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Regulatory Dynamics and Technological Advancements in Nigeria's E-Payment Ecosystem

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Abstract

Nigeria's e-payment ecosystem has grown rapidly through fintech innovation, mobile adoption, and reforms by the Central Bank of Nigeria. While this expansion has improved efficiency and financial access, it has also created risks such as cybersecurity threats, data privacy issues, and interoperability challenges. The study evaluates how current regulations address these risks while balancing innovation with financial stability. The study specifically investigates the role of blockchain for settlement, artificial intelligence for fraud detection, and open APIs for open banking in improving efficiency without compromising security. It also assesses the effectiveness of key regulatory interventions, particularly the eNaira and regulatory sandbox initiatives, in promoting financial inclusion among under-served and rural populations. Using a survey research design on a population of 377, the study applies Structural Equation Modelling to examine regulatory and technological developments. Findings indicate that although regulatory frameworks have improved oversight and risk management, enforcement gaps, infrastructural deficits, and limited digital literacy constrain their effectiveness. Emerging technologies show strong potential to enhance transparency and fraud control, but require clearer regulatory guidance and technical capacity building. while the eNaira and sandbox trials have stimulated innovation, their impact on deepening financial inclusion remains limited. The study recommends strengthening cybersecurity enforcement, improving interoperability standards, enhancing digital literacy, and ensuring continuous regulatory adaptation to foster secure, inclusive, and sustainable growth in Nigeria's e-payment ecosystem.

Keywords: *Regulatory Dynamics, Technological Advancements, Digital economy & E-Payment Ecosystem*

Introduction

The evolution of electronic payment systems has transformed the global financial landscape, redefining how individuals, businesses, and governments conduct transactions. Across both developed and emerging economies, digital payment platforms have reduced reliance on cash, improved transaction speed, enhanced transparency, and broadened access to financial services (Ozili, 2018; World Bank, 2022b). In Nigeria, the growth of the digital economy, rapid mobile phone penetration, and increased internet access have accelerated the adoption of electronic payment channels such as mobile banking, point-of-sale (POS) systems, automated teller machines (ATMs), and online transfer platforms (Akinwale, 2020). Institutions such as the Central Bank of Nigeria and the Nigeria Inter-Bank Settlement System have played pivotal roles in developing, regulating, and supervising the national payments infrastructure (CBN, 2021a; NIBSS, 2022).

Over the past decade, Nigeria's e-payment ecosystem has witnessed remarkable expansion, driven largely by fintech innovation and supportive regulatory initiatives. The introduction of policies such as the cashless policy, payment service bank licensing framework, and open

banking guidelines has encouraged competition and innovation within the financial sector (CBN, 2020; Enhancing Financial Innovation & Access [EFInA], 2021). Fintech companies have leveraged emerging technologies including blockchain for transaction settlement, artificial intelligence (AI) for fraud detection, and application programming interfaces (APIs) for system interoperability to deliver faster, more inclusive, and customer-centric services (PwC, 2022; Deloitte, 2021a). These advancements have contributed significantly to financial inclusion, particularly among previously unbanked and underbanked populations (Demirgüç-Kunt et al., 2022).

However, the rapid expansion of digital payment platforms has introduced complex regulatory and operational challenges. Cybersecurity threats, data privacy breaches, identity theft, and system vulnerabilities have become increasingly prominent concerns (KPMG, 2022a). As financial transactions migrate to digital channels, regulators face the dual responsibility of fostering innovation while safeguarding financial stability and consumer protection (Arner, Barberis, & Buckley, 2017). Ensuring interoperability among diverse fintech platforms and traditional banking institutions further complicates regulatory oversight and compliance (CBN, 2021a). Consequently, the adequacy of existing regulatory frameworks in responding to evolving technological risks remains a critical issue for policy and academic discourse.

Recent regulatory interventions have further reshaped Nigeria's digital payment landscape. The launch of the eNaira as Nigeria's Central Bank Digital Currency (CBDC) marked a significant milestone in Africa's digital finance journey, aimed at improving payment efficiency, reducing transaction costs, and promoting financial inclusion (CBN, 2021). Similarly, the introduction of regulatory sandbox frameworks by the Central Bank provides a controlled environment for fintech experimentation, enabling innovation while mitigating systemic risks (CBN, 2020). These measures reflect an evolving regulatory philosophy that seeks to balance prudential supervision with technological advancement.

Despite these initiatives, debates persist regarding the extent to which Nigeria's regulatory environment effectively supports innovation without constraining growth. Some studies argue that stringent compliance requirements may increase operational costs for fintech startups and slow technological experimentation (Ozili, 2020a), while others emphasize the necessity of robust regulation to manage cybersecurity, data governance, and operational resilience risks (World Bank, 2022a). At the same time, concerns remain about whether regulatory mechanisms are sufficiently adaptive to emerging technologies such as blockchain-based settlement systems, AI-driven fraud analytics, and open banking APIs.

Against this backdrop, examining the interplay between regulatory dynamics and technological advancements in Nigeria's e-payment ecosystem is both timely and necessary. Understanding how current regulatory frameworks address emerging risks, support promising technologies, and advance financial inclusion will provide valuable insights for policymakers, financial institutions, fintech operators, and other stakeholders seeking to strengthen Nigeria's digital financial infrastructure and ensure sustainable growth in the digital payments landscape.

Statement of the problem

Nigeria's e-payment ecosystem has expanded significantly in recent years, fueled by fintech innovation, increased mobile penetration, and regulatory reforms spearheaded by the Central Bank of Nigeria (CBN, 2021b). Digital financial services including mobile transfers, POS

payments, and instant settlement platforms have enhanced transaction efficiency and contributed to financial inclusion (NIBSS, 2022; Demirgüç-Kunt et al., 2022). However, the rapid digitization of financial services has introduced complex risks such as cybersecurity threats, data privacy breaches, fraud, and operational vulnerabilities (KPMG, 2022a). These developments create a broader regulatory challenge: how to maintain financial stability and consumer protection while simultaneously encouraging innovation and competition within Nigeria's evolving digital payments landscape (Arner, Barberis, & Buckley, 2017).

