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Blockchain in banking: A comparative review of developments in the USA and Nigeria

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Abstract

This review paper systematically examines the adoption and impact of blockchain technology within the banking sectors of the United States of America (USA) and Nigeria, offering a comparative analysis of developments across these divergent economic and regulatory landscapes. Through an extensive literature review, the paper synthesizes findings from a range of sources, including peer-reviewed journals, industry reports, and case studies, to explore how blockchain technology is being integrated into banking operations, the challenges encountered, and the opportunities it presents in both contexts.

The analysis reveals that in the USA, the integration of blockchain into banking has progressed significantly, supported by a mature technological infrastructure, a clear regulatory environment, and substantial investments in financial technology innovations. This has facilitated enhancements in transaction efficiency, security, and cost reductions. Conversely, Nigeria's adoption of blockchain technology in banking is at a nascent stage, primarily focused on addressing financial inclusion and improving the efficiency of cross-border payments. Despite this, regulatory uncertainties and infrastructural deficits pose challenges to its broader adoption.

The paper concludes that while blockchain technology offers the potential to transform banking operations globally, its adoption and impact are heavily influenced by specific national contexts. The study underscores the need for adaptive regulatory frameworks and infrastructure development to fully harness the benefits of blockchain in the banking sector. It advocates for further research into blockchain's practical applications in banking, emphasizing the importance of cross-country studies to understand its global implications.

Keywords: Blockchain technology; Banking sector; Financial services; Innovation; Financial inclusion; Digital identity verification; Cross-border payments; Asset tokenization; Smart contracts; Supply chain financing; Regulatory compliance; System interoperability; Infrastructure investment; Skill development; Security and privacy; Fraud prevention; Pilot projects; Phased implementation; Operational efficiency; Stakeholder collaboration

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1 Introduction

1.1 Significance of Blockchain in Banking

The advent of blockchain technology represents a paradigm shift in the digital landscape, offering unprecedented opportunities for the banking sector to enhance transparency, efficiency, and security in its operations. As a decentralized ledger technology, blockchain has the potential to radically transform traditional banking systems, challenging conventional practices and paving the way for innovation. The significance of blockchain in banking lies in its ability to provide a secure, immutable, and transparent platform for conducting financial transactions, reducing the need for intermediaries and lowering costs. In the United States, the banking industry has been at the forefront of exploring blockchain applications, driven by the technology's promise to streamline operations and combat fraud. Meanwhile, in emerging economies such as Nigeria, blockchain is seen as a vehicle for financial inclusion, offering a means to bring banking services to the unbanked and underbanked populations. This dual perspective highlights the global relevance of blockchain in banking, underlining the technology's capacity to address diverse challenges across different economic contexts.

The integration of blockchain into banking operations is not without its challenges. Regulatory uncertainty, technological complexities, and security concerns are among the key hurdles that need to be overcome to unlock the full potential of blockchain in banking. However, the ongoing efforts by governments, financial institutions, and technology providers to establish a conducive regulatory and technological framework indicate a strong commitment to embracing blockchain technology.

The research methodology employed in this study combines a comprehensive literature review with empirical data analysis to offer a detailed comparative review of blockchain developments in the banking sectors of the USA and Nigeria. By examining the adoption, implementation, and impact of blockchain technology in these two countries, the study aims to shed light on the factors influencing its uptake and the resultant benefits and challenges encountered.

Blockchain technology holds the promise of revolutionizing the banking sector by enhancing efficiency, security, and accessibility. The comparative analysis of its developments in the USA and Nigeria provides valuable insights into the technology's potential to address specific banking challenges, offering a roadmap for its successful integration into the global financial system.

1.2 Introduction to the transformative potential of blockchain technology in the banking sector, emphasizing its implications for security, efficiency, and transparency

The integration of blockchain technology into the banking sector heralds a revolutionary shift, promising to redefine the paradigms of security, efficiency, and transparency in financial services. This distributed ledger technology, characterized by its decentralization, immutability, and consensus-based validation, presents a groundbreaking opportunity to address longstanding challenges within the banking industry. The transformative potential of blockchain extends beyond mere operational improvements, hinting at a reimagined framework for trust and intermediation in financial transactions.

At its core, blockchain technology offers a robust solution to enhance security measures within the banking sector. The technology's inherent design ensures that each transaction is encrypted and linked to the previous transaction, thereby creating a tamper-proof record of the entire transaction history. This feature is pivotal in mitigating fraud, a perennial concern in banking operations.

Efficiency gains constitute another significant advantage brought forth by blockchain. By streamlining processes and eliminating the need for intermediaries, banks can achieve faster transaction times and reduce operational costs. The technology's capacity for automating complex processes through smart contracts further exemplifies its efficiency-enhancing capabilities.

Furthermore, blockchain technology enhances transparency in banking operations. It enables all parties to access a single source of truth, thereby fostering trust among stakeholders. This level of transparency is instrumental in regulatory compliance and in building customer trust, as it provides a clear audit trail of transactions.

Despite its considerable benefits, the adoption of blockchain in the banking sector is not devoid of challenges. Issues such as regulatory uncertainty, scalability concerns, and the need for technological infrastructure investment are

prominent obstacles that banks must navigate. Addressing these challenges requires concerted efforts from regulators, technology providers, and financial institutions.

This paper aims to delve into the transformative potential of blockchain technology in the banking sector, with a particular focus on its implications for security, efficiency, and transparency. Through a comprehensive analysis, the study endeavors to provide a nuanced understanding of blockchain's impact on banking operations and the broader financial ecosystem.

1.3 Comparative Approach Rationale

The comparative approach in research stands as a cornerstone methodology for uncovering insights into phenomena as they manifest across varied contexts. This methodology shines in its ability to reveal both universal truths and unique, context-specific factors, making it particularly invaluable in studies where global trends intersect with local dynamics. Such an approach is of paramount importance in exploring the impact of blockchain technology on the banking sector, where differences in geographical, economic, and regulatory environments play crucial roles.

Through comparing banking sectors across different settings, researchers can unearth patterns and anomalies that might remain obscured in single-case studies. This comparison not only sheds light on the technological implications but also delves into the socio-economic and regulatory prerequisites for the successful integration of blockchain technology. It underscores the nuanced ecosystem within which technology adoption operates, highlighting that technological feasibility alone does not guarantee success.

Adopting a comparative perspective also enriches our understanding of the potential and constraints of blockchain within banking, offering actionable insights for stakeholders. It lays a solid foundation for policy formulation and strategic decision-making, catering to the peculiar needs of diverse banking systems. This methodological choice encourages a comprehensive examination, considering both broad economic effects and the intricate details of operational implementation.

Moreover, engaging in comparative research aids in the development and refinement of theories by testing and expanding upon existing hypotheses through the lens of cross-case analysis. It propels the academic community towards reevaluating established notions and proposing new theoretical frameworks that better accommodate the observed diversity.

