# Effect of Digital Payment Channels on Currency in Circulation in Nigeria

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## ABSTRACT

This study examined the impact of digital payment channels (DPCs) on currency in circulation (CIC) in Nigeria using quarterly data from 2009Q1 to 2023Q4. Regression and Vector Error Correction Model (VECM) techniques were applied. Results show that all channels had positive and significant effects on CIC when examined individually, while the result of multiple regression reveals that ATM transactions exert the strongest influence. VECM findings indicated that mobile payments negatively affect CIC in the long run, while POS transactions have a positive long-run effect, with weak short-run relationships overall. The adjustment speed to equilibrium was high (81%). Diagnostic tests show no autocorrelation or heteroskedasticity; nonetheless, multicollinearity and non-normality of residuals existed. ARMA-MLE estimation improved reliability as the model passed all the post diagnostic tests with existing mixed result. The study concludes that DPCs have heterogeneous channel-dependent effects on cash usage and recommends strengthening digital infrastructure and promoting mobile payments.

**Key Words:** Cash-based system, Currency in Circulation, Digital Payment Channel, Digital Payment Systems, Payment System.

## 1.0 Introduction

The global expansion of digital payment systems has transformed financial intermediation, reduced frictions in monetary transactions and reshaped the demand for physical currency across different economies. While advanced economies have rapidly transitioned to cash-lite systems, developing regions, particularly Africa, continue to experience heterogeneous adoption patterns due to infrastructural, socioeconomic and regulatory constraints. Nigeria, as one of Africa's largest economies, presents a unique case where aggressive financial digitisation policies coexist with persistent cash usage (Central Bank of Nigeria [CBN], 2022a).

Historically, Nigeria's payment system, an established means of fulfilling financial commitments, has largely been dominated by cash, with physical currency remaining the commonest medium for transactions nationwide. This cash dominance is linked to its accessibility, particularly in rural and underserved areas where formal banking services are limited or non-existent. Its flexibility and widespread acceptance have supported economic activities even in remote communities. Additionally, the cash cultural familiarity and Nigeria's socio-economic structure have further rooted its reliance (Kanu, Eke, Nwadiubu, & Ikechukwu, 2020). Furthermore, reports from the World Economic Forum (2021) and Global Finance (2021) indicate that about 1.7 billion individuals globally remain underbanked, while 2.3 billion adults are financially excluded and over 60% of Nigerians lack access to proper banking services. Keynes (1936), a renowned economist, also explains why people may prefer to hold cash, including transactional, precautionary and speculative motives. Moreover, a shift in the demand pattern for money (cash) can influence aggregate demand, which in turn impacts other economic variables. Hence, people may still hold cash in the digital environment due to concerns about digital reliability, security and accessibility.

Despite its advantages, the system presents several shortcomings, including the risks of theft, counterfeiting, high costs associated with printing and managing cash and its role in facilitating corruption and money laundering. To address these issues and modernise the financial ecosystem, the Nigerian Government, through the Central Bank of Nigeria (CBN), introduced digital payment systems over a decade ago as part of a cashless policy initiative. The aim was to significantly reduce cash usage to lower operational costs, enhance financial inclusion and improve transaction efficiency (CBN, 2021a).

Globally, financial inclusion and digital payment adoption are recognized as critical components of sustainable economic development. The data from Statistical Bulletin of the CBN (2023a) shows a rising trend in currency outside the banks over the years, indicating limited success in shifting away from the cash system. For instance, currency in circulation (CIC) increased from ₦6.88 trillion in 2015 to ₦12.74 trillion in 2022 and a notable decline was observed only in 2023, with CIC falling to ₦10.70 trillion, largely due to short-term policy interventions such as demonetisation and cash withdrawal limits.

According to the CBN (2011, 2023b), cash withdrawal limits of ₦500,000 for individuals and ₦3,000,000 for corporate entities was introduced to reinforce the adoption of digital payment systems, which was revised in line with redesigned naira notes on December 6, 2022 with maximum cash withdrawal over the counter and via Point of sale (POS) terminals and Automated Teller Machines (ATM) by individuals and the corporates per week to be N100,000 and N500,000 respectively, subject to a maximum of N20,000 processing fees free cash withdrawal daily which took effect January 9, 2023 (CBN, 2022).

Additionally, a significant phase toward digital currency integration was the introduction of the e-Naira by the CBN on October 25, 2021. According to Obiora (2023) e-Naira, also known as Central Bank Digital Currency (CBDC), is a digital equivalent of paper money or an electronic version of cash. It is designed to serve all the functions of money and was created to reduce fraud and money laundering, provide a sovereign alternative for digital payments, complement current forms of money and financial services, ensure efficient transmission of monetary policy, expand financial inclusion, promote mobile money adoption, improve cross-border trade, increase remittance inflows and reduce the costs associated with cash use in society (Bordo, 2021; Calle & Eidan, 2020; Cheng, Lawson & Wong,2021; Elsayed & Nasir, 2022). Its issuance has received mixed reactions; the Bank of International Settlements (BIS) and the International Monetary Fund (IMF) have supported its establishment due to its benefits, while cryptocurrency supporters oppose it, seeing it as a threat. Some studies have argued against issuing and accepting an e-naira, claiming it could probably interrupt the traditional payments system and the financial system, leading to a loss of user privacy, increase in cybersecurity risks and an intensification of the risk of banks' disintermediation system (Bindseil, 2019; Banet & Lebeau, 2022; Darbha & Arora, 2020; Gross, Kipke, Rieger, & Stohr, 2021; Kochergin & Yangirova, 2019; Tian, Xu & Wang, 2022). However, the overall impact of these initiatives on reducing CIC remains unclear, especially considering regional disparities, infrastructural challenges and public resistance in certain sectors. (Olutayo, Olayinka, & Adebayo, 2022).