More specifically, concerns persist regarding whether existing regulatory frameworks adequately address emerging technological risks and support the integration of innovative solutions such as blockchain-based settlement systems, artificial intelligence-driven fraud detection, and open banking APIs (PwC, 2022; Deloitte, 2021b). While regulatory measures including sandbox initiatives and digital currency interventions like the eNaira have been introduced to foster innovation and inclusion (CBN, 2020; CBN, 2021a), questions remain about their effectiveness in promoting interoperability, reducing compliance burdens, and extending financial services to under-served and rural populations (EFInA, 2021; World Bank, 2022b). There is uncertainty as to whether regulatory policies are sufficiently adaptive to technological change or inadvertently constrain fintech growth through stringent requirements and regulatory overlaps (Ozili, 2020a).

Despite increasing policy attention and sectoral growth, there remains a notable empirical gap in systematically evaluating how Nigeria's regulatory dynamics influence technological advancement within the e-payment ecosystem. Existing studies often examine financial inclusion or fintech innovation in isolation, with limited integrated analysis of how regulatory frameworks simultaneously shape risk management, innovation adoption, and inclusion outcomes. Consequently, there is insufficient evidence on whether current regulations strike an optimal balance between fostering innovation and mitigating systemic risk. This study seeks to address this gap by critically assessing how Nigeria's regulatory environment supports or constrains technological advancements in digital payments and their implications for efficiency, security, and financial inclusion.

Objective of the Study

The overall objective of this study is to examine Regulatory Dynamics and Technological Advancements in Nigeria's E-Payment Ecosystem. Specifically, the study aims to achieve the following objectives, namely to:

i. examine how current regulatory measures address emerging risks in electronic payments, including cybersecurity threats, data privacy challenges, and interoperability issues across fintech platforms.
ii. identify promising technologies such as blockchain for settlement, artificial intelligence for fraud detection, and open application programming interfaces (APIs) for open banking, and assess how they can enhance efficiency without compromising security.
iii. assess the effectiveness of regulatory interventions, such as the launch of the eNaira and the implementation of sandbox trials in advancing financial inclusion, particularly among under-served and rural populations.

Research Questions

The research will address the following questions:

i. How do Nigeria's regulatory interventions influence innovation in the e-payment sector?
ii. What are the perceived regulatory barriers to fintech adoption among under-served populations?
iii. How effective are instruments like the regulatory sandbox and eNaira in promoting financial inclusion?

Conceptual Review

E-Payment Ecosystems and Regulatory Dynamics

The electronic payment (e-payment) ecosystem refers to the interconnected network of financial institutions, fintech firms, payment service providers, regulators, technological infrastructure, and end-users that facilitate digital financial transactions (Ozili, 2018). Globally, digital payments have transformed financial intermediation by improving transaction speed, reducing cash dependency, and expanding financial access (Demirgüç-Kunt et al., 2022). In emerging economies, the expansion of digital financial services is often closely linked to regulatory reforms that shape market entry, risk management, and consumer protection standards (Arner, Barberis, & Buckley, 2017).

In Nigeria, the regulatory architecture of the e-payment ecosystem is primarily overseen by the Central Bank of Nigeria, in collaboration with institutions such as the Nigeria Inter-Bank Settlement System. The CBN has introduced multiple frameworks including the cashless policy, Payment Service Bank (PSB) guidelines, open banking regulations, and cybersecurity frameworks to promote innovation while ensuring financial system stability (CBN, 2020; CBN, 2021b). Regulatory dynamics in this context refer to the evolving nature of rules, supervisory mechanisms, and policy responses aimed at balancing innovation with risk mitigation (Ozili, 2020a).

Arner et al. (2017) argue that financial regulation in the fintech era must move from static rule-based supervision to adaptive and technology-informed oversight. This perspective underscores the importance of regulatory flexibility, particularly in fast-evolving digital markets such as Nigeria's.

Regulatory Measures and Emerging Risks in Electronic Payments

The rapid growth of electronic payments has been accompanied by increased exposure to cybersecurity risks, fraud, identity theft, and data privacy breaches (KPMG, 2022a). Digital financial platforms are particularly vulnerable to cyberattacks due to interconnected systems and high transaction volumes. According to the World Bank (2022a), weak cybersecurity infrastructure and inadequate consumer awareness amplify systemic vulnerabilities in emerging markets.

In Nigeria, rising incidents of electronic fraud have intensified regulatory attention on cybersecurity compliance and data protection (NIBSS, 2022). The CBN's risk-based cybersecurity framework seeks to strengthen institutional resilience through mandatory security standards and reporting obligations (CBN, 2021b). However, scholars argue that regulatory measures often lag behind technological advancements, creating enforcement gaps (Ozili, 2020a).

Data privacy is another critical issue. As digital payment systems rely heavily on customer data analytics, concerns about data misuse and breaches have grown significantly (Deloitte, 2021b). Effective regulation must therefore ensure that fintech innovation does not compromise consumer trust. Arner et al. (2017) emphasize that maintaining trust is fundamental to sustaining digital financial ecosystems.

Interoperability across fintech platforms also presents regulatory challenges. Fragmented systems can limit seamless transactions and reduce efficiency (PwC, 2022). The CBN's open banking framework is intended to address these concerns by promoting standardized APIs and secure data sharing (CBN, 2021b). Nevertheless, implementation challenges remain, particularly regarding compliance costs and coordination among stakeholders.

Technological Advancements in Nigeria's Digital Payments Landscape

Technological innovation is central to the evolution of Nigeria's e-payment ecosystem. Blockchain technology, for instance, offers decentralized transaction validation and enhanced transparency, potentially reducing settlement risks and transaction costs (PwC, 2022). Scholars argue that blockchain-based settlement systems can improve cross-border payments and strengthen audit trails (Deloitte, 2021a). However, regulatory uncertainty surrounding distributed ledger technologies may slow adoption (Ozili, 2020a).

Artificial intelligence (AI) has also emerged as a transformative tool in fraud detection and risk analytics. AI-driven systems analyze transaction patterns in real time to detect anomalies and prevent fraudulent activities (KPMG, 2022a). This enhances operational efficiency and strengthens consumer protection. However, the deployment of AI raises regulatory concerns about algorithmic bias, accountability, and data governance (World Bank, 2022a).

