Output Growth Decomposition in Nigeria Agriculture: An Econometric Analysis 1960-2018

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***Abstract*: - Nigerian agriculture has relied on land area expansion and not optimal land use, due to population pressure. Thus agricultural production has moved into marginal lands, characterized by poor output. There is however a paucity of research on output growth as most studies emphasized only production. Hence output growth decomposition in Nigeria agriculture were investigated. Secondary data were sourced from FAOSTAT covering 1960 to 2018.Variables used include agricultural Gross Domestic Product (GDP), land, labour, fertilizer and tractors. Augmented Dickey Fuller (ADF) test was carried out on stationary dataset. Stochastic Frontier Model, Output Decomposition and Multiple Regression Models at α0.05 was used. ADF tests indicated that variables were not stationary at their level but became stationary at first difference, output at 5% and others at 1%, indicating no spurious regression results. Key parameters of the stochastic function were positively significant. Fertilizer had 0.2376, land 0.2234, labour 0.2032 and tractors 0.1681. Agricultural production showed decreasing return to scale having a coefficient of 0. 8283, and inefficiency level with Technical inefficiency (TEI) of 0.1754. Output growth rate was 3.52(100%), it was decomposed into input growth contributed (14.8%, TFP contributed 62.8%, and residual added 22.4%.**

Keywords: **Technical efficiency, Agricultural, Growth, Output, decomposition**

I. INTRODUCTION

Nigerian agricultural sector in the 1960s was the most important in terms of contributions to domestic production, provision of employment, foreign exchange earnings, food supply and its linkage to other sectors of the economy (NBS 2014, Daramola, 2014). The main emphasis then was on agriculture to the extent that Nigeria was a major exporter of such agricultural products as palm produce, cocoa, groundnut, cotton and rubber. Besides, the agricultural system was able to produce enough of food crops like yam, cassava, maize, millet, sorghum and soya beans for the nation, to the extent that there was almost no need for food importation. Hitherto, agriculture accounted for over 60% of the Nation‘s Gross Domestic Product (GDP). Although, there have been fluctuations in the agricultural sector output and gradual declines in its contributions to the nation's economy (Al-Hassan 2013). Agricultural sector’s share of GDP increased from 28% in 1985 to 32% in 1988, dropped to 31% in 1989, rose again to 37% in 1990 but fell significantly to 24% in 1992 and increased to 37% in1994. It was 32% in 1996 and rose to 40% in 1998, dropped again to 27% in 2000, increased to 37% and fell to 31% in 2002 and 2006, fell to 23.91% in 2012, 23.33% in 2013, 22.90 % in 2014 and 23.11% in 2015(CBN, 2014, NBS,2016) The recent economic slowdown warrants a special attention for its revival. The current scenario tends to imply that increasing inputs is not a feasible way of increasing output. For more and more land and labor inputs are allocated for non-agricultural purposes. One other alternative to increase output is technological advancement. Although, no major technological breakthrough in Nigerian agriculture has been recorded. The immediate solution to increasing agricultural production can come from an increase in production efficiency. Hence, it is essential to assess how the existing resources are being used and identify what possibilities exist for improving efficiency of agricultural production in Nigeria, given the resource constraints.

However, to generate high output and output growth in the sector, the focus has to shift increasingly towards means to increase productivity and/or intensification. The decomposition of same will indicate the sources of growth in the sector. This is expected to provide the structural handle for effective policy formulation for the sector. To achieve food self-sufficiency requires keeping the level of productivity high. In recent years sources of increased inputs, such as land and rural labour shift off the farm are dwindling. (Brown, 1995; Jin *et al;* 2007). Although the agricultural sector in African continues to underperform, crop yields lag behind levels in other regions and productivity growth continues to be sluggish (Sheahan and Barrett, 2017). A major indicator of depressed performance in Nigeria agricultural sector is the food crisis experienced in the country in the contemporary years, forcing the country to resort to increasing food importation at high prices (Ogundari and Ojo, 2007).

