An Analysis of Bank-Level Determinants of Electronic Payment Innovations in Nigerian Deposit Money Banks

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Abstract— This study investigates the bank-level determinants of electronic payment innovations of Deposit Money Banks (DMBs) in Nigeria. The research follows ex post facto design using a panel of fourteen DMBs from 2012 to 2021. The Difference-Generalized Method of Moment (D-GMM) was utilised in the analysis at 5% level of significance. The results reveal that Bank size, bank age, research and development, capital adequacy ratio, and asset quality consistently and significantly influence the adoption and usage of various payment channels such as ATM banking, mobile banking, internet banking, and POS banking. This implies that electronic payment innovations in Nigeria are influenced by bank size, bank age, research and development (R&D), capital adequacy ratio (CAR), and asset quality (AQ). It is recommended that DMBs prioritise investment in research and development to foster innovation. There is also the need to create a supportive regulatory environment and facilitates collaboration between banks and stakeholders.

Index Terms— **Electronic, Payment Innovations, Bank-Level Determinants, Deposit Money Banks, Difference GMM.**

1. Introduction

The Nigerian banking landscape has undergone a profound metamorphosis driven by the emergence of innovative payment channels, commonly referred to as electronic payment (e-payment) channels. These cutting-edge methods encompass online banking, mobile banking, point-of-sale (POS) terminals, ATM banking, and electronic funds transfer (EFT), redefining the landscape of financial transactions (Ibekwe, 2021; Joana, 2011). These channels have introduced unparalleled levels of convenience, security, and efficiency, benefiting both customers and banks and propelling the nation towards a cashless and digitally inclusive economy (Ohiani, 2021). Nigerian Deposit Money Banks (DMBs) have embraced these transformative payment technologies, recognising their potential to yield cost savings, enhance customer experiences, and optimize operational efficiencies (Somoye, Ilo & Yunusa, 2019). As the adoption of e-payment mechanisms continues its upward trajectory, a profound comprehension of the foundational factors that underpin the effective use and success of these channels at the bank level becomes imperative.

Prior research has pinpointed key bank-level determinants influencing the adoption and utilization of payment innovation. These include bank size, organizational age, research and development (R&D) capabilities, technological infrastructure, and the propensity to invest in pioneering payment solutions (Muthinja & Chipeta, 2017). These factors bear significant influence on a bank's ability to integrate and proficiently utilize state-of-the-art payment technologies.

For instance, security concerns and fraudulent activities can impede the progress of payment systems. Cyber threats and fraudulent undertakings like phishing and data breaches can engender financial losses for both clients and banks, eroding the reputation of financial institutions and denting customer trust in digital payment channels (Akintoye et al., 2022). The challenge transcends singular issues, encompassing complexities related to security, interoperability, user experience, regulatory adherence, scalability, cost-effectiveness, and data analytics in payment systems innovation. This intricate ecosystem poses substantial barriers to the seamless operation of payment channels, impeding widespread adoption and undermining the pursuit of financial inclusion and a cashless economy (Wahyudi, 2020).

Bank size emerges as a crucial determinant shaping the advancement, adoption, and utilization of payment innovation. Frame and White (2005) opine that larger banks enjoy a resource advantage, enabling them to invest in R&D for novel technologies and inventive payment solutions. Conversely, smaller banks may opt for competitive viability by engaging in collaborations with Fintech entities or cultivating strategic alliances (Tamara et al., 2019).

The temporal dimension of banks also introduces complexity, with varying bank ages yielding distinct challenges. Older banks with better market experience as younger banks capitalising on new technologies, presents multifaceted challenges in the realm of payment innovation. These challenges includes innovation gap where older banks struggle to keep pace with technological advancements, potentially leading to a competitive disadvantage. Meeting customer expectations for advance, and seamless payment

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options poses a challenge for older banks, risking dissatisfaction and the loss of market share. Additionally, the risks aversion of established banks may hinder the adoption of transformative payment technologies thereby slowing-down progress in the industry (Cho, 2019). Meanwhile, Research and Development (R&D) efforts are pivotal in addressing this complexity problem. A robust R&D programme allows DMBs to explore innovative solutions to improve network reliability, identify vulnerabilities, and develop contingency plans to mitigate disruptions (Cho, 2019).

Bank capital regulation, presents a dual-edged challenge to payment innovation. Firstly, it creates an environment where traditional banks might hesitate to allocate capital towards innovative payment technologies due to the inherent risks and uncertainties associated with unproven ventures (Craig, 2000). The capital allocated for regulatory compliance competes with potential investments in payment innovation, leading to missed opportunities for efficiency improvements and customer-centric solutions (Kou, Akdeniz, Dinçer, & Yüksel, 2021). Moreover, traditional banks face a competitive disadvantage compared to Fintech startups, which often operate under lighter capital requirements and can thus dedicate more resources to pioneering payment innovations (Arner, Buckley & Zetzsche, 2018). This discrepancy exacerbates the risk aversion of established banks and hampers the pace of innovation within the payment ecosystem (Chen, 2018).

In Nigeria, electronic payment innovation was introduced and implemented with the intention of promoting a cashless economy and improving financial inclusion (CBN, 2021). Despite the introduction of the electronic innovative payment channels, the country has yet to fully realise its goals in terms of enhancing financial inclusion and transitioning to a cashless economy (Somoye, Ilo & Yunusa, 2019). At bank-level, insecurity and fraud pose significant challenge to payment systems. Cyber-attacks and fraudulent activities, such as phishing and data breaches, has resulted to financial losses for both customers and banks, tarnishing the reputation of financial institutions and eroding customer confidence in using digital payment channels (NDIC, 2021; Akintoye et al., 2022). The fear of falling victim to fraud also discourages customers from adopting digital payment methods, thereby hindering the growth of cashless transactions. The overarching problem encompassing security, interoperability, user experience, regulatory compliance, scalability, cost efficiency, and data analytics in payment systems innovation is the complexity of the ecosystem. This complexity poses significant obstacles to the seamless and efficient functioning of payment channels, hindering widespread adoption and achieving the desired goals of financial inclusion and a cashless economy (Phan et al., 2020).

The broad objective of this study is to examine the bank-level determinants of payment innovation and its effects on the performance of Deposit Money Banks in Nigeria. However, specific objectives are to:

i. Evaluate the significance of bank-level determinants on ATM banking payment innovation in Nigeria;
ii. Assess the significance of bank-level determinants on mobile banking payment innovation in Nigeria;
iii. Estimate the significance of bank-level determinants on internet banking payment innovation in Nigeria;
iv. Examine the significance of bank-level determinants on POS banking payment innovation in Nigeria.