Open Application Programming Interfaces (APIs), central to open banking frameworks, facilitate secure data exchange between banks and fintech firms. Open banking promotes competition, innovation, and improved customer experience (CBN, 2021b). Yet, scholars caution that inadequate regulatory clarity regarding liability and security standards may hinder full integration (Arner et al., 2017).

Regulatory Interventions and Financial Inclusion

Financial inclusion remains a core objective of Nigeria's digital payment reforms. Digital financial services have been shown to expand access to savings, credit, and remittance services among underserved populations (Demirgüç-Kunt et al., 2022). In Nigeria, regulatory initiatives such as agent banking and Payment Service Banks aim to extend financial services to rural and unbanked communities (EFInA, 2021).

The introduction of the eNaira marked a significant milestone in Nigeria's digital finance evolution. As Africa's first central bank digital currency, the eNaira was designed to enhance payment efficiency, reduce transaction costs, and deepen financial inclusion (CBN, 2021a). While initial adoption rates were modest, policymakers view the initiative as a long-term infrastructure investment in digital finance.

Regulatory sandbox initiatives also represent an important policy innovation. Sandboxes provide controlled environments for fintech experimentation under regulatory supervision (CBN, 2020). According to Arner et al. (2017), regulatory sandboxes enable innovation while

minimizing systemic risk. However, empirical evidence on their long-term effectiveness in emerging markets remains limited.

Despite these efforts, financial exclusion persists, particularly in rural areas where infrastructure deficits, low digital literacy, and trust barriers limit adoption of digital financial services (EFInA, 2021; World Bank, 2022b). This suggests that regulatory intervention alone may be insufficient without complementary investments in infrastructure and consumer education.

Theoretical Review

This study is anchored on the theory of Regulatory Balancing and Innovation Diffusion Theory.

Regulatory Balancing Theory posits that regulators must strike an optimal equilibrium between fostering innovation and ensuring stability (Arner, Barberis & Buckley, 2017). Asserts that excessive regulation may suppress innovation, while weak regulation may expose the financial system to systemic risk. They argue that regulators must strike an optimal equilibrium between fostering innovation and ensuring financial stability and consumer protection. According to Arner, Barberis, and Buckley (2017), excessive regulation may suppress innovation by increasing compliance burdens and discouraging market entry, while weak or delayed regulation may expose the financial system to systemic risk, fraud, and instability. Their reconceptualization of financial regulation in the fintech era emphasizes adaptive, technology-informed, and proportionate regulatory approaches.

Innovation Diffusion Theory

Innovation Diffusion Theory (Rogers, 2003) explains how new technologies are adopted over time within a social system. The adoption of block-chain, AI, and open banking in Nigeria depends on perceived relative advantage, compatibility, regulatory support, and user trust. Regulatory clarity and institutional credibility significantly influence the rate of innovation diffusion.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM) (Davis, 1989) posits that perceived usefulness and perceived ease of use determine technology adoption. Studies in Nigeria, such as those by Ayo et al. (2011), have applied TAM to analyze user adoption of e-payment platforms like POS systems, mobile banking, and USSD transactions. Regulatory trust and security measures enhance adoption by reducing perceived risks.

Empirical review

This section reviews empirical studies relevant to regulatory dynamics, technological innovation, and financial inclusion within electronic payment ecosystems, guided by the study's objectives.

i) Regulatory Measures and Emerging Risks in Electronic Payments

Empirical evidence suggests that the rapid expansion of digital payments often outpaces regulatory adaptation, creating vulnerabilities in cybersecurity and consumer protection. Ozili

(2018), in a cross-country analysis of digital finance and financial stability, found that while digital financial services improve inclusion and efficiency, weak regulatory oversight increases exposure to systemic risk and cyber fraud. Similarly, Arner, Barberis, and Buckley (2017), in their empirical examination of fintech regulatory responses across jurisdictions, observed that emerging markets frequently adopt reactive regulatory approaches, which may lead to enforcement gaps in areas such as data privacy and cybersecurity.

In Nigeria, transaction data from the Nigeria Inter-Bank Settlement System (2022) show a consistent rise in electronic transactions alongside reported cases of electronic fraud. Empirical assessments indicate that fraud incidents correlate positively with transaction volumes, highlighting the need for stronger cybersecurity compliance frameworks. KPMG (2022) reported that financial institutions with integrated risk-based cybersecurity systems experienced lower fraud-related losses compared to those with fragmented compliance structures.

Furthermore, a study by Enhancing Financial Innovation & Access (EFInA, 2021) found that while digital payment adoption increased significantly in urban areas, concerns about fraud and data misuse reduced trust among rural users. These findings underscore the empirical link between regulatory effectiveness, consumer confidence, and sustained adoption of digital payment services. However, existing studies often focus on risk trends without systematically evaluating whether current regulatory frameworks adequately address interoperability and emerging fintech risks in Nigeria.

ii) Emerging Technologies and Efficiency–Security Trade-offs

Empirical studies show that technological innovation enhances operational efficiency in digital payments but introduces new governance challenges. Deloitte (2021), in a survey of African fintech firms, reported that blockchain-based settlement systems reduced reconciliation time and transaction costs in pilot programs. However, regulatory uncertainty regarding distributed ledger technology was identified as a key barrier to full-scale adoption.

Similarly, PwC (2022) found that Nigerian fintech firms deploying artificial intelligence (AI) for fraud detection achieved faster anomaly detection and improved transaction monitoring accuracy. The study demonstrated that AI-driven fraud analytics reduced false-positive transaction flags by improving predictive accuracy. Nevertheless, firms reported challenges related to regulatory approval processes and compliance costs associated with algorithm validation and data protection requirements.

Open banking and API integration have also been empirically linked to increased competition and service innovation. Evidence from jurisdictions with open banking frameworks suggests that standardized APIs improve interoperability and customer data portability (World Bank, 2022a). In Nigeria, the Central Bank of Nigeria's open banking guidelines have encouraged fintech–bank collaboration. However, empirical evidence on implementation outcomes remains limited, particularly regarding rural and small-scale fintech participation.