In spite of this, digital payments have continued to expand, driven by innovations in mobile banking, Web (internet) banking, Unstructured Supplementary Service Data (USSD) transfers and fintech platforms such as Opay, Flutterwave and Paystack. The spread of ATMs, POS terminals and card-based transactions further demonstrate the digital transformation of Nigeria's financial landscape. According to the Nigeria Inter-Bank Settlement System (NIBSS, 2023), electronic payment transactions grew by over 40% in 2022, showcasing increasing public confidence in digital platforms. In this context, understanding the effect of digital payment channels on Nigeria's currency in circulation (CIC) is crucial for monetary policy, inflation management and economic planning. Despite the growth of digital infrastructure, CIC remains high, raising the need for empirical inquiry into how digital adoption influences cash usage. This study focuses on four major payment channels: ATMs, mobile money, internet banking and POS transactions, selected for their widespread use and available data.

Accordingly, this study seeks to examine the impact of each channel and its significant correlation with CIC, identify the channel that exerts the greatest influence and evaluate both the short and long run relationships between digital payment channels and currency in circulation, testing the hypotheses of no significant impact exist, no channel exerts greater influence and digital payments have no short- or long-run effects on CIC. Nevertheless, the study seeks to contribute to theory and practice by advancing models of financial innovation and cash demand while providing empirical evidence from a developing economy. Its findings can also guide the Central Bank of Nigeria in assessing the effectiveness of digital channels for promoting a cashless economy.

## 2. Literature review

### 2.1 Conceptual framework

The conceptual frame work offers a painterly image of Nigeria's payment systems interaction. The key concept discussed in this study include:

**Payment system**

A payment system is broadly defined as the infrastructure of institutions, instruments and procedures enabling settlement of financial obligations (Balino et al., 1996; CBN, 2021c). It is therefore referred to as a coordinated set of institutional mechanisms, technological infrastructures and regulatory arrangements that facilitate the transfer of monetary value between economic agents.

**Cash-based system**

The cash-based system, still dominant in Nigeria, involves banknotes and coins mainly used for small transactions (CBN, 2021c). While currency in circulation (CIC) refers to cash held outside the formal banking system by individuals and businesses (CBN, 2021a), cash-based system denotes an economic environment in which transactions are predominantly conducted using physical currency. It represents a structure where banknotes and coins serve as the principal medium for settling payments, reflecting the extent to which economic actors rely on tangible money to facilitate everyday exchange.

**Digital payment systems**

Digital payment systems (DPS) enable electronic transactions without physical cash, including mobile payments, web payments, POS terminals and online gateways (Agarwal & Zhang, 2020). These are facilitated through digital payment channels (DPCs) of which ATM, mobile banking, web payment, POS and NEFT remain the most significant in Nigeria's transition toward a cashless economy. Thus, a digital payment system is the integrated technological framework that enables the electronic transfer of monetary value between transacting parties.

**Currency in circulation**

The CBN (2021a) refers to currency in circulation as cash held by individuals, businesses and other economic units that are not within the formal banking system, which is the total physical currency held in the economy that cannot be subjected to the usual regulatory and operational procedures applying to funds within the banking system. Hence, currency in circulation refers to the total stock of physical money, comprising banknotes and coins, held by individuals, firms and other non-bank entities at a given point in time. It excludes currency maintained in the vaults of commercial banks and monetary authorities, thereby representing the volume of cash actively used in economic transactions.

**Digital payment channels**

These are the digital or electronic tools, instruments, platforms, systems, or networks used in carrying out digital financial transactions in Nigeria. Digital payment channels are also the electronic pathways through which digital transactions are initiated, processed and completed. Within the Nigerian financial landscape, these channels include Automated Teller Machines, mobile banking applications, internet banking platforms, point-of-sale terminals and interbank electronic transfer systems, among others

## 2.2 Theoretical Framework

The theoretical framework guiding the analysis of this study are discussed below.

### Innovation Diffusion Theory

Rogers (1962) proposed this theory to explain how new technologies spread within a population and illustrates the process as it applies to digital payment systems, on how individuals and businesses become aware of, evaluate and adopt digital payment channels. He explained that the successful integration of digital payment systems depends on effective user education, intuitive interfaces and the perceived benefits of these technologies. Its main strength is in the framework for understanding users' adoption patterns and the importance of awareness in spreading new technologies.

