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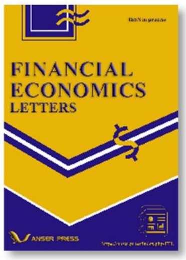


# Electronic Payments System and Banking Industry's Return in Nigeria: A Time-Varying Granger Causality Approach

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## ABSTRACT

The paper is motivated by the growth of the electronic payments system and its relevance in enhancing the banking industry's earnings. Consequently, the paper examines the causal relationship between the electronic payments system and the banking industry's returns in Nigeria. The paper offers some important contributions to the literature involving the use of an approach that allows for data-driven identification of the change points in the electronic payments system and the banking industry's returns nexus. The paper discovered three important findings. First, the causal relationship between the electronic payments system and the banking industry's returns in Nigeria changes with time changes. Second, there is evidence of causality between the electronic payments system and returns on assets and equity, however, the causality was more evident under the recursive window. Third, the causal relationship was more evident in some specific periods such as 2020Q4, all quarters of 2015 to 2016, and 2020 to the end of 2023. The paper recommends that policymakers should revisit and reinvigorate the specific cashless policies instituted in 2012-2016 that aided higher returns to the banking industry. Similarly, the Central Bank of Nigeria and other banking industry players should intensify efforts to encourage the use of electronic payments due to their usefulness and ability to enhance the banking industry's earnings.

## KEYWORDS

Electronic Payments; Banking Industry Returns; Cashless Policy; Granger Causality

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## 1. Introduction

Electronic payment systems have in recent times gained strong momentum, easing the payment process, and offering a convenient banking experience to end-users. The growth in the electronic payment system was bolstered by the development of information technology, cashless-driven policies, and a financial inclusion strategy aimed at closing the gap between the banked and unbanked population.

The banking industry returns, on the other hand, remain a veritable yardstick for measuring banks' profitability, efficiency, and resilience (Kasri et al., 2022; Ullah et al., 2023). The banking industry returns majorly being measured by returns on assets and equity depend on several bank-based and economic factors. Some of the bank-based factors include the monetary value realized from the products and services offered by banks such as the payment channels, which generate returns and boost bank assets and realizable returns on shareholders equity fund.

The focus of this paper is to gain an inkling between the electronic payments system and the banking industry returns in Nigeria, given the recent growth of the various electronic payment channels (Figure 3-6). Thus, the motivation of the paper stems from the cashless policy drives of the Central Bank of Nigeria aimed at reducing the prevalent use of cash payments and enhancing the use of electronic payment channels for exchange and the goal of maintaining a resilient and stable financial ecosystem. The thrives in electronic payments is driven by the growth ambition, lowering the cost of providing banking services and enhancing the ability of the monetary authority to effectively manage the payment ecosystem. Moreover, the demand for electronic payments systems is not unconnected to its ability to enhance the profitability of the service providers, and the resilience of the system, among others, it however, comes with cost (disruptive technology and cybersecurity risk, among others). Thus, the need to constantly examine and re-evaluate the nexus between the electronic payment channels and the banking industry's returns. Against the above backdrop, the objective of this paper is to examine the causal relationship between the electronic payments system and banking industry return in Nigeria, accounting for time heterogeneity.

The paper contributes to the literature in two aspects. First, the paper employed a different estimation technique that accounts for time variation, which was ignored by the previous studies (for instance, Fadoju et al., 2018; Orji et al., 2018; Sylvester Afaha, 2019; Ugwueze & Nwezeaku, 2016; Yang et al., 2018; & Zwingina et al., 2023). Several studies have emerged to confirm that Granger causality could be evident or supported over one time, but such evidence could be weak or absent when an alternative time range is considered (Shi et al., 2020). Thus, the contribution of the paper in this regard is accounting for the possibility of time-heterogeneity in causal relations between electronic payment and banking industry returns in Nigeria. The second contribution of the paper is the expansion of the dataset to the end of the fourth quarter of 2023. The large dataset would improve the reliability of the result as opposed to the limited dataset utilized by Frank & Binaebi (2019). Thus, this paper is an improvement of Frank & Binaebi (2019).

Following this introduction, the literature review is in Section 2, the methodology in Section 3, while results and discussion are featured in Section 4, and the study concludes in Section 5.

## 2. Literature Review

The Schumpeter theory of innovation suggests the role of innovation in promoting creative destruction that translates to progress and growth (Kasri et al., 2022). In the original version of the theory, Schumpeter (1912) proposes that technological advancements create opportunities for new profits, driven by an increase in investment by firms (banks in the context of the paper) in innovative products such as Point of Sale (POS), Automated Teller Machine (ATM), Mobile payment applications, and Web payment channels, among others. This paper, therefore, hypothesizes that innovations in the form of electronic payment systems would change the dynamics of financial activities, creating an opportunity for banks to increase earnings (returns on asset and equity), which would ultimately translate to greater banking industry resilience and effectiveness. Essentially, the realized benefit of electronic payment is likely to create additional economic value with higher liquidity within the financial ecosystem. However, friction in the workings of the electronic payment system would mean customer dissatisfaction and lower returns from such digital infrastructure. From the above, it can be inferred that banking industry returns can by inference and extension be a function of the value of the electronic payment system, mathematically expressed below:

$$Banks\ returns\ = f(electronic\ payment) \tag{1}$$

The above relationship could be further broken to proxy electronic payment systems with several values of electronic channel payment. Similarly, banks' returns can be proxied by returns on assets and equity. In essence, the Schumpeterian innovation theory posits that innovation is a determining factor of growth and returns (profitability). Consequently, this paper adopts this theory to examine the time-varying Granger causality between the electronic payment system and banking industry returns in Nigeria.

