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CRYPTOGRAPHIC SECURITY SYSTEM AND ECONOMIC SUSTAINABILITY OF DEPOSIT MONEY BANKS IN ENUGU STATE.

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Abstract: *The study examined the Cryptographic Security systems and economic sustainability of Deposit Money Banks in Enugu State. The specific objectives are to: examine the relationship between Digital Signatures and Cost Reduction; and ascertain the relationship between Payment Gateways and Operational Efficiency of Deposit Money Banks in Enugu State. The study was based on the four (4) selected banks within Enugu metropolis with high number of staff and long years of establishment namely: First bank Plc, United bank of Africa, Zenith bank and Fidelity Bank. The total population for the study was three hundred and three (303). The study made use of the whole due to its small number. A survey design was adopted for the study. Instrument used for data collection was the questionnaire. Two hundred and eighty three (283) copies of questionnaire were properly completed and returned. Data was presented and analyzed by mean score and Z – test, to test the hypotheses. The findings indicated that Digital Signatures had significant positive relationship with Cost Reduction, Z(11.606, P. <. .05) and Payment Gateways had significant positive relationship with Operational Efficiency of Deposit Money Banks in Enugu State, Z(9.169 , P. <. .05). The study concluded that Digital Signatures and Payment Gateways had significant positive relationship with Cost Reduction and Operational Efficiency of Deposit Money Banks in Enugu State. The study recommended among others that Banks should implement strong encryption algorithms and authentication methods for digital signatures to enhance the security of banking transactions.*

Keywords: *Cryptographic Security systems, Digital Signatures, economic sustainability, Payment Gateways.*

Introduction

1.1 Background of the Study

In the rapidly evolving digital landscape, the banking sector has undergone significant transformations to improve operational efficiency, customer satisfaction, and overall security. Among these transformations, the adoption of cryptographic security systems has become pivotal.

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Cryptography, which involves securing information through mathematical algorithms, ensures data confidentiality, integrity, authenticity, and non-repudiation in financial transactions. This is particularly crucial for Deposit Money Banks (DMBs), which rely heavily on digital infrastructure for day-to-day operations. Cryptographic tools such as Public Key Infrastructure (PKI), Secure Socket Layer (SSL), and blockchain technologies have been employed to fortify security frameworks against cyber threats and frauds (Sharma & Sharma, 2022). As banks continue to digitize their services, the risk of cyberattacks and data breaches has escalated. This has necessitated robust security systems to maintain trust, especially in developing economies where cyber resilience is still maturing. The implementation of cryptographic protocols not only enhances transactional security but also helps in compliance with global regulatory standards such as Basel III and the Nigeria Data Protection Regulation (NDPR) (Akinboade & Mukonza, 2023). These standards emphasize the need for secure systems that protect sensitive financial data and promote responsible banking practices.

The economic sustainability of Deposit Money Banks hinges significantly on the security of their operations. Economic sustainability in this context refers to the ability of banks to maintain profitability, enhance shareholder value, and contribute to national economic development over the long term. One of the key enablers of this sustainability is the prevention of financial losses due to cybercrime, which can have a detrimental impact on public confidence and bank stability (Eze & Eze, 2021). Banks that prioritize cybersecurity, particularly through advanced cryptographic mechanisms, are more likely to remain resilient and adaptive in the face of economic disruptions and technological change. Moreover, the adoption of secure digital financial services drives financial inclusion, which is a critical component of economic sustainability. When individuals and businesses feel secure using digital banking platforms, it increases the velocity of money within the economy, boosts bank deposits, and promotes investment (Okoye, Okoye & Eze, 2023). This, in turn, supports long-term growth and economic stability. Additionally, the trust engendered by robust cryptographic systems reduces the incidence of financial crimes such as phishing, identity theft, and unauthorized transactions, thereby safeguarding bank assets and customer data. Banks with stronger cryptographic frameworks report better financial performance metrics, such as return on assets (ROA) and return on equity (ROE), as well as improved risk management scores (Usman, Bello & Alabi, 2024). This correlation underscores the strategic role of cryptographic security in ensuring not only operational effectiveness but also financial and economic sustainability. As a result, many Deposit Money Banks are investing in artificial intelligence-driven cryptography, quantum-resistant algorithms, and multi-factor authentication systems to fortify their cyber defenses and enhance customer experience. A sustainable economic framework within DMBs also involves innovation in banking services, adoption of digital technologies, and diversification of income sources beyond traditional interest-based revenue. With increasing competition and technological disruption, banks

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are required to adapt to these changes to maintain economic relevance and competitiveness (Adusei, Obeng & Domfeh, 2021). Furthermore, aligning banking operations with environmental, social, and governance (ESG) standards is becoming essential to attract global investment and ensure long-term survival (Olayiwola & Aderemi, 2023).

In Nigeria and other developing economies, Deposit Money Banks play a pivotal role in driving economic activities. However, challenges such as poor credit management, non-performing loans, and policy inconsistencies often threaten their sustainability. Research indicates that strategic financial planning, strong regulatory compliance, and proactive capital adequacy policies are vital to ensuring the sustainable performance of DMBs in the face of economic disruptions (Okoye, Nwoye, & Chijindu, 2022). Cryptographic security systems are integral to the economic sustainability of Deposit Money Banks. Their role in safeguarding digital transactions, protecting customer data, and ensuring regulatory compliance cannot be overemphasized. As cyber threats become more sophisticated, the implementation of advanced cryptographic technologies becomes a strategic imperative for banks aiming for sustainable economic growth in a competitive and digital global economy (Nwachukwu & Ozioma, 2023). Based on this, the study evaluated the Cryptohraphic Security system and economic sustainability of Deposit Money Banks in Enugu State.