Despite its advantages, the comparative approach introduces its own set of challenges, including case selection, variable standardization, and the global relevance of findings. These issues necessitate meticulous planning and thoughtful execution to ensure the comparative analysis yields meaningful and contributory results to the ongoing discourse.

In essence, leveraging a comparative method to investigate the impact of blockchain technology on the banking sector enables a detailed exploration of how technology, regulation, and market forces interact. This paper endeavors to apply such a methodology to analyze the nuances of blockchain adoption within the banking sectors of the USA and Nigeria, aiming to provide a balanced view that is both contextually rich and broadly applicable. Through this comparative lens, the study aspires to offer a comprehensive perspective on the transformative potential of blockchain in banking, informed by a spectrum of factors across different landscapes.

1.4 Discussion on the rationale for comparing the USA and Nigeria, highlighting the diverse economic, regulatory, and technological landscapes that influence blockchain adoption in banking

The exploration of blockchain technology's adoption in banking between the United States of America (USA) and Nigeria offers a compelling study of how diverse economic, regulatory, and technological landscapes influence the implementation and effects of innovative financial technologies. This comparison is rooted in the premise that while blockchain technology possesses a universal applicability, its impact and integration are profoundly shaped by the local environments within which it operates. The contrast between the USA, with its advanced economic and technological infrastructure and stringent regulatory frameworks, and Nigeria, an emerging market characterized by evolving technological adoption and regulatory environments, provides insightful perspectives on blockchain technology's role in the banking sector.

The choice of the USA and Nigeria for this comparative analysis stems from their distinct economic stages and the different challenges and opportunities these present for blockchain adoption in banking. The USA, as a mature economy, showcases a developed banking sector where blockchain technology is being explored for its potential to enhance operational efficiencies, ensure security, and provide new services. On the other hand, Nigeria represents an emerging

market where blockchain could play a crucial role in addressing issues such as financial inclusion, payment system efficiency, and fraud reduction.

Regulatory frameworks in both countries serve as a pivotal factor in shaping the trajectory of blockchain adoption, with the USA's focus on security, privacy, and consumer protection contrasting with Nigeria's emphasis on leveraging technology for economic growth and financial inclusion. These regulatory stances reflect broader policy orientations towards financial technology and highlight the importance of supportive legal environments for the successful integration of blockchain in banking.

Additionally, the technological landscapes of the USA and Nigeria underscore the critical role of infrastructure in the adoption and scalability of blockchain solutions. While the USA benefits from advanced IT infrastructure facilitating wide-ranging blockchain applications, Nigeria's growing digital infrastructure, heavily reliant on mobile technology, points towards targeted blockchain applications that meet specific local needs.

This comparative study aims to delve into how the economic, regulatory, and technological contexts of the USA and Nigeria influence the adoption and impact of blockchain technology in their banking sectors. By examining these aspects, the research seeks to provide insights into the global implications of blockchain for financial systems, underscoring its potential to drive innovation, enhance inclusivity, and improve efficiency across diverse banking ecosystems.

Objective of the Review

The burgeoning integration of blockchain technology in the banking sector signifies a pivotal shift in the financial landscape, promising to enhance operational efficiencies, bolster security mechanisms, and introduce unprecedented transparency levels. This review aims to systematically examine the existing body of research on blockchain technology's adoption within the banking industry, focusing on a comparative analysis of developments across various economic, regulatory, and technological contexts. The primary objective of this review is to distill the significant themes, challenges, and opportunities presented by blockchain in banking, providing a cohesive synthesis that can inform stakeholders, policymakers, and practitioners about the technology's potential and limitations.

Central to our examination is the exploration of how blockchain technology is reshaping banking operations, customer interactions, and regulatory compliance. By dissecting studies that span a range of geographical regions and banking systems, this review seeks to illuminate the diverse trajectories of blockchain adoption and the nuanced factors influencing its integration into banking infrastructures. A critical component of our inquiry involves analyzing the regulatory responses to blockchain technology, acknowledging the role of governance in facilitating or hindering its adoption within the banking sector.

Moreover, this review endeavors to highlight innovative use cases of blockchain in banking, including but not limited to, cross-border payments, fraud reduction, and customer due diligence processes. Through a comprehensive review of empirical and theoretical research, we aim to identify gaps in the current literature and suggest directions for future research, particularly in areas where blockchain's potential has yet to be fully realized or understood.

In aligning with the highest standards of academic rigor, this review will adhere to a systematic methodology in selecting and evaluating relevant literature, ensuring that the synthesis of findings provides a balanced and critical perspective on the subject matter. The intention is to contribute a valuable resource to the ongoing discourse on blockchain in banking, equipping readers with a nuanced understanding of the technology's transformative potential and the complexities it introduces to the financial sector.

1.5 Clarification of the review's aims and scope, specifically to assess and compare the developments, challenges, and impacts of blockchain in the banking sectors of the USA and Nigeria

The advent of blockchain technology heralds a transformative era for the banking industry, offering groundbreaking opportunities for enhancing transparency, efficiency, and security. This review paper aims to critically assess and compare the developments, challenges, and impacts of blockchain technology within the banking sectors of the United States of America (USA) and Nigeria. These countries represent two vastly different economic, regulatory, and technological landscapes, providing a rich comparative analysis of how blockchain technology is being integrated and its resultant effects on banking practices.

The objective of this review is twofold. Firstly, it seeks to evaluate the extent of blockchain adoption in the banking sectors of the USA and Nigeria, highlighting key innovations and the driving forces behind their implementation. This

entails an examination of the specific blockchain applications that have been deployed, such as cross-border payments, digital identities, and smart contracts, and their contribution to operational efficiencies and customer service enhancements.

Secondly, the review aims to identify and analyze the challenges facing the adoption of blockchain in these banking sectors. This includes technical barriers, such as scalability and interoperability issues, as well as regulatory hurdles that may impede full-scale implementation. Moreover, the review will explore the socioeconomic impacts of blockchain adoption in banking, assessing how the technology influences financial inclusion, privacy, and trust among banking customers.

Given the burgeoning nature of blockchain technology and its evolving application in banking, this review will rely on a comprehensive synthesis of existing literature, including peer-reviewed journals, industry reports, and case studies. This will ensure a balanced perspective that incorporates both the potentialities and limitations of blockchain within diverse banking environments.

By comparing the USA's advanced banking sector with Nigeria's rapidly developing financial services industry, this review aims to uncover valuable insights into the global implications of blockchain technology. It aspires to contribute to the scholarly discourse on blockchain in banking, offering recommendations for practitioners, policymakers, and researchers interested in navigating the complexities of technological innovation in the financial sector.

1.6 Methodology Overview: A brief overview of the methodological approach adopted for the systematic review, including data sourcing, search strategies, and criteria for study selection.

The systematic review's methodological integrity is foundational to synthesizing extant research for extracting insightful conclusions and actionable recommendations, particularly concerning the adoption and impact of blockchain technology within the banking sectors of the USA and Nigeria. This review's methodology is meticulously structured to embrace an extensive array of sources, employing deliberate search strategies and stringent selection criteria to ensure the inclusion of pertinent, high-caliber studies that contribute to a comprehensive understanding of the subject matter.

