

ANALYSIS OF THE IMPACT OF SELECTED ECONOMIC VARIABLES ON SORGHUM PRICES IN NIGERIA

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Abstract. Nigeria is the world's leading producer of sorghum intended for use as food grain. Likewise, there has been growing industrial demand for sorghum in the livestock breeding and brewery sectors. As sorghum prices have been on the increase, it becomes pertinent to identify the determinants of this development in order to nip the imminent food crisis in the bud. This study relied on time series data spanning from 1970 to 2015 retrieved from FAOSTAT and World Bank databases. Analytical methods employed include the unit root test, cointegration test and error correction mechanism. The diagnostic tests indicated the presence of autocorrelation which was subsequently adjusted with the Cochrane-Orcutt procedure. Subsequent tests indicated that variables fit well to the model. As shown by the ADF unit root test, the modeled variables were non-stationary but became stationary after first differencing. At a significance level of 5%, the sorghum price was determined by gross domestic product (GDP), annual money supply, official exchange rate and crude oil price, both in the long and short run, whereas the lagged price of sorghum also had an effect on prices in the short run. The study recommends that macroeconomic variables such as GDP, annual money supply and official exchange rate be taken cognizance of when planning the agricultural development in Nigeria.

Keywords: autocorrelation, Cochrane-Orcutt procedure, cereal, cointegration, error correction model, time series

INTRODUCTION

Sorghum is one of the most common and widely consumed staples in Nigeria. The crop is grown mainly in semi-arid areas of the tropics, and ranks fifth in importance among the world's cereals (Doggett, 1996). Sorghum has been a choice crop for the majority of farmers in Northern Nigeria because of its adaptability to a wide range of soil and climatic conditions. Nigeria's sorghum production accounted for 35% of the African production in 2007 (AATG, 2011). The country is the world's third largest producer after the United States and India (FAOSTAT, 2012). However, 90% of sorghum produced by United States and India is destined for animal feed, making Nigeria the world's leader in food grain sorghum production (Gourichon, 2013; FAOSTAT, 2012). In Nigeria, sorghum is the third cereal in terms of production volumes after maize and millet (FAOSTAT, 2012), with more than 4.5 million tons harvested in 2010, representing 25% of the total cereal production (FAOSTAT, 2012). According to Ogbonna (2011) and Gourichon (2013), Nigeria is the largest producer of sorghum in West Africa, accounting for about 71% of the total regional sorghum output. Sorghum is the third cereal in terms of production volume in Nigeria. Beyond consumption of the cereal in its harvested form, there is

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a high demand for sorghum as a major raw material for quite a number of local and industrial products such as food, feed, silage or fuel, to mention a few, which are manufactured in Nigeria (Abdelghafor et al., 2011; Adegbola et al., 2013; Cobley, 1976; Dahlberg et al., 2011; Egharevba, 1979; Reddy et al., 2010). In past years, the ban on imports of such commodities as barley has also put pressure on the demand for sorghum. This is especially true for the red variety, being the raw material for producing malt which, in turn, is a major raw material used in the brewery industry. According to Solange et al. (2014), sorghum grains contain many enzymatic activities involved in the degradation of the endosperm. Red sorghum has a very high enzyme activity compared to white varieties, and this is the reason for its use in the manufacture of beer and industrial traditional sorghum (Dufour et al., 1992; Taylor and Robbins, 1993). Over the years, in the face of the challenge of reducing quantities of feed, factors such as changing climate and crop failures have also resulted in the use of sorghum as a substitute to maize, especially in the formulation of feed in the livestock sub-sector (Legodimo and Madibela, 2013; Olomu, 2011). Based on the foregoing, it may be concluded that the pressure on sorghum is well founded, all the more so since the population is on the increase and generates an increased demand for food commodities. Various measures have been adopted to ensure the sustainability of sorghum production. However, most of these researches were focused on agronomic practices and mostly on how to increase production and boost yield of sorghum in Nigeria. Not too much attention was paid to the dynamics that make various macroeconomic variables interact with each other to affect the sorghum prices in Nigeria. This study was therefore designed to analyze the impact of selected economic variables on sorghum prices in Nigeria from a time series perspective. The specific objective was to determine the macroeconomic variables that influenced sorghum prices in Nigeria over the 1970–2015 period. This study is justified given the high importance of sorghum in the diet of many Nigerians and the crop's contribution to the economy (having in mind its broad use as a raw material in various industries). The high competition among the uses of sorghum as a food security crop, in livestock feed production and in the brewery industry, to mention a few, makes it highly important for the price determinants to be understood. This is because high-quality information on price dynamics will

influence the farmers' cropping decisions while providing a planning framework for the government projects aimed at ensuring a food secure nation.