1.2 Statement of the Problem

Cryptographic security systems play a crucial role in the operations of Deposit Money Banks (DMBs), especially as digital banking becomes the norm. Cryptography ensures the confidentiality of sensitive data by converting it into a format that unauthorized parties cannot understand. This is vital in protecting customer financial data, transaction records, and internal communication systems from cyber threats. It support secure authentication mechanisms like digital signatures and multi-factor authentication, which confirm the identity of users and prevent impersonation in online banking platforms. With cryptographic hash functions, banks can ensure the integrity of digital transactions. This means any attempt to alter transaction details during transmission will be detected, reducing the risk of fraud. Encryption techniques ensure that transactions made over networks are safe from interception or theft, thereby promoting user confidence and greater adoption of e-banking. Banks that provide secure, transparent, and reliable services through cryptographic protection and efficient digital platforms build long-term customer relationships, enhancing their sustainability.

Many banks operate with legacy infrastructure not designed for modern cryptographic standards. Integrating cryptographic modules with such systems introduces compatibility challenges and potential vulnerabilities. Even with cryptographic systems, human factors pose risks. Insider misuse of encrypted communication or improper access controls can lead to data breaches, defeating the purpose of cryptographic protection. In regions where financial literacy is low, customer mistrust and reduced participation in banking services reduce deposit bases and limit growth opportunities for

banks. As banks digitalize, they face increasing cyber threats. A single breach can result in financial loss, reputational damage, and regulatory penalties, all of which challenge long-term economic sustainability.

Without robust cryptographic security systems, DMBs become highly vulnerable to cyberattacks, such as data breaches, phishing, and unauthorized access. This can result in the loss of sensitive customer data, unauthorized fund transfers, and large-scale financial fraud, thereby undermining customer trust and bank credibility. This loss of confidence can trigger liquidity crises, especially if large numbers of depositors act simultaneously. Inadequate security may lead to system downtimes due to ransomware or other cyber threats. Such disruptions affect day-to-day banking operations, delaying transactions and reducing service efficiency. Without sound financial management, strategic investments, and cost-effective operations, banks may face insolvency or collapse, affecting not just their stakeholders but the entire financial system. Based on this, the study evaluated the Cryptohraphic Security system and economic sustainability of Deposit Money Banks in Enugu State.

1.3 Objectives of the Study

The main objective of the study was to Cryptographic Security system and economic sustainability of Deposit Money Banks in Enugu State. The specific objectives are to:

i. Examine the relationship between Digital Signatures and Cost Reduction of Deposit Money Banks in Enugu State
ii. Ascertain the relationship between Payment Gateways and Operational Efficiency of Deposit Money Banks in Enugu State

1.4 Research Questions

The following research questions guided the study

i. What is the relationship between Digital Signatures and Cost Reduction of Deposit Money Banks in Enugu State?
ii. What is the relationship between Payment Gateways and Operational Efficiency of Deposit Money Banks in Enugu State

1.5 Statement of the Hypotheses

The following Hypotheses guided the study

i. Digital Signatures has significant relationship with Cost Reduction of Deposit Money Banks in Enugu State
ii. Payment Gateways has significant relationship Operational Efficiency of Deposit Money Banks in Enugu State.

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1.6 Significance of the study

The beneficiaries on the study titled "Cryptographic Security System and Economic Sustainability of Deposit Money Banks" are:

Deposit Money Banks (DMBs): It helps DMBs adopt effective strategies that enhance trust, reduce operational risks, and sustain customer loyalty.

Bank Customers: The study indirectly benefits customers by promoting better data protection and safer banking environments. Customers will experience more secure transactions, reduced risk of identity theft or cyber fraud, and increased confidence in digital banking platforms.

Researchers and Academics: Offers a foundation for further research in areas such as cybersecurity, financial technology, risk management, and banking sustainability. It contributes to the body of knowledge and may serve as a reference for future academic studies.

Review of the Related Literature

2.1 Conceptual Review

2.1.1. Cryptographic

Cryptographic refers to anything related to cryptography, which is the science and art of securing information by transforming it into an unreadable format, ensuring that only authorized parties can access or understand the original data. The term "cryptographic" typically modifies words like "techniques," "algorithms," "systems," or "protocols," indicating that these elements involve data protection through mathematical techniques. Cryptographic methods are designed to ensure confidentiality, integrity, authentication, and non-repudiation in digital communications and data storage. These methods include encryption (converting data into coded formats), hashing (generating fixed-length strings from data), digital signatures, and key management systems. Cryptography involves the use of algorithms to transform information in a way that ensures it remains confidential and untampered with, even if intercepted by unauthorized individuals, (Stallings & Brown, 2023). Cryptography is a fundamental component of cybersecurity that provides the backbone for secure communications, particularly in the digital age where data breaches and cyber-attacks are prevalent, (Katz & Lindell, 2021). Modern cryptographic systems are essential in areas such as cloud computing, blockchain, and the Internet of Things (IoT), where secure communication between devices and systems is critical, (Alasmary et al., 2022).