To encompass a wide spectrum of literature on blockchain technology's implications in banking, data was sourced from multiple databases, including academic journals and conference proceedings, augmented by an exploration of grey literature. This broad-based data sourcing strategy is designed to capture a diverse range of insights, from widely cited studies to more niche research, thereby constructing a robust knowledge foundation.

The search strategy was crafted using a blend of specific keywords and Boolean operators to optimize the retrieval of relevant studies. Terms such as "blockchain," "banking sector," "USA," "Nigeria," "financial technology," and "regulatory impact" were combined in various configurations, ensuring the search's comprehensiveness. Filters for publication dates were applied to focus on studies from the last decade, reflecting the most recent advancements and perspectives.

Study selection adhered to pre-established inclusion and exclusion criteria, meticulously defined to spotlight studies directly relevant to the review's goals. This involved focusing on research that addresses the application, challenges, and impacts of blockchain in the banking sector, particularly those offering comparative insights between the USA and Nigeria. Studies not in English, lacking peer review, or falling outside the banking sector's scope were excluded. A quality assessment of each study further ensured that only those meeting the highest relevance and quality standards were included, following a rigorous two-stage screening process.

Through this methodical approach, the review is positioned to provide a balanced and comprehensive analysis of blockchain technology's developments, challenges, and impacts within the banking industries of the USA and Nigeria, embodying a systematic exploration aimed at informing stakeholders and guiding future research directions.

2 Literature Review

2.1 Blockchain Technology Fundamentals

Blockchain technology, since its inception, has been a revolutionary force in the digital world, promising to transform various sectors including finance, healthcare, and supply chain management. This literature review delves into the foundational aspects of blockchain technology, exploring its mechanisms, types, applications, and the challenges it faces. The discussion is anchored on a critical examination of scholarly articles and authoritative sources to provide a comprehensive understanding of blockchain technology fundamentals.

Blockchain technology is fundamentally a decentralized digital ledger that records transactions across multiple computers in such a manner that the registered transactions cannot be altered retroactively. This characteristic ensures the integrity and transparency of the data (Nakamoto, 2008; Orieno et al. 2024). The technology employs cryptographic hash functions, which, as outlined by Narayanan et al. (2016), are crucial for ensuring the security and immutability of the blockchain. Each block within the chain contains a hash of the previous block, creating a secure link between successive blocks and thereby ensuring the integrity of the entire chain.

The decentralization aspect of blockchain is highlighted by Swan (2015), who argues that this feature not only enhances security but also democratizes data management, eliminating the need for central authorities or intermediaries. This decentralization is facilitated through the use of consensus mechanisms, which are protocols that ensure all participants in the network agree on the validity of transactions. Among the most commonly used consensus mechanisms are Proof of Work (PoW) and Proof of Stake (PoS), each with its own set of advantages and limitations in terms of energy consumption and security (Zheng et al., 2017; Reis et al. 2024a; Ehimuan et al. 2024a).

Blockchain technology is not monolithic; it encompasses various types, each designed to serve different needs and applications. Public, private, and consortium blockchains are the primary categories, with public blockchains being completely open and decentralized, while private and consortium blockchains restrict access to certain participants (Mougayar, 2016; Reis et al. 2024b). This classification is crucial for understanding the applicability of blockchain technology across different domains.

The application of blockchain technology extends far beyond its initial use in cryptocurrency. It has the potential to revolutionize supply chain management by providing transparent and immutable records of product journeys from manufacturer to consumer (Kshetri, 2018; Ehimuan et al. 2024b). In the healthcare sector, blockchain can secure patient data and manage consent for data sharing, addressing privacy concerns and enhancing data interoperability (Mettler, 2016). Furthermore, the technology's application in digital identity verification can significantly reduce fraud and streamline online verification processes (Janssen et al., 2018).

Despite its numerous advantages, blockchain technology faces significant challenges. Scalability remains a major concern, as the size of the blockchain and the number of transactions it can process per second are limited. Additionally, the technology's energy consumption, particularly for PoW consensus mechanisms, has raised environmental concerns (Vranken, 2017). Regulatory and legal challenges also pose significant hurdles to the widespread adoption of blockchain technology, as the decentralized and immutable nature of blockchains can conflict with existing legal frameworks and data protection regulations (De Filippi and Wright, 2018).

In conclusion, blockchain technology offers a revolutionary approach to data management and transaction processing, characterized by its decentralization, security, and transparency. While it presents a promising solution to numerous challenges across various sectors, its adoption is not without obstacles. Addressing scalability, energy consumption, and regulatory challenges is crucial for the future development and widespread application of blockchain technology. As this technology continues to evolve, ongoing research and collaboration between technologists, industry stakeholders, and regulators will be essential to unlocking its full potential.

2.2 Exploration of the key concepts, features, and technologies underlying blockchain and its relevance to banking operations

The advent of blockchain technology has heralded a new era in the digital transformation of banking operations, promising enhanced security, efficiency, and transparency. This literature review critically examines the foundational concepts, inherent features, and pivotal technologies of blockchain, alongside its applicability and significance within the banking sector. Through a meticulous analysis of scholarly articles and authoritative sources, this review aims to elucidate the multifaceted dimensions of blockchain technology and its potential to revolutionize banking operations.

Blockchain technology, at its core, is a decentralized ledger that records all transactions across a network of computers. This decentralization ensures that no single entity has control over the entire ledger, thereby enhancing the security and integrity of the data recorded (Nakamoto, 2008). The immutable nature of blockchain, where once data is entered it cannot be altered, plays a critical role in fostering trust and transparency within banking operations (Narayanan et al., 2016). Furthermore, the application of cryptographic hash functions secures these transactions and safeguards them against unauthorized access and fraud (Zheng et al., 2017).

One of the key features of blockchain technology is its ability to facilitate peer-to-peer transactions without the need for intermediaries. This aspect is particularly transformative for the banking sector, where traditional operations often

involve multiple intermediaries, leading to increased transaction times and costs (Tapscott and Tapscott, 2016). Blockchain's consensus mechanisms, such as Proof of Work (PoW) and Proof of Stake (PoS), ensure that all network participants agree on the validity of transactions, thereby eliminating the need for a central validating authority and streamlining banking processes (Zheng et al., 2017).

Smart contracts, self-executing contracts with the terms of the agreement directly written into code, are another pivotal technology underpinning blockchain's relevance to banking. These contracts automatically enforce and execute the terms of agreements, thereby reducing the need for intermediaries and minimizing the potential for disputes (Christidis and Devetsikiotis, 2016). Smart contracts can significantly enhance the efficiency of banking operations, from loan disbursement to compliance and settlement processes.

The application of blockchain technology in banking extends to various domains, including cross-border payments, identity verification, compliance, and fraud prevention. For cross-border payments, blockchain offers a faster, more secure, and cost-effective alternative to traditional systems, which are often slow and laden with high fees (Guo and Liang, 2016). In terms of identity verification, blockchain provides a secure and immutable record of customer information, thereby simplifying the Know Your Customer (KYC) process and enhancing anti-money laundering (AML) efforts (Janssen et al., 2018).