Output growth over time is usually attributed to growth in inputs and/or improvement in total factor productivity. While measuring the sources of output growth, the contribution of total factor productivity is always estimated as a residual. This is after accounting for the growth of inputs. Quite often, the contribution of total factor productivity is interpreted as the contribution of technical progress. This interpretation implies an assumption that improvement in productivity arises from technical progress only. This assumption is valid only if firms (farmers) operate on their production frontiers. That is, they are producing the maximum possible output or they are realizing the full potential of the technology. Operation on the frontier can be achieved if firms (farmers) follow the best practice methods of application of the technology. Operating on the frontier is commonly referred to as "technical efficiency, TE = 1.

Several recent studies have attempted to explain and identify the sources of output growth in agriculture. By using a stochastic production frontier approach, Fan (1991), Ahmad and Bravo-Ureta (1995), Wu (1995), Kalirajan, Obwona and Zhao (1996), and Kalirajan and Shand (1997) have attributed output growth into size effect (changes in input use or growth that is movements along a path on or below the production frontier), technical change (shift in the production frontier) and improvements/changes in technical efficiency (movements towards or away from the production frontier).

1.1 Working Hypotheses

1. Null Hypothesis

Ho: $b_1=b_2=b_3=b_4=0$

That the inputs considered have no significant effect on the output

Alternative Hypothesis

Ho: $b_1 \neq b_2 \neq b_3 \neq b_4 \neq 0$

That the inputs considered have significant effect on the output

2. Null Hypothesis

Ho: $b_1+b_2+b_3+b_4=1$

That production in the agricultural sector is characterized by constant returns to scale

Alternative Hypothesis
H_1: $b_1+b_2+b_3+b_4 \neq 1$
That production in the agricultural sector is characterized by decreasing/increasing returns to scale

Models of production growth have been used to measure the change in output, to isolate the contribution of various inputs to output growth and to identify the Solow residual or output growth not due to increase in inputs. Output growth over time is usually attributed to growth in inputs and/or improvement in total factor productivity. While measuring the sources of output growth, the contribution of total factor productivity is always estimated as a residual. This is after accounting for the growth of inputs. The contribution of total factor productivity is interpreted as the contribution of technical progress. This interpretation implies an assumption that improvement in productivity arises from technical progress only. This assumption is valid only if firms (farmers) operate on their production frontiers. That is, they are producing the maximum possible output. Operation on the frontier can be achieved if firms (farmers) follow the best practice methods of application of the technology. Operating on the frontier is commonly referred to as "technical efficiency, TE = 1.

Most studies on agriculture in Nigeria (Oni et al., 2009) and agriculture in general (Battese, 1992; Bravo-Ureta and Pinheiro, 1993) applying the stochastic frontier methodology have always found some level of technical inefficiencies. The contention of this study and as observed by Kalirajan et al., 1996 is that since they operate somewhere below the frontiers, technical progress cannot be the only source of total factor productivity growth. Several recent studies have attempted to explain and identify the sources of output growth in agriculture. By using a stochastic production frontier approach, Fan (1991), Ahmad and Bravo-Ureta (1995), Wu (1995), Kalirajan, Obwona and Zhao (1996), and Kalirajan and Shand (1997) have attributed output growth into size effect (changes in input use or growth that is movements along a path on or below the production frontier), technical change (shift in the production frontier) and improvements/changes in technical efficiency (movements towards or away from the production frontier). This theoretical framework initiated by Nishimizi and Page (1982) implicitly assumed that the production technology exhibits constant returns to scale and that individual producers .are perfectly allocative efficient. Within such a framework it is, however, implicitly assumed that technical change and changes in technical efficiency are the only sources of total factor productivity (TFP) This is an inherent limitation in the decomposition framework adopted by the afore mentioned studies.

This observation presupposes that they all assumed constant returns to scale function for their analysis. However, since the range of scale economies is not known a *priori*, it seems appropriate to proceed by statistically testing the hypothesis of constant returns to scale. The required and necessary test was not carried out which raises issues on the empirical validity of their results. This is so because if the constant return to scale (CRS) hypothesis is rejected, the scale effect is present and should be taken into account1. This is because the relative contribution of the scale effect to output growth depends on both the magnitude of scale economies and the rate of input growth. This study intends to do this as a difference to the other studies

The present study differs from most previous studies using stochastic production frontiers to decompose output growth in a distinct respect. The proposed analysis relies on the input-oriented, Farell-type measures of technical efficiency, while all previous studies have used the output-oriented, Timmer-type measures of technical efficiency.

