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ARTICLE

Financial Inclusion and Agricultural Output Nexus in Nigeria: An asymmetric Approach

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Abstract

The desire to improve financial inclusion and achieve higher productivity in the world is becoming increasingly high in recent times. This study examines the asymmetric effect of financial inclusion proxy by the volume of automated teller machines, point of sale, mobile banking pay, and cheques on agricultural output in Nigeria. Quarterly data between 2010Q1 and 2021Q4 was sourced from the Nigerian Inter-Bank Settlement System Plc (NIBSS) and the CBN statistical bulletin 2021. The non-linear Autoregressive Distributed Lagged (NARDL) model and Stepwise Least Squares (STEPLS) were employed in the estimation. The study reveals that financial inclusion positively and significantly affect agricultural output in Nigeria, especially when proxy by the automated teller machine and point of sale. Therefore, we recommend that to achieve improved agricultural output, government and monetary authority should increase the spread of Automated Teller machines and Point of Sales, especially in the villages where agriculture is their major occupation. Also, we recommend the need to improve internet access in the rural areas of the country. This could boost agricultural output and create employment for the citizenry.

Keywords: *Agriculture, Financial inclusion, Nigeria, NRADL*
JEL Classification: *C32, G20, G21, G53*

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1. Introduction

Agricultural output is important in every developing country, especially in Nigeria as food insecurity, high food import, and increasing food prices are pestering issues that have not been addressed, thus, the growing need to increase agricultural sector output. Before the discovery of oil in commercial quantity in Nigeria, the pride of the country was the agricultural sector, accounting for the majority of foreign exchange earnings and government revenue. It was also the major revenue source for the majority of the population, especially in the rural areas. However, when other resources that gave the government enormous revenue such as oil was discovered, the sector was neglected slowly and the growth rate of the sector began to decline. Although agriculture's contribution to Nigeria's GDP has decreased dramatically, the agriculture value chain remains an essential source of income for many Nigerians and a valuable aspect of the Nigerian economy **(Fowowe, 2020)**. The recent increasing inflation rate triggered by the rise in food inflation and the unpredictable nature of the foreign exchange receipt from oil revenue have underscored the importance of agricultural development in the country.

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Over the last decades, many studies have emphasized the significant role of the agricultural sector in the economy (**Sertoğlu, Ugural, & Bekun, 2017**; **Oyakhilomen & Zibah, 2014**; **Olabanji, Adebisi, Ese, & Emmanuel, 2017**; **Awoyemi, Afolabi, & Akomolafe, 2017**) and this has not gone unnoticed as the number of intervention programs directed towards boosting the agricultural sector have increased significantly within this period. The reason for this is that agriculture like any other business needs money to run its day-to-day operations and needs capital for the business to grow. Thus, finance is seen, as a lubricating mechanism that keeps a business moving, and agricultural businesses are no exception. As a result, the federal government has made significant attempts to improve the agricultural sector of the economy through subsidized loans and an increased number of intervention programs in the sector; nonetheless, in terms of money spent on agriculture, the sector still underperforms and food inflation remains the major driver of inflation. This could be attributed to the exclusion of the core farmers in the country financially and therefore cannot benefit from the government's interventions designed to build the agricultural sector. Thus, the motivation of the study is drawn from this.

The agricultural sector of Nigeria has been characterized as a sector lacking value addition this value addition can be achieved through heavy machinery that needs heavy financing to acquire. This finance is usually limited to rural farmers due to financial exclusion and high-interest rates. Finance is key in the agriculture sector, and its importance cannot be overstated, this is because an inclusive financial system can assist farmers to use financial resources to embrace and develop technology breakthroughs by reallocating financial resources from rich urban regions to disadvantaged rural areas (**Badunenko & Romero-Ávila, 2013**).

Many studies have investigated the drivers of agricultural output such as monetary policy, government expenditure, and other macroeconomic factors (**Hassan, 2012**; **Ajudua, Davis, & Osmond, 2015; Atayi, Boniface, Bobola, & Olorunrinu, 2020**; **Idoko & Jatto, 2018**). However, this study differs from the few studies that have investigated how financial inclusion has driven the agricultural sector in Nigeria (**Abraham, 2018; Atakli & Agbenyo, 2020**; **Kalu, Omeje, & Mba, 2018; Fowowe, 2020**; **Olaniyi, 2017; Okuma, Nwoko, Elugom, & Uche, 2019**) as the study uses time-series data which focuses on the volumes and values of Automated Teller Machine (ATM), Point Of Sale (POS), Mobile Banking Pay (MBP) and Cheques (CHE) of the country and also examined their effect on agricultural output from a non-linear perspective.