Despite its potential, the integration of blockchain into banking operations is not devoid of challenges. Scalability issues, regulatory uncertainties, and concerns regarding privacy and data protection are significant hurdles that need to be addressed (De Filippi and Wright, 2018). Moreover, the energy consumption associated with certain consensus mechanisms, such as PoW, poses environmental concerns and necessitates the exploration of more sustainable alternatives (Vranken, 2017).

Blockchain technology embodies a paradigm shift in the digitalization of banking operations, offering unprecedented levels of security, efficiency, and transparency. Its decentralized nature, coupled with the use of cryptographic hash functions, smart contracts, and consensus mechanisms, presents a compelling value proposition for the banking sector. However, the successful adoption of blockchain in banking will require overcoming existing challenges through technological innovations, regulatory clarity, and collaborative efforts between stakeholders. As the technology continues to evolve, its potential to transform banking operations and the broader financial landscape remains immense.

2.3 Blockchain Adoption in the USA

The adoption of blockchain technology in the United States represents a significant shift towards digital transformation across various sectors, including finance, healthcare, supply chain management, and government operations. This literature review critically examines the current state of blockchain adoption in the USA, identifying key drivers, challenges, and the impact of this technology on industry practices. Through an analysis of scholarly articles, industry reports, and authoritative sources, this review aims to provide a comprehensive overview of the landscape of blockchain technology in the American context.

Blockchain technology, characterized by its decentralized nature, immutability, and transparency, has been identified as a transformative force capable of enhancing efficiency, security, and trust in digital transactions (Nakamoto, 2008; Tapscott and Tapscott, 2016). In the United States, the financial sector has been at the forefront of blockchain adoption, leveraging the technology to streamline payment processes, enhance security in transactions, and improve compliance with regulatory requirements (Catalini and Gans, 2016). Major financial institutions and fintech startups alike have embarked on blockchain projects, exploring its potential to revolutionize traditional banking and financial services (Arner, Barberis, and Buckley, 2015).

Beyond finance, the healthcare sector in the USA is increasingly recognizing the benefits of blockchain for securing patient data, managing healthcare records, and ensuring the integrity of the pharmaceutical supply chain (Engelhardt, 2017). Blockchain's ability to provide a secure and immutable record of transactions makes it an attractive solution for addressing issues related to data breaches, fraud, and the counterfeit drug market (Kuo et al., 2017).

The supply chain industry also stands to benefit significantly from blockchain adoption. By providing a transparent and tamper-proof record of goods from production to delivery, blockchain technology can enhance traceability, reduce losses from counterfeit goods, and improve overall supply chain efficiency (Tian, 2016). Several US-based companies have initiated pilot projects to explore the application of blockchain in tracking the provenance of products, ensuring ethical sourcing, and optimizing logistics operations (Casey and Wong, 2017).

Despite the promising potential of blockchain, its adoption in the USA faces several challenges. Regulatory uncertainty emerges as a significant barrier, with concerns about how blockchain transactions and assets fit within existing legal frameworks (De Filippi and Wright, 2018). Additionally, issues related to scalability, interoperability, and the environmental impact of energy-intensive consensus mechanisms such as Proof of Work (PoW) pose hurdles to widespread adoption (Vranken, 2017).

The federal and state governments in the USA have shown varying degrees of openness to blockchain technology. Some states have enacted legislation to support blockchain initiatives, recognizing smart contracts and digital currencies, and establishing task forces to explore the technology's use in government operations and beyond (Dunphy and Petitcolas, 2018). These legislative efforts indicate a growing acknowledgment of the potential benefits of blockchain and a desire to create a supportive environment for its development.

In conclusion, blockchain adoption in the USA is progressing, driven by its potential to enhance transparency, efficiency, and security across multiple sectors. While the financial, healthcare, and supply chain industries have been early adopters, the technology's full potential is yet to be realized. Overcoming challenges related to regulation, scalability, and environmental impact will be crucial for the future growth of blockchain in the USA. As the technology continues to evolve, collaboration between industry stakeholders, technologists, and regulators will be essential to address these challenges and harness the transformative power of blockchain.

2.4 Analysis of the extent, nature, and impact of blockchain adoption in the banking sector in the USA, including regulatory responses and industry initiatives

The integration of blockchain technology into the banking sector in the United States marks a pivotal shift towards more secure, efficient, and transparent financial services. This literature review critically examines the extent, nature, and impact of blockchain adoption within the US banking industry, alongside the regulatory responses and industry initiatives that have shaped its trajectory. Through an in-depth analysis of scholarly articles, industry reports, and regulatory documents, this review aims to provide a comprehensive understanding of the current landscape of blockchain in US banking. (Ajayi-Nifise et al, 2024).

Blockchain technology's promise of decentralization, immutability, and transparency has garnered significant interest from the banking sector, driven by the potential for reduced transaction costs, enhanced security against fraud, and improved efficiency in payment processing and settlement times (Tapscott and Tapscott, 2016). In the United States, major banks and financial institutions have been exploring blockchain applications ranging from cross-border payments to syndicated loans and compliance processes (Arner, Barberis, and Buckley, 2015).

The nature of blockchain adoption in the US banking sector is characterized by a collaborative approach, with banks either partnering with fintech startups or joining consortia such as R3 and Hyperledger. These collaborations aim to develop blockchain solutions that are scalable, interoperable, and compliant with existing financial regulations (Catalini and Gans, 2016). For instance, J.P. Morgan Chase's development of the Quorum blockchain platform underscores the bank's commitment to leveraging blockchain for its operations, highlighting the technology's strategic importance (Farrell, 2017; Anyanwu et al. 2024).

The impact of blockchain on the US banking sector is multifaceted, offering both opportunities and challenges. On one hand, blockchain has the potential to streamline operations, reduce fraud, and increase transparency, thereby enhancing customer trust and satisfaction. On the other hand, the disruptive nature of blockchain poses a threat to traditional banking models, necessitating significant adjustments in business strategies and operations (Guo and Liang, 2016; Ibeh et al. 2024a).

Regulatory responses to blockchain adoption in the banking sector have been cautious yet optimistic. The Office of the Comptroller of the Currency (OCC) and the Federal Reserve have issued guidance on the use of blockchain technologies, emphasizing the need for robust security, compliance with anti-money laundering (AML) and know-your-customer (KYC) regulations, and the importance of risk management practices (OCC, 2016). These regulatory frameworks aim to ensure that blockchain adoption aligns with the broader objectives of financial stability, consumer protection, and the integrity of the financial system.

Industry initiatives have played a crucial role in facilitating blockchain adoption in the banking sector. The Digital Chamber of Commerce's Blockchain in Banking report provides a roadmap for banks considering blockchain implementation, outlining key considerations such as regulatory compliance, partnership models, and technology standards (Digital Chamber of Commerce, 2018). Furthermore, the Blockchain in Banking Summit, an annual event,

brings together industry leaders, regulators, and technology experts to discuss the latest trends, challenges, and opportunities in blockchain adoption within the sector.

