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Impact of Cereals Production and Cross-border Trade on Food Security in Nigeria: A Time Series Analysis between 1986 and 2017

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Authors' contributions

This work was carried out in collaboration among all authors. Author FAS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SZ and SS managed the analyses of the study. Author YAS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study aims to examine the impact of cereals production and cross-border trade on food security in Nigeria between 1986 and 2017. The Autoregressive Distributed Lag (ARDL) econometric technique was employed to analyze the time series secondary data sourced from World Bank Development Indicators, 2017 in order to explain the relationship between food security and the cereal production and cross-border trade. The findings of this study reveal that both in short-run and long-run estimation of error correction model (ECM), cereal domestic production, cereal exports and cereal imports have significant impact on the food security. Accordingly, cereal domestic production and cereal imports have a positive sign, which implies that an increase in cereal domestic production and cereal imports influence food security. While, cereal exports have a negative sign,

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which suggest that Nigeria as a nation is experiencing deficit in cereal production and therefore, the little quantity produced and exported posit a treat to food security. Based on the findings of this study, it is therefore recommended that policy formulation such as government subsidies in the agricultural sector and any other intervention programmes that will encourage an increase in domestic cereal production as well as policy formulation that will not totally discourage cereal importation should be implemented since its impact on food security is positive. This can be achieved through trade liberalization. On one hand, in as much as cereal export have significant impact on food security; government should be mindful that policy formulation on cereal exports should take into consideration the level of domestic cereal production and consequently its negative impact on food security.

Keywords: Food security; cross border trade; cereal production.

1. INTRODUCTION

Every nation makes efforts in sustaining domestic food production in order to ensure food security for all her citizens. According to Saheed [1], food security refers to the availability of food and access to it. The World Food Summit 1996 opined that food security exists “when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life” [2].

Food production index in Nigeria increased from 27.4 in 1967 to 124.6 index in 2016 growing at an average annual rate of 3.32%. In many cases domestic food production cannot meet the needs of the rising population, therefore, cross-border trade in food export and imports have become necessary to ensuring food security, particularly in developing countries like Nigeria. Often cross-border trade involves both formal and informal setting, of which the formal is regulated, while the latter is unregulated [3,4,5]. Despite this, there are growing concerns about the state of food security in the region, as declining domestic production and increased dependence on imported food create vulnerability.

Cereals crops were among several kinds of food crops grown, consumed, exported and imported in Nigeria in order to ensure food security. Out of the world total cereal production estimated at 2,982 million tones, China produces about 619 million tones which accounts for 20.79%, and the top 5 countries including the United States of America, India, the Russian Federation, and Brazil account for 54.41% of it, while Nigeria’s cereal production accounts for 4.29% [6]. It constitutes about 43% of the total calories’ intake in the country’s food and agriculture [6]. According to the Food Agricultural Organization (FAO), Nigeria’s cereal production (including wheat, rice, and coarse grains) which was 23.9 million tonnes for the year 2016 increased considerably to 28.9 million tonnes in 2017 [6]. Despite the impressive production over the years, Nigeria has been experiencing deficit in its food requirements; For example, the domestic cereal output in Nigeria over the years has been less than the domestic requirement and the difference are realized through importation. Data from the FAO have shown that cereal imports in Nigeria have trended upwards in recent years, due mainly to high urban population growth and changing consumption pattern in the country [6].

Existing studies have identified the leading role of Nigeria in cereals production via cross-border trade in West African toward ensuring food security [7,8,9,10,11,12]. According to Odozi [11], while cross-border trade brings about a stabilization of food supply by moving food from surplus to deficit areas, barriers to trade appear to limit agribusiness participation and the volume of the grain trade.

In discussing the impact of cereals production and cross-border trade on food security, one must consider the levels of domestic food production, inflow (imports) and outflow (exports) of cereals production and foreign exchange rate. It is worthwhile, to note that since cereals production in Nigeria is targeted towards solving the problem of food security, therefore, hypothetically, changes in food security depends on the levels of domestic cereals productions which subsequently determines the quantity requirements for exportation or importation. Despite the importance of cereals production in ensuring food security, the extent of domestic productions of cereals, its cross-border trade and its impact on food security in Nigeria is subject of debate among scholars, stakeholders, and governments at all levels in the region.