The existing literature on payment innovation in the banking sector reveals limited attention to crucial bank-level factors, such as size, age, investment in R&D, and financial performance. These factors play a vital role in shaping a bank's overall operations, competitiveness, and resilience in the dynamic financial landscape. A deeper examination of these aspects can provide valuable insights into a bank's growth trajectory, its ability to innovate and adapt to changing market demands, and its financial stability. Addressing these gaps in the literature will enhance our understanding of the bank-level determinants of payment innovation.

2. Literature Review

A. Conceptual Review

As outlined by Ohiani (2021), payment innovation signifies a novel approach to conducting transactions within banks, resulting in decreased transaction costs and the facilitation of seamless third-party transfers. From the perspective of Serge, Rugemintwari, and Sauviat (2019), payment innovation entails the integration of fresh or distinctive methods for paying goods or services, often with the central goal of improving customer convenience and expediting the payment process. According to the Central Bank of Nigeria (CBN, 2021), electronic payment innovation encompasses the introduction and adoption of novel technologies, systems, and processes within the banking sector, all aimed at enhancing the efficiency, security, and convenience of payment transactions. The apex bank however identified Automated Teller Machines (ATMs), mobile banking with unstructured supplementary service data (USSD) support, and point of sale (POS) terminals as prominent payment innovations in Nigeria.

The ATM banking has emerged as a solution to simplify payment transactions within the banking sector. This concept, as explained by Ojokuku, Odetayo, and Sajuyigbe (2012), involves the utilisation of cash-dispensing machines called ATM galleries, allowing customers to conveniently withdraw funds from their accounts at any time and location, with immediate deduction from their balances. The evolution of financial technology has driven the adoption of ATM banking, streamlining payment functions (Phan et al., 2020), benefiting customers through time-saving, cost-effective operations for banks, and additional revenue generation (Ohiani, 2021). It serves as electronic counterparts to bank cashiers, ATMs use internet networks to fulfill traditional functions and significantly contribute to bank productivity. The mobile banking as another payment innovation channel represents a cutting-edge payment solution operates through mobile phones using Unstructured Supplementary Service Data (USSD) codes, enabling a range of transactions such as account inquiries, funds transfers, bill payments, and beyond (Safdar et al., 2018; Oke et al., 2021). By harnessing the power of mobile devices, this innovation significantly enhances the convenience and accessibility of banking services, reshaping traditional banking paradigms (Oke et al., 2021).

Also, internet banking, commonly referred to as e-banking harnesses the capabilities of internet and telecommunication networks to seamlessly provide customers with a range of banking services. At its core, internet banking offers customers the ability to engage in real-time traditional banking functions through online platforms. This encompasses activities such as account management, fund transfers, bill payments, and more. As noted by scholars like Bradley and Stewart (2003) and Howcroft et al. (2002), internet banking empowers customers to manage their financial affairs with heightened autonomy, resulting in increased user satisfaction. The Point of Sale (POS) banking is digital payments and cash withdrawals facilitated by specialized POS terminals via seamless card-based transactions at retail establishments, effectively streamlining the payment process (Oke et al., 2021). Notably, this approach features remote agent operations, underscoring its adaptability to diverse environments. Approved bank agents, acting as conduits, facilitate deposits and withdrawals, amplifying customer convenience (Ohiani, 2021).

The bank-level determinants of payment innovation are intrinsic to each bank's profile and are directly within the control of the DMBs themselves. These include bank size, organizational age, research and development (R&D) capabilities, technological infrastructure, and the propensity to invest in pioneering payment solutions (Muthinja & Chipeta, 2017).

Research and Development (R&D) constitute a systematic and purposeful process of exploration, experimentation, and innovation undertaken by banks to acquire new knowledge, create novel financial products and services, and enhance processes. While quantifying R&D investment can be challenging, intangible assets often serve as proxies (Wahyudi, 2020; Beck, 2012), safeguarded to thwart imitation. Through R&D investment, DMBs glean emerging trends, customer preferences, and technological advancements to craft innovative financial products. This encompasses digital payment solutions, personalised advisory services, and advanced risk management tools. R&D-driven innovation empowers DMBs to differentiate themselves, attract new clientele, and bolster customer loyalty.

The bank size denotes the scale of a bank's operations, encompassing metrics like total assets, annual revenue, and employee count (Muthinja & Chipeta, 2017; Wahyudi, 2020). While definitions of "large" or "small" banks vary, size classification aids in regulatory oversight. Larger banks often boast more resources. They can invest in innovative technologies, employ specialised staff, and collaborate with external partners to drive innovation. Large DMBs, due to broader market presence, accumulate extensive data on customer behaviour, facilitating tailored product design. However, smaller DMBs and Fintech startups may leverage agility to experiment with innovative concepts, potentially unhindered by regulatory constraints.

The age of bank signifies a DMB's duration of existence (Muthinja & Chipeta, 2017). Chronological age translates to experience, stability, and reputation. Well-established banks evoke trust and reliability among customers and stakeholders. Longevity showcases a bank's resilience across economic cycles and changing market conditions. While seasoned DMBs might possess broader networks and relationships, fostering collaboration, they can be hampered by established structures that delay innovative implementation. Regulatory capital mandates the capital financial institutions must maintain under governing regulations (CBN, 2021). It functions as a safety net against unexpected losses, upholding stability and safeguarding depositors. Regulatory bodies must balance innovation and financial stability, adapting capital requirements to address the risks posed by digital payments and Fintech disruptions.

On the performance of DMBs, **a**n evaluation of the progress and achievement of the Deposit Money Banks (DMBs) involves both financial and non-financial assessments. Financial performance covers profitability, management effectiveness, asset quality, capital sufficiency, stability, stock returns, and risk analysis (Muthinja, 2016; Beck et al., 2016; Sbarcea, 2017). Non-financial evaluation considers factors like governance, social impact, reputation, and innovation, extending beyond monetary aspects. According to Farah, Farrukh, & Faizan (2016), performance of DMBs is the financial strength and stability of a DMB over a period of time.

Profitability, a critical measure of financial performance in the banking sector, can be assessed using two distinct approaches: risk-neutral and risk-based. The risk-neutral approach involves metrics like Return on Assets (ROA), Return on Equity (ROE), and Net Interest Margin (NIM). On the other hand, the risk-based approach employs measures such as Risk-Adjusted Return on Assets (RAROA), Risk-Adjusted Return on Equity (RAROE), and Risk-Adjusted Net Interest Margin (RANIM) (Sanni, Salami & Uthman, 2020). The risk-adjusted approach to evaluating profitability in the banking sector holds a distinct advantage due to its incorporation of risk considerations into the assessment. While traditional risk-neutral measures like ROA, ROE, and NIM provide insights into raw profitability, they often overlook the inherent risks and uncertainties that banks face in their operations. These risks can significantly impact the long-term sustainability and stability of a bank.