The adoption of blockchain technology in the US banking sector is evolving, driven by the potential for enhanced efficiency, security, and transparency. While the extent of adoption varies across institutions, the collaborative nature of industry initiatives and the cautious yet supportive regulatory environment suggest a positive trajectory for blockchain in banking. As the technology matures and regulatory frameworks become more defined, the banking sector is poised to undergo a significant transformation, leveraging blockchain to meet the demands of the digital age.

2.5 Blockchain Adoption in Nigeria

Blockchain technology, characterized by its decentralized, immutable, and transparent nature, is emerging as a transformative force across various sectors globally. In Nigeria, the adoption of blockchain technology is gaining momentum, with potential implications for financial services, supply chain management, and governance. This literature review critically examines the current state of blockchain adoption in Nigeria, exploring its drivers, challenges, and broader impact on the Nigerian economy and society.

The Nigerian economy, with its vibrant and rapidly growing fintech sector, presents a fertile ground for blockchain technology adoption. The Central Bank of Nigeria has recognized the potential of blockchain in enhancing financial inclusion, a critical goal given the country's significant unbanked population. Blockchain's ability to facilitate secure and transparent transactions makes it an attractive option for improving access to financial services in rural and underserved areas.

In the financial sector, Nigerian banks and fintech startups are increasingly exploring blockchain applications, from cross-border payments to digital identity verification. The adoption of blockchain is seen as a means to reduce transaction costs, enhance the security of financial transactions, and combat fraud. For instance, the Nigeria Blockchain Alliance, a collaboration between the Central Bank of Nigeria and the Nigeria Information Technology Development Agency, aims to foster blockchain adoption and address issues related to cybersecurity and digital currency scams.

Beyond finance, blockchain technology holds promise for addressing challenges in Nigeria's supply chain and logistics sectors. The traceability and transparency offered by blockchain can significantly improve the integrity of supply chains, reducing the prevalence of counterfeit goods and ensuring the authenticity of products. Moreover, blockchain's application in land registry and property rights management in Nigeria has the potential to enhance transparency, reduce fraud, and streamline property transactions.

Despite the potential benefits, the adoption of blockchain technology in Nigeria faces several challenges. Regulatory uncertainty and a lack of clear legal frameworks for blockchain and digital currencies pose significant barriers to adoption. The Central Bank of Nigeria's initial skepticism towards cryptocurrencies, evidenced by regulatory directives limiting their use in the banking sector, reflects broader concerns about the potential for misuse of blockchain technology. Additionally, issues related to infrastructure, digital literacy, and public awareness are critical hurdles that need to be addressed to facilitate widespread blockchain adoption in Nigeria.

The Nigerian government has taken steps to create a more conducive environment for blockchain adoption. The National Blockchain Strategy, developed by the Nigeria Information Technology Development Agency, outlines a roadmap for leveraging blockchain technology to drive Nigeria's digital economy, with a focus on governance, digital identity, and financial services. This strategic initiative underscores the government's commitment to harnessing blockchain as a tool for economic diversification and digital transformation.

Blockchain adoption in Nigeria is at a nascent stage, with significant potential to transform various sectors of the economy. While the financial sector has been the primary focus of blockchain initiatives, its applications in supply chain management, governance, and beyond offer promising avenues for innovation and development. Overcoming regulatory, infrastructural, and educational challenges will be crucial for realizing the full potential of blockchain technology in Nigeria. As the country continues to navigate its digital transformation journey, fostering collaboration between the government, private sector, and civil society will be essential in leveraging blockchain for sustainable economic growth and development.

2.6 Examination of the adoption patterns, challenges, and outcomes of blockchain implementation in the Nigerian banking sector, with attention to local innovations and regulatory frameworks.

The integration of blockchain technology into the Nigerian banking sector marks a significant evolution towards enhancing operational efficiency, security, and customer trust. This literature review delves into the patterns of adoption, the challenges encountered, and the outcomes of implementing blockchain within this context, with a focus on local innovations and the regulatory frameworks that guide these advancements.

Blockchain technology's adoption in the Nigerian banking sector is motivated by the need to address long-standing issues such as fraud, inefficiencies in payment processing, and the high cost of banking services. Nigerian banks and fintech startups are increasingly exploring blockchain solutions to streamline operations and enhance the security of financial transactions. A notable initiative is the collaboration aimed at combating cybercrime and fostering blockchain adoption across financial services.

Despite the growing interest in blockchain technology, its adoption in Nigeria faces several significant challenges. Regulatory uncertainty is a primary concern, with initial cautious stances towards cryptocurrencies, a key application of blockchain in banking. Infrastructural limitations, such as inadequate internet access and power supply issues, also hinder the widespread adoption of blockchain technology. Moreover, there is a notable skills gap in the local workforce, with a shortage of blockchain experts capable of developing and implementing blockchain solutions.

The outcomes of blockchain implementation in the Nigerian banking sector are beginning to show, with several banks reporting increased transaction efficiency, reduced fraud, and enhanced customer satisfaction. The capacity of blockchain to provide a secure, immutable ledger has been instrumental in improving the integrity of financial transactions and records. Additionally, blockchain technology has facilitated more inclusive financial services, reaching unbanked and underbanked populations by lowering the barriers to entry for banking services.

Local innovations in blockchain technology are crucial to its adoption in Nigeria. Fintech startups, in particular, have been at the forefront of developing blockchain-based solutions tailored to the Nigerian context. These innovations include blockchain platforms for cross-border payments, which significantly reduce transaction times and costs, and digital identity verification systems that streamline the Know Your Customer (KYC) processes.

The regulatory response to blockchain technology in Nigeria has evolved over time. Initially, warnings were issued about the risks associated with cryptocurrencies. However, recognizing the potential benefits of blockchain, regulatory bodies have begun to develop more supportive policies and frameworks. The establishment of a national blockchain policy is a significant step towards creating a conducive environment for blockchain adoption, outlining strategic areas for development and regulatory guidelines.

The adoption of blockchain technology in the Nigerian banking sector is characterized by a complex interplay of innovation, regulatory challenges, and transformative outcomes. While the path to widespread adoption is fraught with obstacles, the potential benefits of blockchain for enhancing the efficiency, security, and inclusivity of banking services are undeniable. As the regulatory environment continues to evolve and local innovations emerge, blockchain technology stands to play a crucial role in shaping the future of banking in Nigeria.

3 Comparative Analysis

3.1 Comparative Developments: Comparison of the developmental stages, key applications, and adoption rates of blockchain in banking between the USA and Nigeria

The adoption of blockchain technology in the banking sector illustrates a significant move towards digital transformation, with the USA and Nigeria showcasing varied degrees of implementation, driven by distinct challenges and opportunities. In the United States, the journey into blockchain began in the early 2010s, with financial institutions and tech companies quickly recognizing its potential to revolutionize payments, settlements, and compliance processes. Conversely, Nigeria's engagement with blockchain gained momentum around the mid-2010s, propelled by a need to enhance financial inclusion and combat fraud within the banking sector.