### Liquidity Preference Theory

Keynes (1936) proposed this theory to explain the motives behind holding money: transactional, precautionary and speculative. Individuals may still hold cash in the digital context due to concerns about digital reliability, security, or accessibility. Digital payment systems aim to reduce liquidity preference by offering secure and efficient alternatives, thereby encouraging electronic transactions and reducing informal financial activity. It offers insight into why individuals may resist digital transitions, rooted in traditional economic behaviour. Here, digital payment channels or tools seek to fulfil the same roles as cash, especially for transactions, while offering enhanced security and speed.

In conclusion, this theoretical framework integrates key economic and technological theories to explain the evolution and impact of digital payment systems within a cashless policy environment. The implementation of digital payment channels or instruments such as mobile payments, POS terminals and online transfers is moulded by user perceptions, institutional support and technological infrastructure. Jointly, these theories offer a multidimensional thought on how digital payments are transforming the financial landscape and fostering a more inclusive and efficient economy. Although the research is anchored on the Liquidity Preference Theory, it is grounded in explaining how cash is managed in the system. The large proportion of the previous studies also support the aforementioned theories (Mamudu, 2021; Obafemi & Araoye, 2020).

## 2.3 Empirical review

A wide range of studies has examined the nexus between digital payment systems and currency in circulation, with particular emphasis on Nigeria, while also drawing insights from international contexts. Early evidence by Muhibudeen and Haladu (2015)**,** using OLS and ANOVA, was inconclusive due to collinearity and the short post-implementation window of Nigeria's cashless policy. Similarly, Ikpefan et al. (2018)**,** employing ADF and OLS on annual data (2006–2015), found no significant impact of electronic banking tools on currency in circulation, recommending the reduction of service charges to encourage adoption. In contrast, more recent analyses have produced mixed outcomes. Ugwuaniyi et al. (2020) applied ARDL to data from 2009–2018 and reported that POS and web payments positively affected money supply, while ATM usage had a negative effect. Kanu et al. (2020) also found divergent effects, with REMITA and web-based payments reducing currency in circulation, but POS and ATM usage increasing it.

Other studies have linked digital payments to economic outcomes. Mamudu (2021) showed that ATM, web, mobile and NEFT transactions significantly boosted GDP, though cheques, POS and instant payments exerted negative effects. Similarly, Ekong and Ekong (2022**)** reported that ATMs, POS and mobile banking enhanced financial inclusion, while web payments reduced it. Abbas (2022) further confirmed that all digital platforms positively influenced economic growth, with causality running from digital channels to GDP. Supporting this, Andrea et al. (2022) found that ATM, POS and mobile payments significantly contributed to Nigeria's GDP between 2012 and 2020, stressing the need for infrastructural investments and financial literacy programs.

More recently, Okoh et al. (2023) revealed positive effects of mobile and POS payments on GDP but negative contributions from ATM and instant payments, while Suleiman et al. (2023) found POS and mobile payments significantly drove growth, unlike web payments, which showed minimal influence. Adebisi et al. (2023) also noted weak and statistically insignificant effects of ATMs, POS and mobile payments on household consumption, despite evidence of long-run equilibrium among variables. Advancing the analysis, Adedotun et al. (2024) compared regression with Artificial Neural Networks and established that POS transactions had a stronger effect on currency in circulation than ATM transactions, highlighting the importance of expanding POS infrastructure.

Beyond Nigeria, Tee and Ong (2016) observed in five EU countries that cashless payments gradually but significantly influenced economic growth in the long run, while Ocansey et al. (2024) in Ghana demonstrated strong interdependence between mobile banking, web banking and money velocity.

Despite these insights, the literature reveals persistent methodology gaps. Findings remain inconclusive or statistically weak, limited scope and insufficient data coverage in several studies while others highlight contradictions between policy goals and actual outcomes. Consequently, these methodological limitations reduce the generalisability and reliability of their findings, thus underscore the need for more robust, context-specific and longitudinal analyses which this study addressed through its methodology to better understand the evolving dynamics between digital payment adoption and currency in circulation.

## 3. Methodology

This study employed both descriptive and quantitative techniques, to assess the effect of digital payment channels on currency in circulation and also drew approaches from recent literature such as Adebisi et al. (2023), Mamudu (2021), Ocansey et al. (2024) and Suleiman et al. (2023). However, this was subject to the study's objectives modification and the results of preliminary tests that were carried out. Following Andrea et al. (2022), this study adopts an ex-post facto research design, which relies on historical macroeconomic data without manipulating variables.

The data for this study are quarterly time series secondary data sourced from the Central Bank of Nigeria Statistical Bulletin, covering 2009Q1 to 2023Q4, a timeframe that captures the early stages of digital payment system adoption in Nigeria, including the launch of the CBN's Cashless Policy and the subsequent rapid expansion of digital payment technologies.