An inundated number of studies on electronic payment systems and bank returns exist. For instance, Frank & Binaebi (2019) demonstrated that electronic payment transactions enhance the assets base of commercial banks in Nigeria. Conversely, POS transactions channel lower the asset base of banks, indicating a negative relationship. The takeaway of the studies is that some payments system enhances banks' assets while others suppress them. The major shortcoming of Frank & Binaebi's (2019) paper is the limited sample size (only 10 years, i.e. 10 observations). The sample is extremely low to provide a reliable and unbiased result for inference, therefore, the outcome of the paper cannot be reliable. This paper addresses this shortcoming of inadequate data and inappropriate analytical techniques. Contrary to the findings of Frank & Binaebi (2019), the findings of Ugwueze & Nwezeaku (2016) showed the absence of a significant relationship between electronic banking and the banking industry's return. Given this conflicting result, there is a need for a re-examination of this relationship with the updated dataset.

Other emerging studies indicate that e-banking payment channels have the potential to enhance the performance of the DMBs (Ughulu & Agbonkhese, 2020). The study employed Fully Modified Ordinary Least Square (FMOLS) and showed that ATM exerted a negative effect on returns on asset (ROA) and net profit margin, however, it exerts a negative effect on return on equity (ROE). From a different perspective, Nwaiwu and Momoh (2021) showed that the electronic payment paradigm relates significantly to the price-earnings ratio, indicating that the electronic payment paradigm has the potential to improve the price-earnings ratio.

Following the full adoption of the e-banking system in China, Yang et al. (2018) investigated the performance of Chinese banks and discovered that e-banking tends to improve the Chinese bank's performance in terms of ROA, ROE, and operating margin. On the contrary, e-banking has a slight impact on Chinese bank performance concerning net interest margin and efficiency ratio. Furthermore, the impact of the long-term steady-state of the technological innovation of payment on Chinese commercial banks was investigated by Yao et al. (2018) using the Vector Autoregression (VAR) model and suggested that third-party payments appear to positively impact the value creation capabilities of traditional financial industries, and the impact tends to remain in a steady state in the long term. The finding concurs that technological innovation in emerging economies, such as China, has promoted the development of the financial industry and accelerated the process of industrial evolution.

In Kenya, Aduda and Kingoo (2012) show that electronic banking significantly and positively influences returns on assets within the Kenyan banking sector. This suggests a direct relationship between electronic banking and the performance of banks. similarly, Al-Mamoorey and Al-Rubaye (2020) show that electronic payment systems play a crucial role in achieving and maintaining financial stability in Iraq. Additionally, Sumra et al. (2011) demonstrate that e-banking allows banks to meet expenses and generate profits quickly in Pakistan. The impact is similar in India as Saroy et al. (2023) demonstrated that the adoption of digital payment technologies by Indian banks has significantly improved their cost efficiency. The study also reveals that both cost efficiency and technical efficiency show persistence over time. Factors such as banks' relative asset holdings in the industry, non-performing assets, cost of deposits, and returns on advances and equity play a crucial role in driving cost efficiency. For a block of selected Islamic economies including Iran, Indonesia, Jordan, Kuwait, Malaysia, Egypt, Morocco, Oman, Saudi Arabia, Senegal, Turkey, and the United Arab Emirates, Torki et al. (2020) examine the role of electronic payment systems on the performance of the financial sector and conclude that electronic payment indicators such Mobile Bank, Internet Bank, Bank Card, POS machine and ATM enhances the financial sector performance. In Indonesia, Kasri et al. (2022) demonstrated a cointegrating relationship between payment penetration ratio and banking system stability.

In Nigeria, a plethora of studies indicates that the electronic payments system enhances the performance and soundness of the banking system (Orji et al., 2018; Fadoju et al., 2018; Mustapha, 2018; Sylvester-Afaha, 2019; Festus & Olabosipo, 2020; Okonkwo & Ekwueme 2022; Hogan & Okereke, 2023). The improvement in technology has resulted in the development of electronic payment systems, leading to improved banking services (Zwingina et al., 2023). From the foregoing, the erstwhile studies have not established a direct form of relationship between electronic payment and banking industry returns, with most results conflicting another. Thus, the need to allow data to speak for the nexus that exists between electronic payments systems and banking sector return while accounting for time heterogeneity. Another discovery from the review is the limited dataset utilized in previous studies and the concentration of using traditional techniques such as Ordinary Least Square (Frank & Binaebi, 2019), Engel Granger (Ugwueze & Nwezeaku, 2016), cointegration and Granger causality (Nwaiwu & Momoh, 2021), among others. As a departure from the reviewed studies, this paper used time-varying Granger causality, which accounts for the possibility of time-heterogeneity in causal relations between electronic payment and banking industry returns in Nigeria.

## 3. Methodology

### *3.1. Data Sources and Description*

The paper elicits data from the Central Bank of Nigeria database. The data ranged in quarterly frequency from the first quarter of 2009 to the fourth quarter of 2023. The choice of the timeframe was mainly on account of data availability from the sourcing authority. For robust analysis, the paper considered the two most appropriate measures of Bank's returns in the list of financial soundness indicators, comprising of returns on asset and returns on equity, and these variables were found to be widely used in the literature (Cao et al., 2023; Dagher & Hasanov, 2023; Kasri et al., 2022). The paper employed the value of four kinds of electronic payment channels including Automated Teller Machine (ATM), Point-of-Sale (POS), internet and Web (WEB), and Mobile Application (MOP) to measure electronic payment. The choice of the variables was driven by data availability and empirical relevance (Kasri et al., 2022). The ROA and ROE were measured in percent, while the value of the electronic payments systems (ATM, POS, WEB, and MOP) was in billion naira.