Exploring into research gaps in this field, it was identified that few literatures supported the effectiveness of bilateral trade (cross-border trade) in achieving food security, while others opine that cross-border trade is a detriment to local production and causes insecurity. For instances, literatures such as [13,14,15,16] favored cross-border trade due to the benefit it offered for both trading partners while, the studies by Yusuff [17]; Abdallah et al. [18]; Aragie, & Genanu [7] and Uzondu [19] opine that cross-border trade posits a security threat, hence created a gap which called for more empirical research. More so, none of these studies have examined the impact of cereals production cross-border trade on food security in Nigeria between 1986 and 2017. These mixed results and inconclusive evidence could possibly arise from several folds: In one-fold, it could be the results of weaker methodology employed, in another fold, conflicting evidence could be attributed to variables considered in the modeling relationship which may lead to misspecification bias and inconsistent estimates. In another fold, this problem emanates from error in the measurement of the variables that might have led to biased and inconsistent estimates. These motivations among others have arouse the interest of the researchers to revisit the area by contributing on the impact of Agricultural commodities cross border trade on food security in Nigeria and add to the existing literatures on cross border trade and food security. Thus, this study aims to examine the impact of cereals production and cross-border trade on food security in Nigeria between 1986 and 2017. The following hypotheses were set to guide the conduct of the study; First, Cereal domestic production does not have any significant impact on food security in Nigeria. Secondly, Cereal imports does not have any significant impact on food security in Nigeria and thirdly, Cereal exports does not have any significant impact on food security in Nigeria.

The next section of the paper briefly discusses previous studies on cereal production and cross border trade on food security and is followed by a section that discusses the methodology of the study. Thereafter, results and discussion were presented, of which conclusion and recommendation for further study were drawn in light of the findings.

2. THEORETICAL FRAMEWORK AND CONTEMPORARY LITERATURES

Conceptually, according to Gulte et al. [20] and Njiwa [21], cross-border trade is a trade which is carried out across national boundaries or between people or business entities of different countries. Kaminski and Mitra [22] defined cross-border trade as “the flow of goods and services across international land borders within a reach of kilometers specified by law. Meanwhile, cereals domestic production is defined as domestic cultivation of cereals crops in Nigeria [6]. According to Odozi [11], cereal export is defined as quantity in metric tons of cereal crops export to other nation. Similarly, cereal imports have been defined as quantity in metric tons of cereal crops import from other nation [11]. On the other hand, Ismaila et al. [23] and Saheed [1] defined food security as the availability of food and one's access to it.

Theoretically, various models of international trade exist, of which this study anchor on the Neoclassical Trade Models which are considered appropriate in explaining the justification for cross-border trade [24]. In the early 1900s, one of such theories was developed by two Swedish economists, Eli Heckscher and Bertil Ohlin, which subsequently became the Heckscher–Ohlin model (H–O model) [24]. The results of the H–O model are that the pattern of international trade is determined by differences in factor endowments. It predicts that countries will export those goods that make intensive use of locally abundant factors and will import goods that make intensive use of factors that are locally scarce. The H–O model makes the following core assumptions: Labor and capital flow freely between sectors equalizing factor prices across sectors within a country, the amount of labor and capital in two countries differ (difference in endowments), technology is the same among countries (a long-term assumption) and tastes are the same. Thus, the basis for trade lays in the resources endowments of countries. This suggests that Nigeria with endowed in resources to produce cereals should command a good place in the international market as it can produce more of cereals using its endowments at a rate better than other nation can do while exchanging cereals for other goods.

On the explanation of the impact of cereal cross-border trade on food security in the literature, there were few pieces of empirical literature that have examined the impact of cereal crops cross-border trade on the economy of the nation. For instances, Odozi [11] examines cross border trade in grain between Nigeria and Niger focusing on risk management assessment along Sokoto Illela-Konni borderland. The study methodology was qualitative using desk review of literature and field survey. While the survey findings revealed evidence of substantial volume of grain exchange, which consequently have positive impact on the economy, most of the traders indicated transportation, high taxes and low production of grain as the most important risk factors limiting trade.