### 3.1 Model specification

This study is anchored on Keynes' (1936) Liquidity Preference Theory, which highlights the motivation for holding cash and the principles of cash management that support the argument that financial innovations modify the structure of money demand over time, the concepts that remain relevant in today's digital payment era. To empirically examine the impact of each digital payment channel on currency in circulation and identify the channel that exert the greatest influence on currency in circulation, the study applied Ordinary Least Squares (OLS) regression alongside VECM to determine their short-run and the long-run relationships. And key digital payment channels include Automated Teller Machine (ATM), Mobile Payments, Web Payments and Point-of-Sale (POS). Currency in circulation is the dependent variable, while digital payment channels represent the independent variables and digital payment systems indicators. The variables under study are measured in their nominal values (Billion Naira). Accordingly, the adapted functional form of the model based on the objectives of the study is expressed as:

$$CIC = f\ (ATM, MOP, WEP, POS) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: CIC = Currency in circulation, ATM = Automated Teller Machines, MOP = Mobile Payment, WEP = internet/web payment and POS = Point of Sale

Econometrically, this model can be expressed as:

$$CIC = \beta_0 + \beta_1 ATM + \beta_2 MOP + \beta_3 WEP + \beta_4 POS + \mu \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where: CIC is the dependent variable, $\beta_0$ is the intercept, $\beta_1$, $\beta_2$, $\beta_3$ and $\beta_4$ are slope coefficients or parameters in the model. ATM, MOP, WEP and POS are the explanatory variables, $\mu$ = error term. Hence, the log-log version of equation 2 is given as follows:

$$lnCIC = \beta_0 + \beta_1 lnATM + \beta_2 lnMOP + \beta_3 lnWEP + \beta_4 lnPOS + \mu \ldots\ldots\ldots\ldots (3)$$

**A priori expectation**

The a priori expectation of the coefficients are such that $\beta_1 < 0$, $\beta_2 < 0$; $\beta_3 < 0$ and $\beta_4 < 0$

### 3.2 Model Estimation Technique

The model estimation technique was based on the stationarity results of the time series data. ADF and PP tests showed all variables were I (1), leading to Johansen's cointegration test, which confirmed two cointegrating equations and justified the use of the Vector Error Correction Model (VECM). The VECM was adopted to capture both short-run dynamics and long-run equilibrium between currency in circulation (CIC) and digital payment channels (ATM, mobile payments, web payments and POS), with the short-run model incorporating differenced variables and the error correction term, while the long-run equation specifies their equilibrium relationship. Therefore, since the VECM framework models both the short-run dynamics and the long-run equilibrium relationship, the specified VECM for the study can be expressed as follows:

Short-Run VECM Representation:

$$\Delta\ln CIC = \alpha_0 + \sum_{i=1}^{K-1} \alpha_1^i \Delta\ln CIC_{t-1} + \sum_{i=1}^{K-1} \alpha_2^i \Delta\ln ATM_{t-1} + \sum_{i=1}^{K-1} \alpha_3^i \Delta\ln MOP_{t-1} + \sum_{i=1}^{K-1} \alpha_4^i \Delta\ln WEP_{t-1} + \sum_{i=1}^{K-1} \alpha_5^i \Delta\ln POS_{t-1} + \lambda \mathrm{ECT}_{t-1} + \varepsilon t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Long-Run Equation:

$$lnCIC = \beta_0 + \beta_1 lnATM + \beta_2 lnMOP + \beta_3 lnWEP + \beta_4 lnPOS + \mu \ldots\ldots\ldots\ldots (5)$$

Where: Δ denotes first difference, *ln* is log, K is the optimal lag length, $\alpha^i$ are short-run coefficients, λ is the speed of adjustment coefficient, $ECT_{t-1}$ is the lagged error correction term and $\varepsilon_t$ is the white noise error term. CIC = Currency in Circulation, ATM = Automated Teller Machine Transactions, MOP = Mobile Payment Transactions, WEP = Web-based Payment Transactions and POS = Point of Sale Transactions.

Hence, the results from the preliminary diagnostic tests, including the correlation matrix, multicollinearity assessment and the Jarque–Bera normality test, indicated that conventional econometric techniques such as Regression Analysis and the Vector Error Correction Model (VECM) may not adequately address the statistical characteristics of the data. Consequently, a more robust estimation approach was required. The Autoregressive Moving Average (ARMA) Maximum Likelihood Estimation (MLE) technique was considered more suitable for this study objectives, as it provides a modified framework for short-run estimation relative to the VECM and offers improved handling of challenges such as multicollinearity and non-normality in the distribution of variables. Given its methodological strength and its ability to accommodate the irregularities observed in the dataset, the ARMA-MLE technique was therefore recommended for the empirical analysis. Hence, the ARMA maximum likelihood estimation model is specified as follows:

$$\Delta CIC_t = \beta_0 + \beta_1 \Delta CIC_{t-1} + \beta_2 \Delta ATM_{t-1} + \beta_3 \Delta MOP_{t-1} + \beta_4 \Delta WEP_{t-1} + \beta_5 \Delta POS_{t-1} + D_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where:

$\Delta = first\ difference$

$\beta_0 = intercept\ (mean\ short-run\ change\ in\ CIC\ after\ controlling\ for\ regressors)$

$\beta_1 = short-run\ autoregressive\ effect\ how\ last\ period's change\ in\ CIC\ affects\ current\ change\ in\ CIC.$

$\beta_2 = effect\ of\ last\ period's\ change\ in\ ATM\ on\ current\ change\ in\ CIC.$

$\beta_3 = effect\ of\ last\ period's\ change\ in\ MOP\ on\ current\ change\ in\ CIC.$