Collectively, these studies suggest that while blockchain, AI, and open APIs enhance efficiency and security, regulatory clarity and proportional compliance requirements significantly influence their diffusion and effectiveness.

iii). Regulatory Interventions and Financial Inclusion Outcomes

Financial inclusion remains a central objective of Nigeria's digital payment reforms. Demirgüç-Kunt et al. (2022), using Global Findex data, found that digital payments significantly increased account ownership and transaction frequency in developing economies. In Nigeria, EFInA (2021) reported improvements in formal financial access rates following the expansion of mobile money and agent banking frameworks.

The introduction of the eNaira represents a major regulatory intervention aimed at deepening inclusion and enhancing payment efficiency. According to the Central Bank of Nigeria (2021), the eNaira was designed to reduce remittance costs, support government transfers, and extend financial services to unbanked populations. However, early empirical assessments suggest modest adoption levels, largely attributed to limited public awareness, digital literacy gaps, and infrastructural challenges (World Bank, 2022b).

Regulatory sandbox initiatives have also been empirically examined. Arner et al. (2017) found that sandbox frameworks in emerging markets facilitate experimentation and reduce entry barriers for fintech startups. However, they caution that sandboxes must be transparent and inclusive to avoid favoring established firms over smaller innovators. In Nigeria, preliminary evaluations indicate that sandbox participation has encouraged product testing but has not yet generated sufficient large-scale impact on rural financial inclusion (CBN, 2020a).

Overall, empirical findings indicate that regulatory interventions positively influence financial innovation and inclusion when complemented by infrastructure development, consumer education, and trust-building mechanisms. However, limited longitudinal and integrative studies exist that assess the combined impact of cybersecurity regulation, emerging technologies, and targeted inclusion policies within Nigeria's e-payment ecosystem.

Empirical Gap

The reviewed empirical literature reveals three major gaps. First, many studies assess cybersecurity risks or financial inclusion independently, with limited integrated analysis of how regulatory frameworks simultaneously shape innovation adoption and risk mitigation. Second, while evidence exists on the benefits of AI, blockchain, and open banking globally, there is insufficient Nigeria-specific empirical evaluation linking these technologies to regulatory compliance outcomes. Third, the effectiveness of interventions such as the eNaira and sandbox frameworks in achieving measurable financial inclusion outcomes remains underexplored in academic literature.

Therefore, this study seeks to fill these gaps by empirically examining how regulatory dynamics influence technological advancements and financial inclusion within Nigeria's e-payment ecosystem, thereby contributing to both fintech regulation scholarship and policy development discourse.

Methodology

Research Design

This research adopted a survey approach. The qualitative aspect involved questionnaire administered on key stakeholders, including officials from the Central Bank of Nigeria and leaders from fintech companies such as Interswitch, Paystack, and Moniepoint.

Quantitatively, the study analyzed data obtained from the survey. Structural Equation Modelling was used to measure the relationship between policy changes, indicators of innovation, including the number of fintech patents and regulatory policies.

Population and Sample Size

The population of this study comprises three primary categories: (1) regulatory officials from the Central Bank of Nigeria and associated bodies (e.g., NeFF), (2) representatives of licensed fintech companies, including Mobile Money Operators (MMOs), Payment Terminal Service Providers (PTSPs), and Payment Service Banks (PSBs), and (3) consumers of digital financial services across Nigeria. The sample will include 10 regulatory officials, 52 representatives from fintech organizations selected purposively for their market relevance, and 315 consumer respondents across five geopolitical zones, selected using stratified sampling to ensure representativeness. This yields a total sample size of 377 participants.

Participation and Procedure

This research systematically focuses on CBN, fintech and consumers of digital financial services since they are the hub of the Nigerian e-payment. As such, the survey research design was used. The target participants were purposively selected. The snowball sampling technique was employed. The primary instrument that was used in this study is a structured questionnaire. The questionnaire was designed on a 5-point Likert scale. The Likert scale is chosen to allow for a more significant distinction of the intensity of the respondents' feelings and opinions regarding the issue in question. The hypotheses were tested using Structural Equation Modelling.

Table 1. Participants profile

Profile	Response	No.	Percent
Gender	Male	214	57
	Female	163	43
Total		**377**	**100**
Age Distribution	30 – 40 years	130	34.4
	41 – 50 years	140	37.1
	51 – 60 years	75	20
	61 and above	32	8.4
Total		**377**	**100**
Educational Qualification	SSCE	52	14
	ND/NCE	90	24
	B.Sc/BA/B.Ed/HND	110	29
	M.Sc/MA/MBA	118	31
	PhD	7	2
Total		**377**	**100**
Participants	Regulatory Officials	10	3
	Fintech Representatives	152	40
	consumers	215	57
Total		**377**	**100**

Source: Field Survey (2026)

Table 1a shows the respondents' gender, where 214 respondents (57%) were males, while 163 respondents (43%) were females. This implies that the majority of the respondents were male.

The table1b indicates the age brackets of the respondents. The result shows that 130 respondents (34.4%) were between 30 – 40 years of age; 140 respondents (37.1%) were

between 41 – 50 years of age; 75 respondents (20%) were between 51 – 60 years of age, and 32 respondents (8.4%) were 61 years and above. This shows that most of the respondents in the study area were between 41 – 50 years of age.

The table1c reveals the educational qualifications of respondents. It shows that 52 respondents (14%) were SSCE holders, 90 respondents (24%) were ND/NCE holders; 110 respondents (29%) were B.Sc/BA/B.Ed/HND holders: 118 respondents (31 %) had M.Sc/MA/MBA; 7 were PhD holders, representing (2.%).The implication is that most respondents in the study area were B.Sc/BA/B.Ed/HND holders.

Table 1d shows the types of categories of participants. It indicates that 10 respondents (3%) were regulatory officials, 152 respondents (40%) were Fintech representatives, 521 respondents (57%) were consumers. It shows that the majority of the respondents were in consumers of financial services.