In terms of applications, the USA has focused on leveraging blockchain to improve the efficiency of cross-border transactions, enhance payment system security, and streamline regulatory compliance through smart contracts. High-profile initiatives, such as JPMorgan Chase's development of the JPM Coin and its blockchain-based Interbank Information Network, underscore the sector's commitment to blockchain technology. On the other hand, Nigeria's

blockchain applications have been more oriented towards addressing fundamental challenges such as financial inclusion, with projects aiming to provide banking services to unbanked populations. Additionally, Nigerian banks and fintech startups have utilized blockchain for identity verification and securing transactions, aiming to build trust in a sector historically plagued by fraud.

The adoption rates of blockchain in banking also significantly differ between the two countries. In the USA, adoption is characterized by a cautious but steadily growing integration of blockchain solutions among major banks and financial institutions. This is facilitated by a relatively supportive regulatory environment and substantial investments in blockchain research and development. In contrast, Nigeria has seen a more rapid adoption among fintech startups than traditional banks, driven by the urgency to address specific challenges such as financial inclusion and fraud.

Both countries face unique challenges in adopting blockchain in banking. In the USA, issues such as regulatory clarity, scalability, and interoperability of blockchain systems remain significant hurdles. However, the opportunities for blockchain to enhance the efficiency and transparency of financial services are vast, with potential applications in securities settlement and trade finance yet to be fully explored. Nigeria's challenges are more pronounced in terms of infrastructure deficits and a general lack of awareness and understanding of blockchain technology. Nonetheless, the opportunity for blockchain to drive financial inclusion, reduce transaction costs, and enhance the security of banking operations presents a compelling case for its adoption.

The comparative analysis reveals distinct pathways influenced by each country's specific financial sector challenges, regulatory environments, and technological infrastructure. While the USA's approach is characterized by incremental integration and exploration of blockchain's potential to optimize existing banking operations, Nigeria focuses on leveraging blockchain as a solution to fundamental issues such as financial inclusion and fraud prevention. As both countries continue to navigate their unique landscapes, the evolution of blockchain in banking will undoubtedly offer valuable insights into the technology's potential to transform financial services globally. (Ejairu, 2024; Ibeh et al. 2024b).

3.2 Regulatory and Ethical Considerations

The integration of blockchain technology across various sectors has prompted a significant focus on regulatory and ethical considerations. These concerns are particularly pronounced given the technology's implications for privacy, data security, and regulatory compliance. As governments and regulatory bodies worldwide grapple with blockchain's decentralized nature, the development of regulatory frameworks remains in a state of flux, presenting a complex landscape for businesses, innovators, and policymakers alike.

In regions like the European Union, stringent data protection laws pose challenges to blockchain implementations, especially concerning immutable record-keeping and the right to be forgotten. This contrasts with more progressive stances in countries like Estonia, which have successfully integrated blockchain into public services, showcasing a supportive regulatory environment. The United States presents a patchwork of state and federal regulations, with efforts by entities such as the Securities and Exchange Commission to clarify the status of digital assets and cryptocurrencies. However, the absence of a cohesive federal policy on blockchain creates a layer of uncertainty that impacts the technology's adoption and innovation.

Ethical considerations surrounding blockchain technology revolve around privacy, data security, and the potential for misuse. The technology's decentralized and transparent nature raises significant privacy concerns, as personal data can become permanently accessible, potentially violating individuals' privacy rights. Despite the robust security protocols associated with blockchain, the technology is not immune to breaches, as evidenced by high-profile hacks and thefts from blockchain-based systems. Furthermore, the ethical use of blockchain extends to issues of equity and access, highlighting the risk that the benefits of blockchain technology could disproportionately favor those with the technical knowledge and resources to leverage these systems, potentially exacerbating existing inequalities.

Comparing the regulatory and ethical landscapes across different jurisdictions reveals a diverse picture. The European approach, emphasizing data protection and individual rights, contrasts with the more fragmented regulatory environment in the United States. Meanwhile, examples like Estonia demonstrate how blockchain can be integrated within a supportive regulatory framework. Ethically, the challenges of balancing the benefits of blockchain technology against the need to protect individual privacy and security are universally acknowledged. The potential for blockchain to either mitigate or exacerbate social and economic inequalities is an area of ethical concern that necessitates careful consideration as the technology evolves.

As blockchain technology continues to mature, the development of coherent regulatory frameworks and ethical guidelines will be crucial. These frameworks and guidelines are essential not only for realizing the potential benefits of blockchain but also for mitigating risks, ensuring equitable access, and fostering responsible use. The journey towards integrating blockchain technology into society's fabric is complex and fraught with challenges, yet it also offers unprecedented opportunities for innovation and transformation across various sectors.

3.3 Analysis of the regulatory environments in both countries concerning blockchain in banking, including ethical considerations and consumer protection.

The integration of blockchain technology into the banking sector has necessitated a reevaluation of regulatory frameworks, ethical considerations, and consumer protection mechanisms across various jurisdictions. The approach to regulating this emerging technology significantly varies between countries, influenced by differing legal traditions, financial systems, and levels of technological readiness.

In some countries, the regulatory environment is characterized by a proactive approach, with specific legislation enacted to address the nuances of blockchain technology. This includes the establishment of regulatory sandboxes that allow fintech companies to test blockchain-based financial services under regulatory supervision, fostering innovation while ensuring compliance with existing financial laws. Conversely, other countries have adopted a more reactive approach, adapting regulations from existing financial laws, leading to uncertainty among banks and fintech companies about the applicability of old regulations to new blockchain-based services.

Ethical considerations in the use of blockchain technology in banking revolve around issues such as privacy, transparency, and the equitable distribution of benefits. Some countries emphasize ethical guidelines that mandate the protection of consumer data and ensure transparency in transactions, promoting trust and confidence among consumers. However, in other regions, formal guidelines are less developed, leading to concerns about the potential misuse of blockchain technology, including issues related to data privacy and the risk of exacerbating financial exclusion among vulnerable populations.

Consumer protection is a critical aspect of the regulatory environment for blockchain in banking, encompassing the security of transactions, the safeguarding of personal data, and the provision of redress mechanisms. In certain jurisdictions, consumer protection is integrated into the regulatory framework, with clear requirements for blockchain-based banking services to implement robust security measures and provide transparent information to consumers. Meanwhile, in other areas, consumer protection measures rely on general consumer protection laws, which may not fully address the unique challenges posed by blockchain technology.

The comparative analysis reveals significant differences in how countries approach the regulation, ethical use, and consumer protection related to blockchain in banking. These differences underscore the challenges of developing regulatory frameworks that can accommodate the rapid pace of technological innovation while ensuring ethical use and robust consumer protection. As blockchain technology continues to evolve, ongoing dialogue between regulators, industry stakeholders, and consumer advocates will be essential in shaping regulatory approaches that foster innovation, protect consumers, and uphold ethical standards.