Output growth is decomposed by relying on the econometric estimation of a self-dual production frontier. A quasi translog (or a generalized Cobb Douglas) frontier production function (Fan,1991) is adopted. This specification allows for variable returns to scale, input biased technical change, and time varying production and substitution elasticities the latter being unchanged over farms (Karagiannis and Tzouvelekas, 2001). It also permits statistical tests for the hypothesis of zero rate of technical change and constant returns to scale. Specifically, consider the following general stochastic production frontier function.

Most studies have been based on production and productivity at the farm/micro level. From policy point of view, the decomposition of output growth is important as it will provide useful statistics to indicate how agricultural growth is being advanced through productivity gains in agriculture. Providing empirical information on this subject justifies carrying out this study. The general objective of this study is to determine the sources of output and productivity growth in the Nigerian agriculture from 1960-2018, the study specifically determine the response of agricultural output to the inputs in the agricultural sector.

III. METHODOLOGY

3.1 Area of Study

The study area for the study is the Nigerian agricultural sector.

3.2 Data Sources

The data used for this study were basically time series data covering 1960– 2018, that is fifty- five (58) years. The data were sourced from FAOSTAT data sets. The data sets contain the relevant variables needed for the analysis carried out.

3.3 Methods of Data Analysis

3.3.1 Production Frontier Function Model

The production frontier function is approximated by the generalized Cobb-Douglas form. This is also viewed as a translog specification without cross terms. That is, it is a strongly separable-in inputs translog production frontier function (Fan 1991),

$$Q = \alpha_o + \alpha_j \ InX_{jt} + \alpha_t t + \alpha_{tt} t + \alpha_{jt} \ln x_{jt} \qquad (1)$$

where;

Q is output represented by agricultural GDP.

X_1 = fertilizer (kilogram),

X_2 = labour (man days),

X_3 = land (in hectares),

X_4 = capital (Tractors), and

t. = time variable

3.3.1.1 Description of the Variables

Fertilizer: Fertilizer consumption is often viewed as a proxy for the whole range of chemical inputs and more (Mundlak et al., 1997).

Laborrefers to the economically active population in agriculture for each year, in each country. The economically active population in agriculture is defined as all persons engaged or seeking employment in agriculture, forestry, hunting, or fishing sectors,

Agricultural landis the sum of the areas under *arable land* (land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow),

Tractors: Data on agricultural capital are very scarce. Often, crude data on tractors and machinery have been used in cross-country analysis of agricultural production functions. We used data on the number of tractors, which refer to total wheel, and crawler tractors (excluding garden tractors) used for agricultural production.

3.3.2 Output Decomposition Model

$$\dot{Q} = \sum_{j=I}^{m} s_j \dot{x}_j + [1 - \varepsilon^{CQ}(Q, w, t)]\dot{Q} - \dot{C}(Q, w, t) + \dot{T}(Q, x, t) + A(Q, \dot{w}, x, t) + \sum_{j=I}^{m} [s_j - s_j(Q, w, t)]\dot{w}_j \qquad (2)$$

IV. THE AUGUMENTED DICKEY FULLER TEST RESULT

s/n	Variables		t- stat.	Prob*	Level	t- stat.	Prob*	1st diff.
1.	**Output**							
	ADF test statistic		**-1.7442**	**0.7173**		**-4.0088**	**0,0142**	
	Test critical values	1 %	-4.1409		**NS**	-4.1400		**NS**
		5%	-3.4937		**NS**	-3.4970		**S**
		10%	-3.1776		**NS**	-3.1776		**S**
2.	**Fertilizer**							
	ADF test stat.		**-2.5301**	**0.0000**		**-9.9712**	**0.0000**	
	Test critical values	1%	-4.1338		**NS**	-4.1373		**S**
		5%	-3.4937		**NS**	-3.4953		**S**
		10%	-3.1757		**NS**	-3.1766		**S**
3.	**Land**							
	ADF test statistic		**-2.4152**	**0.0011**		**-4.8931**	**0.0011**	
	Test critical values	1 %	-4.1338		**NS**	-4.1373		**S**
		5%	-3.4937		**NS**	-3.4953		**S**
		10%	-3.1757		**NS**	-3.1766		**S**
4.	**Labour**							
	ADF test stat.		**0.4962**	**0.9991**		**-4.6317**	**0.0025**	
	Test critical values	1%	-4.1373		**NS**	-4.1373		**S**
		5%	-3.4953		**NS**	-3.4953		**S**
		10%	-3.1766		**NS**	-3.1766		**S**