$\beta_4 = effect\ of\ last\ period's\ change\ in\ WEP\ on\ current\ change\ in\ CIC.$

$\beta_5 = effect\ of\ last\ period's\ change\ in\ POS\ on\ current\ change\ in\ CIC.$

$D_t = ARMA\ term$

$\boldsymbol{A\ priori\ expectation}$: $The\ a\ priori\ expectation\ of\ the\ coefficients\ is\ such\ that\ \beta_1 < 0,\ \beta_2 < 0;\ \beta_3 < 0;\ \beta_4 < 0;\ and\ \beta_5 < 0$

## 4. Data presentation

This section analyses the empirical findings from both descriptive analysis and econometric techniques such as Unit Root Test, lag length selection, Johansen cointegration test, Regression Analysis, VECM estimation and post-estimation diagnostics. These results provide both econometric evidence and economic insights, addressing the study's research questions and informing policy implications.

## 4.1 Descriptive analysis

**Table 1:**

*Descriptive Statistics*

Sample: 2009Q1 2023Q4

| | CIC | ATM | MOP | POS | WEP |
|---|---|---|---|---|---|
| Mean | 1950.187 | 2328.057 | 6802.823 | 3155.774 | 46996.43 |
| Median | 1804.535 | 1219.287 | 184.2317 | 188.7561 | 33.69440 |
| Maximum | 3653.304 | 10336.56 | 68463.61 | 35080.18 | 356094.3 |
| Minimum | 1006.599 | 62.59000 | 0.060000 | 1.865365 | 3.370000 |
| Std. Dev. | 661.0634 | 2627.347 | 15150.30 | 7302.703 | 87020.91 |
| Skewness | 0.726989 | 1.398284 | 2.575203 | 2.885747 | 1.741719 |
| Kurtosis | 2.718213 | 3.872942 | 8.955552 | 10.77416 | 5.097327 |
| Jarque-Bera | 5.483644 | 21.45704 | 154.9882 | 234.3693 | 41.33279 |
| Probability | 0.064453 | 0.000022 | 0.000000 | 0.000000 | 0.000000 |
| Sum | 117011.2 | 139683.4 | 408169.4 | 189346.5 | 2819786. |
| Sum Sq. Dev. | 25783282 | 4.07E+08 | 1.35E+10 | 3.15E+09 | 4.47E+11 |
| Observations | 60 | 60 | 60 | 60 | 60 |

Source: Computed by the Author using E-view 10 (2025)

Table 1 presents descriptive statistics for currency in circulation (CIC) and digital payment channels, including ATM, Mobile Payments (MOP), POS and Web Payments (WEP) covering 60 quarterly observations from 2009Q1 to 2023Q4. The mean CIC during the period was ₦1,950.19 billion, while digital payments were led by WEP (₦46,996.43 billion), followed by MOP (₦6,802.82 billion), POS (₦3,155.77 billion) and ATM (₦2,328.06 billion), reflecting a growing shift toward electronic transactions. Median values for MOP, POS and WEP were far lower than their means, indicating positive skewness, confirmed by skewness statistics, particularly high for MOP (2.58) and POS (2.89).

High variability was observed, especially for WEP (SD = ₦87,020.91 billion), followed by MOP and POS, highlighting rapid but volatile growth. Kurtosis values for MOP (8.96) and POS (10.77) show leptokurtic distributions, suggesting frequent extreme values.

The Jarque-Bera test indicated approximate normality for CIC but significant departures for ATM, MOP, POS and WEP. Overall, the descriptive results reveal strong growth, volatility and distributional asymmetries in digital payments, setting the stage for further econometric analysis.

### 4.2 Econometrics analysis

The econometric analysis includes unit root tests, lag length selection, Johansen cointegration test, Regression Analyses, Vector Error Correction Model (VECM), to capture both short-term and long-term dynamics and Post diagnostics Test. The focus is on ATM (LNATM), mobile payments (LNMOP), POS (LNPOS) and web payments (LNWEP), with CIC (LNCIC) as the dependent variable.

Stationarity tests with the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests show all variables are non-stationary at levels but become stationary after first differencing, indicating they are I (1) justified in the use of VECM.

**Table 2**

*VAR Lag Order Selection Criteria*

Endogenous Variables: LNCIC, LNATM, LNMOP, LNPOS, LNWEP

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -238.5067 | NA | 0.004822 | 8.854788 | 9.037273 | 8.925357 |
| 1 | -41.54324 | 350.9530 | **9.32e-06** | 2.601573 | **3.696482** | **3.024983** |
| 2 | -29.72254 | 18.91313 | 1.54e-05 | 3.080820 | 5.088153 | 3.857072 |
| 3 | -18.46477 | 15.96556 | 2.69e-05 | 3.580537 | 6.500295 | 4.709631 |
| 4 | 34.03073 | **64.90353** | 1.11e-05 | 2.580701 | 6.412882 | 4.062636 |
| **5** | 65.59113 | 33.28188 | 1.08e-05 | ****2.342141** | 7.086746 | 4.176918 |

** the selected Lag length

Source: Computed by the Author (2025)