2. Literature Review

Empirical studies on agricultural development in Nigeria are largely concerned with how macroeconomic variables such as economic growth, inflation, and the balance of payment (imports, export, and exchange rate) are interlinked with the agricultural sector. There is a consensus in the literature that agriculture has positively affected economic growth in the country (**Ismail & Kabuga, 2016**; **Olajide, Akinlabi, & Tijani, 2012; Osabohien, et al., 2019; Oyakhilomen & Zibah, 2014**; **Joseph & Andrew, 2019**; **Amaefula, 2019**). Similarly, concerning inflation, the empirical literature largely concludes that inflation significantly affects the agricultural sector in Nigeria (**Oyinbo & Rekwot, 2014**; **Akpaeti, Agom, & Frank, 2018)**. In the literature, many have studied the drivers of agricultural output or performance in Nigeria. For example, government expenditure is shown to positively affect the agricultural output in the country (**Iganiga & Unemhilin, 2011**; **Matthew & Mordecai, 2016**; **Adofu, Abula, & Agama, 2012; Vincent, Boniface, Bobola, & Olorunrinu, 2020**). While monetary policy has been significant in influencing the agricultural sector in Nigeria across several studies (**Oboh, Tule, & Ebuh, 2019**; **Udeaja & Udoh, 2014**; **Ogbuabor, Anthony-Orji, Manasseh, & Orji, 2020**).

The effect of financial inclusion on agriculture has been a topic of debate in several developing economies and few empirical studies had focused on this over the years. Several studies opined that financial inclusion has a positive effect on the agricultural sector, most especially in developing nations (**Badmus & Ogundele, 2019**; **Fowowe, 2020; Abraham, 2018**; **Atakli & Agbenyo, 2020**) while some empirical studies showed that financial inclusion has had little or no effect on the agricultural sector (**Olaniyi, 2017; Okuma, Nwoko, Elugom, & Uche, 2019**). In the empirical literature, the most inconsistent and diverse aspect of studies on the relationship between financial inclusion and agriculture is the measurement of financial inclusion.

Severally measures have been used as a way to capture financial inclusion and these methods can be split into cross-sectional, time-series, and panel data approaches. Using the cross-sectional approach, **Atakli and Agbenyo (2020)** used the number of farmers that owned savings accounts as a measure of financial inclusion while **Abraham (2018)** utilized participation in a savings club, a traditional crop insurance plan, and formal financial institution financing as measures of financial inclusion. Similarly, **Kalu, Omeje, and Mba, (2018)** developed the adequacy gap index and timeliness gap index to measure financial inclusion

Employing time series data, **Olaniyi (2017)** explores outstanding loans to the agricultural sector and the number of banks in Nigeria as a measure of financial inclusion, while **Okuma, Nwoko, Elugom, and Uche, (2019)** used deposit

money bank loans to small scale enterprises as a percentage of the total loan and demand deposit from rural areas as a measure of financial inclusion. The panel data approach in measuring financial inclusion was used by **Fowowe, (2020)** in classifying financial inclusion and the study employed ownership of a bank account, access to credit from financial information, and access to savings.

From this, it is evident that the bulk of the literature that studies financial inclusion and the agricultural sector in developing countries uses cross-sectional data to determine and measure financial inclusion. This is because, in measuring financial inclusion, cross-sectional data provide the flexibility the researcher needs to account for a different aspect of inclusion however it omits the influence of time and the financial inclusion drive that has occurred during the past decades.

Our study makes two contributions to the body of literature. First, although other studies examine the effects of financial factors on agricultural output in Nigeria, our study differs as it focuses on financial inclusion in the country using measures such as the volumes and values of ATM, POS, MBP, and CHE as measures of financial inclusion. Secondly, the study employs a non-linear empirical viewpoint in the analysis to check if an increase or decrease in financial inclusion will have the same impact on agricultural output in Nigeria.

3. Methodology

This study used quarterly data ranging between 2010Q1 and 2021Q4 based on data available quarterly in Nigeria. The dependent variable is agricultural gross domestic Product (AGDP), while ATM, POS, MBP, and CHE were used as proxies for financial inclusion, which serve as independent variables. We sourced quarterly data from the Nigerian Inter-Bank Settlement System Plc (NIBSS) and the CBN statistical bulletin 2021. To analyze the agricultural sector GDP and financial inclusion nexus in Nigeria. The financial inclusion was proxy by the volume and value of ATM, POS, MBP, and CHE in Nigeria using the standard growth accounting framework.

The study employs an augmented Solow production function (**Solow, 1956**) where output is measured in terms of capital stocks, labour, human capital, and productivity. We, however, modify the model to incorporate the volume and value of ATM, POS, MBP, and CHE and specify them separately in a Cobb–Douglas production function (**Cobb & Douglas, 1928**). The justification for the incorporation of these variables was hinched on the study conducted by **Asli and Leora (2013)** and **Teslim and Moses (2022)** who used ATM, POS and online banking as a measure of financial inclusion. The function is thus:

$$AGDP_t = A_t K_{ATMt}^{\alpha 1} K_{POSt}^{\alpha 2} K_{MBPt}^{\alpha 3} K_{CHEt}^{\alpha 4} \varepsilon \quad \ldots\ldots\ldots\ldots (3.1)$$

Where $AGDP_t$ is the Agricultural Gross Domestic Product at time t. Total agricultural output is presented as a function of a capital input at time t divided into ATM, POS, MBP, and CHE represented by (K_{ATMt}, K_{POSt}, K_{MBPt}, & K_{CHEt}) in the model.