### *3.2. The Time-Varying Granger Causality Approach*

The concept of predictability was the building block of causal relationship analysis between economic variables in economics, where previous values of a series can predict the future values of another variable (Baum et al., 2022). In the literature, this is typically based on the concept of predictability and is established by testing for Granger causality (Baum et al., 2022). The paper of Granger (1969) proposes the notion of causality and since then several papers have been applying it to analyzing several economic variables. Granger causality gained prominence due to its simplicity, ease of application using reduced-form VAR models, and applicability to a set of potentially jointly determined variables (Baum et al., 2022). Consider a bivariate VAR(q) model given as:

$$y_{1t} = \emptyset_0^{(1)} + \sum_{k=1}^{q} \emptyset_{1k}^{(1)} y1_{t-k} + \sum_{k=1}^{q} \emptyset_{2k}^{(1)} y2_{t-k} + \mu_{1t} \quad (2)$$

$$y_{2t} = \emptyset_0^{(2)} + \sum_{k=1}^{q} \emptyset_{1k}^{(2)} y1_{t-k} + \sum_{k=1}^{q} \emptyset_{2k}^{(2)} y2_{t-k} + \mu_{2t} \quad (3)$$

In equations (2) and (3), $y_{1t}$ and $y_{2t}$ are the time series variables of interest, $t$ is a time trend, $k$ is the lag order, and the $\mu_{1t}$ are the stochastic terms. Given the two equations, $y_{1t}$ is said to Granger cause $y_{2t}$ if the previous values of $y_{1t}$ can predict the current value of $y_{2t}$, conditional on the past returns of $y_{2t}$ (Baum et al., 2022). The null hypothesis of no Granger causality from $y_{1t}$ to $y_{2t}$ requires testing the joint significance of $\emptyset_{1k}^{(2)}$ $(k = 1, \ldots, q)$ using a Wald test, therefore:

$$H_0 = \emptyset_{1q}^{(1)} = \ldots = \emptyset_{1q}^{(2)} = 0 \quad (4)$$

Equation (4) implies that under the null, the estimated coefficient on the lagged values of $y_{1t}$ are jointly zero. Failure to reject the null implies failure to reject the hypothesis that $y_{1t}$ does not Granger cause $y_{2t}$.

In most cases, the Granger causality model framework requires that the variables are stationary (Granger, 1969). If the variables are non-stationary or co-integrated, the asymptotic theory from the traditional Granger causality approach would be invalid for hypothesis testing in the level VAR specification (Shi et al., 2020). To directly account for integrated variables in the modeling framework, two notable studies, Toda and Yamamoto (1995) and Dolado and Lütkepohl, (1996), recommended the estimation of a Lag Augmented VAR (LA-VAR) model, such that equations (2) and (3) transform to:

$$y_{1t} = \emptyset_0^{(1)} + \sum_{k=1}^{q+d} \emptyset_{1k}^{(1)} y1_{t-k} + \sum_{k=1}^{q+d} \emptyset_{2k}^{(1)} y2_{t-k} + \mu_{1t} \quad (5)$$

$$y_{2t} = \emptyset_0^{(2)} + \sum_{k=1}^{q+d} \emptyset_{1k}^{(2)} y1_{t-k} + \sum_{k=1}^{q+d} \emptyset_{2k}^{(2)} y2_{t-k} + \mu_{2t} \quad (6)$$

The additional $d$ lags in the VAR model augment the system for the possible maximum order of integration of the variables.

To allow for time variation in Granger causal orderings, Shi et al. (2020) proposed the use of three recursive testing algorithms for data-driven discovery of the change points in the causal relationships. These include the forward expanding window (FE) earlier considered by Thoma (1994) in the (non-augmented) original VAR model, the recursive rolling window (RO) based on Swanson (1998) and Arora & Shi (2016), and a recursive evolving window (RE) algorithm described in Phillips et al, (2015a, 2015b), all of which utilize sub-sample tests of Granger causality within the LA-VAR framework described in equations (5) and (6).

Following Shi et al., (2020), consider a sample of $T + 1$ observations, $\{y_0, y_1, \ldots, y_T\}$. Let $f_1$ and $f_2$ be the fractional starting and ending points of the regression sub-samples and let the Wald test statistic be calculated from this sun-sample by denoted $W_{f1f2}$. Additionally, let $\tau_1 = [f_1 T]$ *and* $\tau_2 = [f_2 T]$, where $T$ implies the total number of observations. Assume $\tau_0 = [f_0 T]$ denotes the minimum number of observations required to estimate the LA-VAR model.

The FE algorithm, which is a standard forward recursion, first computes the Wald test statistic for a minimum window length, $\tau_0 = [f_0 T] > 0$, and then expands the sample size sequentially by one extra observation until the final Wald test statistic is computed using the entire sample size. The FE considers the first data point $(\tau_1 = 1)$ as the starting point of every sub-sample.

For the RO algorithm, a fixed window size $(\tau_0)$ is rolled through the sample, advancing one observation at a time, and a Wald statistic is computed for each window. In other words, given the fixed regression window size equals $\tau_0$, the start point of the calibration moves from the first observation $\tau_1 = 1$ to $T - \tau_0 + 1$ and the endpoint $\tau_2 = \tau_1 + \tau_0 - 1$. Alternatively, the starting and end point of the regression could be written as $\tau_1 = \tau_2 + \tau_0 + 1$ and $\tau_2 = \{\tau_0, \ldots, T\}$, respectively, where $T$ is the last observation (Shi et al., 2020).

The RE algorithm combines the procedure of both the FE and RO approaches, as a special case. Like the recursive, rolling window (RO) algorithm, the endpoint of the regression window is still $\tau_2 = \{\tau_0, \ldots, T\}$. However, rather than maintaining a fixed distance, the regression procedure allows the distance between the starting point $\tau_1$ and the endpoint $\tau_2$ to vary and cover all possible values in the rolling window. Inference on Granger non-causality for each observation of interest is then based on a sequence of the backward sup Wald statistics, defined by Shi et al. (2020) as:

$$SW_f = f2 = f, f1 \in [0, f2 - f0]^{Sup}\{W_{f1,f2}\} \qquad (7)$$

Where $f$ is the fraction of the total sample, and $f_1$ and $f_2$ are the starting and ending points of the total sample, respectively.

