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Forecasting Sorghum Production in Nigeria – A Box-Jenkins Approach

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Abstract
Sorghum remains a thinly traded commodity in Nigeria due to several disincentives like declining production, poor linkage to international markets and poor market information. Most of Nigeria's huge sorghum production is thus used for household consumption and as fodder. This investigation provided a forecast of the output of sorghum for Nigeria up to 2022 using the Autoregressive Integrated Moving Averages (ARIMA) method based on time series data spanning the period 1961 – 2013 disaggregated into three different eras (1961 – 1986, 1986 – 2013, and 1991-2013). The different policy scenarios of Regulation, Structural Adjustment and Liberalization which the Country has experienced over the years were also stimulated. Overall, output of sorghum maintained an upward trend over the years. However, output predictions were highest for the analysis using the Structural Adjustment policy era. It was concluded that following the ideals of the Structural Adjustment Programme, especially in the area of realizing the potentials the Country has for sorghum exports will greatly increase production and generate much needed foreign exchange for the Nigerian economy. Also, channels for access to international markets for local producers have to be opened and sustained. The market information on sorghum should be made available while processing activities for more value-added production of sorghum be encouraged.

Keywords: Box-Jenkins method.forecast, Sorghum output, time series,

Introduction
Sorghum (*Sorghum bicolor*) is a tropical crop which is indigenous to and a major staple of most of Africa, South America countries and the drier regions of India. It is the fourth most important cereal crop globally after wheat, rice, and maize. Due to its unique morphology, sorghum is better adapted to drought prone areas than maize and thus assumes greater importance in combating food insecurity in many such regions of the world. The secondary roots of the sorghum plant can attain a lateral distribution of up to 1 meter and a depth of up to 2 meters early in its life (Du Plessis, 2008). This feature, combined with a leaf system that protects the plant from moisture stress as well as a stem system that efficiently controls transpiration, makes sorghum a very important crop in the arid and semi-arid regions of the world including the Sudan and Sahel savannah zones of Nigeria which receive less than 500mm per year of rainfall and in which the rainy season lasts barely three months. Sorghum is a very important crop in the diet of many households across Nigeria. It is either consumed as whole grains or processed into a number of other energy and protein-rich meals like *pap* which are staples in many households.

Over the last decade, world sorghum production has risen from 60 million to 65 million metric tons. The United States is the fourth largest producer of the crop and the largest exporter, accounting for 80 percent of world sorghum exports in 2006 and 57 percent in 2011. While The United States, Argentina and Australia produce only about 23 percent of global output, they jointly account for 93 percent of exports (USGC, 2012). Sorghum also has great significance in African agriculture. For instance, Nigeria has ranked among the top 5 producers of the

crop in the world for most of the last 50 years as shown in figure 1, with the few exceptions being the years 1976, 1978 and 1981 in which it ranked 6th globally in sorghum production.

Figures available from the FAO show that among the top 20 sorghum producing nations of the world for 2012, sub-Saharan Africa alone accounts for ten; North-Africa, two; Asia, four; The Americas, three and Europe, one. Nigeria was the highest producer in the world in that year with 6.9 million metric tons, representing around 10 percent of global production (FAOSTAT, 2013). Figure 2 shows Nigeria in relation to the other top-ranked world producers of sorghum for 2012.

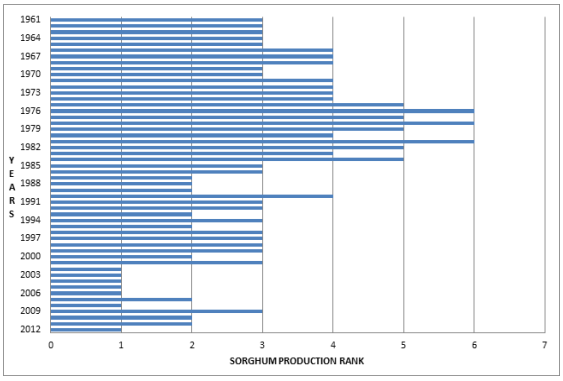

Figure 1. Nigeria's ranking in global sorghum production (1961 – 2012).
Source: Computed from FAOSTAT (2013) and USDA (2013) data.