3.1 Model specification

The variables of the model were found to be stationary in mix levels of I(0) and I(1), therefore, Non-linear Autoregressive Distributed Lagged (NARDL) model was employed and the Stepwise Least Squares (STEPLS) technique, was used in estimating the model. According to **Shin et al. (2014)**, the advantage of NARDL was its ability and flexibility to be applied to variables with a mixed order of integration and to capture the non-linear nature of the time series. Based on the theoretical framework adopted in this study, the Non-linear Autoregressive Distributed Lag model was specified as follows:

$$\begin{aligned}\triangle logAGDP_t = {} & \gamma 0 + \gamma 1 logAGDP_{t-1} + \gamma 2 logATM_{t-1_{POS_{t-1}}} + \gamma 3 logATM_{t-1_{NEG_{t-1}}} + \gamma 4 logPOS_{t-1_{POS_{t-1}}} + \\ & \gamma 5 POS_{t-1_{NEG_{t-1}}} + \gamma 6 MBP_{t-1_{POS_{t-1}}} + \gamma 7 MBP_{t-1_{NEG_{t-1}}} + \gamma 8 CHE_{t-1_{POS_{t-1}}} + \gamma 9 CHE_{t-1_{NEG_{t-1}}} + \sum_{k=1}^{n} \gamma 10 \triangle logAGDP_{t-1} + \\ & \sum_{k=1}^{n} \gamma 11 \triangle logATM_{POS_{t-1}} + \sum_{k=1}^{n} \gamma 12 \triangle logATM_{NEG_{t-1}} + \sum_{k=1}^{n} \gamma 13 \triangle logPOS_{POS_{t-1}} + \sum_{k=1}^{n} \gamma 14 \triangle logPOS_{NEG_{t-1}} + \\ & \sum_{k=1}^{n} \gamma 15 \triangle logMBP_{POS_{t-1}} + \sum_{k=1}^{n} \gamma 16 \triangle logMBP_{NEG_{t-1}} + \sum_{k=1}^{n} \gamma 17 \triangle logCHE_{POS_{t-1}} + \sum_{k=1}^{n} \gamma 18 \triangle logCHE_{NEG_{t-1}} + \\ & \tau ECM(-1) + \mu t1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3.2)\end{aligned}$$

Where: LogAGDP is the natural logarithm of agricultural GDP, logATM is the natural logarithm of volume and value of automated teller machine usage; logPOS is the natural logarithm of the volume and value of point of sale usage; log MBP is the natural logarithm of the volume and value of mobile banking payments, log CHE is the natural logarithm of the volume and value of cheques, $logATM_{t-1_{POS_{t-1}}}$ is the natural logarithm of positive change in the volume and value of automated teller machine usage, $logATM_{t-1_{NEG_{t-1}}}$ is the negative change in the volume and value of automated teller machine usage, $logPOS_{t-1_{POS_{t-1}}}$ is the positive change in the volume and value of point of sale usage, $logPOS_{t-1_{NEG_{t-1}}}$ is the negative change in the volume and value of point of sale usage, $logMBP_{t-1_{POS_{t-1}}}$ is the positive change in the volume and value of mobile banking payments, and $logMBP_{t-1_{NEG_{t-1}}}$ is the negative change in the volume and value of mobile banking payments $logCHE_{t-1_{POS_{t-1}}}$ is the positive change in the volume and

value of cheques, and $logCHE_{t-1_{NEG}t-1}$ is the negative change in the volume and value of cheques in Nigeria.

$\gamma 0$ is the constant, $\gamma 1 - \gamma 10$ are the long-run coefficients, $\gamma 11 - \gamma 18$ are the short-run coefficients, τ is the speed of adjustment parameter.

Model 3.2 captures the response of agricultural output to both positive and negative changes in the ATM, POS, MBP, and CHE in Nigeria. To evaluate the presents or otherwise of asymmetries in the model we adapted Shin et al. (2014), which account for the short and long run asymmetries. Model 3.2 decomposes the independent variables of the model ATM, POS, MBP, and CHE into positive and negative changes. This is because it is assumed that economic agents react differently to positive and negative changes in ATM, POS, MBP, and CHE.