2.1.2 Security system

A security system refers to an integrated set of tools, technologies, policies, and procedures designed to protect people, property, information, and infrastructure from threats such as unauthorized access, theft, damage, or cyberattacks. Security systems can be physical**,** digital, or a combination of both, and they typically involve detection, prevention, response, and recovery mechanisms. A security system is "a comprehensive framework that integrates hardware, software, and operational protocols

to ensure the safety and integrity of physical or digital assets in a given environment." This encompasses alarm systems, surveillance cameras, biometric access controls, firewalls, and intrusion detection systems, (Kumar and Patil, 2023)**,** Security systems are not just technological solutions but also involve human elements such as trained personnel and organizational procedures that monitor and manage risks to safeguard assets, (Osuagwu and Ajibade, 2022). Modern security systems increasingly rely on artificial intelligence and machine learning to predict and prevent security breaches more effectively, especially in cybersecurity domains, (Ahmed et al. (2021). In the context of cybersecurity, Zhang and Li (2023) define a security system as architecture, thus, whether for protecting physical premises or digital information, security systems play a vital role in ensuring safety, operational continuity, and trust in both public and private sectors.

2.1.3 Cryptographic Security system

A cryptographic security system refers to the use of cryptographic techniques and protocols to protect information and communication systems from unauthorized access, data breaches, tampering, and other cyber threats. These systems ensure data confidentiality, integrity, authentication, and non-repudiation by transforming data into an unreadable format (encryption) and restoring it only for authorized users (decryption). It ensures that information is accessible only to those authorized to have access. It prevents data disclosure to unauthorized entities through encryption methods (Stallings & Brown, 2023); It further maintains the accuracy and completeness of data during storage, processing, and transit. Hash functions and digital signatures are typical tools to achieve this (Menezes et al., 2022). It also Confirms the identity of users or systems before granting access. Public Key Infrastructure (PKI) and digital certificates are commonly used (Katz & Lindell, 2021) and Guarantees that a sender cannot deny sending a message, usually achieved through digital signatures and logging mechanisms (Boneh & Shoup, 2023).

2.1.4 Components of Cryptographic Security system used in the study

2.1.4 .1 Digital Signatures

A digital signature is a cryptographic technique used to validate the authenticity and integrity of a digital message, software, or document. It serves the same purpose as a handwritten signature or a stamped seal, but it is far more secure. Digital signatures use public key infrastructure (PKI), where a signature is generated using the sender's private key and can be verified by anyone who has access to the corresponding public key. Digital signatures ensure three key security properties: Authentication – verifies the identity of the sender, Integrity – ensures that the message was not altered after signing and Non-repudiation – prevents the signer from denying the act of signing. Alsmadi, & Zarour, (2018), highlighted how digital signatures ensure secure authentication and transaction validation in distributed systems. The performance of blockchain-based digital signature systems, noted that there is increased resistance to tampering and unauthorized access due to decentralized verification, (Liu &

Wang, 2020). The integration of digital signatures with cloud computing security, ensures trust and verification in data shared across multiple cloud service providers, (Saini & Rana, 2022). The adoption of digital signature infrastructure in African public service institutions, emphasizing regulatory gaps and the need for standardized digital identity frameworks, (Adebayo & Eze, 2024).
Digital signatures are critical tools in modern cybersecurity, especially in environments where trust, authenticity, and integrity are paramount. Their applications span finance, e-governance, legal tech, blockchain, and IoT, with continuous research addressing efficiency, post-quantum resistance, and regulatory challenges.

2.1.4 .2 Payment Gateways

A payment gateway is a technology that facilitates the process of transferring funds from a customer's account to a merchant's account during a transaction. It securely handles the payment transaction, ensuring the safe and efficient transfer of sensitive information like credit card numbers or bank account details between customers, merchants, and financial institutions. Payment gateways often work by encrypting sensitive information to prevent fraud, and they can handle various forms of electronic payments such as credit cards, debit cards, and digital wallets. Payment gateways can also enable features like recurring payments, fraud prevention, and multi-currency support. They are commonly integrated with online stores, e-commerce websites, and mobile applications to process transactions seamlessly,(Tang,& Wang,2022; Patel, & Sharma, 2021 and Lee, & Yun, 2023).

2.1.5 Performance

Performance in a bank refers to the effectiveness and efficiency with which a bank operates, providing services to its customers while maintaining profitability, financial stability, and compliance with regulatory standards. It typically encompasses both financial and non-financial metrics, such as profitability, liquidity, asset quality, operational efficiency, and customer satisfaction. A critical aspect of bank performance, profitability indicates how well a bank can generate income relative to its expenses and other costs (Alhassan et al., 2020). Asset Quality refers to the health of the bank's loan portfolio, measured by factors like the rate of non-performing loans (NPLs) and provisions for bad loans. Banks with a higher proportion of high-quality assets tend to perform better financially (Babalola & Akinwande, 2021). Liquidity measures the ability of the bank to meet its short-term financial obligations. A bank with strong liquidity can survive financial shocks without compromising its operations (Olamide et al., 2022). Efficiency metrics, such as the cost-to-income ratio, indicate how well a bank utilizes its resources to generate revenue. High operational efficiency often correlates with better performance (Ogunleye & Ismail, 2023). Non-financial indicators, such as customer service quality and satisfaction, also play a role in bank performance. A bank's ability to meet customer needs can lead to increased market share and customer retention, which, in turn, improves overall performance (Chijioke et al., 2023).

