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Rice Supply Response in Nigeria: An Application of the Nerlovian Adjustment Model

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Abstract: Rice is an important food crop in Nigeria. However, the inadequate level of the crop's production in Nigeria is evidenced by problems, usually in terms of the ever widening supply and demand for the crop in the country. This in turn has resulted in the use of scarce foreign reserve on importation of the commodity that can be efficiently produced locally. This study therefore examined the response of rice supply to its demand in Nigeria for the period 1967-2004. The study applied the Nerlovian adjustment model to the Nigerian rice data set for the period 1967-2004. The estimated trend equations showed that time had significant influence on output, area and yield of rice over the period and sub-periods at 1% level mostly. The results tend to imply that almost all growth in output has been due to increases in area cultivated to rice. This is inferred from the growth rates for the entire period 1967-2004, the sub-periods 1967-1985 and 1986-2004 which were 9.31, 7.04 and 9.42, respectively. For these periods, the yield growth rates were -0.6, 2.74 and -4.5. The results also showed that for the entire period, area contributed 113% to output as against -7.4% by yield. The sub-period 1967-1985, typified as the era of non-intervention by the government, showed that area contributed 77%, while yield was responsible for 30% of the output. During the sub-period 1986-2004, the policy intervention era, area was responsible for 225% of the output as yield contributed -107% to output. The time trend variable used to represent the policy intervention point had no significant effects on the variables of interest in this study. Hence, rice supply does not seem to have responded to rice production policies before and after 1986. The S/R and L/R price response elasticities are inelastic as they are all less than one. The estimated coefficients of adjustment ranged between 0.23 and 0.33; hence, the speed of adjustment by the variables is said to be sluggish. Under this situation, achieving significant increases in output will be hard to attain. Measures that will lead to productivity increases in rice production are therefore, nessary. It is therefore, recommended rice farmers should be encouraged to adopt and use improved technologies like the New Rice for Africa (NERICA) variety. The extension service delivery system must also be improved in order to achieve the desired results.

Key words: Supply response, adjustment model, price response elasticities, adjustment speed, Nigeria

INTRODUCTION

One of the most important issues in agricultural development economics is supply response of crops. (Mushtaq and Dawson, 2002). This is because the responsiveness of farmers to economic incentives determines agriculture's contribution to the economy especially where the sector is the largest employer of labour. Agricultural pricing policy plays a key role in increasing farm production. Supply response is fundamental to an understanding of this price mechanism (Nerlove and Bachman, 1960).

In Nigeria, the aims of agricultural price policy are inter alia, fair incomes for farmers, low food prices for urban consumers, cheap raw materials for manufacturing and increasing exports. Price support (Strategic Grain Reserve, Nigerian Grain Board) is a main instrument. The prices of major commodities have been set below world prices using subsidies and trade barriers, guaranteed prices (act as floors) and domestic market forces determine actual prices (FAO, 1996).

Up till the early 1960's, Nigeria was self-sufficient in food production (Ojo, 1991). The Nigerian agriculture, with a near total dependence on rain produced food and raw materials to the industrial sector of the economy. As from 1970, the decline in farming activities became more pronounced (Oludimu and Imoudu, 1998). There were widening food supply-demand gaps and rising food import bills (Falusi, 1990). The food self-sufficiency index-ratio of aggregate local food supply to the aggregate food demand fell (Rahji, 1999). The output of local rice was estimated to be three million tons while the demand amounted to 5 million tons (Falusi, 1990). The Federal Government, in an attempt to, boost rice production allocated N1.5 billion for certified seeds multiplication and distribution to rice farmers.