The partial sums for the increase and decrease in the independent variables are thus:

$$ATM_{POS} = \sum_{k=1}^{n} \triangle logATM_{POS} = \sum_{k=1}^{n} \max(\triangle logATM, 0) \quad (3.3)$$

$$ATM_{NEG} = \sum_{k=1}^{n} \triangle logATM_{NEG} = \sum_{k=1}^{n} \min(\triangle logATM, 0) \quad (3.4)$$

$$POS_{POS} = \sum_{k=1}^{n} \triangle logPOS_{POS} = \sum_{k=1}^{n} \max(\triangle logPOS, 0) \quad (3.5)$$

$$POS_{NEG} = \sum_{k=1}^{n} \triangle logPOS_{NEG} = \sum_{k=1}^{n} \min(\triangle logPOS, 0) \quad (3.6)$$

$$MBP_{POS} = \sum_{k=1}^{n} \triangle logMBP_{POS} = \sum_{k=1}^{n} \max(\triangle logMBP, 0) \quad (3.7)$$

$$MBP_{NEG} = \sum_{k=1}^{n} \triangle logMBP_{NEG} = \sum_{k=1}^{n} \min(\triangle logMBP, 0) \quad (3.8)$$

$$CHE_{POS} = \sum_{k=1}^{n} \triangle logCHE_{POS} = \sum_{k=1}^{n} \max(\triangle logCHE, 0) \quad (3.9)$$

$$CHE_{NEG} = \sum_{k=1}^{n} \triangle logCHE_{NEG} = \sum_{k=1}^{n} \min(\triangle logCHE, 0) \quad (3.10)$$

3.2 A priori Expectation

The coefficients of logATM_POS, logPOS_POS, logMBP_POS, and logCHE_POS are expected to have positive signs, while the coefficient of logATM_NEG, logPOS_NEG, logMBP_NEG, and logCHE_NEG are expected to have negative signs. That is $\gamma 0, \gamma 2, \ \gamma 4, \ \gamma 6, \ \gamma 9, \ \gamma 11, \ \gamma 13, \gamma 15, \gamma 17 > 0$ While, $\gamma 3, \ \gamma 5, \ \gamma 7, \gamma 9 \ \gamma 12, \ \gamma 14, \ \gamma 16, \gamma 18 < 0$.

Table 4.1: Descriptive Statistics

Variable	AGDP	ATM	POS	MBP	CHE
Mean	4026401	1587606	721508.8	1523412	2433821
Maximum	5550941.	5469487.	6423603.	13035590	6109320.
Minimum	2594760.	62590.00	1865.365	870.0000	1099700.
Std.Dev	850596.6	1505915.	1456281.	3398675.	1491798.
Skewness	0.230417	1.508146	2.823663	2.591547	1.204546
Kurtosis	1.958758	4.097537	9.921237	8.346555	2.936674
Jarque-Bera	2.593108	20.60520	159.5916	110.9002	11.61547
Probability	0.273473	0.000034	0.000000	0.000000	0.003004
No. of Obs.	48	48	48	48	48

Source: Authors' compilation

Table 4.2: Unit root test for stationarity

	Philip-Perron (PP) (Constant)			Augmented Dicker-Fuller (ADF) (Constant)		
	T-Stats/probability values			T-Stats/probability values		
Variables	AT levels	At first Diff.	Order	AT levels	At first Diff.	Order
log AGDP	-5.48 (0.000)*		I(0)	-3.628 (0.009)*		I(0)

Log ATM	-3.674 (0.008)*		I(0)	-3.646 (0.008)*		I(0)
Log POS	0.275 (0.975)	-14.737 (0.000)*	I(1)	-0.346 (0.910)	-8.839(0.000)*	I(1)
Log MBP	-1.196 (0.669)	-6.578 (0.000)*	I(1)	-1.066 (0.721)	-6.576(0.000)*	I(1)
Log CHE	-2.579 (0.104)	-9.488 (0.000)*	I(1)	-2.715 (0.079)	-9.247(0.000)*	I(1)

Notes: * and ** imply that the series is stationary at 1 per cent (**Source:** Authors' compilation)

Table 4.3: The Long run ARDL Coefficients (logAGDP)

DEPENDENT VARIABLE: LogAGDP				
Variables	**Coefficients**	**Se**	**t-Statistic**	**Prob.**
LogATM	0.0184	0.0055	3.3340	0.0021*
LogPOS	0.0353	0.0037	9.4852	0.0000*
LogMBP	0.0026	0.0042	0.6223	0.5380
LogCHE	-0.0445	0.0054	-8.2339	0.0000*
C	29.6137	0.4994	59.2985	0.0000*

Notes: * imply that the series is stationary at 1 per cent. Se is a standard error (Source: Authors' compilation)

4.1 Results and discussion

Table 4.1 presents the summary statistics for the agricultural GDP, value of ATM, POS, MBP, and CHE in Nigeria. The study finds that AGDP, ATM, POS, MBP, and CHE skewed positively. The probability values of the Jarque-Bera indicate that only AGDP is normally distributed, but ATM, POS, MBP, and CHE are not normally distributed. This does not affect the validity of the results of the study.