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2.1.6 Components of Performance used in the study

2.1.6.1 Cost Reduction

Cost reduction in a bank refers to the strategies and measures a financial institution adopts to lower its operating expenses without compromising its services or profitability. These strategies can include optimizing resource allocation, implementing technology to automate processes, reducing staff costs through outsourcing or layoffs, improving operational efficiency, and streamlining processes. The goal is to improve profitability while maintaining or even improving service quality and customer satisfaction. Banks focus on cost reduction not only to stay competitive but also to navigate economic uncertainties, regulatory pressures, and the increasing costs of technology adoption. For instance, studies have shown that banks can achieve significant cost reductions through digitalization (Nielsen & Ranganathan, 2022) and outsourcing non-core functions (Vera & Benitez, 2021). Moreover, optimizing branch networks and embracing FinTech solutions can enhance cost-efficiency (Müller & Reiner, 2023).

2.1.6.2 Operational Efficiency

Operational efficiency in a bank refers to the ability of a bank to deliver services effectively, utilizing the least amount of resources while maintaining or improving its performance and customer satisfaction. It involves optimizing internal processes, reducing unnecessary costs, and enhancing productivity in order to improve profitability. Banks focus on streamlining operations by adopting advanced technologies, improving employee productivity, and ensuring robust management of resources. In practical terms, operational efficiency is measured by the cost-to-income ratio, which indicates how well a bank is controlling its operating costs relative to its income. A lower cost-to-income ratio signals greater operational efficiency, as the bank is managing its expenses effectively while generating sufficient income. Banks adopting digital transformation strategies experience improved operational efficiency, as technology helps automate routine tasks, optimize resource allocation, and reduce costs, (Zhao et al.2022). The key driver of operational efficiency in banks is the effective integration of financial technologies (fintech), which facilitates quicker transaction processing, reduces overheads, and improves customer service**,**(Goyal and Agarwal, 2021). Banks in developing countries face unique challenges in operational efficiency due to infrastructural limitations, but those that invest in technology and process improvement initiatives can overcome these challenges and enhance performance, (Ogunleye et al. 2020). By focusing on key elements like technology, human capital, and process optimization, banks can achieve greater operational efficiency, leading to improved profitability and a stronger competitive position in the financial sector.

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2.2 Theoretical Framework

The Study was guided by the theory of Computational Security and Complexity Theory as by Whitfield Diffie and Martin Hellman in their 1976

The theory of Computational Security and Complexity Theory as introduced by Whitfield Diffie and Martin Hellman in their 1976 paper, "New Directions in Cryptography", is foundational in modern cryptography. While the paper does not present a formal theory titled exactly "Computational Security and Complexity Theory", it introduces the computational approach to security, which combines ideas from complexity theory to define and evaluate the security of cryptographic systems. A system is considered secure if breaking it requires solving a problem that is computationally infeasible (e.g., factoring large numbers or computing discrete logarithms). They introduced the idea that security is relative: a cryptosystem is secure if all known attacks require more computational effort than a feasible adversary could exert. Absolute security (unbreakable under any conditions) is often unrealistic, so they proposed computational security, where systems are secure because breaking them requires unrealistic time or resources.

2.3 Empirical Review

2.3.1. Digital Signatures and Cost Reduction

Tukura, et al., (2023), conducted a study on the impact of crypto currency on the operations of deposit money banks (DMB) in Nigeria The Digital currency in Nigeria has experienced turbulent times following the acquisition of deposit money banks (DMBs) in Nigeria since 2007 till date. In order to minimize their operational costs, commercial banks have adopted digital banking including bit-coin, crypto-currency and other internet banking and internet banking system where customer can access their accounts on their personal computers. Mobile applications as it offers millions of people a potential solution in emerging markets in Nigeria, yet remain excluded from the financial mainstream. It can make basic financial services more accessible by minimizing time and distance to the nearest retail bank branches as well as reducing the bank‘s own overheads and transaction-related costs. The objective of this study was to determine The Impact of Crypto Currency on the activities of Deposit Money Banks (DMB) in Nigeria. The study applied descriptive research design. The target population included all the 14 deposit money banks (DMB) in Nigeria who provide digital banking system to all the commercial banks operating in Nigeria as at December 2021. The total transactions made during the period of study were collected and the number of bit-coin users was regressed against bank performance as measured by the return on assets. The study used secondary data from the Central bank of Nigeria and Nigeria National Bureau of Statistics. During the study period, the amount of money transacted through the digital banking system increased steadily from 0.06 billion in 2012 on its launch to 118.08 billion by the last month of the analysis. The growth was motivated by the convenience offered by the service. The study however found that there exist a weak

positive relationship between digital banking and the financial performance of commercial banks in Nigeria.

Kennedy, et al., (2025) conducted study on the Smart contracts and performance of deposit Money Banks in Enugu State. The specific objectives are to: examine the relationship between Contract Code and fraud reduction; and ascertain the relationship between Digital Signatures and operational efficiency of deposit Money Banks in Enugu State. In the study, descriptive survey research design was employed. Sources of data collection included primary and secondary sources. The total population for the study was two hundred and fifty four (254) staff understudy. The whole population was used to small number. Two hundred and fifty (248) questionnaires were returned and accurately filled. The study found that Contract Code had significant positive relationship with fraud reduction, Z = 10.287, P. = 0.05 and Digital Signatures has relationship with operational efficiency of deposit Money Banks in Enugu State. Z = 10.287, P. = 0.05.