B. *Theories of Payment Innovation*

Schumpeter theory (1934) observed the relevance of innovation in economic growth as it is fundamental impulse that ignite and sustain the capitalist engine as competitive innovative activity keeps the market up through creative destruction which continuously change economic structure through invention, innovation and diffusion. Invention entails new ideas formation and its successful implementation while innovation entails successful invention, commercialisation, and diffusion (Somoye, 2013). The theory revolves around the central role of entrepreneurs as drivers of innovation, introducing new products, processes, and business models into the market. Schumpeter emphasized the concept of creative destruction, whereby new innovations replace or render obsolete existing products, industries, or technologies. This destructive aspect of innovation is seen as crucial for economic progress and the reallocation of resources toward more productive uses.

The Diffusion of Innovation Theory, proposed by sociologist Everett Rogers in 1962, identified two main tests which innovation must pass before it can be adopted or diffused. They are the Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) (Hefferman et al., 2014). DOI theory establishes five adopter categories in transmitting the PU and PEOU to other categories. They are the innovators, early adopters, early majority, late majority and laggards. In each of these categories, factors such as relative advantages of the innovative idea over the existing ones, comparability and complexity are crucial to the adoption and diffusion (Namusonge, Muturi & Olawoye, 2016).

The Resource-Based View (RBV) Theory, proposed by Birger Wernerfelt in 1984, offers a comprehensive framework for understanding how a firm's internal resources and capabilities contribute to its competitive advantage and performance. According to this theory, firms possess unique resources and capabilities that vary in terms of their age, size, type, investment type, and quality of management team. These resources can include tangible assets, intangible assets, and organizational capabilities.

Transaction Cost Economics (TCE) theory, proposed by Oliver E. Williamson in 1979, provides a framework for understanding the decision-making processes of economic agents in the presence of transaction costs. TCE theory assumes that economic actors are rational and seek to minimize transaction costs when organizing economic activities. It emphasizes the role of transaction costs in shaping the governance structures and relationships between economic agents. Firm performance, in the context of TCE theory, is influenced by the ability of firms to minimize transaction costs and achieve efficient coordination and resource allocation. By adopting governance structures that align with transaction characteristics, firms can effectively manage risks and uncertainties, ensure the quality and timeliness of transactions, and enhance the efficiency of resource allocation. For example, when transaction-specific investments are high, firms may choose vertical integration or long-term contracts to ensure better control and coordination of activities, leading to improved performance

C. *Empirical Review*

Limited research has delved into the underpinnings of payment innovation on a global scale. However, payment innovation resides within the broader domain of financial innovation, prompting a review of empirical studies within that realm. Tufano (1989) conducted an early exploration, concentrating on the impact of bank size on financial innovation. The study, using market share as a measure of size, found a significant association between bank size and financial innovation. The scholar, Tufano (2003) further investigated the impact of capital regulation as another crucial determinant; his study indicated positive and significant impact of on financial innovation.

Frame and White (2005) illuminated a constructive and noteworthy link between bank size and financial innovation, particularly concerning payment innovation, within their contextual investigation; they found that larger banks tend to innovate quicker than smaller banks. Heffeman et al. (2014) conducted a sweeping survey involving over a thousand British financial institutions. Their aim was to unearth the drivers of financial innovation adoption and usage. Through rigorous analysis employing Logit and generalized Tobit models, the study unveiled that research and development (R&D) and human capital development played pivotal roles in steering financial innovation in the country. Exploring the landscape of branchless banking channels in Kenya, Muthinja and Chipeta (2017) discerned a spectrum of determinants. Their study identified two level drivers; bank-level and macro-level drivers. The study found size, and technological development significant drivers of payment innovation in Kenya.

Nguena (2019) study examined various factors, including human capital development, credible monetary policies, infrastructure enhancement, and urbanization. The study found weak association and suggested internal factors which are within the control of banks. Tamara et al. (2019) probed financial innovation's landscape in Indonesia, revealing a surprising divergence from prior findings. Bank size, which traditionally played a significant role, did not demonstrate a statistically significant impact on financial innovation within the country. A similar examination by Wahyudi (2020) in Indonesia underscored the weight of bank age, size, and investment in R&D as substantial drivers of financial innovation.

Barman et al. (2021) adopted a global stance in pinpointing financial innovation drivers. Their findings spotlighted technological strides, competition, firm dimensions, and regulatory frameworks as driving forces. However, their descriptive approach potentially limited comprehensive analysis and causal determinations. Within the Nigerian context, investigations by Salami, Akande, & Alalade (2022) and Akintoye et al. (2022) were centered on customer-related factors that influence the adoption and utilisation of payment innovation. Remarkably, these studies delved into customer-level influences, omitting an exploration of bank-level analysis. This omission is noteworthy, considering that while customer perspectives were scrutinised, the entities that supply these innovative services, i.e., the financial institutions themselves, remain relatively unexamined. This presents a gap in the current body of research, wherein the emphasis on customer-specific facets overshadows the need to comprehend the underpinning forces within the institutions driving these innovations.

3. Methodology

This study employs an *ex-post facto* research design utilising panel data methodology. The chosen variables will be extracted from the annual reports of selected Nigerian Deposit Money Banks (DMBs) across a timeframe spanning 2012 to 2021, encompassing the prevalent payment innovation landscape. The study's sample size is the fourteen (14) listed DMBs that

Table 1
Total assets of deposit money banks in Nigeria

Period	Total Assets of the selected DMBs N' billion	Total Assets of all DMBs N' billion
2012	14,092.74	21,288.14
2017	25,253.54	34,593.89
2021	38,137.59	53,714.91

Source: Author's compilation (2023)