Table 4.2 contains the stationarity test for the LogAGDP, LogATM, LogPOS, LogMBP, and LogCHE in Nigeria. LogAGDP and LogATM are stationary at levels, while LogPOS, LogMBP, and LogCHE became stationary at first difference. The study, therefore, reveals a mixture of I(0) and I(1) levels of integration, which justifies the choice of the NARDL model and the estimation technique of OLS (Pesaran & Shin, 1999).

Table 4.3 presents the long run symmetry ARDL coefficients for the symmetric financial inclusion and agricultural output nexus in Nigeria. The study reveals that LogATM, LogPOS, and LogMBP affect agricultural output positively in Nigeria, while LogCHE affects agricultural output negatively in Nigeria. In addition, ATM and POS have a positive and significant effect on agricultural output. This is not surprising as ATM and POS have wider coverage and acceptance in the country. On the other hand, MBP positively but insignificant affects the agricultural output. This could be attributed to limited or lack of access to Android phones, especially in the villages where agriculture is the major occupation. CHE affects agricultural output positively and significantly in Nigeria.

Table 4.4: The Short run ARDL Coefficients and ECM

Variable	**Coefficient**	**Se**	**t-Statistic**	**Prob.**
C	29.6137	0.4994	59.2985	0.0000*
D(LogAGDP(-1)	1.0058	0.0204	49.3188	0.0000*
D(LogPOS)	0.0356	0.0127	2.8097	0.0083*
D(LogPOS(-1))	-0.0198	0.0112	-1.7632	0.0871
D(LogMBP)	-0.0277	0.0126	-2.1962	0.0352**
D(LogMBP(-1))	-0.0234	0.0136	-1.7178	0.0952
D(LogCHE)	-0.0250	0.0132	-1.8985	0.0664
D(LogCHE(-1))	0.0396	0.0135	2.9434	0.0059*
ECM(-1)	-1.9871	0.0282	-70.4127	0.0000*

Notes: * and ** imply that the series is stationary at 1 per cent and 5 per cent respectively. SE is a standard error

Table 4.5: The Long run NARDL coefficient for Volume

Variable	Coefficients	Se	t-Statistic	Prob.
LogAGDP(-1)	-1.5344	0.1853	-8.2799	0.0000*
LogATM_P(-1)	0.0049	0.0083	0.5852	0.5641
LogATM_N(-1)	0.2474	0.0334	7.4036	0.0000*
LogPOS_P(-1)	0.0660	0.0103	6.3819	0.0000*
LogPOS_N(-1)	0.0697	0.0143	4.8835	0.0001*
LogMBP_P(-1)	-0.0185	0.0072	-2.5567	0.0176**
LogMBP_N(-1)	-0.0293	0.0177	-1.6561	0.1113
LogCHE_P(-1)	0.0725	0.0175	4.1531	0.0004*
LogCHE_N(-1)	-0.0777	0.0131	-5.9220	0.0000*

Notes: * and ** imply that the series is stationary at 1 per cent and 5 per cent respectively. SE is a standard error

Table 4.6: The Short run NARDL coefficient Volume

DEPENDENT VARIABLE: D(LogAGDP)

Variable	Coefficients	Se	t-Statistic	Prob.
C	22.953	2.7756	8.2697	0.0000*
DLogAGDP(-2)	-0.2265	0.0921	-2.4588	0.0219**
DLogAGDP(-1)	0.7796	0.0915	8.5242	0.0000*
DLogATM_N	0.1426	0.0205	6.9434	0.0000*
DLogCHE_N	-0.0377	0.0096	-3.9410	0.0007*
DLogATM_N(-1)	-0.1577	0.0283	-5.5751	0.0000*
DLogPOS_P(-1)	-0.0155	0.0081	-1.9207	0.0673
DLogCHE_P(-2)	-0.0475	0.0101	-4.7096	0.0001*
DLogATM_P(-2)	0.0187	0.0094	1.9987	0.0576
DLogMBP_N(-1)	0.0620	0.0155	4.0019	0.0006*
DLogMBP_N(-2)	0.0371	0.0120	3.0932	0.0051*
DLogPOS_P	0.0301	0.0114	2.6367	0.0147**
DLogATM_P	0.0166	0.0079	2.0934	0.0475**
F-Statistic	1569.8	DW-Statistic	2.3498	
Prob.(F-Statistic)	0.0000*			

Notes: * and ** imply that the series is stationary at 1 per cent and 5 per cent respectively. Se is a standard error

Table 4.4 presents the short run symmetry ARDL coefficients. It was found that POS affects agricultural output positively and significantly in Nigeria. The coefficients of MBP and CHE show that they affect agricultural output negatively and significantly in Nigeria. The error term parameter value of -1.9871 that captures the speed of adjustment of the model to the equilibrium level, in the long run indicates that the economy will converge at 198.75 per cent quarterly. The basis for this study is the use of a NARDL in the analysis of the data collected.