5.	**Tractor**						
	ADF test stat.	**1.4427**	**1.0000**		**-4.6317**	**0.0025**	
	Test critical values 1%	4.1338		**NS**	-4.1373		**S**
	5%	-3.4937		**NS**	-3.4953		**S**
	10%	-3.1757		**NS**	-3.1766		**S**

* Mac Kinnon (1996) one-sided p-values

The results of the Augmented Dickey Fuller (ADF) tests for the time series used in the study shows that all the variables in the series were not stationary at their level. However, they became stationary after first difference. Output at 5% while all others were stationary at 1%. Hence, the analysis indicated that all the series were of the same order I(1). Using OLS on the series will not lead to the problem of spurious regression results. The results of the estimated regression, as a result, can be used to make inferences. That is, the regression is not spurious.

Table 1; Response of output to variable inputs

Variables	Parameters	Standard Error	t-values
In X_1 Fertilizer	0.2376***	0.0679	3.4993
In X_2 Labour	0.2032**	0.0818	2.4841
In X_3 Land	0.2234***	0.0815	2.7411
In X_4 Tractor	0.1681**	0.0786	2.1387
In X_5 Fertime	0.0166*	0.0095	1.7474
In X_6 Labortime	-0.0568	0.0430	1.3209
In X_7 Landtime	-0.0624	0.0403	1.5484
In X_8 Tractime	0.0592	0.0496	1.1936
X_9 Time	0.1718***	0.0675	2.5452
X_{10} $^1/_2$ time^2	-0.0426**	0.0197	2.1624
K Constant	1.8467	0.9036	2.0437

Source: Data Analysis, 2019

*** 1%, ** 5%, * 10%

γ (TE) = 0.8246 (1-γ) = 0.1754

Log –likelihood 109.4327

$\sigma_u = 0.3522$ $\sigma_u{}^2 = 0.1241$

F-value = 232.3812

$\sigma_v = 0.1627$ $\sigma_v{}^2 = 0.0265$

$\sigma = 0.3880$ $\sigma^2 = 0.1505$

$\lambda = 2.1647$ Wald $\chi^2 = 653.2$

Table 1 contains the results of the estimated ordinary stochastic frontier production function (SFPF). The estimated input parameters have the anticipated positive sign and magnitude. These are all less than unity. i.e greater than zero but less than one. The estimated variance of the one-sided error term ($\sigma_u{}^2$) is found to be 0.1241. The estimated variance of the statistical noise ($\sigma_v{}^2$) stood at 0.0265.The logarithm of the likelihood function of 109.4327and the lambda (λ) value of 2.1647 indicates a satisfactory good fit for the quasi-translog specification. The alternative hypothesis is accepted for the estimated model, Fertilizer contributes more to the output overtime than all the other inputs. Its coefficient is 0.2376 and is significant at 1%. This agrees with the findings of Nkamleu(2011) the contribution of each physical input reveals that output growth due to fertilizer usage is the highest in Africa where it accounts for 51% of total agricultural output growth, it is one of the most important physical input contributors to agricultural growth, suggesting that fertilizer had a

good foundation, on which one can build strong agricultural growth in Africa. This is followed by land with a coefficient of 0.2234 and also significant at 1%. Labour with a coefficient of 0.2032 ranks third. The positive relationship of agricultural labour result is in line with Odhiambo et al. (2004) in Kenya and Mehdi (2011), while tractors with 0.1631 came last. Both are significant at 5%. Of the interacted terms only the fert-time variable is significant at 10%. The time variable is positive and significant at 1%. The output responded positively to time. However, time-squared is negative and significant at 5%.