The lag length selection criteria presented in Table 2 are used to determine the most appropriate number of lags to include in the Vector Autoregressive (VAR) or Vector Error Correction Model

(VECM). Based on the results, several criteria are considered, namely the Likelihood Ratio (LR) test, Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Criterion (SC) and Hannan-Quinn (HQ) criterion. Among these, the AIC selected lag 5 as the optimal lag length, indicating that the model performs best in terms of prediction accuracy and information content when five lags are included. So, optimal lag length for this

study model is five**.**

**Table 3**

*Johansen Cointegration Test Results*

Unrestricted Cointegration Rank Test (Trace and Maximum Eigenvalue)

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value (Trace) | Trace Prob.** | Max-Eigen Statistic | 0.05 Critical Value (Max-Eigen) | Max-Eigen Prob.** |
|---|---|---|---|---|---|---|---|
| None * | 0.471072 | 93.68408 | 69.81889 | 0.0002 | 36.94034 | 33.87687 | 0.0209 |
| At most 1 * | 0.402687 | 56.74375 | 47.85613 | 0.0059 | 29.88824 | 27.58434 | 0.0249 |
| At most 2 | 0.252044 | 26.85551 | 29.79707 | 0.1052 | 16.84386 | 21.13162 | 0.1795 |
| At most 3 | 0.157231 | 10.01164 | 15.49471 | 0.2798 | 9.921633 | 14.26460 | 0.2171 |
| At most 4 | 0.001551 | 0.090012 | 3.841466 | 0.7642 | 0.090012 | 3.841466 | 0.7642 |

**Source**: Computed by the Author (2025)

The results from both the Trace test and the Maximum Eigenvalue test in Table 3 consistently indicate the presence of two cointegrating relationships at the 5% significance level. Specifically, the Trace test shows that the trace statistics at the "None" and "At most 1" levels (93.68 and 56.74, respectively) are greater than their corresponding critical values (69.82 and 47.86), leading to the rejection of the null hypotheses of no cointegration and at most one cointegration. Similarly, the Maximum Eigenvalue test supports this conclusion. The max-eigen statistics at the "None" and "At most 1" levels (36.94 and 29.89, respectively) exceed their critical values (33.88 and 27.58), confirming the presence of at least two significant cointegrating vectors. The Johansen cointegration test found two cointegrating relationships at the 5% level, indicating a long-run equilibrium between CIC and digital payment channels, thus supporting the use of the VECM over a regular VAR.

**Regression analysis**

**Table 4**

Simple Regression Analysis
Dependent variable: LNCIC

| Variable | Coefficient | T-Statistic | P-Value | $R^2$ |
|---|---|---|---|---|
| LNWEP | 0.0677 | 11.56 | 0.0000 | 0.6972 |
| LNPOS | 0.1073 | 18.05 | 0.0000 | 0.8489 |
| LNMOP | 0.0858 | 19.43 | 0.0000 | 0.8668 |
| LNATM | 0.2382 | 19.94 | 0.0000 | 0.8727 |

**Source**: Computed by the Author using EViews 10 (2025)

To empirically examine the impact of each digital payment channel on currency in circulation and identify the channel that exert the greatest influence on CIC, an econometric technique by Frisch (1930) was employed which comprises simple and multiple regression. The result of simple regression in Table 4. shows that individually, all digital payment channels have positive and significant effects on CIC, suggesting that increase in digital payment channels is associated with increase in currency in circulation and it also implies that there was increase in transactional demand for cash via digital platform. This result aligns with the findings of Kanu et al. (2020) and Adebisi et al. (2023).

**Table 5**

*Multiple Regression Results Using Experimental Technique*

Dependent Variable: LNCIC

| Model Type | Variable | Coefficient | T-Statistic | P-Value | $R^2$ |
|---|---|---|---|---|---|
| 3-Variable Regression | LNATM | 0.132209 | 3.085844 | 0.0031 | |
| | LNMOP | 0.039725 | 2.566365 | 0.0129 | 0.885846 |
| 4-Variable Regression | LNATM | 0.126687 | 2.926067 | 0.0050 | |
| | LNMOP | 0.034958 | 2.142780 | 0.0365 | |
| | LNWEP | 0.006815 | 0.934674 | 0.3540 | 0.887599 |
| 5-Variable Regression | LNATM | 0.127661 | 2.834223 | 0.0064 | |
| | LNMOP | 0.036554 | 1.498872 | 0.1396 | |
| | LNWEP | 0.006896 | 0.930208 | 0.3563 | |
| | LNPOS | –0.002593 | –0.088698 | 0.9296 | 0.887615 |

**Source**: Computed by the Author using EViews 10 (2025)

To identify the channel that exert greatest influence on CIC, ATM usage emerged as the strongest predictor with coefficient of 0.2382. However, this dominance was confirmed by the result of the multiple regression in Table 5, where only ATM transactions retained its significance, while other channels lost their significance, pointing to severe multicollinearity among the independent variables, particularly between POS and MOP. From this result one can infer that ATM exert the greatest influence on currency in circulation (aligns with the findings by Adedotun et al. (2024), Ikpefan et al. (2018) **and** Muhibudeen &Haladu (2015)