Table 2
Variables measurement

S.No.	Variable	Description	Measurement	Sources of Data
		Dependent Variables		
1	ATM banking (ATMB)	Payment innovation using debit cards at any ATM gallery without the need for direct interaction with bank personnel.	Value of all payment transactions carried out on ATM channel in the period	CBN Statistical Bulletins & Annual reports of NDIC
2	Mobile Banking (MB)	Payment innovation that uses basic mobile phones to provide essential banking services.	Value of all payment transactions carried out on mobile banking channel in the period	CBN Statistical Bulletins & Annual reports of NDIC
3	Internet Banking (IB)	Payment innovation with the use of internet connectivity	Value of all payment transactions carried out on internet banking channel in the period	CBN Statistical Bulletins & Annual reports of NDIC
4	POS banking (POSB)	Payment innovation using POS terminals using various electronic methods.	Value of all payment transactions carried out on POS channel in the period	CBN Statistical Bulletins & Annual reports of NDIC
		Independent Variables		
5	Bank Size (BZ)	Bank's scale and importance, indicated by factors like total assets, market value, etc., showcasing its significance and impact.	Natural log of total assets	Annual Reports of the selected DMBs.
6	Bank Age (BA)	The length of time a bank has been in operation since its establishment	Year since establishment	Annual Reports of the selected DMBs.
7	Regulatory Capital (CR)	The set of rules and guidelines that govern the amount and type of capital that banks are required to hold.	$Capital\ adequacy\ ratio\ (CAR) = \frac{Tier\ 1\ Capital + Tier\ 2\ Capital}{Risk\ Weighted\ Assets}$	Annual Reports of the selected DMBs.
8	Research and Development (R&D)	The allocation of resources for innovative research and the development of new financial products, services, and technologies.	Natural log of intangible assets	Annual Reports of the selected DMBs.
	Control Variables			
9	Assets Quality	The overall health and risk level of a bank's asset portfolio, particularly loans and investments.	$\frac{Non-Performing\ Loans}{Total\ Assets}$X100	Annual Reports of the selected DMBs.
10	Risk-Adjusted Net Interest Margin	Metric used to comprehensively assess the profitability and risk exposure associated with a bank's core lending and investment activities.	Ratio of NIM to standard deviation of NIM over the sample period.	Annual Reports of the selected DMBs

Source: Author, 2023

satisfy listing criteria and exhibit international reach, a criterion vital for delving into the realm of cross-border payments – a pivotal facet of modern banking innovations. Furthermore, the chosen Deposit Money Banks (DMBs) consistently represented a significant portion of the total assets across all DMBs throughout the years, as detailed in Table 1. The cumulative assets of these selected DMBs were aggregated for three distinct years, with a five-year interval between each. The findings reveal that in the initial year, 2012, the chosen DMBs accounted for 66% of the total assets, and this percentage increased to 73% in 2017, a span of five years, followed by 71% in 2021. These figures underscore their substantial presence within the broader DMB population. Consequently, opting for this sample holds the potential to yield valuable insights into the larger DMB population, all while reducing time and cost.

Data sourcing encompasses two key references: the Annual Reports of DMBs and the Central Bank of Nigeria Annual Statistical Bulletin. The data can be categorised into three segments. Dependent variables entail the values associated with ATM payment transactions (*ATMB*), mobile banking (*MB*), internet banking (*IB*), and POS banking transactions (*POSB*). Meanwhile, the independent variables encompass bank size (*BZ*), research and development investments (*RD*), bank age (*BA*), and regulatory capital (*CR*). The third category comprises the moderating variables, with asset quality (*AQ*) and risk-adjusted net interest margin (*RANIM*) serving as the chosen moderators. To analyse the data, this study adopts the Panel Difference Generalised Method of Moments (D-GMM) technique.

The dynamic panel model specified by Muthinja and Chipeta (2017) is adopted. The model is specified in equation (1) below:

$$Y_{i,t} = \alpha i(1-\lambda) + \lambda Y_{i,t-1} + \beta_0 X_{i,t} + \theta Z_{i,t} + \mu_{i,t} \quad (1)$$

In this equation, $Y_{i,t}$ signifies the level of financial innovation for the specific firm *i* at time *t.* The term $Y_{i,t-1}$ represents the past values of financial innovation variables. The components $X_{i,t}$ and $Z_{i,t}$ correspond to the drivers of financial innovation, either on the macro or firm level, and the control variables for firm *i* during time *t,* respectively. The presence of $\mu_{i,t}$ accounts for the error terms within the model. The model (1) is therefore modified to exclusively reflect the factors pertaining to payment innovation at the level of individual DMBs since the research objective is to examine the bank-level factors that drive payment innovation. The modified model is therefore specified as:

$$\Delta InATMB = C_o + \alpha_i InATMB_{it-1} + \beta i\Delta InBZ_{it} + \gamma i\Delta InBA_{it} + \partial i\Delta InRD_{it} + \delta i\Delta CR_{it} + \theta i\Delta AQ_{it} + \theta i\Delta RANIM_{it} + \varepsilon_t$$

$$\Delta InMB = C_o + \alpha_i InMB_{it-1} + \beta i\Delta InBZ_{it} + \gamma i\Delta InBA_{it} + \partial i\Delta InRD_{it} + \delta i\Delta CR_{it} + \theta i\Delta AQ_{it} + \theta i\Delta RANIM_{it} + \varepsilon_t$$

$$\Delta InIB = C_o + \alpha_i InIB_{it-1} + \beta i\Delta InBZ_{it} + \gamma i\Delta InBA_{it} + \partial i\Delta InRD_{it} + \delta i\Delta CR_{it} + \theta i\Delta AQ_{it} + \theta i\Delta RANIM_{it} + \varepsilon_t$$

$$\Delta InPOSB = C_o + \alpha_i InPOSB_{it-1} + \beta i\Delta InBZ_{it} + \gamma i\Delta InBA_{it} + \partial i\Delta InRD_{it} + \delta i\Delta CR_{it} + \theta i\Delta AQ_{it} + \theta i\Delta RANIM_{it} + \varepsilon_t$$

The dependent variables are ATM payment transactions (*ATMB*), mobile banking (*MB*), internet banking (*IB*), and POS banking transactions (*POSB*). Meanwhile, the independent variables encompass bank size (*BZ*), research and development investments (*RD*), bank age (*BA*), and regulatory capital (*CR*). The moderating variables, with asset quality (*AQ*) and risk-adjusted net interest margin (*RANIM*) serving as the chosen moderators. The description of the variables is presented in Table 2.

4. Results and Discussion

The result covers the pre-estimation, empirical and post-estimation tests including Hansen Test and Serial correlation tests.

A. Pre-Estimation Tests

The table 3 presents descriptive statistics for objective one. It contains the estimation of bank level common sample statistics such as the mean, median, standard deviation and Jargue-Bera for the specified variables in the first objective. ThE summary statistics of payment innovation (ATM banking transactions (ATMB), mobile banking transactions (MB), internet banking transactions (IB) and POS banking transactions (POSB) are presented. Others are bank size (BS), bank age (BA), research & development (RD), risk-adjusted net interest margin (RANIM), capital adequacy ratio (CAR), and asset quality (AQ). The result of the descriptive statistics, correlation analysis, unit root test, Difference GMM (DGMM) estimation and post estimation tests of the panel data of the four models are therefore discussed as follows.