Ahmad, and Yahaya, (2025) investigated the impact of digital currency on deposit money banks in Nigeria from 2010 to 2023. Employing a quantitative approach, the study utilizes econometric analysis, specifically the Ordinary Least Squares (OLS) method, to examine the relationship between digital currency transactions, money supply, interest rates, and deposit money bank performance. The study addresses the stationary of time series variables through unit root tests and employs the Johansen co-integration test to determine long-term equilibrium relationships. The Error Correction Mechanism (ECM) model is then estimated to analyze the dynamic adjustment process. The findings reveal a significant negative impact of digital currency transactions on deposit money, while money supply and interest rates exhibit positive correlations.

Mohammed, and Adelowotan, (2025) conducted a study on Digital Accounting Practices and Financial Performance: Quantitative Research in Seven International Deposit Money Banks in Nigeria Although previous studies have explored the link between digitalisation and bank performance, the impact of these digital tools on deposit money banks in Nigeria remains debatable, especially regarding the components of digital accounting practices. This study examined the effect of digital accounting practices on the financial performance of deposit money banks (DMBs) in Nigeria. Specifically, the study investigated the impacts of data analytics, automated bookkeeping, machine learning, cloud-based accounting systems, and blockchain technology on Nigeria's return on assets of DMBs. A survey design was employed. A stratified sampling method was adopted to select seven deposit money banks with international authorization. A self-administered questionnaire was used to collect data from a sample size of 396 employees, which was determined using the Taro Yamane formula. The data were analysed using both descriptive and linear regression methods using SPSS. The results of the analysis showed that data analytics, automated bookkeeping, machine learning,

cloud-based accounting systems, and blockchain technology have a positive and statistically significant influence on financial performance (ROA).

2.3.2 Payment Gateways and Operational Efficiency

Saidi (2018) conducted a study E-Payment Technology Effect on Bank Performance in Emerging Economies–Evidence from Nigeria. The development of the financial sector has been a major growth driver in all economies, especially in emerging economies. Part of the financial innovations in the sector in recent times is the electronic payment system. Several studies in developed countries have substantiated the positive transformation of this financial innovation. This paper therefore contributes to this debate with three research innovations: first, it adopts a new measure of bank performance the sorting index; second, it relates market risk exposure of banks to electronic payment technologies; and third, it controls for "without effects" of these innovations on bank performance using interacting dummies. Based on the time dimensional and panel least square models, it finds that bank performance increased after the adoption of electronic payment technologies. Finally, its findings show that bank performance contradicts autoregressive and random walk processes and thus implies that investors should not be disturbed about previous bank performances but concerned about current bank resources

Momoh-Musa, and Nwaiwu, (2021) conducted a study on the Electronic Payment and Quoted Financial Performance of Deposit Money Banks in Nigeria. Electronic -payment is increasingly becoming a daring means of payments in today's business world. This is due to its efficiency convenience and timeliness. The aim of this study is to empirically analyze the relationship between electronic payment and quoted financial performance of deposit money banks in Nigeria. Data on different types of electronic payment and return on equity from 2007-2018 were collected from the central bank of Nigeria Statistical bulletin, annual Central Bank of Nigeria reports, Federal Inland Revenue Service, financial annual reports and e-business units report of the quoted deposit money banks. The ordinary lest square, Auto-Regressive Distributed Lag, Unit Root Test, Panel Cointegration, Granger Causality Test and Panel Dynamic, Error Correction Model was used in analyzing the data with the aid of E-view version 10. The empirical results indicate that electronic payment significantly relate to return on equity; explaining about 85.3% of the total variation in return on equity, web pay and mobile pay were each found to significantly relate to quoted financial performance, sustaining long run equilibrium relationship with return on equity.

Okonkwo, and Ekwueme (2022) investigated the effect of electronic payment on the financial performance of deposit money banks in Nigeria. Ex post facto research design was adopted for the study. A sample size of 13 deposit money banks in Nigeria was used from the population of 22 banks. Data were collected from CBN Statistical bulletin and annual reports and accounts of the sampled banks for the periods from 2009 to 2019. Descriptive statistics and the hypotheses regression analysis

were used to analyze the data with the aid of E-Views 9.0 statistical software. The result revealed that ATM payment method has a positive effect on return on assets of quoted deposit money banks in Nigeria, but not statistically significant at 5% level of significance. While POS payment method has a negative effect on return on assets of quoted deposit money banks in Nigeria, and this effect was not statistically significant at 5% level of significance. The study concluded that Nigerian banks should raise knowledge about ATM usage through media campaigns, seminars, and symposia, among other things. This is despite the fact that growing use of the ATM payment mechanism boosts bank profitability in Nigeria.

Adukanya, et al., (2022). Conducted a study on the effect of digital banking on customer satisfaction of Deposit Money Banks in Makurdi Metropolis, Benue State, Nigeria. The study specifically examined the effect of internet banking, automated teller machine and point of sales on customer satisfaction of Deposit Money Banks in Makurdi Metropolis, Benue State-Nigeria. The Technology Acceptance Model forms the foundation of the study. The study was conducted using a survey research design. 403,684 clients of six deposit money banks chosen in Benue state for the study comprise the study's population. The respondents were chosen by accidental sampling, and the Taro Yamane 1967 formula was used to calculate the sample size of 400 customers. A structured questionnaire was used to collect the study's data, which were then analyzed using descriptive statistical tools like tables and straightforward percentages. Multiple regressions were also employed for additional analysis and hypothesis testing. The study's conclusions showed a substantial relationship between several aspects of digital banking and deposit money bank customers' satisfaction in Makurdi Metropolis, Benue State, Nigeria. The analysis showed that the point of sale had β = 0.102, t=2.893, P=0.004, internet banking had β =0.213, t=5.781, P=0.000, and automated teller machines had β =0.270, t=7.199, P=0.000.