**Table 6**

*VECM Short-Run Adjustment Dynamics*

| Variable | D(LNCIC) | D(LNATM) |
|---|---|---|
| CointEq1 | –0.811661 [–4.57311] | 0.316123 [0.85005] |
| CointEq2 | 0.069442 [2.86497] | –0.121060 [–2.38369] |
| D (LNCIC (–1)) | 0.127026 [0.83449] | –0.272536 [–0.85449] |
| D (LNATM (–1)) | 0.028312 [0.38154] | –0.109614 [–0.70501] |
| D (LNMOP (–1)) | 0.001620 [0.04462] | –0.081683 [–1.07415] |
| D (LNPOS (–1)) | –0.033726 [–0.60311] | 0.060059 [0.51259] |
| D (LNWEP (–1)) | –0.007774 [–0.40020] | 0.042238 [1.03774] |
| C (Constant) | 0.024510 [1.34768] | 0.081149 [2.12955] |

Source: Computed by the Author using EViews 10 (2025)

In addition, the short-run and long-run relationship between digital payment channels and currency in circulation were evaluated using VECM. The VECM results in Table 6 indicate a weak short-run effects of digital payments on CIC likely due to multicollinearity; this aligns with the findings by Adebisi et al. (2023) and Ocansey et al. (2024) but show a highly significant and negative error correction term of -0.8117) meaning that over 81% of disequilibrium adjusts within one quarter, confirming strong long-run stability and establishing that a shift from cash to digital payment system is gradual and this aligns with the findings by Tee and Ong (2016).

**Table 7**

*VECM Long-Run Relationships*

| Variable | CointEq1 (LNCIC Equation) | CointEq2 (LNATM Equation) |
|---|---|---|
| NCIC (-1) | 1.000000 | 0.000000 |
| LNATM (-1) | 0.000000 | 1.000000 |
| LNMOP (-1) | –0.223019 [–5.32474] | –1.962744 [–6.98707] |
| LNPOS (-1) | 0.140156 [2.76416] | 1.711942 [5.03403] |
| LNWEP (-1) | 0.009679 [0.88152] | 0.143087 [1.94310] |
| C (Constant) | –7.147083 | –6.589901 |

**Source**: Computed by the Author using EViews 10 (2025)

Table 7 shows that mobile payments have negative and significant long-run effect on CIC with coefficient of -0.2230, meaning mobile payment system has the potential to reduce CIC over time highlighting their role in lowering cash demand (align with Abbas, 2022), whereas POS transactions have positive and significant long-run influence on CIC with coefficient of 0.1402, which suggests that in the long-run POS could increase CIC likely due to their frequent use for cash-out-services and it could serve as a potential instrument for financial inclusion especially in the rural and underserved areas where formal banking services are limited. Web payments had no significant effect. This result aligns with the findings by Adedotun et al. (2024). A secondary cointegration equation with ATM as the dependent variable revealed that mobile payments reduced ATM reliance, while POS and web payments increased it, further emphasising mobile payments as the most effective channel for reducing cash dependence.

**Post estimation results**

The post-diagnostic test results show that the model was robust against autocorrelation and heteroskedasticity, but non-normality of residuals and serious multicollinearity were identified (aligns with the findings by Adebisi et al. 2023, Muhibudeen and Haladu, 2015). VIF results show that MOP (34.30) and POS (30.85) had exceptionally high VIF values, exceeding the critical threshold of 10, while ATM (15.27) also indicate serious multicollinearity concerns. The residual normality test further rejected the assumption of multivariate normality, suggesting efficiency and inference concerns. Based on these irregularities observed in the models, the study employed ARMA Maximum Likelihood Estimation (ARMA-MLE) as advanced corrective approaches to strengthen the robustness of the findings.

### 4.3 Corrective measures for short-run VECM estimates and non-normality in VECM residuals:

**Table 8**

*ARMA Maximum Likelihood Estimation*

Dependent Variable: CIC

| Variable | Coefficient | Std. Error | t-Statistic | Prob. | | |
|---|---|---|---|---|---|---|
| C | -167.8968 | 53.96814 | -3.111035 | 0.0031 | Durbin-Watson stat | 1.692217 |
| CIC (-1) | 1.179674 | 0.046870 | 25.16924 | 0.0000 | Probability (F-statistic) | 0.000000 |
| ATM (-1) | -0.123381 | 0.026797 | -4.604316 | 0.0000 | R-squared | 0.926624 |
| POS (-1) | 0.136494 | 0.013471 | 10.13233 | 0.0000 | Adjusted R-squared | 0.916552 |
| MOP (-1) | -0.073269 | 0.007059 | -10.37878 | 0.0000 | F-statistic | 92.00667 |
| WEP (-1) | 0.004831 | 0.000550 | 8.780830 | 0.0000 | | |
| D | -1.463254 | 0.152986 | -9.564636 | 0.0000 | | |
| SIGMASQ | 31012.91 | 7730.831 | 4.011588 | 0.0002 | | |