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Self-sufficiency in rice production is now an important political-economic goal of the Nigerian government (Bello, 2004). As a development strategy, it is a necessary precursor to the ultimate goal of self-reliance standards which is a desirable goal of society. Such an economic policy has major implications for the dynamics of the socio-economic and institutional environments within which farmers operate. It has been justified as a means through which farmers can enhance their efficiency and productivity. But in the unfolding process of agricultural and economic reforms since independence-over four decades ago, what has been the farmers' response especially in terms of rice production in Nigeria? How has rice import-ban, triggered by the self-sufficiency drive, impacted on the short-run and long-run rice supply response in Nigeria? Are the policies put in place effective as supply shifters for adequate rice supply response by the farmers? Are the price, output and non-price incentives adequate? Can these rice farmers change set habit of production?

Rice is widely grown in Nigeria under the upland rain fed, inland shallow swamp, deep water/floating and lowland irrigated production systems (Olayemi, 1997). The land area under rice cultivation in Nigeria was about 1.64 million ha. This decreased to about 1.25 million hectares in 2004 (Nigerian Business, 2004). Improved rice management production practices have been developed and disseminated to farmers for years in Nigeria. The rate of adoption has however been reported to be low (Ayoola, 1990). The rate of use of the adopted practices relative to the recommended level is reported to be equally low (Uwatt, 1998).

Misari *et al.* (1996) reported that the ban on rice importation in 1986 led to an increased rice production from 0.94 in 1986 to 2.54 million tons in 1994. But Nigeria expends N250 billion yearly to import agricultural products. Rice alone gulps N60 billion (Abdullahi, 2002; NAMIS, 2004). In 1990, Nigeria imported 224,000 metric tons of rice valued at US 60 million dollars. This increased to 345,000 metric tons in 1996 with a value of US 130 million dollars. By 2001, rice import increased to 1.51 million metric tons valued at US 288.1 million dollars (FAO, 1996). These figures indicate a 500% rise in foreign exchange expenditure on rice imports within eleven years. With an exchange rate of US1 dollar to N140, this constitutes a great drain on the nation's foreign exchange. The possible trade imbalances that the import of such a single item could cause prompted the government to embark on measures targeted at rice self-sufficiency.

Nigeria is known to have the potential to produce enough rice for its needs and even export (Bello, 2004; Nasko, 1989). Hence, the government seeks ways of reducing external payment imbalances through a renewed interest in agricultural supply response policy. As a result, a clear understanding of the principles and factors influencing the dynamics of local rice supply and demand in Nigeria can constitute a major issue in her policy formulation. This study is therefore deemed to be of immediate application in rice production policy decisions in Nigeria and in other African countries facing similar situation.

Problem statement: Cereals are important food crops in Nigeria (CBN, 2000). The inadequate level of cereal production in Nigeria has manifested in high prices and an annually increasing expenditure on the importation of some of them e.g. rice, wheat and even maize (CBN, 2000). This constitutes a problem in terms of the supply and demand for them and in the use of scarce foreign reserve on importation of commodities that can be efficiently produced locally. The high variations in the annual domestic production of these crops are ascribed to hectarage cultivated and the productivity or yield per hectare of the crops. Three variables are of research importance in the production of these crops. There are output, productivity and total land allocated to the crops.

According to Aiyelari and Rahji (2000), the need to increase food and fibre production in Nigeria has been highlighted in different forums and at different times. However, Ikpi (1994) pointed out that agricultural productivity and total annual food and fibre production in Nigeria are pitiably poor and much below expectation. While Falusi (1995) stated that in spite of all human and materials resources put into the sector, the rate of productivity increase in Nigeria agriculture was declining. Fulginito and Perrin (1998) pointed out that a characteristic of the developing countries agriculture is a wide-spread of productivity decline.

Instability in food production in Nigeria was said to be higher between 1986 and 1991 than in 1981-1985 period. Olayemi (1996) found that the annual coefficient of variation was between 20 and 45% for major food crops between 1980 and 1994, while the World Bank (1996) stated that the average annual variation was 24% between 1971 and 1989. These are short-term analyses. The need for a long-term study arises from this observation. According to FAO (1996), the discrepancy between the rates of increase in total production (output) and productivity (yield per hectare) indicates that increasingly less fertile land is being cultivated.