For full sample analysis, testing the null hypothesis that a given variable does not Granger cause another at any time during the sample, against the alternative that there is Granger causality at some time, required a single Wald test statistic. The maximal FE, RO, and RE statistic is the largest element of the first row of the upper triangular matrix, the main diagonal matrix, and the entire upper triangular matrix of test statistics, respectively. Beyond these summary measures for the full sample, the sequence of FE, RO, and RE statistics can also be graphed and compared with the bootstrap percentiles derived by the methods described in (Shi et al., 2020). Given these estimates, period(s) in which the Granger-causal relationship exists can be identified, where the test statistic exceeds the corresponding critical value.

Although (Shi et al., 2020) have provided forward expanding window, rolling window, and recursive evolving window algorithms to estimate the time-varying causality test, it has been proved that the recursive evolving window algorithm (which combines the features of the other two algorithms) provides the most reliable results with the highest power. For this reason, some authors have chosen to report only the RE window algorithm in their papers (e.g., Espoir et al., 2023). Hence, in this paper, we present the results for all three but rely more on the sequence of the RE test statistics in adjudging the validity of the time-varying Granger causality results.

## 4. Result and Discussions

### *4.1. Preliminary Analysis*

The analysis began with a pre-test estimation by exploring the data-generating process of the series via descriptive statistics, trend analysis, correlation matrix, and a unit root test for stationarity.

#### 4.1.1. Descriptive Statistics and Trend Analysis

The paper explores the descriptive statistics of the bank's returns measures and electronic payment system variables employed in the study. In Table 1, the summary statistics indicate that the average web transaction was higher than the average payment through other electronic payment channels, with transactions via automated teller machines appearing the least channel. The average bank's returns were positive indicating the efficiency of the banking industry in maximizing its returns on investment. The variability of electronic payment system and bank returns was close to the averages, indicating relative stability of the variables, except for point-of-sale and mobile applications, whose standard deviation doubled their averages implying variability from the average positions.

The electronic payment and bank return variables appear to deviate from a normal distribution, as shown by the non-zero skewness statistics and the leptokurtic nature of the series. These suggest that the series under investigation may need to be evaluated for features of non-normal series, such as serial correlation and conditional heteroscedasticity that often plague high-frequency series. The paper, therefore, extends the preliminary analysis to include some formal econometric tests, namely the unit root test for stationarity. The stationary test, which is the formal test for validating the stationarity status of economic indices revealed that all the variables are stationary, thereby, qualifying them for formal analysis and inference.

**Table 1.** Descriptive Statistic.

| Statistic | ROA | ROE | ATM | POS | WEB | MOP |
|---|---|---|---|---|---|---|
| Mean | 1.831 | 19.156 | 1817.873 | 3665.965 | 46998.800 | 7093.035 |
| Median | 2.182 | 20.629 | 176.830 | 1064.185 | 34.390 | 154.640 |
| Maximum | 4.279 | 65.400 | 10336.560 | 35080.180 | 356094.300 | 68463.610 |
| Std. Dev. | 1.694 | 14.904 | 2874.355 | 7111.681 | 87184.900 | 15136.790 |
| Skewness | -4.402 | -1.609 | 1.420 | 2.935 | 1.741 | 2.525 |
| Kurtosis | 27.854 | 11.898 | 3.661 | 11.087 | 5.075 | 8.790 |
| Jarque-Bera | 1738.035 | 223.842 | 21.247 | 249.632 | 41.073 | 147.595 |
| Prob. | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Obs. | 60.000 | 60.000 | 60.000 | 60.000 | 60.000 | 60.000 |

*Source: Author's Computation.*

Figure 1-6 contained the graphical plots of the electronic payments system and bank returns variables being examined. A cursory look at Figures 1 and 2 shows that both returns on asset and equity have for most of the study period remained above zero implying relative efficiency and resilience of the banking industry. However, in 2009 and 2010, returns on assets and equity were negative indicating loss to the banking industry due to the impact of 2007/2008 Global Financial Crises (GFC). The negative impact extended up to the first quarter of 2011, before recovering to the positive trajectory.

For the electronic payment systems, it was observed that the value of transactions through ATM, POS, Web, and mobile applications have been trending upward throughout the study period, with more pronounced growth from 2020 to 2023. The persistent growth in the value of transactions using electronic payment channels was bolstered by the combined impact of the COVID-19 pandemic, the cashless policy, and the naira redesign policy. These factors have resulted in higher use of electronic payment channels. Similarly, higher financial inclusion has contributed to the positive trajectory of the value of electronic payment channels.

It is, however, difficult from the nature of the trend analysis to draw inferences about the nature of the relationship between the electronic payments channels and banking industry returns. However, at a glance, it was observed that banks' returns were lower and even negative around 2009 and 2010, which correspond to the period of very low value of electronic payments transactions. At this point, it is inevitable to subject this trend analysis to a more rigorous empirical test.