The study was carried out in Nigeria, a country consisting of 36 states and the Federal Capital Territory, Abuja. Located in West Africa on the Gulf of Guinea, Nigeria has a total area of 923,768 km² (356,669 sq mi). Nigeria shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north. Nigeria is a huge country with a diverse climate and landscape, ranging from the equatorial climate of the southern lowlands, through the tropical central hills and plateau, to the arid northern plains which mark the southernmost extent of the Sahara desert. Nigeria is one of the world's most ethnically and linguistically diverse countries, with three major ethnic groups (Hausa, Yoruba and Igbo) and several minor ones. It is the Africa's most populous country and one of the ten most populous countries in the world. The population is growing rapidly, rising from 88.9 million in 1991 to 140 million in 2006 and 193.4 million in 2017 (NPC, 2017). The country is endowed with rich natural resources, of which oil and gas have been the mainstay of the economy in the last few decades, providing 20% of GDP, 95% of foreign exchange earnings, and around 65% of budgetary revenues (World Factbook, 2012). About 70% of the population are engaged in agricultural production. However, the largely subsistence-based agricultural sector has failed to keep up with rapid population growth, and Nigeria, once a large net exporter of food, now must import food (World Bank, 2015).

MATERIALS AND METHODS

This study relies on time series data spanning from 1970 to 2015, retrieved from the Food and Agricultural Organization statistical database for the United Nations and from the World Bank database. Once collected, the data was analyzed with econometric tools, including the unit root test, cointegration test and error correction mechanism. Before proceeding to examine the effect of the modeled macroeconomic variables on sorghum producer prices in Nigeria over the period considered, the time series data was first subjected to a unit root test. This is a basic preliminary test computed on time series data to establish the order of integration of variables. In this study, the augmented Dickey-Fuller test (Dickey and Fuller, 1979) was employed in checking

the presence of a unit root in the time series. In examining the long-run relationship between the variables covered by the model for sorghum, the cointegration regression test was carried out on the logarithmic values of the variables. Logarithmic values of the variables were used in this study in order to linearize the series prior to further analysis, given that many macroeconomic series increase exponentially. Subsequently, econometrics diagnostics tests were applied to ascertain the validity of the result. Furthermore, error correction analysis was carried out in order to examine the determinants of sorghum price in the short run.

The cointegration test was employed to investigate if the modeled time series data represent a stationary process in a linear combination despite the presence of non-stationarity characteristics in specific variables. This was done with the two-stage Engle-Granger procedure (Engel and Granger, 1987). The presence of cointegration would imply the existence of a long-run relationship between the dependent and independent variables, indicating that at least one of the variables modeled responds to deviations from the long-run relationship. Once the presence of long-run relationships among the variables was detected, the error correction model was specified in order to determine the roles of the independent variables modeled in adjusting the disequilibrium.

The linear regression model used in order to investigate the determinants of sorghum prices in the period under investigation is considered to be of the general form specified as:

$$\text{Ln}Y_i = \beta_0 + \beta_1 \text{Ln}X_{1i} + \beta_2 \text{Ln}X_{2i} + \dots + \beta_4 \text{Ln}X_{4i} + \varepsilon_i \quad (1)$$

$i = 1, 2, \dots, 46$

The findings from the cointegration test indicated the presence of cointegration which implies that at least one of the variables in the model responds to deviations from the long-run relationship. The short-run dynamics, otherwise known as the dynamic causal link between the lagged exogenous variables and the price of sorghum, was modeled as:

$$\Delta \text{Ln}Y_i = \theta_0 + \theta_1 \Delta \text{Ln}X_{i-1} + \theta_2 \Delta \text{Ln}X_{i-2} + \dots + \theta_5 \Delta \text{Ln}X_{i-5} + \theta_{15} \text{ECT}_{i-1} + \tau_i \quad (2)$$

With: Y_i = annual producer price of sorghum (NGN/ton), X_1 = gross domestic product (2005 prices), X_2 = annual money supply (NGN), X_3 = annual USD/NGN exchange rate, X_4 = crude oil prices (USD/barrel), ε_i = stochastic error term, $\varepsilon_i \sim \text{IID}(0, \sigma^2)$, ECT_{i-1} is the error

correction term and τ_i is the error term from the static regression equation (i). The meaning of ECT_{i-1} is that an adjustment mechanism of sorghum price is in place as a response to the changes in the exogenous variables modeled in the study.

RESULTS AND DISCUSSION

The Augmented Dickey-Fuller unit root test was conducted on the logarithmic values of the modeled variables to examine the stationarity and the order of integration. As shown by the results, the variables were non-stationary but became stationary after first differencing. This implies that the variables are integrated of order one, i.e. $I(1)$.

The result obtained for the long-run study is as depicted in Table 1. The parameter values were estimated using the cointegration regression based on the Cochrane-Orcutt procedure.