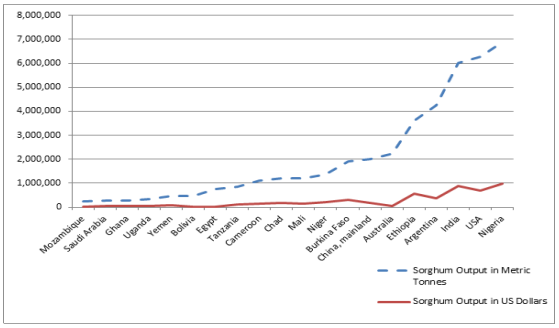

Figure 2. World's top sorghum producing nations for 2012.
Source: Computed from FAOSTAT (2013) and USDA (2013) data.

Nigeria is the largest regional producer of the crop, usually accounting for around 71 percent of West Africa's annual sorghum output (Aba *et al*., 2005). In Nigeria, sorghum is mainly grown in the Northern Guinea and Sudan/Sahel ecologies with Kaduna, Kano, Jigawa, Zamfara, Sokoto, Kebbi, Borno, Plateau, Bauchi, Adamawa and Gombe states being the major producers of the crop in the Country (Aba *et al*., 2005).

In spite of the foregoing, however, sorghum remains a thinly traded commodity in the country due to several factors like declining production, poor linkage to international markets and poor market information (FAO, 2013).

Agricultural/economic policy and sorghum production in Nigeria

Sorghum production in Nigeria has been affected by different economic policy environments that the country has experienced. Four of such economic policy situations that have had a direct bearing on Nigerian agriculture (and, in effect, sorghum production) are the pre-Structural Adjustment period (regulation) (1961 – 1986), the Structural Adjustment era (1986 – date), the era of Trade Liberalization (1991 – 2018) and the recent Agricultural Transformation era (2011 – 2014). The trade liberalization policy was an offshoot of the principles of Structural Adjustment Programme (SAP) and thus both regimes had similar goals of boosting domestic production as well as trade in all sectors of the economy including agriculture. The policy measures implemented included the

elimination of non-tariff barriers to imports, the rationalization and reduction of tariffs, the institution of market determined exchange rates and the removal of fiscal disincentives and regulatory deterrents to exports (Agbeyegbe *et al*., 2004).

The Agricultural Transformation era, on the other hand, began in 2011 with the launch of the Agricultural Transformation Agenda (ATA) of the Federal Government with a vision to create an agricultural sector that will drive income growth, accelerate achievement of food and nutritional security, generate employment and transform the country into a net exporter of agricultural commodities.

This paper simulated three of the different policy environments (while excluding the ATA from forecast equations due to its short span) by using production data covering the periods of enactment of each of the policies. However, the performance of sorghum production in Nigeria during all four pre- and post- SAP policy periods is shown in Table 1

Table 1,shows that the liberalization period has had the best effect on sorghum production in Nigeria while output was poorest during the era of regulation (pre-SAP) based on average figures. Given the significant position Nigeria occupies in global sorghum production, the crop's importance in the diet of Nigerian households and its critical role as a potential tool for eradicating food insecurity and poverty across Nigeria and the African sub-region, it becomes necessary to examine the likely trend of sorghum production in Nigeria by making reliable forecasts.

This paper relied on sorghum production data spanning 53 years (from FAOSTAT and USDA data) and the projection was based on existing area planted and climatic factors. The box-jenkins (BJ) methodology was used to estimate future production figures. This is expected to guide efforts at sustaining or improving the yield of the crop for the coming years.

Materials and Methods

Secondary data that covered the period of 1961-2013, spanning 53 years was used in this study. The data was sourced from FAOSTAT (2013) and the USDA's Global Agricultural Information Network (GAIN) report for 2013.

The Box-Jenkins (BJ) (also known as the autoregressive integrated moving average, ARIMA) methodology was used to generate a model for forecasting sorghum

Table 1. Nigeria's sorghum output (1961 – 2013)

Policy Period	Years covered	Output (metric tons)	Average annual output for period
Pre-Structural Adjustment (regulation)	1961 – 1986	96,661,000	3,717,731
Structural Adjustment (SAP)	1986 – 2013	193,473,200	6,909,757
Trade Liberalization	1991 – 2013	168,395,200	7,321,530
Agricultural Transformation	2011 – 2014	19,697,060	6,565,687

Source: Computation from FAOSTAT (2013) and USDA (2013) data

output for the period 2018 – 2022. In view of the *Lucas Critique* which states that the parameters estimated from an econometric model are dependent on the policy prevailing at the time the model was estimated and will change with changes in policy (Gujarati, 2004), the Box-Jenkins model was estimated under three simulated policy situations in Nigeria as earlier discussed: regulation, SAP, and liberalization.