Adegeye and Rahji (2000), however, opined that low productivity and contraction in output and farming activities are due to the increasing use of marginal lands. The research question among others is how productivity has and area cultivated affected output over the years? What is the relative contribution of area and productivity to total output of the crops? What is the level of inter annual variations in these key variables in cereals production in Nigeria?

This study, therefore applies the Nerlovian adjustment model to rice production in Nigeria. The study specifically examined the response of rice production to policies since 1986 and estimates the price supply response elasticities for rice, determined the speed of adjustment of rice output to policies as well as determined the sources of growth in rice production.

MATERIALS AND METHODS

Data sources: Data were sourced from Food and Agriculture Organizations (FAO) under the FAOSTAT data base (2004). Accessed 24/02/2005. The data set covers the period 1967-2004 as data on producer prices are not available for the period 1960-1966. This happens to be one of the key limitation in the study. The analyses would have covered the 1961-2004 periods. Data were collected on output and prices over the period.

Methods of data analysis: To test the response of rice farmers to price, the Nerlovian adjustment model (Nerlove, 1979) is adopted. The model is cast within a stock adjustment framework. It is therefore assumed that the desired output of rice (Q*) is given by the following long-run relationship

$$\text{In}Q^*_t = a + b\ln P_{t-1} \quad (1)$$

where, P denotes the price of rice, t is time and In is the natural logarithm.

It is reasonable to assume that the actual output of rice (Q) does not immediately move to Q* as P changes, but it responds or its response is by the following process:

$$\ln Q_t - \text{In}Q_{t-1} = \lambda\,(\text{In}Q^*_t - \text{In}Q_{t-1}) \quad (2)$$

where, the speed of adjustment (λ), obeys $0 \leq \lambda \leq 1$

By substituting Eq. 2 into (1), adding a time trend (t) to account for such effects as advances in agro-technology and policy reforms on rice and including an error term (u), the model can be expressed as:

$$\text{In}Qt = Ao + A_1\text{In}Q_{t-1} + A_2\,\text{In}P_{t-1} + A_3\,t + Ut \quad (3)$$

Where,
$Ao = \lambda a$; $Ai = I-\lambda$; $A_2 = \lambda b$ and U is assumed to follow the expression

$$Ut = \rho\, U_{t-1} + et;\ \text{such that } I\,\rho\, I < 1;$$
$$E(e) = 0;\ Cov(e) = \sigma^2 I.$$

The short-run price elasticity of supply is given by A_1 and the long-run price elasticity is b. with respect to the dependent variable. In this study, Output, area and yield (productivity) are used separately as dependent variables in different equations.

The diagnostic statistics of interest are R^2, the standard error of regression (SE), estimates of ρ and λ and Durbin-h statistics as Durbin Watson statistics is inappropriate in this instance. For purposes of comparison, the model is to be re-estimated without the time trend as:

$$\text{In}Q_t = Bo + B_1\,\text{In}Q_{t-1} + B_2\,\text{In}P_{t-1} + \Sigma t \quad (4)$$

Since, the time trend represents the post 1986 period as one and zero otherwise which is denoted as the policy era on rice, this formulation is used to examine the response of rice production to without the trend variable.

Trend equations: Trend equations were estimated for each of the variables with time (t) as the explanatory variable in all cases. The trend equation is of the form.

$$\text{In}Q_t = d + \chi t + v. \quad (5)$$

The purpose of this, is to obtain the growth rate of the variable as

$$G = [(\exp \chi)-1]\,100$$

This growth rate (G) was decomposed into the contributions to output by area and productivity.

Limdep 7.0 software was used in estimating the Nerlovian models while Microsoft Excel software was used in estimating the trend equations.