Validity and Reliability of Instrument

Uzoagulu (2011) asserts that the accuracy of a measurement tool determines its suitability in gauging the intended parameters. This study specifically employed content validity. This was also triangulated with a thorough pre-test conducted using the Structural Equation Model (SEM) within the Amos framework. This meticulous approach ensured that the survey questions effectively measured the intended variables and could yield reliable results. The choice of utilising the Structural Equation Model from Amos reflects the need to ensure a scientifically rigorous validation process. By leveraging this analytical tool, the study aimed to enhance the precision and credibility of its findings, reinforcing the confidence in the instrument's ability to capture and measure the targeted constructs accurately.

Internal consistency reliability was adopted to establish the reliability of the instrument. The assessment of internal consistency was conducted using a statistical measure known as Cronbach's coefficient alpha. Creswell (2003) posits that reliability coefficients of 0.70 or higher indicate high reliability. In Table 2, we present the results of the internal consistency and accuracy of the instruments' constructs.

Table 2. Validation of Instrument

S/N	Question Items	A	Factor Loading	SE	AVE	CR
	Emerging risks in e-payment	.982			0.935	0.967
1	ER1		1.000	-		
2	ER2		.957	.016		
3	ER3		.943	.012		
	Promising technologies	.986			0.966	0.983
4	PT1		1.005	.006		
5	PT2		.943	.018		
6	PT3		1.000			
	Regulatory interventions	.990			0.893	0.987
7	RI1		1.031	.011		
8	RI2		1.032	.015		
9	RI3		.962	.014		
10	RI4		1.000	-		

	Level of E-payment	.957			0.826	0.967
11	EP1		1.000	.042		
12	EP2		0.976	.043		
13	EP		0.967	.044		
14	EP4		1.000	-		
	Cybersecurity threats	.993			0.972	0.986
15	CST1		1.000	.010		
16	CST2		.976	.013		
17	CST3		.967	.015		
18	CST4		1.000	-		
	Fraud Detection	.991			0.966	0.983
19	FD1		1.000	-		
20	FD2		.979	.011		
21	FD3		.969	.009		
	Data privacy challenges	.951			0.962	0.981
22	DPC1		1.000	-		
23	DPC2		.961	.034		
	Growth of Electronic payment	.986			0.985	0.980
24	GEP1		1.000	-		
25	GEP2		0.934	.016		
26	GEP3		0.947	.013		
	Financial Inclusion	.985			0.929	0.914
27	FI1		1.000	-		
27	FI2		0.934	.017		
28	FI3		0.939	.019		

Source: AMOS SPSS, 2026

In Table 2, we present the results of the validation of the instrument, assessing the factor loadings, standard errors (SE), average variance extracted (AVE), and composite reliability (CR) for each question item within the identified constructs. The factor loading of 1.000, 0.957 and 0.943 indicate a high level of correlation between the items and the perceived level of emerging risk. The composite reliability is 0.967, suggesting good internal consistency. ER1, ER2, and ER3 show factor loadings of ,957 0.943, and 1.000, respectively, indicating a strong correlation with the perceived level of regulatory interventions. The composite reliability is 0.967, indicating good internal consistency.

For the level of regulatory interventions, the factor loadings for PT1, PT2, and PT3, are 1.0000, .0943 and 0.962, respectively. These values demonstrate a high correlation with the perceived level of promising technology construct, and the composite reliability is 1.000, indicating good internal consistency. For the level of regulatory interventions, R1, R2, R3, and R4 have factor loadings of 1.000, 0.932, 0.962, and 1.000, respectively. These values strongly correlate with the perceived level of the sandbox trials construct. The composite reliability is 0.987, indicating good internal consistency; for fluctuation of the electronic payment, EP1, EP2, EP3, and EP4 exhibit factor loadings of 1.000, 0.976, 0.967, and 1.000, respectively, demonstrating a high correlation with the cybersecurity construct. The composite reliability is 0.967, indicating good internal consistency.

CST1, CST2, and CST3 show factor loadings of 1.000, 0.976, and 0.967, respectively, indicating a strong correlation with the cybersecurity construct. The composite reliability is

0.983, suggesting good internal consistency. FD1 and FD3 have factor loadings of 1.000, 0.979, and 0.969 respectively, indicating a strong correlation with the financial inclusion construct. The composite reliability is 0.981, suggesting good internal consistency. DP1, and DP2 exhibit factor loadings of 1.000, and 0.961, respectively, indicating a strong correlation with the data privacy challenge construct. The composite reliability is 0.980, indicating good internal consistency. GEP1, GEP2, and GEP3 show factor loadings of 1.000, 0.934, and 0.947, respectively, indicating a strong correlation with the innovativeness construct. The composite reliability is 0.914, suggesting good internal consistency. FI1, FI2 and FI3 shows a factor loading of 1.000. 0.952 and 0.939 respectively indicating good internal consistency with financial inclusion construct.

In addition, we have the reliability statistics for different constructs measuring the elements of the technological advancement. The Cronbach's Alpha for perceived risk level is exceptionally high at 0.982, indicating a very high internal consistency among the three items assessing the perceived level of emerging risk. For the level of electronic payment, Cronbach's Alpha is equally high at 0.986, indicating a strong internal consistency among the three items measuring level of electronic payments. The level of regulatory interventions has a high internal consistency with a Cronbach's Alpha of 0.990. The Cronbach's Alpha for the level of fraud detection is 0.957, while that of cybersecurity is 0.993.

The table also shows that Cronbach's Alpha for the Cybersecurity threat construct is 0.991, the electronic payments construct is 0.951, the fraud detection construct is 0.986, and the financial inclusion construct is 0.985. Each of these indicates a very high level of internal consistency.