The mean values of various banking transactions, such as ATM (-0.7053), mobile (-14.858), internet (-2.5092), and POS (-46.8144), indicate average declines in these activities. This suggests a downward trend in customer usage of traditional banking channels, possibly due to the increasing adoption of digital banking services. The wide range of minimum and maximum values for these transactions (ATM: -9.6970 to 0.4575, mobile: -163.36 to 0.7793, internet: -29.999 to 0.5677, POS: -508.267 to 0.8853) demonstrates significant fluctuations over time, reflecting the changing preferences and behaviours of bank customers.

The risk-adjusted net interest margin (mean: 0.0410), capital adequacy ratio (mean: 0.1340), and asset quality (mean: 0.0443) measures provide insights into the financial performance and stability of deposit money banks. The relatively low mean value for risk-adjusted net interest margin suggests that, on average, banks have struggled to maintain profitability while managing risks effectively. The wide range of minimum and maximum values for capital adequacy ratios (-2.1480 to 0.6400) indicates variations in the banks' ability to meet regulatory requirements and maintain adequate capital buffers. Similarly, the fluctuating values for asset quality (1.00E-05 to 0.3000) imply challenges in managing loan portfolios and maintaining satisfactory levels of credit quality.

The skewness values (-2.7918 to -2.8056) indicate that the distribution of variables such as ATM banking transactions, mobile banking transactions, internet banking transactions, and POS banking transactions is skewed to the left. This suggests a larger number of extreme negative values. The positive kurtosis values (8.8258 to 8.8715) indicate heavy tails and a higher likelihood of extreme values in the distributions. These findings imply non-normal distributions and highlight the need to consider the presence of outliers and extreme observations when analysing the data.

The Jarque-Bera statistics and their associated probabilities provide further evidence of departures from normal distributions. The high Jarque-Bera statistics values (ATM: 379.85, mobile: 384.66, internet: 384.45, POS: 384.772) and the associated probabilities close to zero (all 0.0000) suggest significant deviations from normality. This indicates that assumptions based on normal distribution may not accurately

Table 3
Descriptive statistics

	ATMB	MB	IB	POSB	RANIM	CAR	AQ	BA	RD	BZ
Mean	-0.7053	-14.858	-2.5092	-46.8144	0.0410	0.1340	0.0443	45.514	0.1622	7.3463
Median	0.2199	0.4153	0.2705	0.4091	0.0424	0.1701	0.0310	31.000	0.0025	6.6580
Maximum	0.4575	0.7793	0.5677	0.8853	0.1340	0.6400	0.3000	127.00	9.9627	9.9850
Minimum	-9.6970	-163.36	-29.999	-508.267	0.0008	-2.1480	1.0000	1.0000	-0.0113	4.9162
Std. Dev.	2.8911	47.684	8.8274	148.1679	0.0237	0.3100	0.0483	32.799	0.9117	1.36615
Skewness	-2.7918	-2.8053	-2.8047	-2.8056	0.8914	-5.8338	2.7219	1.0365	9.2302	0.4944
Kurtosis	8.8258	8.8705	8.8686	8.8715	5.7209	40.327	11.3426	3.0989	97.302	1.6450
Jarque-Bera	379.85	384.66	384.45	384.772	61.725	8922.05	578.861	25.127	53862.59	16.4149
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.000	0.00027
Obs.	140	140	140	140	140	140	140	140	140	140

Note: ATMB: ATM banking transactions; MB: mobile banking transactions; IB: internet banking transactions; POSB: POS banking transactions; RANIM: risk-adjusted net interest margin; CAR: capital adequacy ratio; AQ: asset quality; BZ: bank size; BA: bank age; and RD: research & development (RD). The variables are as defined in Table 1. The data is on 14 listed deposit money banks in Nigeria from 2012 to 2021. All variables were converted in rates.
Source: Author's Computation, 2023

represent the underlying patterns and behaviours of the variables under consideration.

Based on the descriptive statistics, it is evident that the banking sector is undergoing significant changes and challenges. The decline in traditional banking transactions and the increasing adoption of digital channels reflect the evolving preferences of customers and the impact of technological advancements. The fluctuations in risk-adjusted net interest margin, capital adequacy ratio, and asset quality highlight the need for banks to enhance risk management practices and maintain financial stability. The non-normal distribution characteristics of most of the variables indicate the presence of outliers and extreme observations. This suggests that the data may not conform to traditional statistical assumptions and calls for robust statistical methods that are better suited for non-normal data analysis.

The correlation analysis provides the correlation coefficients for the association between a pair of variables in the dataset. The result is presented in Table 4.

Table 4 on the correlation statistics of the variables provides insights into the relationships between different factors in the Nigerian deposit money bank sector. ATM banking transactions, mobile banking transactions, internet banking transactions, and POS banking transactions exhibit strong positive correlations among themselves (ranging from 0.9984 to 1.0000). This indicates a high degree of association between these digital banking channels. The strong positive correlations imply that as the usage of one channel increases, the usage of the other channels tends to increase as well. This finding is consistent with the ongoing trend of digitization in the banking sector in Nigeria, where customers are increasingly adopting various digital banking platforms.

The risk-adjusted net interest margin shows weak positive correlations with ATM, mobile, internet, and POS transactions (ranging from 0.1651 to 0.1685). Although these correlations are relatively low, they suggest a modest positive relationship between payment innovation channels and the profitability of banks. This implies that banks with higher digital transaction volumes may experience slightly better risk-adjusted net interest margins. It highlights the potential benefits of leveraging digital banking channels to enhance profitability in the Nigerian banking sector.

The capital adequacy ratio exhibits weak negative correlations with all types of payment innovation channels (ranging from -0.0538 to -0.0599). These correlations suggest that as the usage of digital banking channels increases, banks may experience slightly lower capital adequacy ratios. This finding implies that increased reliance on payment innovation channels may have a slight impact on the capital position of banks. It emphasizes the importance of maintaining adequate capital buffers to support the growth of digital banking services in Nigeria. Asset quality shows weak positive correlations with payment innovation channels (ranging from 0.0201 to 0.0275). This suggests a low positive relationship between the usage of digital channels and the quality of bank assets. The correlations imply that as payment innovation channels increase, there may be a slight improvement in asset quality. This underscores the potential benefits of digital banking in enhancing credit risk management and reducing non-performing loans in the Nigerian banking sector.

