VECTOR AUTOREGRESSIVE (VAR) ANALYSIS OF THE DYNAMIC LINK AMONG PRODUCER PRICES, AREA AND YIELD OF CASSAVA IN NIGERIA

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ABSTRACT
This study analyzed the relationship among producer prices, area harvested and yield of cassava in Nigeria. The study used annual time series data spanning from 1991 to 2014. Results from Augmented Dickey Fuller test showed that the series were integrated of order one, I(1). Johansen cointegration test showed there was no long-run relationship among the variables. Results from the VAR estimates showed that producer prices have significant influence on area harvested and yield of cassava even though there was no long-run relationship among the variables during the period of study. Also the variance decomposition analyses showed that over time the results reveal that only about 26.21 and 27.91 percent of changes in producer prices is explained by changes in area harvested and yield respectively. This implies that producer prices are mainly influenced by changes in its own shock and not changes in area harvested and yield. Results showed that there exist bidirectional causalities between yield and area harvested, while a unidirectional causality was found to exist between producer prices and area harvested as well as between yield and producer prices. Consequently, given the influence of producer prices on the area harvested and yield of cassava, price policies that will encourage farmers to put additional area into the cultivation of cassava ought to be promoted.

KEYWORDS: VAR, Variance decomposition, Producer Prices, Area, Yield, Cassava

INTRODUCTION
Cassava (*Manihot esculenta crantz*) is one of the principal root and tuber crops of the tropics widely grown and consumed as subsistence staple (FAO, 2017b). According to Nteranya and Adiel (2015), some of the compelling reasons for encouraging the cultivation of root and tuber crops for sustainable food production in Africa are: (i) they are versatile staples capable of addressing food and nutrition security and produce more food per unit area of land, compared to many other crops; (ii) though longer in their cropping cycle, are vital in the annual cycle of food availability due to their broader agro ecological adaptation, diverse maturity period and in-ground storage capability, permitting flexibility in harvesting period for sustained food availability and (iii) they are far less susceptible to large-scale market shocks and price speculation experienced by more widely traded staples, such as grains. It is highly productive, it is available throughout the year, and can be processed into many foods, depending on local customs and preferences (IITA, 2005). Cassava production has been increasing for the past 20 years in area cultivated and in yield per hectare (Amans, 2004). Nigeria was the world largest producer of cassava in the world with an estimated output of 54 million metric tons in 2013, accounting for 21% of the global total (Olaniyan, 2015). Cassava is also a major cash crop that generates income for a large number of households. It is produced in Nigeria largely by small-scale farmers using simple farm implement.
Producer prices are prices received by farmers for primary crops, live animals and livestock products as collected at the point of initial sale, that is, prices paid at the farm-gate (FAO, 2017a). These prices are considered at the farm gate, that is, at the point where the commodity leaves the farm and hence does not include the costs of transport and processing. Producer prices are usually an inducement for farmers to produce (Enete and Amusa 2010). According to Ndhlovu and Seshamani (2016), farmers are more likely to consider past experiences and make the best guess of the price. Producer prices may impact on the area and yield of cassava. Given the role cassava play as a major source of staples,

availability of cassava products may be affected by producer prices directly or indirectly through its impacts on area harvested and yield.

Against this background, this study examines the relationship among producer prices, area harvested and yield of cassava in Nigeria. The specific objectives of this study are to examine the long-run relationship among producer prices, area harvested and yield, the short-run relationship among these variables as well as the causal relationship among them. To achieve these specific objectives, the following null hypotheses were tested: the first null hypothesis is that there is no long-run relationship among these variables. The second null hypothesis is that there is no short-run relationship among these variables. The third null hypothesis is that there is no significant causal relationship between producer prices and area harvested of cassava in Nigeria. While the fourth null hypothesis is that there is no significant causal relationship between producer prices and yield of cassava in Nigeria.

METHODOLOGY

Data and Empirical Models

Annual time series data on producer prices, area harvested and yield of cassava spanning from 1991 to 2014 were collected from FAOSTAT (2017a). Producer prices were measured in naira per tonne, area harvested was measures in hectare and yield was measured in tones per hectare. Given that the study used time series, a preliminary analysis of the unit root properties of the variables was carried to avoid spurious regression. In order to examine the long-run relationship between producer prices, area harvested and yield, the Johansen (1991, 1995) co-integration technique was employed. For the short-run relationship between producer prices, area and yield, the vector autoregressive (VAR) model was used. To analyze the causal relationship between producer prices and area as well as the causal relationship between producer prices and yield, the Granger causality test (Granger, 1969) was employed. Furthermore, the logarithm transformed variables were used in the analysis.