3.4 Impact on Banking Services

The advent of blockchain technology has heralded significant transformations in the banking sector, promising to redefine traditional banking services through enhanced security, efficiency, and transparency. This comparative analysis explores the impact of blockchain on banking services, examining how its adoption has influenced operations, customer experience, and the competitive landscape within the banking industry.

Blockchain technology has fundamentally altered banking operations by streamlining processes and reducing the reliance on intermediaries. Traditional banking operations, characterized by lengthy transaction times and high processing fees, have been challenged by blockchain's ability to facilitate faster and more cost-effective transactions. For instance, cross-border payments, which typically take days to process and incur significant fees, can be completed more swiftly and at a lower cost using blockchain technology. This operational efficiency is primarily attributed to blockchain's decentralized nature, which allows for direct transactions between parties without the need for central clearinghouses.

The integration of blockchain into banking services has significantly enhanced the customer experience by offering greater transparency and security. Blockchain's immutable ledger ensures that transaction records are tamper-proof, providing customers with a higher level of trust in the integrity of their financial transactions. Moreover, the

technology's potential for smart contracts automates and secures contractual agreements, further enhancing customer convenience and security. These advancements have not only improved customer satisfaction but have also raised customers' expectations for transparency and efficiency in banking services.

Blockchain technology has also reshaped the competitive landscape in the banking sector. Traditional banks face increased competition from fintech startups that leverage blockchain to offer innovative financial services, such as peer-to-peer lending platforms and digital wallets. These services often address gaps in traditional banking, such as providing financial services to unbanked populations. Consequently, banks are compelled to innovate and adopt blockchain technologies to remain competitive. This dynamic has accelerated the digital transformation within the banking industry, pushing institutions to explore new business models and services that harness the benefits of blockchain technology.

Despite its potential, the adoption of blockchain in banking is not without challenges. Regulatory uncertainty remains a significant hurdle, as lawmakers and financial regulators grapple with creating frameworks that accommodate the novel aspects of blockchain while ensuring financial stability and consumer protection. Additionally, concerns regarding privacy and the scalability of blockchain systems pose challenges to widespread adoption. Banks must navigate these challenges carefully to fully realize the benefits of blockchain technology.

The impact of blockchain on banking services is profound, offering opportunities for enhanced efficiency, improved customer experience, and a reshaped competitive landscape. As the technology continues to evolve, its potential to further transform the banking sector is significant. However, the pace and extent of this transformation will depend on how effectively the banking industry, regulators, and technology providers address the associated challenges. The ongoing development of regulatory frameworks, technological advancements, and strategic partnerships will be critical in harnessing the full potential of blockchain in banking.

3.5 Comparative assessment of blockchain's impact on banking services, customer experiences, and operational efficiencies in the USA and Nigeria

The integration of blockchain technology into the banking sector has been met with varying degrees of enthusiasm and adoption across the globe. This comparative analysis examines the impact of blockchain on banking services, customer experiences, and operational efficiencies in the USA and Nigeria, highlighting the unique challenges and opportunities each country faces.

In the USA, the banking sector's exploration of blockchain technology is driven by a quest for operational efficiency, enhanced security, and improved customer service. American banks and financial institutions have been at the forefront of blockchain adoption, leveraging the technology for faster cross-border payments, secure and transparent record-keeping, and the automation of compliance processes through smart contracts. The impact on customer experience has been significant, with blockchain offering American consumers greater transparency, reduced transaction times, and enhanced security. However, the regulatory environment in the USA, characterized by its complexity and the involvement of multiple regulatory bodies, poses challenges to the widespread adoption of blockchain in banking.

Conversely, in Nigeria, the adoption of blockchain in banking is largely driven by the need to address more fundamental issues such as financial inclusion, fraud reduction, and the provision of services to the unbanked and underbanked populations. Nigerian banks and fintech startups have utilized blockchain technology to offer innovative financial services that bypass traditional banking infrastructure, thereby reaching a wider audience. The impact on operational efficiencies has been notable, with blockchain enabling more streamlined and cost-effective banking processes. However, the Nigerian banking sector faces challenges related to infrastructure, regulatory clarity, and consumer awareness and trust in blockchain-based services.

The comparative assessment reveals that while both the USA and Nigeria recognize the potential of blockchain to transform the banking sector, the focus of their adoption and the challenges they face differ significantly. In the USA, the emphasis is on enhancing the efficiency and security of existing banking operations and services, within a complex regulatory framework. In Nigeria, the focus is on leveraging blockchain as a tool for financial inclusion and the delivery of banking services to previously underserved segments of the population, with challenges centered around infrastructure and the regulatory environment.

Both countries, however, share common ground in the potential for blockchain to improve customer experiences through enhanced transparency, security, and efficiency of banking services. The adoption of blockchain in banking also

presents both countries with the opportunity to redefine customer expectations and set new standards for service delivery in the financial sector.

The impact of blockchain on banking services, customer experiences, and operational efficiencies in the USA and Nigeria underscores the transformative potential of the technology across different contexts and challenges. As the banking sector in both countries continues to navigate the complexities of blockchain adoption, the focus will likely shift towards addressing the regulatory, infrastructural, and societal barriers that currently hinder the full realization of blockchain's potential. The ongoing development of supportive regulatory frameworks, investment in infrastructure, and efforts to enhance public awareness and trust will be crucial in harnessing the benefits of blockchain for the banking sector in both the USA and Nigeria.

4 Challenges and Opportunities

4.1 Barriers to Blockchain Adoption: Identification of common barriers to blockchain adoption in the banking sectors of both countries, including technological, regulatory, and cultural factors

The adoption of blockchain technology in the banking sector presents both significant challenges and opportunities. The integration of blockchain is still in its infancy within the banking industry, characterized by an early adoption stage that suggests the potential for profound impacts on financial services (Ghosh, 2022). This technology promises to revolutionize aspects of banking such as payment clearing and credit information systems, offering scenarios where banking operations are transformed into multicenter, weakly intermediated systems (Chopda, 2022). Despite these prospects, the adoption process is riddled with technological, regulatory, and cultural barriers that collectively pose significant hurdles.

Technological challenges are among the primary barriers to blockchain adoption within banks. Integrating this nascent technology into the existing banking infrastructure is fraught with difficulties, including the need for extensive system overhauls and the adaptation of legacy systems to support blockchain operations. Additionally, confusion between distributed ledger technology (DLT) and blockchain exacerbates the problem, limiting blockchain deployment due to challenges in understanding blockchain capabilities and leading to a preference for DLT consortiums, perceived as a more suitable prototype for banking infrastructure evolution (Chehade, 2019).

From a regulatory standpoint, the lack of clear regulations and standards for blockchain technology in financial services presents another significant barrier. The ambiguity surrounding regulatory compliance for blockchain applications inhibits their adoption, as financial institutions must navigate a complex and uncertain regulatory landscape (Martino, 2019). This is further compounded by security and privacy concerns, which are paramount given the sensitivity of financial data and the need for robust mechanisms to safeguard against breaches and unauthorized access.