RESULTS AND DISCUSSION

Table 1 presents the result of the trend equations for the variables of interest. Over the periods, output and area recorded positive growth rates in all cases. Yield on the

Table 1: Growth rates of the variables in the analysis

Growth rates	Q	A	Y
1967-2004	8.22	9.31	-0.61
1967-1985	9.20	7.04	2.74
1986-2004	4.19	9.42	-4.50

Source: Data analysis, 2007

other hand produced positive result in the 1967-1985 (the pre-ban period) and negative results for the ban and post-ban period 1986-2004 and over the entire period 1967-2004.

Table 2 contains the result of the growth rate decomposition. In the 1967-2004 period, area contributed some 113% of the output while yield recorded a decline of 7.4% even with rice policies operating in the economy. Pre-reform, 1967-1985, area contributed about 77% to the output while yield accounted for about 30% of the output. In 1986-2004, area was responsible for 225% of output and yield recorded decline of 107% contribution to output. Yet time had a significant effect on all the variables in the trend equations and eight of the parameters were significant at the 1% level while the ninth was significant at the 5% level (Appendix 1). It must be realized here that time had significant positive effects on output and area for the periods and positive effect on yield for the 1967-1985 sub-period while it had significant negative effects on yield for the 1967-2004 period and 1986-2004 sub-period.

Table 3 presents the regression estimates of the supply response for rice with time trend as an explanatory variable. The estimated coefficients for lagged output (A_1) and price (A_2) have the correct signs and are plausible. The goodness of fit for the estimated equations as measured by the R^2 is reasonably good. R^2 ranges between 0.61 and 0.96. In all cases, the estimated lagged area variable coefficients are significant at the 1%. The estimated price coefficient is only negatively significant for yield at the 10% level. All the parameters of trend are not significantly different from zero even at the 10% level of significance. This finding tends to support the estimation of a model without this variable for comparative purposes.

Table 4 shows the results of the model without the trend variable. As in the fast model, all the estimated coefficients of lagged output are positive and significant at the 1% level. It is however worth mentioning here that all the estimated price coefficients are significant at the 10% level of significance. These results tend to imply improvement in the second model over the first. The R^2 for all the equations in the second model are almost the same as those of the first model in all cases. Similarly, the standard errors of regression are almost the same for the 2 models.

The speed or coefficient of adjustment (λ) for the variables are close enough to one another. However, since they range between 0.23 and 0.33 and they are less than 0.5, the speed of adjustment to production is small or sluggish. If $\lambda \geq 0.5$, the adjustment speed is said to be big (Olayemi, 1998).

Test of autocorrelation: The Durbin-Watson (DW) statistic is the most popular and reliable test for detecting autocorrelation. However, the test is valid only if the following conditions are fulfilled: the study uses a time series data, autocorrelation is of the first order, there is a constant in the equation and the equation does not include lagged values of the dependent variable as regressor.

In our study, the equations all have lagged values of the dependent variable as regressor. Since the equations have lagged value of the dependent variable as regressor, a variant of DW known as Durbin h statistic is used to carry out the test (Durbin, 1970). The test statistic is represented as:

Table 2: Decomposition of the growth rates by contribution of area and yield

Growth decomposition	Q	A	Y
1967-2004	100	113.0	-7.4
1967-1985	100	76.5	29.8
1986-2004	100	224.8	-107.4

Source: Data Analysis, 2007

Table 3: Estimated model with trend variable

Var	Ao	A_1^{t-1}	A^2	A^3	R^2	SE	rho(ρ)	h	λ	b.	DW
Q	3.13	0.75***	0.06	0.14	0.93	0.25	0.04	0.30	0.25	0.24	1.9306
	(2.34)	(6.52)	(1.11)	(0.69)							
A	2.53	0.77***	0.09	0.10	0.96	0.21	-0.05	-0.52	0.23	0.39	2.1010
	(1.79)	(5.73)	(1.24)	(0.65)							
Y	3.50	0.67***	-0.05	0.13	0.61	0.18	-0.24	-2.50	0.33	-0.15	2.4855
	(2.59)	(5.17)	(1.67)	(1.04)							dF=34