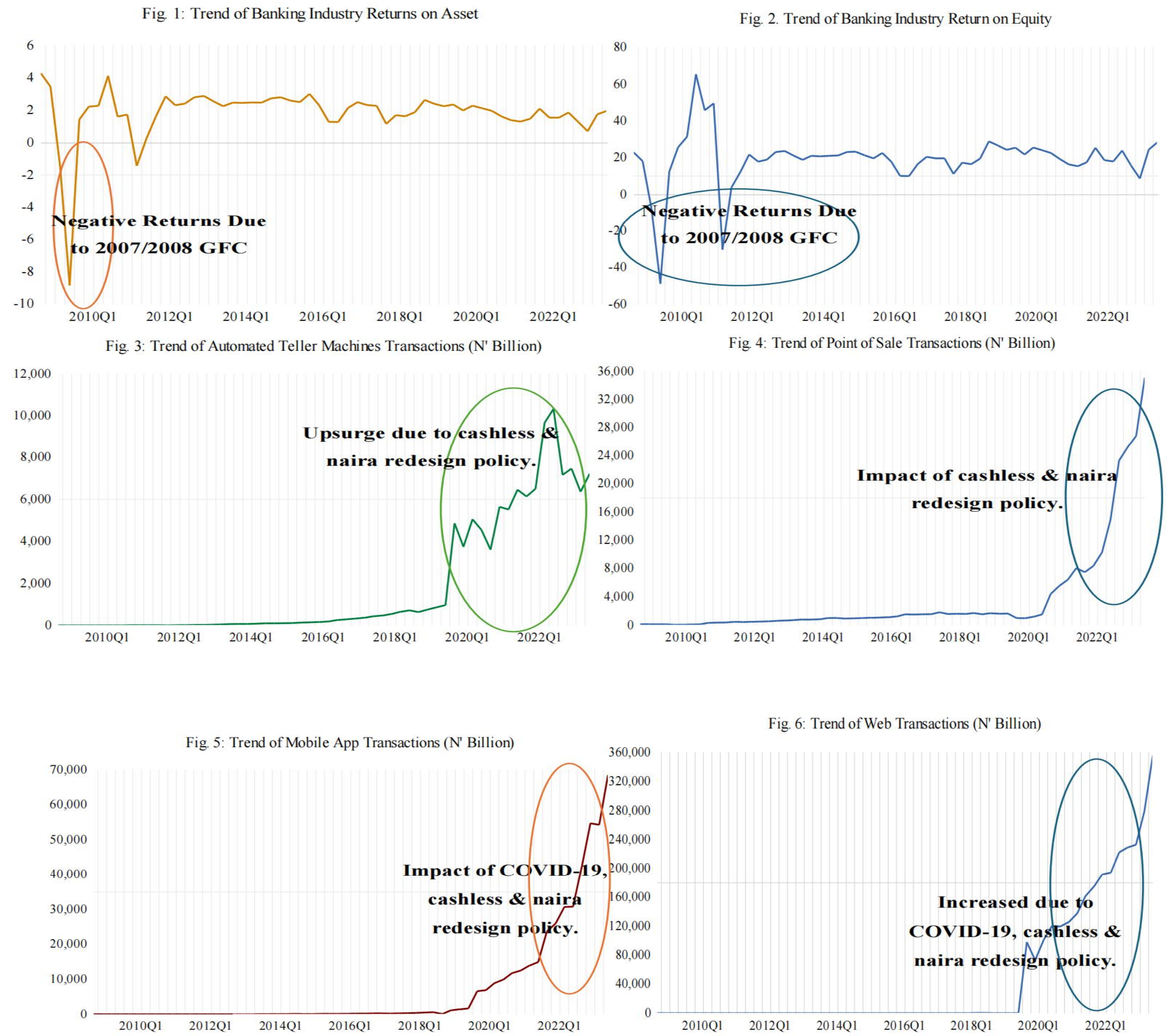


**Figure 1-6.** Trend of variables.

The simple correlation results are displayed in Table 2. The motive of the analysis is to obtain an inkling relationship between the electronic payments system and banking industry returns. The correlation matrix produces mixed relationships (positive and negative). Notably, all the electronic payment variables exhibit a negative relationship with the banking industry returns on assets, although, at a statistically insignificant level of inference. It is, however, imperative to note that a negative correlation does not signify causality. To verify this, formal analysis such time-varying Granger causality test is required.

Contrary to the observed negative relationship between returns on assets and various forms of electronic payment systems, the relationship between returns on equity and electronic payment systems appears to be positive and statistically insignificant. It is insufficient for the paper to conclude the exact nexus between electronic payments and banking industry returns based on this correlation analysis. Thus, a time-varying Granger causality analysis is performed in the later part of the paper.

**Table 2.** Correlation Matrix.

| Variables | ROA | ROE | ATM | MOP | POS | WEB |
|---|---|---|---|---|---|---|
| ROA | 1.000 | | | | | |
| ROE | 0.811* | 1.000 | | | | |
| | (0.000) | | | | | |
| ATM | -0.055 | 0.045 | 1.000 | | | |
| | (0.674) | (0.731) | | | | |
| MOP | -0.065 | 0.038 | 0.837* | 1.000 | | |
| | (0.620) | (0.775) | (0.000) | | | |
| POS | -0.055 | 0.033 | 0.748* | 0.978* | 1.000 | |
| | (0.679) | (0.800) | (0.000) | (0.000) | | |
| WEB | -0.062 | 0.051 | 0.937* | 0.957* | 0.901* | 1.000 |
| | (0.639) | (0.701) | (0.000) | (0.000) | (0.000) | |

*Note: * indicates significance at p<0.05; the values in the bracket are the p-values*

4.1.2. Unit Root Test

The time-varying Granger causality was based on the lag-augmented VAR (LA-VAR) framework, where the LA-VAR does not require pre-testing for stationarity, however, requires information about the maximum possible order of integration (see Shi et al., 2020). Against this backdrop, the paper performed a unit root test using the Augmented Dickey-Fuller (ADF) tests for the series (Dickey & Fuller, 1979), with a constant and a linear time trend assumption in the regression equation. Furthermore, the paper deployed the unit root test procedures of Perron and Vogelsang (1992) and Clemente, Montanes, and Reyes (1998) to account for potential structural breaks in the data series; each of these test searches for unknown structural breaks with either additive outliers (AO) or innovational outliers (IO). The Perron-Vogelsang test allows for one structural break, and the Clemente et al. (1998) test allows for two breaks. The null hypothesis, for both tests, is that there is a unit root, against the alternative of stationarity series.