Data Analysis and Results

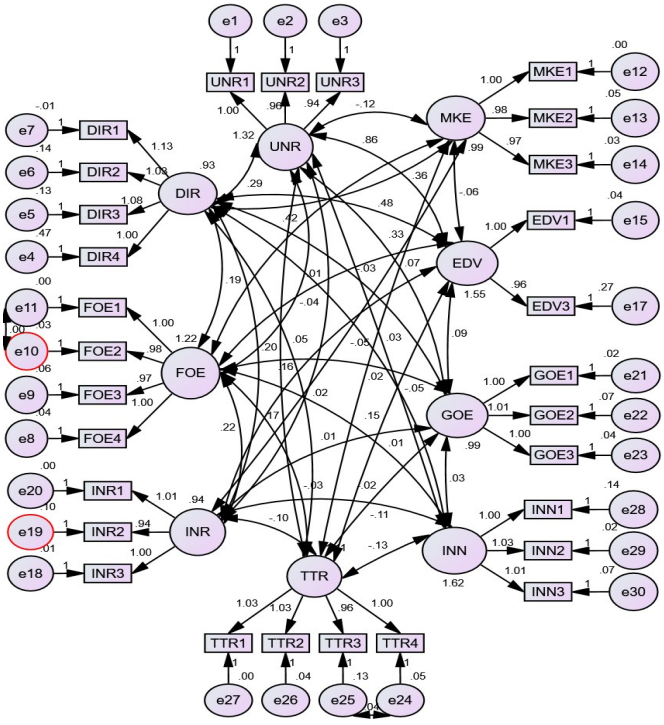

Figure 3: Structural Equation Model
Source: AMOS SPSS, 2026

Figure 3 shows the correlations between the latent variables. This is presented in Table 3.

Table 3. Covariance of Variables

Latent Variables			Estimate	SE.	CR.	P-value
Emerging Risk	<-->	Fintech start-ups	-.119	.059	-2.026	.043
EmergingRisk	<-->	Technology adoption	.291	.060	4.863	***
Emerging Risk	<-->	Technology acceptance	-.043	.065	-.667	.505
Emerging Risk	<-->	Digital payment volume	.018	.057	.319	.749
Emerging Risk	<-->	Mobile transfers	.167	.063	2.650	.008
Emerging Risk	<-->	Promising technology	.858	.087	9.912	***
Regulatory Interventions	<-->	Fraud detection	.188	.056	3.348	***
Regulatory Interventions	<-->	Cyber security threats	.197	.050	3.974	***
Regulatory Interventions	<-->	Data privacy	.055	.053	1.043	.297
Regulatory Interventions	<-->	Innovativeness	-.045	.053	-.854	.393
Regulatory Interventions	<-->	Growth Of Fintech	-.033	.046	-.724	.469
Regulatory Interventions	<-->	Sandbox trials	.478	.070	6.876	***
Cyber Security Risk	<-->	Fraud detection	.220	.056	3.908	***
Cyber Security Risk	<-->	Data privacy	.024	.053	.446	.656
Cyber Security Risk	<-->	Security compliance	.009	.072	.132	.895
Cyber Security Risk	<-->	Promising technology	-.416	.061	6.861	***
Growth of electronic payment	<-->	Data privacy challenges	.159	.063	2.514	.012
Level of e-payment	<-->	Tech adoption	-.328	.052	6.273	***
Promising technology	<-->	Tech acceptance	-.128	.070	-1.835	.066
Growth Of e- payment	<-->	Mobile transfers	-.016	.055	-.286	.775
Growth Of e- payment	<-->	Ict infrastructure	.145	.069	2.112	.035
Financial Inclusions	<-->	Digital transfer volume	-.052	.054	-.969	.332
Growth of E- payment	<-->	Digital transfer volume	.092	.065	1.406	.160
Growth of E- payment	<-->	Technological acceptance	.025	.066	.381	.704

Source: AMOS SPSS, 2026

Table 3 shows the covariance of latent variables. The threshold for the covariance outcome is less than 50% (that is < 0.5). The table shows that a one-unit decrease in the regulatory is associated with a 0.119-unit increase in cybersecurity threats, statistically significant at p-value < 0.05. A one-unit increase in the emerging risk is associated with a 0.291-unit increase

in the fintech starup, highly statistically significant at p-value < 0.001. A slight negative association exists between the regulatory intervention and the cybersecurity threats, but it is not statistically significant (p-value = 0.505). A one-unit increase in the regulatory intervention is associated with a 0.018-unit increase security compliance; not statistically significant (p-value = 0.749). A one-unit increase in regulatory intervention is associated with a 0.167-unit increase in the total tax rate, statistically significant at p-value < 0.01. A one-unit increase in the regulatory intervention is associated with a substantial 0.858-unit increase in sandbox trials, highly statistically significant at p-value < 0.001. A one-unit increase in the regulatory intervention is associated with a 0.074-unit increase in the growth of e - payment; not statistically significant (p-value = 0.211). A one-unit increase in the regulatory intervention is associated with a 0.032-unit increase in regulatory dynamics; not statistically significant (p-value = 0.601).

The table also shows that a one-unit increase in the emerging risk is associated with a 0.188-unit increase in the technological acceptance, highly statistically significant at p-value < 0.001. A one-unit increase in the emerging risk is associated with a 0.362-unit increase in digital payment, highly statistically significant at p-value < 0.001. A one-unit increase in the emerging risk is associated with a 0.197-unit increase in the mobile transfers, highly statistically significant at p-value < 0.001. A one-unit increase in the emerging risk is associated with a 0.055-unit increase in the ict infrastructure; not statistically significant (p-value = 0.297). There is a slight negative association between the emerging risk and fraud detection, but it is not statistically significant (p-value = 0.393). There is a slight negative association between the emerging risk and the market expansion, but it is not statistically significant (p-value = 0.469). A one-unit increase in the emerging risk is associated with a substantial 0.478-unit increase in regulatory dynamics, highly statistically significant at p-value < 0.001.

The table shows that a one-unit increase in the cybersecurity threat is associated with a 0.220-unit increase in the fraud detection, highly statistically significant at p-value < 0.001. There is a slight negative association between the fluctuation of the cybersecurity threat and the data privacy, but it is not statistically significant (p-value = 0.655). There is a small positive association between the cybersecurity threat and security compliance, but it is not statistically significant (p-value = 0.844). There is a small positive association between the cybersecurity threat and the promising technology, but it is not statistically significant (p-value = 0.656). There is a minimal positive association between the cybersecurity threat and regulatory dynamics, but it is not statistically significant (p-value = 0.895). A one-unit increase in the cybersecurity threat is associated with a substantial 0.416-unit increase in regulatory dynamics, statistically significant at p-value < 0.001.

