fertilizer liberalization era.

Based on the empirical results of this study, the main policy conclusion that can be deduced is that the present dual dysfunctional fertilizer procurement and distribution

arrangement erodes all gains expected from the government's adoption of the fertilizer liberalization process in 1997. The challenge to Nigerian policy makers is how to fully and effectively liberalize the Nigerian fertilizer subsector; or alternatively, how to make the present dual fertilizer market arrangement functional and efficient to achieve the benefits expected from the fertilizer liberalization process.

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Table A1. Time series data on maize production, hectarage, and fertilizer use in Nigeria (1990-2006).

Year	Maize production ^a (‘000 MT)	Maize hectarage ^b (‘000 Ha)	Fertilizer used ^d (MT)
1990	5768	5105	380900
1991	5810	5142	400340
1992	5840	5223	429200
1993	6290	5309	440000
1994	6902	5426	461000
1995	6931	5497	296000
1996	6217	4273	183000
1997	6285	4200	173500
1998	6435	3884	137700
1999	6515	3965	203500
2000	6491	3999	173100
2001	8188.5	4041	323874 ^e
2002	8527.9	3282 ^c	325301 ^e
2003	8685.1	3469 ^c	333156 ^e
2004	9503.4	3479 ^c	346385 ^e
2005	10369.6	3589 ^c	400734 ^e
2006	11087.4	3905 ^c	431325 ^e

Sources: ^aCBN (2007); ^bNagy and Edun (2002); ^cFAO (2009); ^dNagy and Edun (2002); and ^eNigeria Fertilizer Strategy Report (2006).

Table A2. Results of regression analysis (level model) Equation (3).

Independent variables	Coefficients	t-values	p-values
Constant term	1312.007	2.548a	0.024
Fertilizer use	0.006	4.529a	0.001
Maize hectarage	0.086	-1.890	0.081
Dummy	767.154	1.113	0.286

$R^2 = 0.767$; Adjusted $R^2 = 0.713$; $R = 0.876$; $F(\text{model})=14.279$; p-value for $F(\text{model}) = 0.0001$; DW d = 0.800. ^aStatistically significant statistics at = 5%