Source: Data analysis, 2007 ***Significant at 1% *Significant at 10%

Table 4: Estimated model without trend variable

Var	Ao	A_1	A^2	A^3	R^2	SE	rho(ρ)	h	λ	b	DW
Q	2.79	0.76***	0.08*	-	0.93	0.25	0.04	0.30	0.24	0.33	1.9286
	(2.26)	(6.94)	(1.74)								
A	2.45	0.77***	0.11*	-	0.96	0.21	-0.03	0.33	0.23	0.48	2.0647
	(1.76)	(5.76)	(1.82)	-							
Y	2.82	0.73***	-0.02*	-	0.60	0.16	-0.30	2.76	0.27	-0.07	2.6018
	(2.38)	(6.09)	(1.81)	-							df = 34

Source: Data analysis, 2007 ***Significant at 1% *Significant at 10%

$$h = (1-1/2DW)\sqrt{n} / 1-(n \text{ var } b);$$

Where,

DW = Computed DW statistic,
n = Sample size
var(b) = Variance of the coefficient of the lagged dependent variable.

The h statistic for the output and area equations are 0.30 and-0.52, respectively for the trended equations. These are compared with the critical Z-value at 5% level of significance of 1.6449. Since, both h values are less than the critical value, the null hypothesis that $\rho = 0$ and that there is no autocorrelation in the Eq. 2 is accepted (Olayemi, 1998). These results are consistent with those of Gafar (1980).

The ρ values for the equations are 0.04 and 0.05, respectively. However, the h statistics for the trended yield equation is -2.50 with p = -0.24. This is greater than 1.6449 in absolute value. This means that there is an evidence of negative first order autocorrelation in its equation. A similar result is obtained for the untended equations. The output and area equations have h statistics of 0.30 and -0.33, respectively. The null hypothesis H: $\rho = 0$ is accepted in both cases. Hence, no autocorrelation in these equations. The yield equation however, displayed negative first order autocorrelation.

Table 5 and 6 present the estimates of price elasticities for the models with trend and without trend, respectively. There are only slight differences in the estimates for the S/R for the models as well as for the L/R for the 2 models. The L/R estimates are much larger than the S/R values. Both the S/R and L/R price elasticities are inelastic as they are all less than one.

Table 5: Estimates of elasticities with policy dummy

Variable	S/R	L/R	Differential
Q	0.06	0.24	0.18
A	0.09	0.39	0.30
Y	-0.05	-0.15	0.10

Source: Data analysis, 2007

Table 6: Estimates of price elasticities without policy dummy

Variable	S/R	L/R	Differential
Q	0.08	0.33	0.25
A	0.11	0.48	0.37
Y	-0.02	-0.07	0.05

Source: Data analysis, 2007

Appendix 1: Parameter Estimates from Trend Equations Period χ

Variables	Q	A	Y
1967-2004	0.0793***	0.0675***	0.0265***
	(17.4922)	(6.2206)	(4.8131)
1967-1985	0.0878***	0.0900***	0.0458***
	(6.5505)	(11.1018)	(11.0535)
1986-2004	0.0407***	0.0887***	0.0064**
	(4.9122)	(24.9862)	(1.8614)

Source: Data Analysis, 2007. ***significant at 1%**significant at 5%

POLICY IMPLICATIONS

The policy implications derived from the observation that the S/R and L/R price response elasticities are all less than unity and that the coefficients of adjustment are less than 0.5 and hence are said to be sluggish. Measures that will lead to productivity increases in rice production are called for. This cam be achieved by encouraging the adoption and use of improved technology like the New Rice for Africa (NERICA) variety. The extension service delivery system must also be improved in order to achieve the desired results.

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