The table shows that a one-unit increase in growth of e-payment is associated with a -0.100-unit decrease in the total digital transfer volume, marginally insignificant at p-value = 0.060. A one-unit increase in the growth of e-payment is associated with a -0.107-unit decrease in technological acceptance. There is a small positive association between the growth of e-payment and the growth of technological adoption, but it is not statistically significant (p-value = 0.810). A one-unit increase in regulatory dynamics is associated with a 0.159-unit increase in the digital transfer volume. A one-unit increase in growth of e-payment is associated with a 0.328-unit decrease in the regulatory dynamics, statistically significant at p-value < 0.001.

The table shows that a one-unit increase in fintech inclusion is insignificantly associated with a -0.128-unit decrease in sandbox trials (p-value = 0.066). There is a slight negative association between the fintech inclusion and the open application programing, but it is not statistically significant (p-value = 0.775). A one-unit increase in regulatory dynamics is

associated with a 0.145-unit increase in the data privacy challenges, statistically significant at p-value < 0.05. There is a slight negative association between innovativeness and the mobile transfers, but it is not statistically significant (p-value = 0.332). There is a slight negative association between market expansion and regulatory dynamics, but it is not statistically significant (p-value = 0.347). A one-unit increase in regulatory dynamics is insignificantly associated with a 0.092-unit increase in the growth of e-payment. There is a small positive association between the fintech inclusion and innovativeness, but it is not statistically significant (p-value = 0.704). These results provide insights into the covariance between the latent variables in the model. The statistical significance does not imply causation, and all the results are below 0.5 except for the covariance between the technological advancement and regulatory dynamics. However, these unveil that there is no covariance between the latent variables.

Table 4.
Model Fit Summary

	Default model	Independence model
RMR	.031	.223
GFI	.931	.214
AGFI	.912	.211
PGFI	.732	.216
NFI	.981	.000
RFI	.977	.000
IFI	.996	.000
TLI	.996	.000
CFI	.996	.000
PRATIO	.842	.000
PNFI	.826	.000
PCFI	.839	.000
RMSEA	.025	.218
LO 90	.016	.219
HI 90	.033	.225

Source: AMOS SPSS, 2026

Table 4 shows the RMR value of 0.031, which suggests a reasonably good fit, as it is a relatively small value. The GFI value 0.931 suggests a good fit, as it is close to 1. The AGFI value of 0.912 indicates model fit, although it is slightly lower than GFI. The PGFI value of 0.732 indicates that considering the model's simplicity, it still provides a reasonably good fit. The NFI value of 0.981 suggests a perfect fit, as it is close to 1. The RFI value 0.977 indicates a perfect fit relative to the null model. The IFI value of 0.996 indicates a significant fit improvement over the baseline model. The TLI value 0.996 suggests a perfect fit, accounting for model complexity. The CFI value of 0.996 suggests an excellent fit.

The PRATIO value of 0.842 indicates a relatively good balance between fit and complexity, with a lower value being preferable. The PNFI value of 0.826 suggests a reasonable fit after adjusting for model complexity. The PCFI value of 0.839 suggests a relatively good fit after adjusting for model complexity. The RMSEA value of 0.025 suggests a relatively good fit of the default model to the observed data. The lower 90% Confidence Interval for RMSEA represents the lower bound of the 90% confidence interval for the RMSEA. It provides a range of plausible values for the true RMSEA. The lower limit of 0.016 indicates a relatively narrow range of plausible values for the RMSEA. The upper 90% Confidence Interval for RMSEA represents the upper bound of the 90% confidence interval for the RMSEA. A higher

upper limit suggests a broader range of plausible values for the RMSEA. Thus, the upper limit value of 0.033 is still relatively small, indicating a relatively precise estimate of the RMSEA.

Table 5.
Regression Weights

			Estimate	SE.	CR.	P-value
Regulatory Intervention	<---	Technological acceptance	.957	.016	58.464	***
Regulatory dynamics	<---	Technological adoption	1.077	.044	24.524	***
Growth of E-payment	<---	Digital transfer volume	.967	.015	66.428	***
Fraud detection	<---	Cybersecurity threat	.943	.018	53.134	***
Fintech Inclusion	<---	ICT infrastructure	.962	.014	66.781	***

***p < .001.

Table 5 shows the regression weights on the effect of different variables. The estimated regression weight (β= 0.957; C.R.= 58.464) for the relationship between Regulatory intervention and technological acceptance has a p-value less than 0.01. This implies an expected 0.957-unit increase in regulatory intervention for a one-unit increase in technological acceptance. This means that regulatory intervention has a significant positive effect on technological acceptance.

The result (β= 1.077; C.R.= 24.524) for the relationship between regulatory dynamics and the technological adoption has a p-value less than 0.01. A one-unit regulatory dynamics relates to technological adoption estimated 1.077-unit increase in e- payment volume. This shows that a regulatory dynamics has a positive significant effect on technological advancement of e-payment ecosystem.

The result (β= 0.967; C.R.= 66.428) on the relationship between growth of E-payment and digital transfer volume has a p-value of less than 0.01. This suggests that a one-unit increase in moderate e-payment fluctuation is associated with a 0.967-unit increase in digital transfer volume. This shows that moderate fluctuation of the e-payment significantly and positively affects transfer volume.

The result (β= 0.943; C.R.= 53.134) shows the relationship between fraud detection and cybersecurity threat with a p-value less than 0.01. This suggests that a one-unit increase in fraud detection is associated with a 0.943 unit increase in cybersecurity. This shows that a moderate fraud detection has a positive significant effect on cybersecurity.

The result (β= 0.962; C.R.= 66.781) shows the relationship between fintech inclusion and ICT infrastructure with a p-value less than 0.01. A one-unit increase in fintech inclusion is associated with an estimated 0.962 unit increase in ICT infrastructure. This means that an acceptable fintech inclusion has a significant positive effect on ICT infrastructure.

Discussion of Findings

i. How do Nigeria's regulatory interventions influence innovation in the e-payment sector?