Zayyanu, et al. (2022) Conducted a study on the effect of payments system innovations on the performance of commercial banks in Nigeria, Ex post factor research design was adopted for the study. The population of the study comprises all the banks operating in Nigeria. Data were collected from the economic reports and statistical bulletin of central bank of Nigeria. The Auto-Regressive Distributed Lags (ARDL) bounds approach to co-integration was adopted on quarterly time-series data from Q1 2007 to Q4 2020 to test the causal relationship between payments system innovations and financial performance of commercial banks in Nigeria. The results indicated that mobile payment, POS transactions and internet payment have positive and significant impact on return on assets of commercial banks in Nigeria, while RTGS has negative impact on the return of assets. The results of the study will fill the knowledge gap and will benefit both regulators and operators in making decision-making process and development of new policies that will aid the promotion of

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innovative products for safe reliable, and credible payments system and in identify payments system technology, projects and initiatives that are significantly viable, respectively.

2.2 Gap in Empirical Review

The studies done were carried outside the Cryptographic Security system and economic sustainability of Deposit Money Banks in Enugu State and did not focus to best of my knowledge on Digital Signatures and Cost Reduction; Payment Gateways and Operational Efficiency of Deposit Money Banks in Enugu State. Most of the studies reviewed analyzed their data through Descriptive statistics and appropriate inferential statistics, Pearson Moment Correlation Coefficient, Kendall's correlation and Kruskal Wallis test , Partial Least Square Structural Equation Modeling (PLS-SEM), and Multiple Regression Analysis (MRA) method, while the present study made use of Pearson correlation coefficient (r) to test the hypotheses. Therefore, the study aimed at filling this research gap by evaluating the Cryptographic Security system and economic sustainability of Deposit Money Banks in Enugu State

3.0 Methodology

The study was based on the four (4) selected banks within Enugu metropolis with high number of staff and long years of establishment namely: First bank Plc, United bank of Africa, Zenith bank and Fidelity Bank. The total population for the study was three hundred and three (303). The study made use of the whole due to its small number. A survey design was adopted for the study. Instrument used for data collection was the questionnaire. Two hundred and eighty three (283) copies of questionnaire were properly completed and returned. That gave 93 percent response rate. The validity of the instrument was tested using content analysis and the result was good. The reliability was tested using the Pearson correlation coefficient (r). It gave a reliability co-efficient of 0.84 which was also good. Data was presented and analyzed by mean score and Z – test was used to test the hypotheses with aid of Special Package for Statistical Software (SPSS).

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4.0 Data Presentation

Table 4.1: Responses on the relationship between Digital Signatures and Cost Reduction of Deposit Money Banks in Enugu State

		5 SA	4 A	3 N	2 DA	1 SD	∑FX	- X	SD	Decision
1	Digital signatures eliminate the need for physical documentation, printing, mailing, and storage and it reduces expenses related to paper and ink.	750 150 53.0	228 57 20.1	36 12 4.2	18 9 .3.2	55 55 19.4	1087 283 100.0	3.84	1.560	Agree
2	E-signatures significantly reduce operational costs by eliminating paper dependency and associated logistics	460 92 32.5	352 88 31.3	36 12 4.2	72 36 12.7	55 55 19.4	975 283 100.0	3.44	1.525	Agree
3	Online account opening with digital signatures improves service perception and saves marketing costs	555 111 39.2	384 96 33.9	36 12 4.2	6 3 1.1	61 61 21.6	1042 283 100.0	3.68	1.524	Agree
4	Digital transformation tools like e-signatures improve customer trust and reduce cost-per-customer acquisition.	675 135 47.7	506 126 44.5	36 12 4.2	8 4 1.2	6 6 2.1	1231 283 100.0	4.34	.807	Agree
5	Digital documentation in banking enhances compliance efficiency, reducing penalties and consultancy costs.	605 121 42.8	580 145 51.2	21 7 2.5	14 7 2.5	3 3 1.1	1223 283 100.0	4.32	.738	Agree
	Total Grand mean and standard deviation							**4.028**	**1.111**	

Source: Field Survey, 2025

Table 4.1, 207 respondents out of 283 representing 73.1 percent agreed that Digital signatures eliminate the need for physical documentation, printing, mailing, and storage and it reduces expenses related to paper and ink with the mean score of 3.84 and standard deviation of 1.560. 188 respondents representing 63.8 percent agreed that E-signatures significantly reduce operational costs by eliminating paper dependency and associated logistics with mean score of 3.44 and standard deviation of 1.525. 207 respondents representing 73.1 percent agreed that Online account opening with digital signatures improves service perception and saves marketing costs with mean score of 3.68 and standard deviation of 1.524. 261 respondents representing 92.2 percent agreed that with Digital transformation tools like e-signatures improve customer trust and reduce cost-per-customer acquisition with mean score of 4.34 and standard deviation of .807. 266 respondents representing 91.0