Model Specification

The VAR models specified for this study are expressed as follows:

$$\ln PPCASS_t = \partial_1 + \sum_{j-1}^{m} \beta_j \ln PPCASS_{t-j} + \sum_{j=1}^{m} \alpha_j \ln ACASS_{t-j} + \sum_{j-1}^{m} \varphi_j \ln YCASS + \varepsilon_{1t} \quad (1)$$

$$\ln ACASS_t = \partial_1 + \sum_{j-1}^{m} \beta_j \ln ACASS_{t-j} + \sum_{j=1}^{m} \alpha_j \ln PPCASS_{t-j} + \sum_{j-1}^{m} \varphi_j \ln YCASS + \varepsilon_{2t} \quad (2)$$

$$\ln YCASS_t = \partial_1 + \sum_{j-1}^{m} \beta_j \ln YCASS_{t-j} + \sum_{j=1}^{m} \alpha_j \ln ACASS_{t-j} + \sum_{j-1}^{m} \varphi_j \ln PPCASS + \varepsilon_{3t} \quad (3)$$

Where: lnPPCASS$_t$ is logarithm of Producer prices of cassava, lnACASS$_t$ is logarithm of Area cultivated of cassava. lnYCASS$_t$ is the yield of cassava and ε_t is the stochastic error term which takes care of other variables not specified in the model and while m is the optimal lag length order of the variables.

RESULTS AND DISCUSSION

Unit Root Test

To establish the unit root properties of the data, the Augmented Dickey Fuller (ADF) test was employed. The results of these tests are presented in Table 1. Based on the ADF unit root tests, the null hypothesis of existence of unit root cannot be rejected for all the variables in levels as evidenced by small t-statistic and large p-values. This implies that producer prices, area harvested and yield have unit roots and consequently are non stationary. As a result, the unit root tests were performed again on the first differences of these variables. The null hypothesis in ADF tests is rejected at 1% for all the variables. This implies that the series are stationary in their first difference. Hence, it is concluded that producer prices, area harvested and yield are integrated of order one, $I(1)$

Table 1: ADF Test of Producer Prices, Area and Yield of Cassava

Variables	Levels		First Difference		Decision
	t-statistic	Probability	*t*-statistic	Probability	
lnPPCASS	1.996231	0.9859	-4.799082	0.0000	*I(1)*
lnACASS	1.898045	0.9829	-3.270035	0.0023	*I(1)*
lnYCASS	-0.611719	0.4413	-3.476800	0.0014	*I(1)*

***Indicates significance at 1 per cent level. Lag length selection was automatic based on Schwarz information criterion (SIC).
Source: Author's computations using E-views

Long-run Relationship among Producer Prices, Area Harvested and Yield

The long-run relationship among producer prices, area and yield of cassava was examined using the Johansen co-integration test. Results from both the trace and maximum Eigen value are presented in Table 2. The trace test and maximum Eigen values indicate no co-integration at the 5 per cent level. Consequently the null hypothesis that there is no long-run relationship between producer prices, area and yield of cassava cannot be rejected. Hence, this implies that there is no long-run relationship between producer prices, area and yield of cassava. This on the other hand implies that the variables do not move jointly over time. The nonexistence of long-run relationship also implies that if these variables move away from the mean or equilibrium level, it will not be easy to bring them back to equilibrium since there is no error correction for the link.

Table 2: Johasen Cointegration Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None	0.601513	28.24669	29.79707	0.0746
At most 1	0.304507	8.004908	15.49471	0.4649
At most 2	0.000725	0.015955	3.841466	0.8993
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.601513	20.24178	21.13162	0.0662
At most 1	0.304507	7.988953	14.26460	0.3798
At most 2	0.000725	0.015955	3.841466	0.8993

Trace and Max-eigenvalue tests indicate no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: Author's computations using E-views software

Short-run Relationship among Producer Prices, Area Harvested and Yield

In view of the fact that the Johansen co-integration test did not identify a long-run relationship connecting producer prices, area and yield of cassava, the short-run investigation was carried out in a VAR framework. The major strong point of the VAR model is that it facilitates the observation of impulse response mechanisms, examines variance decomposition of variables in the system, for forecasting, causality, and policy analysis (Alege, 2010; Alege & Osabuohien, 2010). The VAR estimates are presented in Table 3. Results showed that the three variables have influence on each other at various lags. This implies there is a short-run relationship between the variables.