The ARIMA model generated from the sorghum production data is of the form:

Q_t $Q_{t\ 1}$ .....(1)

That is, after a few iterations, the sorghum production data fitted an AR (1) process w here;

Q_t = sorghum output (in metric tonnes)

$Q_{t\ 1}$ = *sorghum* output lagged by one period (one year)

δ = *constant term (autonomous output)*

α = coefficient to be estimated

However, since the actual equation estimated is of the f orm: Q_t $Q_{t\ 1}$ (where Q_t is the first difference of sorghum output), in order to forecast sorghum output and not the *change in sorghum output*, the equation used for forecasting is therefore the integrated form of the first differenced series which is as follows:

Q_t (1)$Q_{t\ 1}$ .....(2)

Results and discussion

The estimated equation parameters from the different policy scenarios using the ARIMA model are shown in Table 2. Based on the results presented in Table 2, the predicted values for sorghum output in Nigeria for the period (2018 – 2022) are shown in Table 3. The huge economic potentials of sorghum can also be seen in its increasing use as a substitute for more expensive and imported raw materials For example, the sorghum malting plant in Abia state reduced its imports of malted barley in 2012 in preference for sorghum, thus pointing to investor confidence in the continued competitiveness of Nigerian sorghum in the local beverage industry (USAID, 2012); and as beer demand rises, sorghum production is expected to be impacted positively.

Table 3 reveals that, over the forecast period, sorghum production in Nigeria shows an upward trend under any of the given policy scenarios. However, the SAP period showed the highest values over the projection years. The regulation era, on the other hand, showed the lowest projection figures. Using all of the data, the same upward trend of production is predicted. However, the projection figures were better than those of the regulation and liberalization eras.

This paper has shown that sorghum production will rise in Nigeria over the next few years and even beyond. However, it was also shown that the policy setting of structural adjustment favours increased sorghum production the most. Thus, following the ideals of the SAP, especially in the area of realizing the potentials the Country has for sorghum exports will greatly increase production and generate much needed foreign exchange for the Nigerian economy. In this regard, channels for access to international markets for local producers have to be opened and sustained and market information made available while also encouraging processing activities for more value-added production.

The huge economic potentials of sorghum can also be seen in its increasing use as a substitute for more expensive and imported raw materials.

Table 2: Estimated ARIMA parameters.

PERIOD	δ	α	R^2
All (1961 – 2013)	586,434.9	0.8976	0.8125
Regulation (1961 – 1986)	1,839,887	0.5119	0.1750
SAP (1986 – 2013)	1,727,660	0.7538	0.5641
Liberalization (1991 – 2013)	3,025,063	0.5937	0.3428

R^2= Coefficient of multiple determination

Table 3.Forecast of Sorghum Production in Nigeria (in metric tons) (2018 – 2022).

Projection year	All (1961 – 2013)	Regulation (1961 – 1986)	SAP (1986 – 2013)	Liberalization (1991 – 2013)
2018	160,591,505.53	71,408,165.64	133,629,135.56	107,946,469.98
2019	305,324,875.80	109,801,982.62	236,806,437.95	175,059,352.20
2020	579, 970,919.21	167,849,368.46	415,776,054.87	282,017,152.60
2021	1,101,139,251.20	255,611,347.17	730,915,705.04	452,475,799.10
2022	2,090,108,277.98	388,298,682.79	1,283,607,623.50	724,135,744.03

It is expected that with continuous drive from the federal government towards agricultural transformation, sorghum production will definitely be boosted in Nigeria as predicted. Sorghum was picked as one of the priority agricultural products under the Staple Crop Processing Zones (SCPZ) initiative of the ATA with core investors sought to drive production and export. If this initiative is sustained by the current political administration in the country, sorghum production will be significantly boosted in Nigeria, probably even beyond the predicted values.

Recommendations

It is recommended that more direct focus be placed on the sorghum industry in Nigeria so as to achieve its huge potentials. Policies that will protect the local sorghum value-chain should be implemented. The tariffs on imported industrial substitutes such as barley and hops along with the sustenance of the current land boarder closure should be put in place until the local industry becomes sufficiently strong and self-reliant. Furthermore, the productivity of local producers should be enhanced deliberately through credit and input support to the farmers. The Federal Ministry of Agriculture and Rural Development should also champion an out-grower/up-taker programme in collaboration with the private sector in order to enhance interest in sorghum production by farmers and

potential producers.

Finally, institutions in the sector, such as sorghum farmer cooperatives and unions should be strengthened in order to provide adequate support to the producers.

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