Based on diagnostic testing of the result obtained for the cointegration model (as reported in Table 3), autocorrelation became an obvious challenge, as the Durbin-Watson statistic was 1.683595. In addition, the Breusch-Godfrey test was carried out and demonstrated that autocorrelation was highly probable, given the distributed chi-squared statistic of 0.584345 with a p value of 0.449. Therefore, the authors rejected the null hypothesis of the absence of autocorrelation. There were no issues of multicollinearity as the variance inflation factors were all below 10 upon testing. Likewise, the White test statistic indicated the absence of heteroscedasticity. In order to adjust the model for autocorrelation, the Cochrane-Orcutt procedure was employed, and the result is as reported in Table 1.

With a Durbin-Watson statistic of 2.01982, it can be concluded that autocorrelation is not present in the model. The R-squared value of 0.9838 indicates that the model's independent variables explained up to 98.38% of the price of sorghum in the period under investigation.

Table 1 indicates that the gross domestic product, annual money supply, official exchange rate and crude oil price were statistically significant at 5 percent. The gross domestic product can be perceived as having a negative effect on sorghum prices. Holding all other variables constant, a unit increase in the GDP resulted in a 1.64992 unit decrease in the sorghum price. One unit increase in the annual money supply resulted as well in an increase in sorghum price by 0.8798 unit. The official

Table 1. Results of the cointegration regression of the model (based on the Cochrane-Orcutt procedure) showing the determinants of sorghum prices in the long run

	Coefficient	Std. error	<i>t</i> -ratio	<i>p</i> -value
Const	5.60144**	2.13658	2.622	0.0123
Ln GDP2005	−1.64992***	0.369656	−4.463	< 0.0001
Ln annual money supply	0.879768***	0.137250	6.410	< 0.0001
Ln official exchange rate	0.355826**	0.137828	2.582	0.0136
Ln crude oil price	−0.409219**	0.177972	−2.299	0.0268
Statistics based on the Rho-differenced data				
Mean dependent variable	3.518322	S.D. dependent variable	1.087550	
Sum of squared residuals	0.841823	S.E. of regression	0.145071	
R-squared	0.983824	Adjusted R-squared	0.982207	
F(4, 40)	484.3072	<i>p</i> -value (F)	2.72e-33	
Rho	0.007856	Durbin-Watson	2.01982	

Source: own elaboration.

exchange rate in Nigeria can be seen to have a positive influence on the price of sorghum as a one-unit rise in the exchange rate resulted in a 0.3558 unit increase in the sorghum price. It can also be seen that crude oil prices have a negative influence on the price of sorghum: a one-unit increase in crude oil prices results in a 0.4092 unit decrease in the sorghum price.

As expected, GDP has a negative influence on sorghum price. An increase in the GDP means the economy is thriving which may be attributed to a growth of production across diverse sectors. This, in turn, could account for the observed price reduction. The above is in tandem with the findings of Faheem and Dilawar (2015) who carried out a study to examine the determinants of food price inflation in Pakistan. Their conclusion was that the GDP has a negative influence on food price inflation. Meanwhile, the increase in sorghum prices in response to annual money supply increases is consistent with a priori expectations and economic principles. This is because the increase in money supply may, in some cases, lead to inflation which will cause more money to be available. Without a corresponding increase in output, this may result in an increase of the general price level, including sorghum prices. The official exchange rate had a positive influence on sorghum price which may be accounted for by the rise in exports by sorghum

producers. Such a development should be expected in the event of a rise in the exchange rate, considering that exports will become more lucrative and attractive to the producers than domestic sales of their sorghum output. This will eventually lead to a shrinkage in the sorghum volume available for domestic consumption. In such a situation, the demand is in excess of supply, hence causing a rise in sorghum prices. Contrary to what has been observed in many developed countries where increasing crude oil prices have led to a rise in food prices, it can be seen that in Nigeria, the increase in crude oil prices led to a decrease in sorghum prices in the period under review. This may be because biogas production from sorghum has not yet gained prominence in Nigeria, thus reducing the pressure observed in some other countries. It could have been expected that sorghum prices and crude oil prices would move in the same direction, given that some of the farm inputs are sourced from crude oil. However, the explanation is that the bulk of sorghum production comes from subsistence farmers who are less dependent on such farm inputs (petroleum for powering machineries, fertilizers etc.) in their production activities.

The result of the error correction modeled to estimate short-run dynamics between the variables in question is as shown in Table 2.