Table 4.5 presents the long run coefficients of the NARDL model. The long run coefficients are obtained as follows -c(i)/c(2), where c(i) represents the coefficients of independent variables and c(2) is the long run coefficient of the lagged dependent variable in this case LogAGDP(-1) (see **Shin, et al 2014**). The long run coefficients are

computed below: LogATM_P =(-0.0049/-1. 5344)=0.0032, this implies that a 1 per cent increase in the volume of ATM may likely increase agricultural output in Nigeria by 0.0032 per cent. This further indicates that a positive change in ATM may likely have a positive effect on agricultural output and is consistent with the theoretical expectation of this study. The coefficient of LogATM_N=(-0.2474/-1.5344)=0.1612 implies that a 1 per cent reduction in the volume of ATM may likely reduce the output of the agricultural sector by 0.1612 per cent in Nigeria. Agricultural output response positive but insignificantly to positive change in the volume of ATM, but positive and significant to a negative change in the volume of ATM in Nigeria.

Similarly, the coefficient of LogPOS_P=(-0.0660/-1.5344)=0.0430 show that a 1 per cent point rise in the volume of POS may likely increase the output of the agricultural sector by 0.0430 per cent in Nigeria, while the coefficient of LogPOS_N=(-0.0697/-1.5344)=0.0454 implies that a 1 per cent reduction in the volume of POS may likely decrease agricultural output by 0.0454 per cent in Nigeria. The result further shows that both increase and decrease in the volume of POS in Nigeria have a significant effect on agricultural output as indicated by their probability values of 0.0000 and 0.0001 respectively (see **table 4.5**).

On the other hand, the coefficient of LogMBP_P= -(-0.0185/-1.5344)=-0.0120 show that a 1 per cent rise in the volume of MBP may likely reduce agricultural output by 0.0120 per cent in Nigeria, while the coefficient of LogMBP_N=-(-0.0293/-1.5344)= -0.0191 implies that a 1 per cent reduction in the volume of MBP may likely increase the output of agricultural sector by 0.0191 per cent in Nigeria. The result further indicates that a positive change in the volume of MBP affects agricultural output significantly, while a negative change in the volume of MBP in Nigeria has an insignificant effect on agricultural output as indicated by their probability values of 0.0176 and 0.1113 respectively (see **table 4.5**).

The coefficient of LogCHE_P= (-0.0725/-1.5344)=0.0473 show that a 1 per cent point rise in the volume of MBP may likely increase agricultural output by 0.0473 per cent in Nigeria, while the coefficient of LogCHE_N=-(-0.0777/-1.5344)= -0.0508 implies that a 1 per cent reduction in the volume of CHE may likely lead to 0.05081 per cent increase in agricultural output in Nigeria. Both positive changes and the negative changes in the volume of CHE in Nigeria have a significant impact on agricultural output as indicated by their probability values of 0.0004 and 0.0000 respectively (see **table 4.5**).

The long run results reveal that financial inclusion affects agricultural output positively and significantly in Nigeria, particularly the volume of ATM and POS as they have a direct impact on the agriculturalist. This finding corroborated **Badmus and Ogundele (2019)**, **Fowowe (2020)**, and **Atakli and Agbenyo (2020)**.

Table 4.6 presents the NARDL short run coefficients for the asymmetric model. The study finds that in the short-run, positive change in both the volume of ATM and POS may likely lead to an increase in agricultural output in Nigeria. The coefficients of DLogATM_P, DLogPOS_P, and DLogMBP_P(-1 and -2) of 0.0166, 0.0301, 0.0620, and 0.0371 respectively, implies that a 1 per cent point increase in the volume of ATM, POS, and MBP may likely translate into an increase in agricultural output in Nigeria. The study further reveals that positive change in the volume of ATM, POS, and MBP impacted positively and significantly agricultural output in Nigeria. On the other hand, the coefficients of the volume of DLogCHE_P(-2) of -0.0475 and DLogCHE_N of -0.0377 implies that a 1 per cent point increase in the volume of CHE may likely lead to a 0.0475 decrease and 0.0377 increase in agricultural output respectively. Finally, the study finds that ATM, POS, MBP, and CHE have affected agricultural output significantly in Nigeria, with ATM and POS having a positive effect while MBP and CHE have a negative effect. This result was further confirmed with the 1569.8 value of the F-statistics and the 0.0000 corresponding probability.

Financial inclusion in form of the volume of ATM, POS, MBP, and CHE are the drivers of agricultural output in Nigeria. Table 4.7 presents the wald test for the long run cointegration between financial inclusion and agricultural output in Nigeria. The probability value of F-statistics of 0.0000 indicates the presence of long run relationship between financial inclusion and the output of agricultural sector in Nigeria.