The outcome of the unit root test based on the ADF test procedure that assumes no structural breaks in the variables indicates that all the variables are stationarity at the first difference, except for the banking sector returns variables that were stationary at levels. Accounting for one or two structural breaks with innovative and additive outliers suggests the presence of structural breaks in the variables. This further justifies the application of time-varying Granger causality that accounts for the time factor. The paper further discovered the maximum order of integration to be 1 i.e. I(1). Thus, the paper proceeds with the main analysis in the context of the LA-VAR model where $d = 1$ in equations 5 and 6.

**Table 3.** Unit Root Tests.

| | ADF | Perron & Vogelsang (1992) | | Clemente et al (1998) | |
|---|---|---|---|---|---|
| | Const. & Trend | AO | IO | AO | IO |
| Panel A: Levels | | | | | |
| ROA | -5.500*** | -2.823*** | -2.477*** | -2.235** | -4.160 |
| ROE | -5.157*** | -3.835*** | -3.945*** | -2.859*** | -11.068*** |
| ATM | -2.063 | 0.333*** | -10.258*** | -1.013*** | -1.359*** |
| MOP | 4.853 | 0.841*** | 6.766*** | 0.533*** | 19.553*** |
| POS | 5.731 | -1.794*** | 1.755 | -3.598 | -3.441*** |
| WEB | 1.731 | 1.787*** | 4.661*** | 1.595*** | 1.988*** |
| Panel B: First Difference | | | | | |
| ROA | -8.723*** | -6.591 | -10.224*** | -3.927 | -11.807 |
| ROE | -9.350*** | -4.213 | -10.768*** | -3.708 | -18.469*** |
| ATM | -9.395*** | -1.932 | -6.543*** | -1.149 | -5.667*** |
| MOP | -6.365*** | -0.777*** | 1.437 | -1.242 | -6.309*** |
| POS | -3.373** | -1.072*** | -0.853 | -0.440*** | -3.191*** |
| WEB | -7.769*** | -2.682*** | 8.482*** | -3.179*** | 80.953*** |

*Note: *** & ** show significance at p<0.01 & p<0.05, respectively.*

### 4.2. Causality Result between Electronic Payments System and Banking Industry Returns

Analyzing the time-varying Granger causality between electronic payment and banking industry returns follows the time-varying procedures, where the maximum number of lags is set as 4 as chosen by the Akaike Information Criteria. The decision rule in each case is by comparing the estimated FE, RO, and RE critical values with the 90th, 95th, and 99th percentile. The granger-causal relationship is identified, where the test statistic exceeds the corresponding critical value.

The result in Table 4 revealed that under FE, RO, and RE, ATM appears not to Granger cause returns on assets. However, FE suggests evidence of time-varying causality between ATM and returns on equity. This outcome implies that the value of ATM transactions enhances returns on shareholders' equity in the banking industry. Similarly, the value of POS, WEB, and mobile applications appears to Granger cause returns on the asset under the recursive window. In the same spirit, recursive windows show that the value of WEB Granger causes returns on equity while rolling windows show that the values of POS and mobile applications Granger cause returns on equity. Thus, rolling window and recursive evolving window algorithms show robust evidence of causality running from most of the electronic payments system to bank returns.

The inability of the forward expanding window to reveal causality between some of the specific electronic payments systems and bank returns confirms a well-known problem with the FE algorithm, i.e. it is not sensitive to changes in the sample period. This finding confirms the theoretical underpinning of Schumpeterian theory that electronic payments enhance the returns of banks. Also, the results have conformed to the group of studies that discover evidence of causality or significant positive impact of electronic payments system on baking sector returns (Fadoju et al., 2018; Okonkwo & Ekwueme, 2022; Zwingina et al., 2023). In addition to conforming to the findings of these studies, the result has shown the relevance of times where the recursive window revealed evidence of causality in instances where the forward expanding window fails to indicate.

**Table 4.** Granger Causality Between Electronic Payments System and Banking Industry's Returns.

| Direction of Causality | Max Wald FE | Max Wald RO | Max Wald RE |
|---|---|---|---|
| Panel 4a: Electronic Payments System and Banking Industry’s Returns on Asset | | | |
| ATM Cause ROA | 1.259 | 0.000 | 1.203 |
| | (1.735) | (1.735) | (1.735) |
| | [5.826] | [5.826] | [5.826] |
| POS Cause ROA | 3.987** | 0.000 | 2.776** |
| | (1.874) | (1.874) | (1.874) |
| | [8.919] | [8.919] | [8.919] |
| WEB Cause ROA | 2.707*** | 0.000 | 4.389*** |
| | (3.039) | (3.039) | (3.039) |
| | [1.041] | [1.041] | [1.041] |
| MOP Cause ROA | 1.134 | 0.000 | 2.867*** |
| | (1.495) | (1.495) | (1.495) |
| | [1.536] | [1.536] | [1.536] |
| Panel 4b: Electronic Payments System and Banking Industry’s Returns on Equity | | | |
| ATM Cause ROE | 6.469*** | 0.000 | 1.292 |
| | (4.167) | (4.167) | (4.167) |
| | [2.871] | [2.871] | [2.871] |
| POS Cause ROE | 1.467 | 5.747*** | 1.668 |
| | (3.271) | (3.271) | (3.271) |
| | [2.111] | [2.111] | [2.111] |
| WEB Cause ROE | 1.117 | 0.000 | 2.847*** |
| | (1.846) | (1.846) | (1.846) |
| | [1.191] | [1.191] | [1.191] |
| MOP Cause ROE | 1.280 | 9.457*** | 1.280 |
| | (1.904) | (1.904) | (1.904) |
| | [1.563] | [1.563] | [1.563] |

*Note: The 95th and 99th percentiles of the empirical distributions of the bootstrap statistics are in parenthesis () and brackets [], respectively; ** and *** denote significance at 5% and 1%, respectively. FE=Forward Expanding Window; RO=Rolling Window; and RE = Recursive Evolving Window. The granger-causal relationship is identified, where the test statistic exceeds the corresponding critical value.*

To uncover the time-varying dimensions of the relationship, the paper plots the sequence of the FE, RO, and RE test statistics and the corresponding 90th and 95th percentiles of the bootstrap statistics, in Figures 7 to 8. The figures show the time that drives the causal relationship, implying that the relationship between both variables could be extremely dynamic over time and highlights the danger of using Wald tests of Granger causality indiscriminately over the full sample.