Table 3: Vector Autoregression (VAR) Estimates of the Short-run relationship

	LNPPCASS	LNACASS	LNYCASS
LNPPCASS(-1)	0.333600	-0.333392	0.049394
	(0.23409)	(0.07994)	(0.07887)
	[1.42510]	[-4.17031]***	[0.62627]
LNPPCASS(-2)	-0.410305	0.221762	-0.195619
	(0.26631)	(0.09095)	(0.08973)
	[-1.54068]*	[2.43829]**	[-2.18017]**
LNPPCASS(-3)	0.342638	0.057263	-0.024450
	(0.22645)	(0.07734)	(0.07630)
	[1.51306]*	[0.74044]	[-0.32046]
LNPPCASS(-4)	0.213470	-0.067788	0.133836
	(0.20779)	(0.07096)	(0.07001)
	[1.02733]	[-0.95526]	[1.91169]*
LNACASS(-1)	-0.242380	2.323684	-1.264877
	(0.71696)	(0.24485)	(0.24156)
	[-0.33807]	[9.49022]***	[-5.23634]***
LNACASS(-2)	1.147668	-0.976463	0.870770
	(0.98582)	(0.33667)	(0.33214)
	[1.16418]	[-2.90035]**	[2.62168]**
LNACASS(-3)	-0.226774	-1.402356	1.173873
	(0.99501)	(0.33981)	(0.33524)
	[-0.22791]	[-4.12688]***	[3.50159]***
LNACASS(-4)	-0.385398	1.457577	-0.611069
	(0.83291)	(0.28445)	(0.28062)
	[-0.46271]	[5.12421]***	[-2.17754]**
LNYCASS(-1)	-0.771614	1.260594	-0.446437
	(0.95679)	(0.32676)	(0.32236)
	[-0.80646]	[3.85790]***	[-1.38489]
LNYCASS(-2)	2.293495	-1.070232	0.846623
	(1.13334)	(0.38705)	(0.38185)
	[2.02365]**	[-2.76508]**	[2.21718]**
LNYCASS(-3)	-3.166073	-1.640700	0.746043
	(1.11489)	(0.38075)	(0.37563)
	[-2.83982]**	[-4.30914]***	[1.98612]*
LNYCASS(-4)	1.123927	2.010914	-1.555495
	(0.93838)	(0.32047)	(0.31616)
	[1.19773]	[6.27490]***	[-4.91997]***
C	6.859275	-11.29776	14.17918
	(11.8027)	(4.03078)	(3.97657)
	[0.58116]	[-2.80287]**	[3.56568]***
R-squared	0.947731	0.987657	0.962060
Adj. R-squared	0.858128	0.966497	0.897021
F-statistic	10.57696	46.67652	14.79196

Standard errors in ( ) & t-statistics in [ ]
Source: Author's computations using E-views

Variance Decomposition

The variance decomposition analysis was conducted for ten horizons (that is ten years). The results for year 1, 5, and 10 are presented in Table 4 for briefness. From the first section of Table 4, it can be seen that 100 percent of changes in producer prices is explained by changes in own shock or innovations in the first year, but in the fifth and tenth period the proportion explained by producer prices declined to 45.87 and 18.57 per cent, respectively. Also, the results reveal that only about 26.21 and 27.91 percent of changes in producer prices is explained by changes in area harvested and yield respectively in the 5th year, with an increase of 62.02 per cent for area harvested and a decrease of

19.39 per cent in yield in the tenth year. This implies that producer prices are mainly influenced by changes in its own shock and not changes in area harvested and yield. From Table 4, it can be seen that 94.04 percent of changes in area cultivated are explained by changes in its own shock. On the other hand by the fifth and tenth periods producer prices explained about 11.37 and 9.36 percent of changes in area harvested while yield explained about 11.75 and 10.51 percent of the changes in area harvested in the fifth and tenth periods. Further, the variance decomposition in the third panel shows that although the variation in yield is largely due to changes in area harvested accounting for 23.02 percent in the first year, then increased to 60.45 percent in the fifth and dropped to 30.90 per cent in the tenth periods. This is then followed by changes in producer prices which contributed 3.49 percent in the first year and increased to 16.36 and 26.40 percents in the fifth and tenth periods.

Table 4: Variance Decomposition

Variance Decomposition of Producer prices (LNPPCASS):				
Period	S.E.	LNPPCASS	LNACASS	LNYCASS
1	0.146012	100.0000	0.000000	0.000000
5	0.237627	45.87530	26.21025	27.91445
10	0.406694	18.57814	62.02997	19.39189
Variance Decomposition of area harvested (LNACASS):				
Period	S.E.	LNPPCASS	LNACASS	LNYCASS
1	0.049865	5.958279	94.04172	0.000000
5	0.251535	11.37820	76.86322	11.75857
10	0.738225	9.365139	80.12689	10.50798
Variance Decomposition of yield (LNYCASS):				
Period	S.E.	LNPPCASS	LNACASS	LNYCASS
1	0.049194	3.493516	23.02131	73.48518
5	0.116056	16.36951	60.45318	23.17732
10	0.166956	26.40087	30.90932	42.68980

Source: Author's computations using E-views

Granger Causality

VAR-based Granger causality was used to determine whether there is any form of causality between the variables and the direction of such causality. The result suggests that area cultivated does not granger cause producer prices due to the fact the p-value is 0.5987 and exceeded 0.05 (Table 5). Therefore, the null hypothesis that area cultivated does not granger cause producer prices cannot be rejected. This outcome implies that area harvested had not influenced producer prices during the period of study. The test, however, showed that yield does cause producer prices because of the p-value of 0.0390 which is less than 0.05. Hence, the null hypothesis that yield does not granger cause producer prices is rejected. Results also showed that producer prices granger causes area harvested and yield granger causes area harvested. The result also signals the fact that there exist bidirectional causalities between yield and area cultivated. While a unidirectional causality exists between producer price and area harvested as well as yield and producer prices.