Table 4.7: Wald test for cointegration

Statistics	Values	Df	Probabilities
F-Statistic	15.8808	(7, 23)	0.0000
Chi-Square-Stat.	111.1656	7	0.0000

Source: Authors' compilation

Table 4.8. Wald Test for Long-Run Asymmetry

Variables	LogATM		LogPOS		LogMBP		LogCHE	
t-statistic/Prob.	-7.4709	(0.0000)*	-0.2655	0.7930	0.4778	0.6373	6.4269	0.0000*
F-statistic/Prob.	55.8145	(0.0000)*	0.0705	0.7930	0.2283	0.6373	41.3048	0.0000*
Chi-square/Prob.	55.8145	(0.0000)*	0.0705	0.7906	0.2283	0.6328	41.3048	0.0000*

Notes: * and ** imply that the series is stationary at 1 per cent

Table 4.9: Diagnostics for value

Technique	**F-Stat & JB/ (Prob)**	**Null Hypothesis**	**Decision**
	Actual (Volume)		
Serial Correlation	1.3056(0.2921)	No serial correlation	Accepted
Heteroscedasticity	0.8984(0.5954)	Homoscedascity	Accepted
Normality Test	0.0200(0.9901)	Normal distribution	Accepted
	Robustness (Value)		
Serial Correlation	0.6975(0.5143)	No serial correlation	Accepted
Heteroscedasticity	1.0355(0.4852)	Homoscedascity	Accepted
Normality Test	2.1060(0.3489)	Normal distribution	Accepted

Table 4.8 contains the wald test result for the long run asymmetric model. The result reveals that LogATM and LogCHE have a long run asymmetric effect on agricultural output, while LogPOS and LogMBP have no asymmetric effect on agricultural output in Nigeria. This implies that the effect of only ATM and CHE on agricultural output can better be detected using a non-linear approach, while the effect of POS and MBP can be analysed using a symmetry (linear) approach.

Table 4.9 presents the diagnostic test for the model of agricultural output and financial inclusion in Nigeria for actual analysis and the robustness check. The result reveals that both the actual model and the robustness model passed the test for serial correlation, heteroscedasticity, and normality. We, therefore conclude that there is no serial correlation, no heteroscedasticity, and the data is normally distributed at 5 per cent significant levels. For normality tests see appendix I **figure 4.1**

Figure 4.2 shows the CUSUM and CUSUM of squares graphs for the stability test. The result reveals that the blue lines fall within the 5 per cent bound, therefore the model of this study passed the stability test.

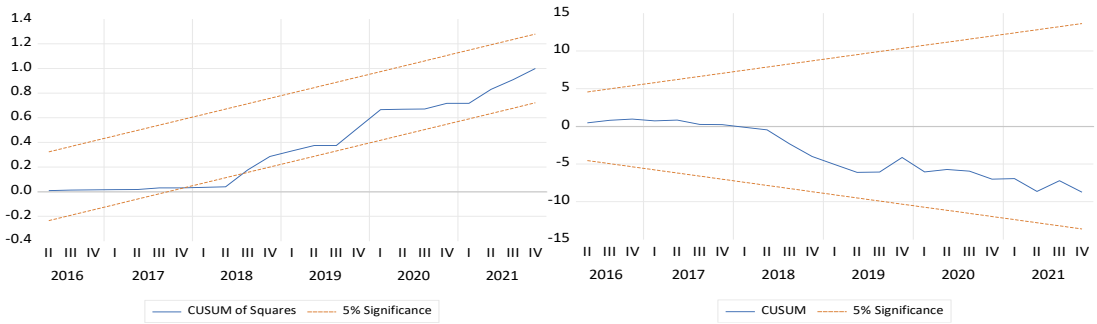

Figure 4.2: Stability test

4.2 Robustness test using Value

Table 5.1: NARDL Long run coefficient for Robustness

Variable	Coefficients	Se	t-Statistic	Prob.
LAGDP(-1)	-1.8596	0.3033	-6.1321	0.0000*
LATM_P(-1)	-0.0185	0.0181	-1.0201	0.3228
LATM_N(-1)	0.5687	0.0934	6.0898	0.0000*
LPOS_P(-1)	-0.0584	0.0224	-2.6001	0.0193**
LPOS_N(-1)	0.4453	0.0660	6.7433	0.0000*
LMBP_P(-1)	0.1317	0.0206	6.4086	0.0000*
LMBP_N(-1)	-0.1112	0.0425	-2.6166	0.0187**
LCHE_P(-1)	-0.0456	0.0514	-0.8866	0.3885
LCHE_N(-1)	-0.3502	0.1160	-3.0184	0.0082*

Notes: * and ** imply that the series is stationary at 1 per cent and 5 per cent respectively. SE is a standard error

Table 5.2: NARDL Short run coefficient for Robustness

DEPENDENT VARIABLE: D(LogAGDP)