Table 2. Error correction model developed using the Cochrane-Orcutt procedure showing the summary of results of short-run relationships with OLS residuals (sorghum)

	Coefficient	Std. Error	<i>t</i> -ratio	<i>p</i> -value
Const	5.19058***	0.0969049	53.56	< 0.0001
Δ LnGDP2005	−1.52939***	0.0281364	−54.36	< 0.0001
Δ LnannualMoneySup	0.813322***	0.0111005	73.27	< 0.0001
Δ Ln official exchange rate	0.311448***	0.00868019	35.88	< 0.0001
Δ Ln crude oil price	−0.392701***	0.0103979	−37.77	< 0.0001
Δ Ln sorghum price	0.0936442***	0.00855269	10.95	< 0.0001
ECT _{<i>it</i>−1}	−0.974963***	0.00834700	−116.8	< 0.0001
Statistics based on Rho-differenced data				
Mean dependent variable	3.555539	S.D. dependent variables	1.070745	
Sum of squared residuals	0.002033	S.E. of regression	0.007412	
R-squared	0.999959	Adjusted R-squared	0.999952	
F (6, 37)	72 843.36	<i>p</i> -value (F)	9.16e-74	
Rho	0.023929	Durbin's h	0.158984	

Source: own elaboration.

Table 3. Results of the cointegrating regression of the model showing the determinants of sorghum prices in the long run

	Coefficient	Std. error	<i>t</i> -ratio	<i>p</i> -value
Const	6.03240	2.24617	2.686	0.0104**
LnGDP2005	−1.75503	0.343801	−5.105	< 0.0001***
LnannualMoneySup	0.899520	0.185671	4.845	< 0.0001***
LnoffxchageRt	0.355220	0.194237	1.829	0.0747*
LnCOilprice	−0.350475	0.247279	−1.417	0.1639
Statistics based on Rho-differenced data				
Mean dependent variable	3.479141	S.D. dependent variable	1.107745	
Sum of squared residuals	0.940288	S.E. of regression	0.151439	
R-squared	0.982972	Adjusted R-squared	0.981310	
F(4, 41)	663.3303	<i>p</i> -value (F)	1.16e-36	
Log-likelihood	24.20367	Akaike criterion	−38.40733	
Schwarz criterion	−29.26412	Hannan-Quinn	−34.98223	
Rho	0.119277	Durbin-Watson	1.683595	

Source: own elaboration.

Because the lagged values of the dependent variable (sorghum price) are included on the right side of the equation, the dependent variable becomes an independent variable as well. Therefore, it is necessary to use another test than the Durbin-Watson statistic (which is no longer valid) to check for autocorrelation. In this study, the Durbin's h was used, resulting in a value of 0.15898 which suggests the absence of autocorrelation.

The Durbin's h statistic follows the standard normal distribution with zero mean and unit variance. The null hypothesis that $p = 0$ is rejected if the computed h statistic exceeds the critical h value. At 5%, the critical h value is $-1.96 - +1.96$. If the computed h value exceeds 1.96, the null hypothesis is rejected. If it does not, the null hypothesis of the absence of (first order) autocorrelation is not rejected. In this study, the Durbin's h statistic of 0.15898 does not exceed the critical value, and therefore the null hypothesis of the absence of autocorrelation in the specified model is accepted.

The R-squared value of 0.9999 suggests that exogenous variables included in the model are capable of explaining up to 99.99 percent of the price of sorghum examined in the study. The result revealed that the gross domestic product, annual money supply, official exchange rate, crude oil price, price of sorghum in the previous year, and the sorghum error correction model were statistically significant at 5 percent. The gross domestic product can be perceived as having a negative influence on the price of sorghum. A unit increase in the GDP resulted in 1.52939 unit decrease in the sorghum price. One unit increase in the annual money supply resulted as well in an increase in sorghum price by 0.81332 unit. The official exchange rate in Nigeria can be seen to have a positive influence on the price of sorghum as a one-unit rise in the exchange rate resulted in a 0.31145 unit increase in the sorghum price. It can also be seen that the crude oil prices has a negative influence on the price of sorghum: a one-unit increase in crude oil prices results in a 0.3927 unit decrease in the sorghum price. A one-unit increase in the lagged price of sorghum leads to a 0.09364 unit increase in the price of sorghum in the current year. The error correction model also validated the existence of a long-run equilibrium relation between the modeled variables. In the absence of changes in the explanatory variables, the deviation of the model from the long term-path is balanced by a 97.49 percent increase in sorghum price the following year.

CONCLUSION AND RECOMMENDATIONS

The analysis carried out in this study revealed that sorghum prices in Nigeria respond negatively to the gross domestic product and crude oil prices. However, they do respond positively to the annual money supply and official exchange rate in both the short and long run. In the short run, sorghum price is also positively influenced by its price in the previous year.

It is therefore recommended that macroeconomic variables such as annual money supply, official exchange rate, crude oil price and the gross domestic product be taken cognizance of when planning the agricultural development in Nigeria since they have been demonstrated to be a driver of sorghum prices in the country.

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