Chiappini and Jégourel [25] investigate the impact of exchange rate on bilateral cereals exports in France. The study adopted Poisson pseudo-maximum likelihood (PPML) estimator methodology. Findings of the study showed that exchange rate uncertainty has a strong impact on French cereals trade. However, this study was not carried out in a middle-income setting like Nigeria and therefore may not be applicable. Yusuff [17] examines the dynamics of women in agricultural commodities cross border trade along the ECOWAS sub-region. Using a qualitative approach, the findings of the study revealed that there are several insecurities posed by informalities of women trading practices. Nevertheless, the study is salient on the impact of cereal production cross-border trade on food security, particularly in Nigeria. Herath [13] examine the effect of free agricultural commodities trade agreement (AFTA) on food security of its member countries. They employed the multiple regression analysis in Panel data to disentangle the impact of trade liberalization on food security with the use of regional trade agreement dummy variables. The findings of the study supported that AFTA has influenced positively on the food security of its member nations, although the study did not focus on the impact of cereal production cross-border trade on food security. Olayiwola et al. [26] examine the interaction between economic integration and trade facilitation in Economic Community of West African States (ECOWAS) and how the regional bloc has performed in promoting agricultural export. The study employed descriptive statistical and econometric analyses of annual data covering the period spanning 1995-2009. The finding of the study reveals that on the average, the level of trade facilitation in ECOWAS is below world average. Furthermore, the results indicate that economic integration and trade facilitation in agricultural production had significant impact on agricultural exports. However, the study was not specific on cereal production cross-border trade.

3. METHODOLOGY

This section discusses the source of data collection, model specification and method of data analysis. Secondary data (time series data) was employed to test Hypotheses one, two and three using ARDL/Bounds approach to cointegration analysis. The method has some advantages, first, the ARDL approach is applicable irrespective of whether all the series are I(0) or I(1) [27]. Therefore, the need to need to pre-test for integrational properties of the series associated with the other forms of cointegration analysis is avoided. Additionally, Narayan [28] argue that the small sample properties of this procedure are superior to that of multivariate cointegration. However, the major drawback of this procedure is that it is in appropriate when there are more than two cointegration relationships.

Secondary time series data used in this study was sourced from the World Bank/World Development Indicator and FAO [6] on variables which includes; Nigeria food production index (FPI) as a proxy for food security serve as dependent variable while, Cereal domestic production (CDP), Cereal exports (CEV) and Cereal imports (CIV) in Nigeria, between 1986 and 2017 serve as independent variables.

Thereafter, econometric technique analysis was adopted in analyzed the data sourced. In particular, the Autoregressive Distributed Lag Model was used in estimation after undergoing time-series property tests. The Microfit 5.0 was used to generate and analyzes the inferential statistics for the study. The model specification is stated as follows;

$$FS= f\,(CDP, CEV, CIV,) \quad (1)$$

Where;

FS = food security measure and proxied by consumer price index, CDP = cereal domestic production, CEV = cereal exports and CIV = cereal imports.

The generalized ARDL model consists of a set of *K* endogenous variables

$$yt = c + \beta_1 y_{t-1} + \beta_{21} y_{t-2} + \beta_{32} y_{t-3} + \ldots\ldots + \beta_{pyt-p} + \boldsymbol{\varepsilon} \quad (2)$$

Alternatively, substitute the variables understudy in this equation is written as follows;

$$\Delta FS_t = y_0 + y_1 \Delta FS_{t-1} + y_2 \Delta CDP_{t-1} + + y_1 \Delta CEV_{t-1} + y_1 \Delta CIV_{t-1} + \ldots + ECM + \varepsilon_t \quad (3)$$

b_0 = intercept, b_1, b_2 and b_3= Coefficient of the independent variables

Δ = First difference operator, μ = white noise or error term

To examine the impact of cereal production and cross-border trade on food security spanning period of 1986 to 2017 following Pesaran et al. [29], the study first test, based on Wald test (F-statistics), for the joint significance of the coefficients of the lagged levels of the variables, i.e.