Variable	Coefficients	Se	t-Statistic	Prob.
DLAGDP(-2)	-0.0901	0.1516	-0.5943	0.5606
DLAGDP(-1)	0.9555	0.1545	6.1848	0.0000*
DLMBP_P	0.0903	0.0232	3.8872	0.0013*
DLCHE_N	-0.1153	0.0710	-1.6246	0.1238
DLPOS_P	-0.0868	0.0333	-2.6037	0.0192**
DLCHE_N(-2)	0.1144	0.0647	1.7670	0.0963
DLATM_P(-2)	0.0810	0.0184	4.4079	0.0004*
DLCHE_P(-2)	-0.0330	0.0277	-1.1916	0.2508
DLATM_N	0.1517	0.0687	2.2089	0.0421**
DLPOS_P(-1)	0.0692	0.0240	2.8909	0.0106**
DLPOS_N(-2)	-0.1117	0.0531	-2.1025	0.0517
DLMBP_P(-2)	0.0612	0.0146	4.1894	0.0007*
DLPOS_N(-1)	-0.2942	0.0719	-4.0931	0.0008*
DLCHE_N(-1)	0.2534	0.0799	3.1702	0.0059*
DLATM_N(-1)	-0.2925	0.0997	-2.9344	0.0097*
DLATM_N(-2)	-0.1932	0.0842	-2.2940	0.0357**
DLCHE_P(-1)	0.0340	0.0347	0.9792	0.3421
DLATM_P	0.0123	0.0128	0.9581	0.3523
DLPOS_N	0.0326	0.0455	0.7166	0.4839
F-Statistic	773.87	DW-Statistic	2.4350	

Prob.(F-Statistic)	0.0000*

Notes: * and ** imply that the series is stationary at 1 per cent and 5 per cent respectively. Se is a standard error

Table 5.3: NARDL cointegration test for Robustness

Statistics	Values	Df	Probabilities
F-Statistic	3.1476	(7, 31)	0.0124
Chi-Square-Stat.	22.0329	7	0.0025

Table 5.3 confirmed the presence of cointegration in the model of the study even when using the value in place of the volume of ATM, POS, MBP, and CHE in Nigeria.

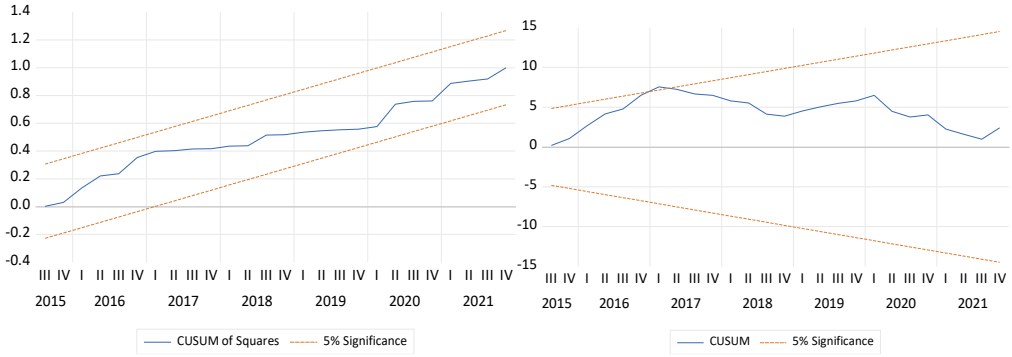

Figure 5.1: Stability test for Robustness

Table 5.1 contains the NARDL long run coefficients for the asymmetric model using the value of ATM, POS, MBP, and CHE to check the robustness of the results of the study. The result supports the actual result using the volumes of ATM, POS, MBP, and CHE. This implies that the model and result of the study pis robust for policy.

Table 5.2 presents the NARDL short run coefficients for the asymmetric model using the value of ATM, POS, MBP, and CHE. The result supports the actual result using the volumes of ATM, POS, MBP, and CHE.

Figure 5.1 confirmed that the model of the study is stable even when value is used in place of volume as the blue lines fall within the 5 per cent bound. The robustness supports the model as the best model to analyse the asymmetric relationship between financial inclusion and agricultural output in Nigeria.

5. Conclusion and policy implication

The study examines the asymmetric relationship between financial inclusion proxy by the volume of ATM, POS, MBP, and CHE. Quarterly data between 2010Q1 and 2021Q4 was sourced from the Nigerian Inter-Bank Settlement System Plc (NIBSS) and the CBN statistical bulletin 2021. The non-linear Autoregressive Distributed Lagged (NARDL) model and Stepwise Least Squares (STEPLS) were employed in the estimation. We find that financial inclusion affects the output of the agricultural sector positively and significantly in Nigeria, especially when proxy by the automated teller machine and point of sale. Therefore, we recommend that to achieve improved agricultural output, government and monetary authority should increase the spread of Automated Teller machines and Point of Sales, especially in the villages where agriculture is their major occupation. Also, we recommend the need to improve internet access in the rural areas of the country. This could boost agricultural output and create employment for the citizenry.

Competing interests: There is no conflict of interests reported by the authors

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Appendix I

Figure- 4.1: Normality test