The findings indicate that Nigeria's regulatory interventions have exerted a dual influence on innovation within the e-payment sector. On one hand, regulatory frameworks introduced by the Central Bank of Nigeria (CBN), including licensing requirements, risk-based supervision, Know-Your-Customer (KYC) guidelines, and consumer protection policies, have enhanced

stability, credibility, and investor confidence in the ecosystem. These measures have reduced systemic risk and strengthened trust in digital payment platforms, thereby creating an enabling environment for sustainable fintech growth. This supports Regulatory Balancing Theory, which posits that effective regulation can stimulate innovation when it ensures market confidence without imposing excessive compliance burdens.

On the other hand, the study reveals that frequent policy changes, high compliance costs, and complex licensing structures may constrain smaller fintech startups. Participants noted that evolving guidelines particularly those related to capital requirements and data governance sometimes slow product rollouts and discourage experimentation. Nevertheless, most respondents agreed that the regulatory environment in Nigeria has generally encouraged structured innovation rather than stifling it. Overall, regulatory interventions appear to have moderated innovation by promoting responsible technological advancement while minimizing financial instability in the e-payment sector. This finding is supported by Arner et al (2017) regulatory balancing theory which asserts that excessive regulation may suppress innovation.

ii. What are the perceived regulatory barriers to fintech adoption among under-served populations?

The findings reveal that regulatory barriers significantly shape fintech adoption among under-served populations, particularly rural dwellers, informal sector workers, and low-income earners. A major barrier identified is stringent KYC documentation requirements, which exclude individuals lacking formal identification or proof of address. Although tiered KYC frameworks exist, their implementation remains inconsistent, limiting broader access.

Additionally, regulatory compliance costs borne by fintech firms often translate into higher transaction charges for end-users, discouraging adoption among price-sensitive populations. Some respondents also highlighted limited digital literacy and infrastructural constraints such as unreliable electricity and internet connectivity as indirect regulatory challenges, since policy efforts have not sufficiently integrated infrastructure development with digital finance expansion.

Moreover, trust deficits persist, partly due to concerns about fraud, data protection, and dispute resolution mechanisms. While regulatory authorities have introduced consumer protection frameworks, awareness among under-served groups remains low. Consequently, regulatory structures, though designed to enhance security and accountability, may unintentionally reinforce financial exclusion when inclusivity considerations are not fully embedded in policy implementation. This finding is supported by Rudger, (2003) innovation diffusion theory which posits that technology adoption depends on perceived relative advantage, compatibility and regulatory support.

iii. How effective are instruments like the regulatory sandbox and eNaira in promoting financial inclusion?

The findings suggest that policy instruments such as the regulatory sandbox introduced by the Central Bank of Nigeria and the eNaira have shown moderate but evolving effectiveness in promoting financial inclusion. The regulatory sandbox has provided a controlled environment for fintech innovators to test products under regulatory supervision, thereby reducing entry barriers and encouraging experimentation. Respondents acknowledged that the sandbox enhances collaboration between regulators and innovators, shortens time-to-market for compliant products, and strengthens regulatory learning. However, participation remains

limited to firms with sufficient technical and financial capacity, restricting its inclusivity impact.

Regarding the eNaira, findings indicate that it holds significant potential for deepening financial inclusion by facilitating low-cost digital transactions and expanding access to central bank–backed digital currency. Nonetheless, adoption levels remain below expectations due to limited public awareness, low digital literacy, and competition from established mobile payment platforms. While the eNaira represents a strategic innovation aligned with Nigeria's cashless policy objectives, its short-term impact on inclusion has been modest.

Overall, the evidence suggests that while these regulatory instruments demonstrate institutional commitment to innovation and inclusion, their effectiveness depends largely on complementary investments in infrastructure, digital literacy, stakeholder engagement, and policy consistency. This finding is further supported by Davis (1989) technology acceptance theory which posit that perceived usefulness and ease of use determines technology adoption, regulatory trust and security measures enhance adoption by reducing perceived risks.

Conclusion

This study concludes that regulatory dynamics and technological advancements are central to the growth and stability of Nigeria's e-payment ecosystem. While existing regulatory measures have helped address emerging risks such as cybersecurity threats, data privacy concerns, and interoperability challenges, continuous adaptation is necessary to keep pace with rapid technological change. Innovations such as blockchain, artificial intelligence, and open APIs offer significant potential to enhance efficiency and security when supported by clear regulatory frameworks. Interventions by the Central Bank of Nigeria, including the eNaira and regulatory sandbox initiatives, reflect progress toward financial inclusion, but their sustained impact depends on complementary investments in digital infrastructure and financial literacy to ensure broader access, particularly among under-served populations.

Recommendations

i) Regulators, especially the Central Bank of Nigeria, should adopt adaptive, risk-based frameworks to address cybersecurity, data privacy, and interoperability risks. This requires regular regulatory reviews, mandatory cybersecurity audits for fintech firms, unified data protection standards aligned with national frameworks, interoperable technical standards, and the use of supervisory technology to ensure innovation does not outpace oversight while preserving financial stability.

ii) To harness the benefits of blockchain for settlement, artificial intelligence for fraud detection, and open APIs for open banking, regulators should issue comprehensive innovation guidelines that balance efficiency with security. This includes setting technical standards for blockchain-based settlement systems, ethical AI governance frameworks for fraud monitoring, and robust API security protocols to prevent data breaches.

iii) Furthermore, collaboration between regulators, fintech firms, banks, and technology providers should be institutionalized through innovation hubs and controlled experimentation environments such as the CBN Regulatory Sandbox. This will reduce uncertainty, encourage responsible experimentation, and accelerate scalable technological adoption within the ecosystem.

iv) To improve the effectiveness of regulatory interventions such as the eNaira and sandbox initiatives, policymakers should complement these instruments with targeted digital infrastructure expansion and financial literacy campaigns in rural and under-served

communities. This includes expanding broadband penetration, incentivizing agent banking networks, simplifying onboarding requirements for low-income users, and integrating local languages into digital payment interfaces.

v) Monitoring and evaluation mechanisms should also be embedded within inclusion-focused programs to measure adoption rates, transaction volumes, and user trust levels. By aligning regulatory innovation with grassroots accessibility strategies, Nigeria's e-payment ecosystem can achieve both technological advancement and inclusive growth.

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