Bank age exhibits weak positive correlations with payment innovation channels (ranging from 0.0266 to 0.0277). These correlations suggest a weak association between the age of banks and the usage of payment innovation channels. It indicates that older banks may have slightly higher payment innovation transaction volumes. This finding may reflect the efforts of established banks to adapt to changing customer preferences and invest in digital banking infrastructure. Research and development (R&D) shows weak positive correlations with payment innovation channels (ranging from 0.0447 to 0.0457). These correlations indicate a small positive relationship between R&D investments and the usage of digital channels. Banks that allocate resources to R&D activities may be more inclined to develop and promote digital banking services. This highlights the role of innovation and technological advancements in driving the adoption of digital banking in Nigeria.

Bank size exhibits weak positive correlations with payment innovation channels (ranging from 0.0792 to 0.0814). These correlations suggest a minor positive relationship between the size of banks and the usage of payment innovation channels. Larger banks may have higher digital transaction volumes, potentially due to their greater resources and ability to invest in digital infrastructure. It emphasizes the competitive advantage of larger banks in the digital banking landscape.

The unit root analysis test for the presence or otherwise of stationarity of the variables in the dataset. For robustness, two different panel unit root test comprising of Levin, Lin & Chu

Table 4
Correlation matrix

	ATMB	MB	IB	POSB	RANIM	CAR	AQ	BA	RD	BZ
ATMB	1.0000									
MB	0.9984	1.0000								
IB	0.9991	0.9998	1.000							
POSB	0.9986	0.9999	0.999	1.0000						
RANIM	0.1684	0.1651	0.167	0.1659	1.0000					
CAR	-0.0538	-0.0583	-0.059	-0.0585	0.0162	1.0000				
AQ	0.0201	0.0275	0.025	0.0269	-0.0417	0.1972	1.0000			
BA	0.0277	0.0266	0.027	0.0268	-0.1136	0.2049	0.4459	1.0000		
RD	0.0447	0.0457	0.044	0.0453	0.0894	0.0025	-0.0204	0.0522	1.0000	
BZ	0.0814	0.0792	0.080	0.0795	0.3471	-0.1436	-0.2588	-0.2426	-0.2319	1.0000

Note: ATMB: ATM banking transactions; MB: mobile banking transactions; IB: internet banking transactions; POSB: POS banking transactions; RANIM: risk-adjusted net interest margin; CAR: capital adequacy ratio; AQ: asset quality; BZ: bank size; BA: bank age; and RD: research & development (RD). The variables are as defined in Table 1. The data is on 14 listed deposit money banks in Nigeria from 2012 to 2021. All variables were converted in rates.
Source: Author's Computation, 2023

and Augmented Dickey Fuller (ADF) Fisher chi-square unit root tests were conducted. The tests were conducted based on automatic lag selection. The result is presented in Table 5.

Table 5
Panel unit root test results

Variables	Levin, Lin & Chu		ADF-Fisher χ^2	
	Level	1st Diff.	Level	1st Diff.
ATMB	-3.1615	-12.0002	24.5216	-12.0027
	(0.0008)	(0.0000)	(0.0000)	(0.0000)
MB	-14.5658	-25.2989	111.098	214.284
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
IB	1.9998	-13.7932	3.8763	103.157
	(0.9772)	(0.0000)	(1.0000)	(0.0000)
POSB	-21.2708	-49.0025	34.6287	140.588
	(0.0000)	(0.0000)	(0.1809)	(0.0000)
RANIM	3.5957	-6.9213	8.3002	84.2983
	(0.9998)	(0.0000)	(0.9999)	(0.0000)
CAR	-1.6465	-9.6455	28.9368	110.541
	(0.0498)	(0.0000)	(0.4157)	(0.0000)
AQ	-1.0027	-6.9426	31.5056	-6.9426
	(0.1580)	(0.0000)	(0.2951)	(0.0000)
BA	-0.0278	-7.2410	49.0565	5.4011
	(0.4889)	(0.0000)	(0.0084)	(0.0000)
RD	-3.1538	-10.5451	54.8674	104.398
	(0.0008)	(0.0000)	(0.0018)	(0.0000)
BZ	4.5883	-2.3809	4.5883	40.8787
	(1.0000)	(0.0086)	(1.0000)	(0.0551)

Note: ATMB: ATM banking transactions; MB: mobile banking transactions; IB: internet banking transactions; POSB: POS banking transactions; RANIM: risk-adjusted net interest margin; CAR: capital adequacy ratio; AQ: asset quality; BZ: bank size; BA: bank age; and RD: research & development (RD). The variables are as defined in Table 1. The data is on 14 listed deposit money banks in Nigeria from 2012 to 2021. All variables were converted in rates. *Source: Author's Computation, 2023*

In Table 5, the unit root test results shows evidence of mix stationarity as some variables (ATMB, MB, and RD) are stationary at level while others are non-stationary except at first difference (POSB, IB, BZ, BA, AQ, CAR and RANIM).

B. Empirical Results

The analysis of the objective to determine the bank-specific factors that drive payment innovation within the Nigerian Deposit Money Banks based on panel data is on 14 listed deposit money banks in Nigeria from 2012 to 2021 was carried out using the Difference Generalised Method of Moment (D-GMM) panel estimation technique. The result is presented in Table 6.

In the first model, the coefficient of the lagged dependent variable 0.0008 is not statistically significant (p-value = 0.9596), indicating a lack of association between lagged ATM banking transactions and current transactions. The coefficient is marginal in size, suggesting a minimal impact of lagged transactions on current ATM activity. The coefficient of bank size 33.7100 is statistically significant at the 5% level (p-value = 0.0435). It indicates a positive relationship between bank size and ATM transactions, with an average size effect. Larger banks tend to have higher ATM transaction volumes in Nigeria's deposit money banks.

The coefficient of bank age 0.06504 is statistically significant at the 5% level (p-value = 0.0417). It suggests a positive relationship between bank age and ATM transactions, with a marginal effect. Older banks tend to have slightly higher ATM transaction volumes. The coefficient of research and development 0.6924 is statistically significant at the 5% level (p-value = 0.0273). It indicates a positive relationship between research and development activities and ATM transactions, with a marginal effect. This implies that, banks that invest more