Ho: $\delta 1= \delta 2= \delta 3= 0$
H1: $\delta 1\neq \delta 2\neq \delta 3\neq 0$

The asymptotic critical values bounds, which were tabulated in Pesaran et al. [29], provide a test for cointegration with the lower values assuming the regressors are I(0) and upper values assuming purely I(1) regressors. If the calculated F-statistics exceeds the upper critical value, the null hypothesis is rejected, implying that there is cointegration. However, if it is below the lower critical value, the null hypothesis cannot be rejected, indicating lack of cointegration. If the calculated F-statistics falls between the lower and upper critical values, the result is inconclusive. Once cointegration is established, the conditional ARDL long-run model can be estimated.

4. RESULTS AND DISCUSSION

In the first stage, ARDL modeling specifies the impact of cereal domestic production, cereal export, cereal import (explanatory variables) on food security (dependent variable). The existence of long run cointegration effect is investigated by computing F-statistic test. The F-statistics for testing the joint null hypothesis that there exists no long run effects between the variables.

Table 1 present the computed F statistic of 8.3308. The relevant critical value bound for this test as computed by Pesaran et al. [29] at the 95% level is given by 4.7049 – 5.9016. Since the F statistics exceeds the upper bound (5.9016) of the critical value band the null hypothesis of no association between the variables is rejected. The test result suggests that CDP, CEV, CIV and FPI are jointly associated. Having rejected the null hypothesis of no longrun cointegration effects between CDP, CEV, CIV and FPI, the ARDL model is estimated using univariate ARDL cointegration test option of Microfit 5.0 with the maximum optimal lag of 2 length was chosen in line with Schwarz Bayesian Criterion (SBC) and the selected ARDL representation for the model was ARDL (1,1,0,2).

Table 2, present Autoregressive Distributed Lag Estimates, the result show that all the probability value of the regressor (Cereal domestic production (CDP), cereal exports (CEV) and

Table 1. Testing for existence of a level relationship among the variables in the ARDL model

F-statistic	95% lower bound	95% upper bound	90% lower bound	90% upper bound
8.3308	4.7049	5.9016	3.8479	4.9504

Source: Author calculations using Microfit (5.0)

Table 2. Autoregressive distributed lag estimates (1,1,0,2) selected model, dependent variable is FPI

Regressor	Coefficient	Standard error	T-ratio	[Prob]
FPI(-1)	.66228	.11526	5.7461	[.000]
CDP	.14623	.014451	10.1190	[.000]
CDP(-1)	-.17538	.021562	-8.1341	[.000]
CEV	-.020507	.0097313	-2.1073	[.047]
CIV	-.3660E-3	.1185E-3	-3.0887	[.006]
CIV(-1)	.6835E-3	.1596E-3	4.2816	[.000]
CIV(-2)	-.5444E-3	.1402E-3	-3.8827	[.001]
INPT	1929.0	299.2740	6.4457	[.000]
R-squared	**.99746**	**R-Bar-squared**	**.99650**	
S.E. of regression	144.6713	F-Stat. F(8,21)	1032.7	[.000]
Mean of dependent Variable	8723.0	S.D. of dependent variable	2444.9	
Residual sum of squares	439525.2	Equation Log-likelihood	-186.4520	
Akaike Info. criterion	-195.4520	Schwarz Bayesian Criterion	-201.7573	
DW-statistic	2.2436	Durbin's h-statistic	-.86004	[.390]

Source: Author calculations using Microfit (5.0) cereal imports (CIV)) were statistical significant in determining food security and in conformity with the *apriori* expectation. However, CDP with positive sign suggest that CDP move in the same direction with food security. According to ARDL model test results, coefficient of CDP is found to be 0.14 indicating that one percent change in CDP leads to 0.14 percent change in Food security. That is, an increase by one unit in cereal domestic production will enhanced food security by 14.6%. While, coefficient of CEV is found to be - 0.02 and CIV - 0.36 indicating that one percent change in CEV leads to - 0.14 percent change in Food security and one percent change in CIV leads to -0.36 change in Food security.CEV and CIV with negative sign show that both variables were moving in opposite direction with food requirement of the nation. This implies that decrease in CEV and CIV lead increase in to food security. Though, the percentage change in CEV on food security is inconsequential.