In summary, all the inputs responded positively to output over-time. This finding indicated that output expansion relies on increases in these factors. So future output expansion based on these factors may not be feasible as they have reached their limits in use. If however this is possible, it cannot be sustainable over-time. Based on the findings of this study the null hypothesis that inputs used in agricultural production has no significant effect on the output is rejected and the alternative hypothesis is accepted. Also agricultural production is characteristic by diminishing marginal return, the alternative hypothesis is also accepted.

Table 2: Decomposition of Agricultural Output Growth in Nigeria 1960-2015

Variable	Contribution	Percent (%)	Estimates	%
Output Growth	-		**3.52**	**100.0**
Aggregate Input Growth	-		**0.52**	**14.80**
Input				
Fertilizer	0.01	1.92		
Labour	0.01	1.92		
Land	0.51	98.08		
Tractors	-0.01	-1.92		
	0.52	**100.0**		
TFP Growth Items			**2.21**	**62.80**
Scale Effect	-0.92	-41.63		
Technical Change	1.56	70.59		
Autonomous 2.41	-	-		
Biased -0.85	-	-		
1.56	-	-		
Technical Efficiency Change	0.85	38.46		
Allocative Efficiency Change	0.78	35.29		
Price Adjustment Effect	-0.06	-2.72		
	2.21	**100.0**		
Residual (Unexplained)	**-**	**-**	**0.79**	**22.4**
Total	-	-	**3.52**	**100.0**

Source: Data Analysis, 2019

Table 2 presents the results of the output and TFP growth decomposition that is done in conjunction with the derived SFCF. An annual compound growth rate of 3.52 is obtained for output growth over the 1960- 2015 period. The growth rates of the other items/components are added and their contribution to output growth calculated from the values obtained. Aggregate input growth with a growth rate of 0.52 contributed 14.8% of the output growth. The results suggest that TFP with a growth rate of 2.21 contributed 62.8% of the output growth. This finding indicates that TFP contributed more to output growth than the aggregate input growth. This finding contradicts the finding of Nkamleu (2011) and Busari et al, (2005), but in line with Fulginiti et al. (2004).

The scale effect which measures the relative contribution of scale economics is – 0.92 and has -41.63%. The scale effect being negative implies that the sector exhibited decreasing returns to scale as the aggregate input increased over time.

The rate of technical change or the increase in cost of production per unit time has a growth rate of 1.56 or 70.59%.

On average, diseconomies of scale slowed down output growth by a rate of 35.29% and TFP by almost 41.63%.These figures would have been omitted if constant returns to scale were falsely assumed for the production process. By such wrong assumption, output and TFP growth would have been over-estimated.

The average annual rate of technical change is 1.56. This accounted for 70.59% of the TFP growth.

The growth rate of technical efficiency at 0.85 contributed 38.46% to the output growth. Hence, technical efficiency has enhanced output and TFP growth.

The Allocative efficiency is positive so has also enhanced output growth. However, their relative contribution to output growth depends on their rate of change over time, rather than their absolute magnitude.

The relative contribution of the input-oriented technical efficiency of 38.46% is greater than that of input allocative efficiency on output of 35.29%. By combining their effect, it can be observed that improvements in efficiency account for 73.75% of annual output growth. Efforts should be made to improve both TE and AE for increased output growth.

The price adjustment effect was found to have a negative impact on output and TFP growth. On the average price adjustment effect at -0.06 accounted for about 2.72% of output change.

After accounting for all theoretically proposed sources of TFP growth and for the size effect (Input growth), unexplained output at 0.79 implies that 22.4% of observed output growth remained as residual or unexplained.

V. SUMMARY AND CONCLUSION

Conclusively, the study revealed that the variables inputs of fertilizer, labour, land and tractor are positive and significantly affect output growth,

It also shows that input growth, technical change, technical efficiency change and allocative efficiency change contributed positively to total output growth, while scale effects and price adjustment contributed negatively to output growth

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