Table 6
Panel D-GMM results

Variables	Model 1: ATMB	Model 2: MB	Model 3: IB	Model 4: POSB
LAG	0.0008	-1.2767	-1.0028	-1.0007
	(0.9596)	(0.0000)	(0.0000)	(0.0000)
	[0.0508]	[-31.0511]	[-3714.756]	[-11.4437]
BZ	33.7100	-0.7153	0.6974	0.0714
	(0.0435)	(0.0658)	(0.0000)	(0.0041)
	[2.0431]	[-1.8263]	[15.2565]	[2.9351]
BA	0.06504	0.1525	-0.0127	-0.0013
	(0.0417)	(0.0000)	(0.0000)	(0.4537)
	[2.0622]	[11.1281]	[-4.5700]	[-0.5521]
RD	0.6924	-0.0790	0.0532	0.0147
	(0.0273)	(0.0538)	(0.0000)	(0.0000)
	[2.2383]	[-1.9541]	[14.4846]	[16.4415]
RANIM	-0.5873	1.2792	-0.1334	-0.0736
	(-0.2417)	(0.0000)	(0.0000)	(0.1528)
	[-1.1773]	[14.6575]	[5.4159]	[-1.4401]
CAR	2.7759	-1.4090	0.1968	-0.0414
	(0.0536)	(0.0004)	(0.0000)	(0.3408)
	[1.9520]	[-3.6447]	[5.4159]	[-0.9570]
AQ	0.6781	0.1120	-0.0097	0.0376
	(0.9059)	(0.2638)	(0.3301)	(0.1309)
	[0.1185]	[1.1256]	[-0.9784]	[1.5226]
J-statistics	1.5709	11.4924	13.7965	13.9164
Prob(J-Stats.)	0.4559	0.0424	0.0549	0.05269
Instrument	9	12	14	14
AR(1)	0.9943	0.0018	0.0154	0.0056
AR(2)	0.0000	0.0139	0.0161	0.0352
F-Statistics	0.0462	0.0000	0.0000	0.0000

Note: ATMB: ATM banking transactions; MB: mobile banking transactions; IB: internet banking transactions; POSB: POS banking transactions; RANIM: risk-adjusted net interest margin; CAR: capital adequacy ratio; AQ: asset quality; BZ: bank size; BA: bank age; and RD: research & development (RD). The variables are as defined in Table 1. The data is on 14 listed deposit money banks in Nigeria from 2012 to 2021. All variables were converted in rates.
Source: Author's Computation, 2023

in research and development tend to have slightly higher ATM transaction volumes. The coefficient of risk-adjusted net interest margin -0.5873 is not statistically significant (p-value = 0.2417), implying a lack of association between the risk-adjusted net interest margin and ATM transactions. The coefficient is small in size, suggesting a minimal insignificant impact of the net interest margin on ATM activity.

The coefficient of capital adequacy ratio 2.7759 is marginally significant at the 5% level (p-value = 0.0536). It suggests a positive relationship between the capital adequacy ratio and ATM transactions, with an average size effect. This suggests that banks with higher capital adequacy ratios tend to have slightly higher ATM transaction volumes. The coefficient of asset quality 0.6781 is not statistically significant (p-value = 0.9059), indicating a lack of association between asset quality and ATM transactions. The coefficient is small in size, suggesting a minimal impact of asset quality on ATM activity.

The J-statistics and their corresponding probability values indicate the goodness-of-fit of the models. The J-statistics for all models have p-values above 0.05, suggesting that the null hypothesis of no serial correlation cannot be rejected. This indicates that the models adequately capture the serial correlation in the data.

The instrument counts (9, 12, 14, & 14) represent the number of instrumental variables used in each model. The AR(1) and AR(2) statistics provide information about the presence of autocorrelation in the models. The F-statistics are used to assess the overall significance of the models. In this case, all the F-statistics have p-values close to zero, indicating that the models as a whole are statistically significant.

In the second model, the analysis focused on the relationship between various variables and mobile banking transactions in Nigeria's deposit money banks. The coefficient of the lagged dependent variable is -1.2767, which is statistically significant at the 5% level (p-value = 0.0000). This indicates a negative relationship between previous mobile banking transactions and current transactions. The large coefficient suggests that past mobile banking activity has a substantial impact on current usage. The coefficient of bank size is -0.7153, which is marginally significant at the 5% level (p-value = 0.0658). It suggests a negative relationship between bank size and mobile banking transactions, indicating that larger banks tend to have slightly lower transaction volumes in the mobile banking sector

The coefficient of bank age is 0.1525, which is statistically significant at the 5% level (p-value = 0.0000). It indicates a positive relationship between bank age and mobile banking transactions, suggesting that older banks have significantly higher transaction volumes in the mobile banking sector. Research and Development (R&D) with coefficient of -0.0790, is marginally significant at the 5% level (p-value = 0.0538). It suggests a negative relationship between R&D activities and mobile banking transactions, indicating that banks investing more in research and development tend to have slightly lower transaction volumes in the mobile banking sector.

The coefficient of the risk-adjusted net interest margin is 1.2792, which is statistically significant at the 5% level (p-value = 0.0000). It indicates a positive relationship between the risk-adjusted net interest margin and mobile banking transactions, implying that banks with higher net interest margins tend to have significantly higher transaction volumes in the mobile banking sector. The coefficient of the capital adequacy ratio is -1.4090, which is statistically significant at the 5% level (p-value = 0.0004). It suggests a negative relationship between the capital adequacy ratio and mobile banking transactions, indicating that banks with higher capital adequacy ratios tend to have significantly lower transaction volumes in the mobile banking sector. Asset Quality is another variable examined. The coefficient of asset quality is 0.1120, which is not statistically significant (p-value = 0.2638). This implies an insignificant relationship between asset quality and mobile banking transactions.

Furthermore, the model's diagnostic tests indicate that there is no evidence of residual autocorrelation, as suggested by the J-statistics value of 11.4924 at the 5% significance level. The inclusion of relevant variables as instruments (12 in total) helps control for endogeneity and enhances the validity of the results. The AR(1) and AR(2) coefficients suggest a very low level of autocorrelation in the model's residuals. Finally, the F-Statistics value of 0.0000 indicates that the overall model is statistically significant at the 5% level, implying that the independent variables collectively have a significant impact on mobile banking transactions.

In the third model, the analysis focused on the relationship between various variables and internet banking transactions in Nigeria's deposit money banks. The coefficient of lagged internet banking transactions is -1.0028, which is statistically significant at the 5% level (p-value = 0.0000). This indicates a negative relationship between previous internet banking transactions and current transactions. The large coefficient suggests that past usage has a significant impact on current internet banking activity. The analysis reveals that bank size has a positive and statistically significant relationship with internet banking transactions. The coefficient of bank size is 0.6974 (p-value = 0.0000), indicating that larger banks tend to experience significantly higher transaction volumes in the internet banking sector.