Table 3, present estimated long run coefficients, the estimated coefficients of the long run relationship is base on the Schwarz Bayesian Criterion for the optimal lags shows that all the regressor (CDP, CEV and CIV) were negative and insignificant for the estimation period 1986 to 2017. This implies that there is no significant evidence to indicate that Cereal domestic products, cereal exports and cereal imports impacts on food security at 5% level. The implication of this long run result is that decline in Cereal domestic product, cereal exports and cereal imports posits a threat to food security. However, estimation of error correction mechanism which is expected to measures the speed of adjustment whereby short-run dynamics converge to the long-run equilibrium path in the model will provide better result.

The long run model corresponding to ARDL (1, 1, 0, 2) for food security can be written as:

$$\mathrm{FPI} = 5712.0 - .086322*\mathrm{CDP} - .060721*\mathrm{CEV} - .6720\mathrm{E}{-}3*\mathrm{CIV}$$

Table 4 presents the results of the estimated ECM corresponding to the long run estimates. The coefficients estimates show that the dynamic adjustment of dCDP, dCEV and dCIV are statistically significant at the 5% level in conformity with the *apriori* expectation. While, the coefficient of error correction term ecm(-1) estimated at -.33772 is highly significant indicating that the food security, cereal domestic product, cereal exports and cereal imports are cointegrated. The short run and long run estimates changes in cereal domestic product and previous year's cereal imports are associated with food security increase, while increase in cereal exports and current cereal import is associated with decrease in food security. The estimated value of the coefficient indicates that about 33.7 percent of the disequilibrium in food security is offset by the short run adjustment in the same year.

Furthermore, the result in the short run and long run estimates shows that R^{-} Bar- Square is 0.92, which measures the goodness-of-fit, is 92%. This means that 92% of the changes in the food security are explained by the changes in the dCDP, dCEV and dCIV. The F-test shows that the overall model is statistically significant at 5% level while the DW = 2.24 shows there is the absence of serial autocorrelation.

4.1 Discussion of Hypotheses

This study examines the impact of cereals production and cross-border trade on food security in Nigeria between 1986 and 2017 using three null hypotheses. The three hypotheses ($H0_1$ $H0_2$ $H0_3$) set and tested were used to provide insight into the research gap explored. The test of the hypotheses is based on ECM corresponding to both the short-run and long-run estimates as presented in the mathematical

Table 3. Estimated long run coefficients using the ARDL approach

ARDL(1,1,0,2) selected based on Schwarz Bayesian criterion dependent variable is FPI			
Regressor	**Coefficient**	**Standard error [Prob]**	**T-ratio**
CDP	-.086322	.092491	-.93330 [.361]
CEV	-.060721	.041525	-1.4623 [.158]
CIV	-.6720E-3	.4002E-3	-1.6792 [.108]
INPT	5712.0	1802.7	3.1686 [.005]

Source: Author calculations using Microfit (5.0)

Table 4. Error correction presentation of the selected ARDL model (1,1,0,2) dependent variable is DFPI

Regressor	Coefficient	Standard error	T-ratio	[Prob]
dCDP	.14623	.014451	10.1190	[.000]
dCEV	-.020507	.0097313	-2.1073	[.046]
dCIV	-.3660E-3	.1185E-3	-3.0887	[.005]
dCIV(-1)	.5444E-3	.1402E-3	3.8827	[.001]
ecm(-1)	-.33772	.11526	-2.9301	[.008]
R-squared	**.94537**	**R-bar-squared**	**.92456**	
S.E. of Regression	144.6713	F-Stat. F(6,23)	60.5672	[.000]
Mean of Dependent Variable	291.0000	S.D. of Dependent Variable	526.7162	
Residual Sum of Squares	439525.2	Equation Log-likelihood	-186.4520	
Akaike Info. Criterion	-195.4520	Schwarz Bayesian Criterion	-201.7573	
DW-statistic	2.2436			

Source: Author calculations using Microfit (5.0)

equations. The decision criteria to reject or accept the stated hypotheses is based on the p-value, where p-value is less than 0.05% level of significance null hypothesis will be rejected, where p-value is greater than 0.05% level of significance alternative hypothesis will be accepted.