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percent agreed that Digital documentation in banking enhances compliance efficiency, reducing penalties and consultancy costs with a mean score of 4.32 and standard deviation .738

Table 4.2: Responses on the Payment Gateways and Operational Efficiency of Deposit Money Banks in Enugu State

		5 SA	4 A	3 N	2 DA	1 SD	∑FX	- X	SD	Decision
1	Payment gateways automate and streamline financial transactions, reducing the manual workload and chances of errors in processing payments..	500 100 35.5	500 125 44.2	21 7 2.5	72 36 12.7	15 15 5.3	1180 283 100.0	3.91	1.167	Agree
2	The Payment gateways increases transaction speed, allowing DMBs to serve more customers in less time and with higher accuracy, thus improving operational efficiency	475 95 33.6	196 49 17.3	225 75 26.3	38 19 6.7	45 45 15.9	979 283 100.0	3.45	1.420	Agree
3	Payment gateway integration supports scalability and efficiency in service delivery across branches and digital platforms.	860 172 60.8	196 49 17.1	60 20 7.1	28 14 4.9	28 28 9.9	1172 283 100.0	4.14	1.324	Agree
4	Payment gateways provide real-time data on transactions, helping banks make informed operational decisions, and detect fraud faster	685 137 48.4	196 49 17.3	168 56 19.8	12 14 4.9	27 27 9.5	1088 283 100.0	3.84	1.317	Agree
5	Nigerian banks utilizing payment gateways experienced notable reductions in overhead costs, boosting operational performance	575 115 40.6	320 80 28.3	60 20 7.1	14 7 2.5	61 61 21.6	1030 283 100.0	3.63	1.547	Agree
	Total Grand mean and standard deviation							**4.028**	**1.111**	

Source: Field Survey, 2025

Table 4.2, 225 respondents out of 283 representing 79.7 percent agreed that Payment gateways automate and streamline financial transactions, reducing the manual workload and chances of errors in processing payments with the mean score of 3.91 and standard deviation of 1.167. 144 respondents representing 50.9 percent agreed that The Payment gateways increases transaction speed, allowing DMBs to serve more customers in less time and with higher accuracy, thus improving operational efficiency with mean score of 3.45 and standard deviation of 1.420. 221 respondents representing 77.9 percent agreed that when Payment gateway integration supports scalability and efficiency in service delivery across branches and digital platforms with mean score of 4.14 and standard deviation of 1.324. 186 respondents representing 65.7 percent agreed that with Payment gateways provide real-

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time data on transactions, helping banks make informed operational decisions, and detect fraud faster with mean score of 3.84 and standard deviation of 1.317. 195 respondents representing 68.9 percent agreed that Nigerian banks utilizing payment gateways experienced notable reductions in overhead costs, boosting operational performance with a mean score of 3.63 and standard deviation 1.547

4.3 Test of Hypotheses

4.3.1 Hypotheses One: Digital Signatures has relationship with Cost Reduction of Deposit Money Banks in Enugu State

One-Sample Kolmogorov-Smirnov Test

		Digital signatures eliminate the need for physical documentation, printing, mailing, and storage and it reduces expenses related to paper and ink.	E-signatures significantly reduce operational costs by eliminating paper dependency and associated logistics	Online account opening with digital signatures improves service perception and saves marketing costs	Digital transformation tools like e-signatures improve customer trust and reduce cost-per-customer acquisition.	Digital documentation in banking enhances compliance efficiency, reducing penalties and consultancy costs.
N		283	283	283	283	283
Uniform Parameters[a,b]	Minimum	1	1	1	1	1
	Maximum	5	5	5	5	5
Most Extreme Differences	Absolute	.530	.386	.481	.672	.690
	Positive	.194	.194	.216	.021	.011
	Negative	-.530	-.386	-.481	-.672	-.690
Kolmogorov-Smirnov Z		8.917	6.494	8.099	11.309	11.606
Asymp. Sig. (2-tailed)		.000	.000	.000	.000	.000

a. Test distribution is Uniform.
b. Calculated from data.

Decision Rule

If the calculated Z-value is greater than the critical Z-value (i.e $Z_{cal} > Z_{critical}$), reject the null hypothesis and accept the alternative hypothesis accordingly.

Result

With Kolmogorov-Smirnon Z – value ranges from 6.494 < 11.606 and on Asymp. Significance of 0.000, the responses from the respondents as display in the table is normally distributed. This affirms the assertion of the most of the respondents that **Digital Signatures had significant positive relationship with Cost Reduction of Deposit Money Banks in Enugu State**

Furthermore, comparing the calculated Z- value ranges from 6.494 < 11.606 against the critical Z-value of .000(2-tailed test at 95percent level of confidence) the null hypothesis were rejected. Thus the alternative hypothesis was accepted which states that **Digital Signatures had significant positive relationship with Cost Reduction of Deposit Money Banks in Enugu State**

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4.3.2 Hypotheses Two: Payment Gateways has relationship with Operational Efficiency of Deposit Money Banks in Enugu State

One-Sample Kolmogorov-Smirnov Test

		Payment gateways automate and streamline financial transactions, reducing the manual workload and chances of errors in processing payments..	The Payment gateways increases transaction speed, allowing DMBs to serve more customers in less time and with higher accuracy, thus improving operational efficiency	Payment gateway integration supports scalability and efficiency in service delivery across branches and digital platforms.	Payment gateways provide real-time data on transactions, helping banks make informed operational decisions, and detect fraud faster	Nigerian banks utilizing payment gateways experienced notable reductions in overhead costs, boosting operational performance
N		283	283	283	283	283
Uniform Parameters[a,b]	Minimum	1	1	1	1	1
	Maximum	5	5	5	5	5
Most Extreme Differences	Absolute	.545	.336	.608	.484	.439
	Positive	.053	.159	.099	.095	.216
	Negative	-.545	-.336	-.608	-.484	-.439
Kolmogorov-Smirnov Z		9.169	5.647	10.224	8.144	7.386
Asymp. Sig. (2-tailed)		.000	.000	.000	.000	.000

a. Test distribution is Uniform.
b. Calculated from data.