Specifically, recursive window algorithms were more reliable in showing the time effect in the causal relationship, where for instance, Figure 6b indicates that the value of ATM transactions granger caused returns on assets profoundly in 2020Q4 as indicated by the spark in the graph. This period corresponds to the COVID-19 pandemic period where most bank transactions move online using electronic channels. The recursive window in Figure 6k has also shown the specific period where the value of mobile bank applications promotes returns on assets of banks, where it peaks in 2015 and 2020 corresponding to the period of enhanced campaign for a policy shift to cashless policy and the COVID-19 pandemic period. This feature of showing the time dimension is one of the attractions and advantages of the time-varying Granger causality.

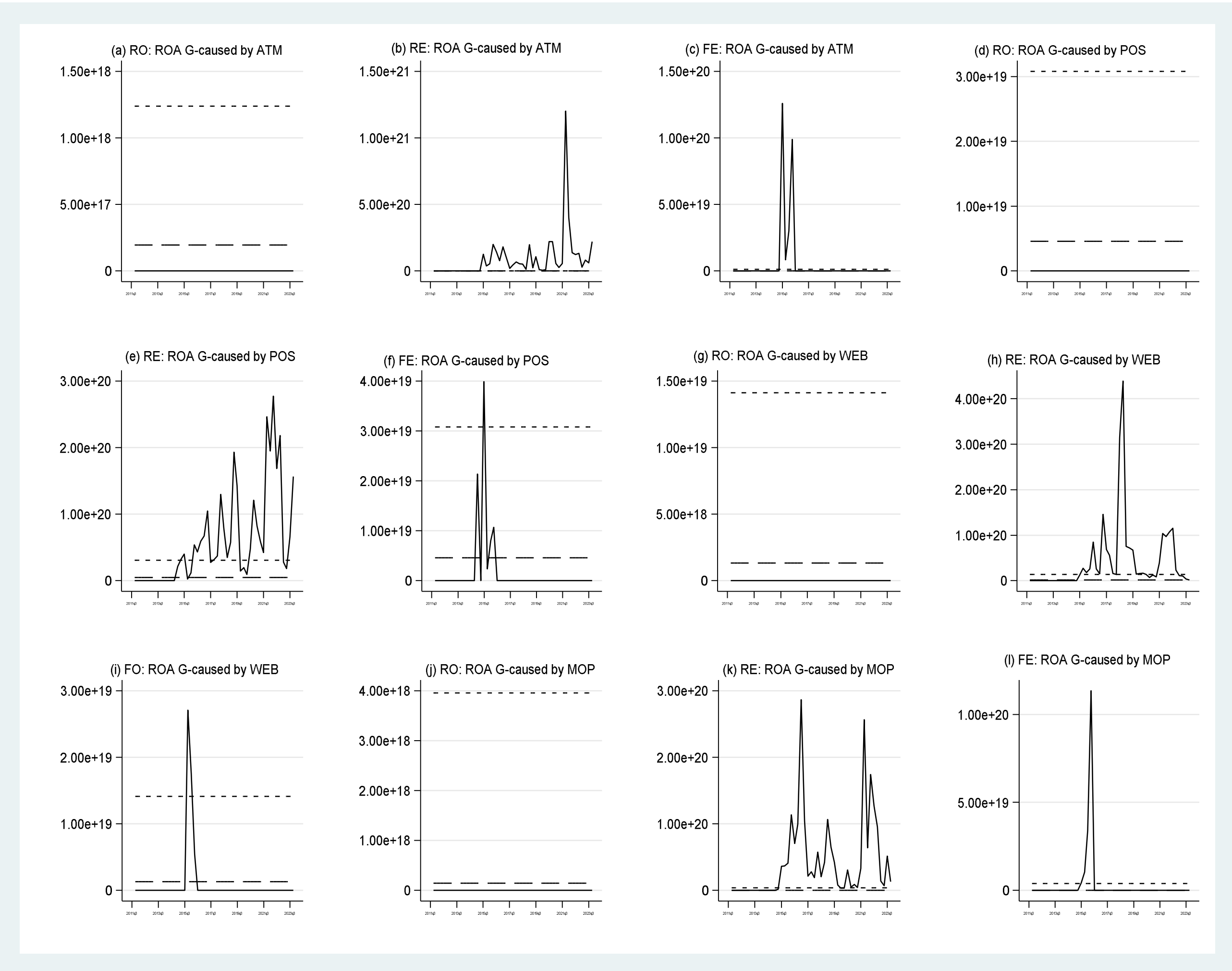


**Figure 7.** Time-Varying Granger Causality of Payment Systems and Returns on Asset.

*Note: The upper green horizontal line and the lower black dotted line represent the 90th and 95th percentiles of the empirical distributions of the bootstrapped test statistics, respectively. The black line graphs show the sequence of RO, RE, and FE robust statistics (from 199 replications). The granger-causal relationship is identified, where the test statistic exceeds the corresponding critical value.*

For the causality of electronic payments to returns on equity, Figure 8 revealed a similar outcome shown in Figure 7, where the recursive window produced a more reliable outcome in detecting the time variation in the causal relationship. Thus, using the most reliable RE window, the evidence of Granger causality is apparent in 2012, 2015, and 2020 to the end of the study period.