Model 1: ARDL Short-run analysis

dFPI = 0.146*dCDP - 0.0205*dCEV - 0.366*dCIV + 0.544*dCIV1

P-value = (0.000) (0.04) (0.05) (0.001)

Model 2: ARDL Long-run analysis

$\mathrm{FPI} = 5712.0 -$ .086322*CDP - .060721*CEV - .6720E-3*CIV

P-value = {0.005} {0.361} {0.156} {0.108}

Although, no statically significant finding was found in the long-run (model 2) for cereal domestic production (p=0.361), cereal export (p=0.156) and cereal import (p=0.108) on food security, however, the findings indicated positive outcome in the short-run (model 1). Considering the first hypothesis ($H0_1$), which examine the relationship between cereal domestic production and food security in Nigeria between 1986 and 2017; the cereal domestic production (CPD) short-run analysis result in model 1 shows that the p-value (0.00) is less than 0.05, which indicates a statistically significant finding at 5% level of significance. Therefore, the study rejects the null hypothesis ($H0_1$) and concludes that cereal domestic production has significant impact on food security in Nigeria between 1986 and 2017. This finding is in agreement with the findings of Odozi [11] on cross border trade between Nigeria and neighboring Niger, who posited that cereal production have positive impact on food security. In the second hypothesis ($H0_2$), which looks into the relationship between cereal export and food security in Nigeria between 1986 and 2017; the short-run analysis cereal exports (CEV) in model 1 with a p-value of 0.04 less than 0.05 is statistically significant at 5% level of significance. Consequently, the study rejects the null hypothesis ($H0_2$) and concludes that cereal export has significant impact on food security in Nigeria between 1986 and 2017. This finding is in line with the study carried out by Chikhuri [30] in sub-Saharan African region and Olayiwola et al., [26] in Nigeria, both of which concluded that food exports have significant impact on food security. Considering the third hypothesis ($H0_3$), which examine the relationship between cereal imports and food security in Nigeria between 1986 and 2017; the short-run current cereal imports (CIV) with a p-value of 0.05 and previous years' cereal imports (CIV1) with a p-value of 0.001 in model 1 is statistically significant at 5% level of significance. Consequently, the study rejects the null hypothesis ($H0_3$) and conclude that cereal imports have significant impact on food security in Nigeria between 1986 and 2017. This finding is supported by the results of Olayiwola et al. [26], who concluded that cereal import and exports have significant impact on regional trade and by extension food security in Nigeria. It was further supported by the finding of Zhu [31] on international trade and food security, which concluded that international agricultural grains have significant impact on food security. These findings therefore indicate the need for policy formulation in Nigeria such as government subsidies in the agricultural sector and other nongovernmental interventions to encourage an increase in domestic cereal production, be mindful on cereal exportation as well as policies that would not totally discourage cereal importation to ensure food security in the country.

5. CONCLUSION

Based on the findings of this study, it was concluded that in short-run estimation of error correction model (ECM), cereal domestic production, cereal exports and cereal imports have significant impact on the food security in Nigeria. However, cereal domestic production and cereal imports have a negative sign in conformity with the *apriori* expectation, which implies that an increase in cereal domestic production and cereal imports will guarantee food security. Similarly, cereal exports have a negative sign, which suggest that Nigeria is experiencing deficit in cereal production which is insufficient for exportation and therefore, the little quantity produced and exported posit a threat to food security in the country. A limitation of the findings of this study is the fact that it is centralized on cereal commodities mostly traded across Niger - Nigeria the border areas. Therefore, it is recommended that further studies should look into cereal commodities trade across other Nigerian borders, particularly Cameron and Ghana.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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