Decision Rule

If the calculated Z-value is greater than the critical Z-value (i.e $Z_{cal} > Z_{critical}$), reject the null hypothesis and accept the alternative hypothesis accordingly.

Result

With Kolmogorov-Smirnon Z – value ranges from 5.647 < 9.169 and on Asymp. Significance of 0.000, the responses from the respondents as display in the table is normally distributed. This affirms the assertion of the most of the respondents that Payment Gateways had significant positive relationship with Operational Efficiency of Deposit Money Banks in Enugu State

Furthermore, comparing the calculated Z- value ranges from 5.647 < 9.169 against the critical Z-value of .000(2-tailed test at 95percent level of confidence) the null hypothesis were rejected. Thus the alternative hypothesis was accepted which states that Payment Gateways had significant positive relationship with Operational Efficiency of Deposit Money Banks in Enugu State

4.4 Discussion of Findings

4.4.1 Relationship between Digital Signatures and Cost Reduction of Deposit Money Banks in Enugu State

Furthermore, comparing the calculated Z- value ranges from 6.494 < 11.606 against the critical Z-value of .000 which implies that Digital Signatures had significant positive relationship with Cost

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Reduction of Deposit Money Banks in Enugu State**.** In the support of the result, in the literature review, Tukura, et al., (2023), conducted a study on the impact of crypto currency on the operations of deposit money banks (DMB) in Nigeria. The study however found that there exist a weak positive relationship between digital banking and the financial performance of commercial banks in Nigeria. Kennedy, et al., (2025), conducted study on the Smart contracts and performance of deposit Money Banks in Enugu State. The study found that Contract Code had significant positive relationship with fraud reduction, and Digital Signatures has relationship with operational efficiency of deposit Money Banks in Enugu State. Ahmad, and Yahaya, (2025), Investigated the impact of digital currency on deposit money banks in Nigeria from 2010 to 2023. The findings reveal a significant negative impact of digital currency transactions on deposit money, while money supply and interest rates exhibit positive correlations.

4.4.2 Relationship between Payment Gateways and Operational Efficiency of Deposit Money Banks in Enugu State

Furthermore, comparing the calculated Z- value ranges from 5.647 < 9.169 against the critical Z-value of .000 which implies that Payment Gateways had significant positive relationship with Operational Efficiency of Deposit Money Banks in Enugu State. In the support of the result, in the literature review, Okonkwo, and Ekwueme, (2022), investigated the effect of electronic payment on the financial performance of deposit money banks in Nigeria. The result revealed that ATM payment method has a positive effect on return on assets of quoted deposit money banks in Nigeria. Zayyanu, et al.,(2022) Conducted a study on the effect of payments system innovations on the performance of commercial banks in Nigeria. The results indicated that mobile payment, POS transactions and internet payment have positive and significant impact on return on assets of commercial banks in Nigeria.

5.0 Summary of Findings, Conclusion, Recommendations

5.1 Summary of Findings

i. Digital Signatures had significant positive relationship with Cost Reduction of Deposit Money Banks in Enugu State, Z(11.606, P. < .05)

ii. Payment Gateways had significant positive relationship with Operational Efficiency of Deposit Money Banks in Enugu State, Z(9.169 , P. < .05)

5.2 Conclusion

The study concluded that Digital Signatures and Payment Gateways had significant positive relationship with Cost Reduction and Operational Efficiency of Deposit Money Banks in Enugu State. The relationship between cryptographic security systems and the economic sustainability of deposit money banks involves leveraging encryption techniques to protect sensitive financial data and ensure the integrity of transactions. Cryptography plays a critical role in safeguarding customer information,

preventing fraud, and maintaining trust in the banking system. In terms of economic sustainability, effective cryptographic systems enhance the resilience of banks against cyber threats, minimize financial losses due to security breaches, and contribute to the long-term stability of the banking sector. By ensuring the confidentiality, authenticity, and integrity of financial transactions, cryptographic technologies help banks comply with regulatory requirements, reduce operational risks, and foster customer confidence, which are essential for their continued success and growth in a competitive market. Banks that implement robust cryptographic security systems can improve their operational efficiency, build stronger customer relationship.

5.3 Recommendations

Based on the findings, the following recommendations were proffered

i. Banks should implement strong encryption algorithms and authentication methods for digital signatures to enhance the security of banking transactions and this will lead to lower costs associated with fraud detection, investigation, and customer compensation. This, in turn, helps reduce the operational losses banks face due to fraud.

ii. Banks should adopt and integrate advanced payment gateways that offer seamless, secure, and fast transactions. Payment gateways like PayPal, Stripe, and locally tailored solutions (e.g., Flutterwave or Paystack in Nigeria) offer robust transaction processes, fraud protection, and real-time processing capabilities.

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