Table 5: VAR Granger Causality/Block Exogeneity Wald Tests

Excluded	Chi-sq	df	Prob.
Dependent variable: LNPPCASS			
LNACASS	2.760364	4	0.5987
LNYCASS	10.08667	4	0.0390
All	14.50897	8	0.0694
Dependent variable: LNACASS			
LNPPCASS	22.18229	4	0.0002
LNYCASS	45.90024	4	0.0000
All	71.27751	8	0.0000
Dependent variable: LNYCASS			
LNPPCASS	6.645139	4	0.1559
LNACASS	44.52166	4	0.0000
All	47.07802	8	0.0000

Source: Author's computations using E-views

CONCLUSION

This study analyzed the relationship among producer prices, area and yield of cassava in Nigeria. The study used annual time series data spanning from 1991 to 2014. Results based on Augmented Dickey Fuller test showed that the series are integrated of order one, I(1). Johansen co-integration test showed there was no long-run relationship among the variables. The VAR estimates showed that producer prices had significant influence on area harvested and yield of cassava. Also the variance decomposition analyses showed that over time, only about 26.21 and 27.91 percent of changes in producer prices is explained by changes in area cultivated and yield respectively in the 5th year, with an increase of 62.02 per cent for area and a decrease of 19.39 per cent in yield in the tenth year. This implies that producer prices are mainly influenced by changes in its own shock and not changes in area and yield. Results also showed that producer prices granger causes area harvested and yield granger causes area harvested. The results also indicate existence of bidirectional causalities between yield and area cultivated. While a unidirectional causality exists between producer price and area cultivated as well as yield and producer prices. Consequently, given the influence of producer prices on the area harvested and yield of cassava, price policies that will encourage farmers to put additional area into the cultivation of cassava ought to be promoted.

REFERENCES

Alege, P. O. (2010). Are there any feasibile anti-cyclical policies for Nigeria in the era of global economic crisis? *Covenant Journal of Business and Social Sciences, 3*, 25–50.

Alege, P. O., and Osabuohien, E. (2010). *Globalization as a development model: Economic implications for Africa.* Global Economic Analysis Conference, Bangkok, Thailand

Amans, E. B., Ahmed, B. J., Mahmud, M., Tshiunza, M and Dixon, A. G. O. (2004). The Status of Cassava Production and Strategies for Expansion in the Semi-Arid Zone of Nigeria. *Savanna Journal.* 19(1):21-31.

Enete, A.A and Amusa, T. A. (2010). Challenges of Adaptation to Climate Change in Nigeria: a Synthesis from the Literature. *Field Actions Science Reports* [Online], 4.2010.

FAOSTAT (2017a). Producer Prices: Annual. Statistical Database of Food and Agriculture Organization of the United Nations, FAO, Rome, Italy. Accessed on April 27, 2016 Available at http:www//fao.org/faostat/en/# data/PP.

FAO (2017b). Storage and Processing of Root and Tuber Crops in the Tropics. Food and Agriculture Organization. Available at www.fao.org/docrep/X5415/x5415eo/.htm. Accessed 15/5/2017.

Granger, C. W. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. *Econometrica, 37*, 424-438.

IITA. (2005). *The Nigeria Cassava Industry Statistical Handbook.* IITA, Ibadan, Nigeria. International Institute for Tropical Agriculture.

Ndhlovu, O and Seshamani, V. (2016). The linkage between price and output of cotton in Zambia. *African Journal of Agricultural Economics and Rural Development,* 4 (4): 328-336.

Nteranya, S, and Adiel, M. (2015). Root and Tuber Crops (Cassava, Yam, Potato and Sweet Potato). A background paper presented at Feeding Africa 21-23, Abdou Diouf International Conference Center, Dakar Senegal. Available at *https://www.afdb.org/.../ Accessed 2/5/2017.*

Olaniyan, F. (2015). Profitability and Growth of Cassava Business in Nigeria. A Keynote Address delivered by Folusho Olaniyan, OON at The National Cassava Stakeholders Forum, FUNAAB. Friday 21st May, 2015.