On the other hand, the coefficient of bank age is -0.0127 (p-value = 0.0000), showing a negative and statistically significant relationship between bank age and internet banking transactions. This suggests that older banks have slightly lower transaction volumes in the internet banking sector. Furthermore, the coefficient of research and development (R&D) activities is 0.0532 (p-value = 0.0000), signifying a positive and statistically significant relationship with internet banking transactions. This implies that banks that invest more in research and development tend to observe slightly higher transaction volumes in the internet banking sector. The coefficient of the risk-adjusted net interest margin is -0.1334, which is statistically significant at the 5% level (p-value = 0.0000). It indicates a negative relationship between the risk-adjusted net interest margin and internet banking transactions, suggesting that banks with higher net interest margins tend to have slightly lower transaction volumes in the internet banking sector

The coefficient of the capital adequacy ratio is 0.1968, which is statistically significant at the 5% level (p-value = 0.0000). It suggests a positive relationship between the capital adequacy ratio and internet banking transactions, indicating that banks with higher capital adequacy ratios tend to have slightly higher transaction volumes in the internet banking sector. The coefficient of asset quality is -0.0097, which is not statistically significant (p-value = 0.3301). This implies a lack of association between asset quality and internet banking transactions.

Furthermore, the model's diagnostic tests indicate no evidence of residual autocorrelation, as suggested by the J-statistics value of 13.7965 at the 5% significance level. The inclusion of relevant variables as instruments (14 in total) helps control for endogeneity and enhances the validity of the results. The AR(1) and AR(2) coefficients suggest a low level of autocorrelation in the model's residuals, but the coefficients are relatively small, indicating that the residuals are not significantly correlated over time. Finally, the F-Statistics value of 0.0000 indicates that the overall model is statistically significant at the 5% level, implying that the independent variables collectively have a significant impact on internet banking transactions.

In the fourth model, which examined POS banking transactions, the findings revealed several important insights. First, the coefficient of lagged POS banking transactions (-1.0007) was statistically significant at the 5% level (p-value = 0.0000), indicating a negative relationship between past POS transactions and current transactions. This suggests that the volume of POS banking transactions is influenced by previous usage, with a substantial impact of past activity on the present. Furthermore, the coefficient of bank size (0.0714) was statistically significant at the 5% level (p-value = 0.0041), indicating a positive relationship between bank size and POS banking transactions. Larger banks tended to have slightly higher transaction volumes in the POS banking sector within Nigeria's deposit money banks. On the other hand, the coefficient of bank age (-0.0013) was not statistically significant (p-value = 0.4537), suggesting a lack of association between bank age and POS banking transactions.

The coefficient of research and development (0.0147) was statistically significant at the 5% level (p-value = 0.0000), indicating a positive relationship between research and development activities and POS banking transactions. Banks that invested more in research and development tended to have slightly higher transaction volumes in the POS banking sector. However, the coefficient of risk-adjusted net interest margin (-0.0736) and the coefficient of capital adequacy ratio (-0.0414) were not statistically significant (p-values = 0.1528 and 0.3408, respectively), suggesting a lack of association between these variables and POS banking transactions. Additionally, the coefficient of asset quality (0.0376) was statistically significant at the 5% level (p-value = 0.0309), indicating a positive relationship between asset quality and POS banking transactions. Banks with better asset quality tended to have slightly higher transaction volumes in the POS banking sector.

The model's goodness of fit was supported by the J-statistics value of 13.9164, suggesting no evidence of residual autocorrelation at the 5% significance level. The inclusion of 14 relevant variables as instruments controlled for endogeneity and enhanced the validity of the results. Moreover, the low AR(1) coefficient of 0.0056 and AR(2) coefficient of 0.0352 indicated a minimal level of autocorrelation in the model's residuals. Lastly, the overall model was statistically significant at the 5% level, as indicated by the F-Statistics value of 0.0000. This implies that the independent variables collectively have a significant impact on POS banking transactions.

C. *Discussion of Findings*

The empirical findings have several implications for the ATM payment channel. The significant positive effect of bank size, bank age, research and development (R&D), and the capital adequacy ratio on ATM transactions indicates their importance in promoting and facilitating the usage of ATMs in Nigeria's deposit money banks. The positive effect of bank size on ATM transactions aligns with the economies of scale theory. Larger banks often have a wider network of ATMs, making them more accessible to customers, and this can lead to increased ATM usage. This aligns with the research findings reported by Muthinja and Chipeta (2017) and Agwu (2016). Moreover, larger banks may have more resources to invest in ATM infrastructure, maintenance, and technological advancements, which can enhance the convenience and reliability of ATM services.

The positive effect of bank age on ATM transactions suggests that older banks have accumulated more experience, customer trust, and a well-established customer base over time. Customers may have a higher level of familiarity and trust in older banks, leading to increased ATM usage. This is confirmed by the previous findings of Zhang et al., 2020. The positive effect of research and development (R&D) on ATM transactions indicates that DMBs that invest in innovation and technological advancements are likely to attract more customers to use their ATMs. This finding is in line with studies highlighting the importance of technological innovation in driving the adoption and usage of electronic payment channels (Dwivedi et al., 2017 and Muthinja & Chipeta, 2017). Continuous investments in R&D can lead to the development of user-friendly interfaces, enhanced security features, and innovative functionalities that encourage customers to prefer ATMs for their banking needs.

The significant positive effect of the capital adequacy ratio on ATM transactions implies that banks with higher capital adequacy are more capable of expanding their ATM network and providing better ATM services. A strong capital base enables banks to invest in ATM infrastructure, deploy ATMs in strategic locations, and maintain a high level of service quality, thereby attracting more customers to use ATMs for their banking transactions. The weaker or insignificant effect of lagged payment channel, risk-adjusted net interest margin, and asset quality on ATM transactions suggests that these factors may have less direct influence on customer preferences for ATM usage. However, it is important to note that the lack of significance does not necessarily indicate their insignificance in the broader context of banking operations and customer preferences (Sanni, Salami & Uthman, 2020). For instance, while lagged payment channel usage may not directly impact current ATM usage, it could indirectly influence customer behaviour through habit formation or network effects. It is worth considering that the implications drawn from these empirical findings provide insights into the factors that contribute to the adoption and usage of ATMs in a Nigerian context, and they can inform DMBs' strategies to enhance ATM services and promote customer engagement.

5. Conclusion and Recommendations

This study concludes that payment innovation in Nigerian Deposit Money Banks (DMBs) is influenced by bank-size, research and development and regulatory capital. Based on the findings and conclusion of this study, the following recommendations are made to various stakeholders in the finance and banking industry: Recognise the importance of bank-specific factors such as bank size, age, research and development activities, and capital adequacy ratio in driving payment innovation. Foster a supportive regulatory environment that encourages and facilitates payment innovation in DMBs. Work closely with banks and policymakers to develop policies that promote the adoption of innovative payment solutions.

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