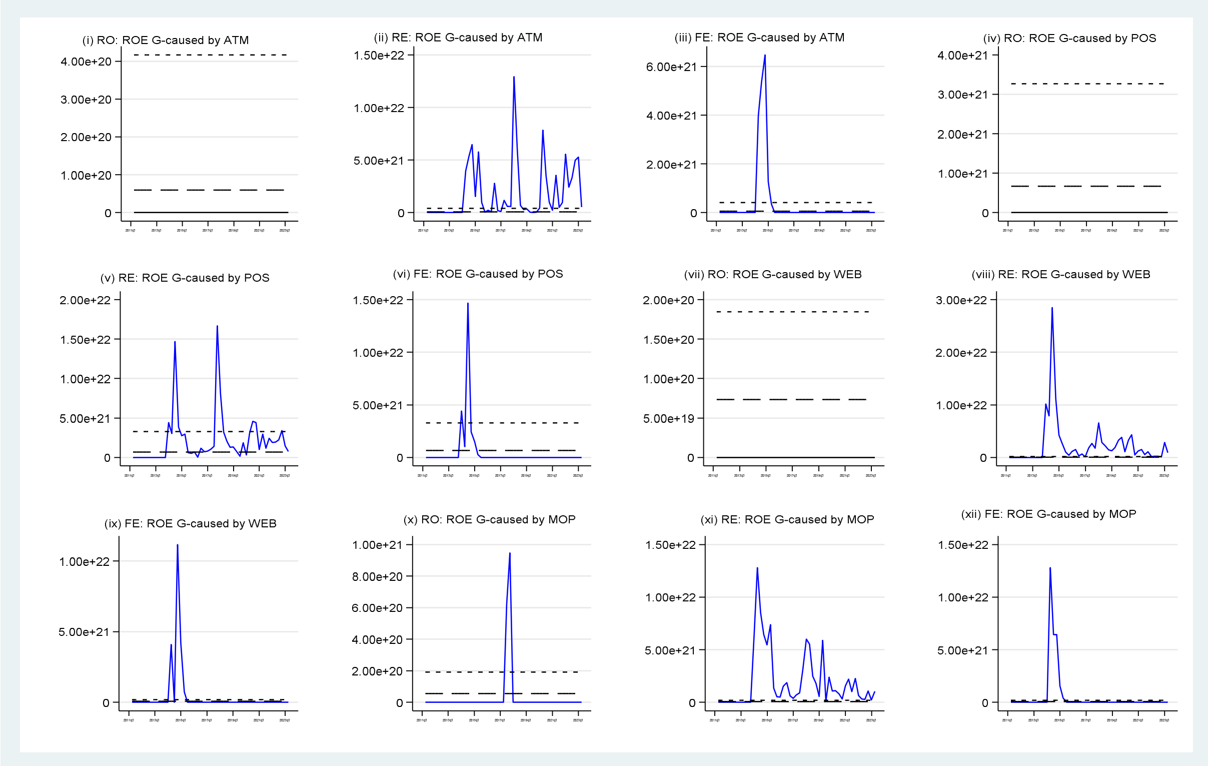


**Figure 8.** Time-Varying Granger Causality of Payment Systems and Returns on Equity.

*Note: The upper green horizontal line and the lower black dotted line represent the 90th and 95th percentiles of the empirical distributions of the bootstrapped test statistics, respectively. The blue line graphs show the sequence of RO, RE, and FE robust statistics (from 199 replications). The granger-causal relationship is identified, where the test statistic exceeds the corresponding critical value.*

## 5. Conclusion and Recommendations

This paper offered some contributions to the literature on electronic payments systems and banking industry returns nexus in Nigeria. First, the paper extended the sparse empirical scrutiny of the subject for Nigeria. Secondly, the analytical approach involves a time-varying Granger causality approach that allows for data-driven identification of the change points in the nexus. This represents a major improvement over other existing studies that do not account for such dynamism in the relationship.

The paper concludes that the value of electronic payment system transactions including automated teller machines, point of sale, mobile bank applications, and web transactions Granger cause banking industry returns in Nigeria. The recursive evolving window algorithms show robust evidence of causality running from most of the electronic payments system to bank returns. Furthermore, FE provides evidence of causality between POS, WEB, and ROA. It also shows the causation between ATM and ROE.

The paper adds to the literature by showing the relevance of the time dimension in the causal relationship, where for instance, the findings indicate that the value of ATM transactions granger caused returns on assets profoundly in 2020Q4. This period corresponds to the COVID-19 pandemic period where most bank transactions move online using electronic channels. The result has also shown that the value of mobile bank applications promotes returns on assets of banks, profoundly in 2015 and 2020 corresponding to the period of enhanced campaign for a policy shift to a cashless policy and the COVID-19 pandemic period. Additionally, the causality of electronic payments to returns on equity was apparent in 2012, 2015, and 2020 at the end of the study period.

The implication of the finding implies the relevance of the electronic payments system in stimulating the banking industry returns. Therefore, the paper offers the following recommendations, with a peculiar focus on the period that drives the causal relationship between the electronic payments system and banking industry returns:

(1) The policymakers should revisit and reinvigorate the specific cashless policies instituted in 2012-2016 that aid in higher returns to the banking industry.

(2) The Central Bank of Nigeria and other industry players should also intensify efforts to encourage the use of electronic payments due to their usefulness and ability to enhance the banking industry's returns.

(3) The Central Bank of Nigeria should also strengthen and encourage deposit money banks to strengthen their digital infrastructure to support the growing demand for electronic payment systems.

(4) Further studies that involve causality should consider accounting for the time-varying effect due to its ability to portray the time effect.

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## Conflict of interest

All the authors claim that the manuscript is completely original. The authors also declare no conflict of interest.

## Author contributions

Conceptualization: Abubakar Sani Ibrahim; Drafting of original draft: Abubakar Sani Ibrahim; Data curation: Obumneke Ezie; Methodology and Formal Analysis: Abubakar Sani Ibrahim; and Writing-review & editing: John Olu-Coris Aiyedogbon & Obumneke Ezie.

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