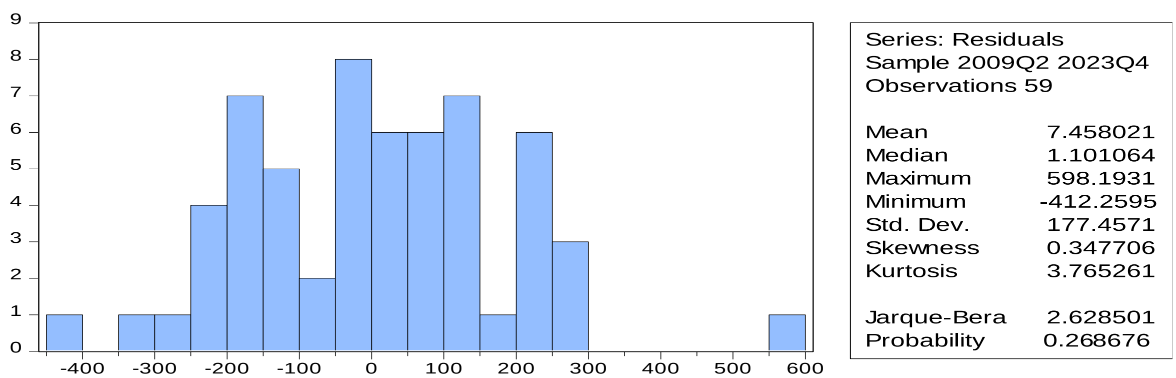
**Source:** Computed by the Author using EViews 10 (2025)

The ARMA Maximum Likelihood (BFGS) approach was applied as a corrective measure to the VECM follow the insignificant short-run coefficients and non-normal residuals which involves re-estimating the model as shows in Table 8 as it was more robust to non-normality. The quarterly data from 2009Q2–2023Q4 was used, the model converged no serious autocorrelation (Durbin-Watson = 1.692). Results show that ATM (-1) have negative and significant effect on CIC with coefficient of -0.1234, while MOP (-1) shows a strong negative effect on CIC with coefficient of -0.0733 and significantly reducing CIC. On the contrary, POS (-1) and WEP (-1) show positive and significant effect on CIC with coefficient of 0.1365 and 0.0048 respectively, meaning increase in these channels was associated with increase in CIC, although if properly manage, it could serve as a strategic financial inclusion instrument particularly in informal sector. This aligns with the findings by Asongu et al. (2021) and Porteous & Bankable Frontier Associates (2012)**,** who emphasise that mobile platforms enhance financial inclusion and facilitate cashless transactions, particularly in peer-to-peer and small-value payments.

**Residual and stability test after correction**

**Figure 1**

**Residual Diagnostics of the ARMA-MLE Model**



**Source:** Computed by the Author (2025)

The residual diagnostics confirmed the correction's effectiveness, as the model passed all the post diagnostic tests, with the Jarque-Bera test (JB = 2.63; p = 0.269) supporting normality, resolving earlier non-normality issues, thus complement the result from the VECM and ensuring reliable estimates (see Figure 1) while all the variables show significant effects with strong explanatory power ($R^2 = 0.9266$; Adjusted $R^2 = 0.9166$) which indicated no serious multicollinearity in the model. Hence, the Heteroskedasticity ARCH Test indicates that the residuals do not suffer from heteroskedasticity, as p-value of 0.2261 was greater than the conventional 5% significance level, meaning that the error variances are stable over time.

Stability and specification check further validated the model. The Ramsey RESET test reported no evidence of specification errors (p-values > 0.70), affirming the appropriateness of the model's functional form. These confirm the model's robustness for policy and forecasting.

Empirically, the study makes three contributions. First, it clarifies earlier inconclusive findings by showing that digital payment channels are channel-specific as the model show a mixed result in the short run in ARMA-MLE model and supporting Mobile payments significantly reduce CIC in the long run in VECM. Second, it reconciles the contradiction between Nigeria's cashless policy and rising CIC by revealing that POS and web payments may sustain or increase cash demand due to cash-out transactions in underbanked areas. Third, by employing quarterly data from 2009Q1–2023Q4 and applying advanced econometric techniques (regression, VECM and ARMA-MLE), the study provides more valid, generalisable and policy-relevant evidence on digital payment systems and currency in circulation in Nigeria.

## 5. Conclusion and Recommendations

This study examined the impact of each digital payment channels on currency in circulation (CIC) in Nigeria using Regression, VECM and ARMA-MLE methods. Results show that while all channels have positive and significant effect individually on CIC, only ATM exerts greatest influence in the multiple regression. VECM result revealed that MOP reduce cash demand in the long run, whereas POS sustains cash-based activity. ARMA-MLE estimation improved reliability as the model passed all the post diagnostic tests with a mixed result existed, supporting the VECM long-run effect of MOP and POS and established the significant effect of ATM and Web payment. The findings clarify inconsistencies in prior literature, demonstrating that digital payment effects are channel-specific rather than uniform and digital payment system complement cash rather than substituting it.

Hence, the study recommends expansion of Mobile Payments system as it could serve as a potential instrument for reducing cash demand and lowering its associated cost, especially in rural and informal sectors, by improving access to smartphones, internet services, cybersecurity and digital literacy. ATM and POS functions should be reoriented toward digital-to-digital use. Hence, future studies could thus expand the model by including fintech platforms and crypto payment system and explore the sectoral impacts of digital payments.

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