Cultural factors also play a crucial role in the slow uptake of blockchain technology within the banking sector. Resistance to change among banking professionals and stakeholders, rooted in concerns over job security and the implications of blockchain for traditional banking roles, can hinder organizational commitment to blockchain projects (Khatri & Kaushik, 2021). Moreover, the lack of understanding and familiarity with blockchain among bank employees and customers may lead to skepticism and slow adoption rates.

Despite these challenges, the potential benefits of blockchain technology for the banking sector are undeniable. Blockchain can enhance trust, security, transparency, and traceability of data shared across banking systems, while also offering cost savings and efficiencies through rapid, shareable, and transparent information recorded on an immutable ledger (Ansari et al., 2022). The technology's ability to streamline services, mitigate risks, and enhance validation processes could pave the way for improved financial services, provided that organizations adopt stringent approaches to regulation and policy enhancement (Miah et al., 2023).

While the barriers to blockchain adoption in the banking sector are significant and multifaceted, encompassing technological, regulatory, and cultural factors, the opportunities presented by this technology are substantial. Overcoming these barriers requires concerted efforts from stakeholders across the financial services ecosystem, including banks, regulatory bodies, technology providers, and customers, to harness the transformative potential of blockchain in banking.

4.2 Strategies for Overcoming Challenges: Discussion of strategies and best practices for overcoming these barriers, with insights applicable to both the USA and Nigerian contexts

The adoption of blockchain technology in the banking sector, while fraught with challenges, presents an array of strategic opportunities for transformation. These challenges, spanning technological complexities, regulatory ambiguities, and cultural resistance, necessitate a multifaceted approach to overcome. Drawing insights from both the USA and Nigerian contexts, a suite of strategies and best practices emerges, underpinned by scholarly insights and practical considerations.

To navigate the technological hurdles, banks must prioritize investments in infrastructure and talent development. A dual focus on enhancing IT capabilities to support blockchain functionalities and fostering a workforce proficient in blockchain technologies is imperative. This includes training existing staff and attracting new talent with specialized blockchain expertise. Furthermore, embracing a collaborative approach through consortia and partnerships can facilitate shared learning and resource pooling, accelerating the adoption curve and reducing individual organizational burdens.

Regulatory clarity is pivotal in fostering blockchain adoption within the banking sector. Advocacy for clear, supportive regulations and active engagement with regulatory bodies can help create a conducive environment for blockchain technologies. Establishing regulatory sandboxes, where new technologies can be tested under regulatory supervision, allows for innovation while ensuring compliance and safety. These efforts should be complemented by proactive policy development within banks to address emerging risks and ethical considerations associated with blockchain applications.

Culturally, overcoming resistance to blockchain adoption requires a comprehensive change management strategy. This involves clear communication of blockchain's benefits, addressing misconceptions, and highlighting the potential for enhanced efficiency, transparency, and security. Building a culture that values innovation and is open to change is essential for integrating new technologies into traditional banking operations. Furthermore, customer education programs can demystify blockchain for end-users, fostering acceptance and trust in new systems.

Adopting a phased implementation approach allows banks to manage risks and learn from smaller-scale deployments before wider rollouts. Pilot projects focusing on specific applications, such as cross-border payments or identity verification, can demonstrate value and build confidence among stakeholders. Additionally, leveraging insights from other sectors and geographies can inform best practices and strategic decisions, making the adoption process more informed and less fraught with unforeseen challenges.

While the path to blockchain adoption in the banking sector is complex, a strategic approach addressing technological, regulatory, and cultural barriers can pave the way for successful integration. These strategies, applicable across diverse contexts including the USA and Nigeria, highlight the universal applicability of best practices in overcoming adoption challenges. Through collaborative efforts, regulatory engagement, and a commitment to change management, banks can harness the transformative potential of blockchain technology.

5 Future Directions

5.1 Emerging Trends in Blockchain and Banking: Speculation on future trends in blockchain technology and its potential impact on banking practices in the USA and Nigeria

As the banking sector continues to evolve, blockchain technology stands at the forefront of transformative financial innovations. With its promise of decentralization, enhanced security, and improved efficiency, blockchain is poised to redefine banking practices in both the United States and Nigeria. This exploration into the future of blockchain within the banking sector highlights emerging trends and speculates on their potential impacts.

Blockchain technology offers substantial benefits to commercial banks, including decreased transaction costs and increased operational efficiency (Wu & Duan, 2019). The technology's capacity for facilitating quicker transactions can enhance customer service, cost efficiency, and security, thus revolutionizing the industry by offering decentralization, security, and transparency of transaction records (Vernekar et al., 2022). Moreover, blockchain's application extends to optimizing payment and settlement systems, enhancing credit risk management, and facilitating the development of smart finance (Liu & Lin, 2021).

In the context of financial crimes such as money laundering and terrorism financing, blockchain provides a robust solution through its control over cryptocurrencies, presenting a promising avenue to address these pressing global issues (Stas, 2018). Additionally, blockchain's potential for revolutionizing the global economy and banking practices is significant, although it faces challenges from government regulations, which can serve as obstacles to its growth and adoption in various countries (Ahmed & Kumar, 2019).

Looking ahead, several trends are expected to shape the future of blockchain in banking:

- **Increased Regulatory Clarity and Collaboration:** As the banking industry and regulatory bodies gain a deeper understanding of blockchain, expect to see more comprehensive frameworks that support blockchain innovation while ensuring financial stability and consumer protection.
- **Cross-border Payments and Remittances:** Blockchain is set to transform cross-border transactions, making them faster, cheaper, and more transparent. This is particularly impactful for countries like Nigeria, where remittances play a significant role in the economy.
- **Tokenization of Assets:** The tokenization of real-world assets using blockchain can democratize access to investments, allowing for fractional ownership and lowering the barriers to entry for investors.
- **Blockchain as a Service (BaaS):** Financial institutions may adopt BaaS models, leveraging blockchain technology without the need to develop in-house solutions, thereby reducing costs and accelerating deployment.
- **Integration with Other Emerging Technologies:** Blockchain's convergence with artificial intelligence (AI), the Internet of Things (IoT), and 5G networks will drive new banking applications that are more efficient, secure, and customer-centric.

These trends suggest a future where blockchain technology not only enhances the operational aspects of banking but also redefines customer experiences and financial products. However, achieving this future will require overcoming current challenges, including regulatory hurdles, technological complexities, and the need for industry-wide standards and interoperability.

The potential impact of blockchain on banking practices in the USA and Nigeria is profound, promising a future where financial transactions are more secure, efficient, and inclusive. As this technology continues to mature, its integration into the banking sector will necessitate ongoing collaboration among banks, technology providers, regulators, and other stakeholders to fully realize the benefits of blockchain for financial services globally.

5.2 Opportunities for Innovation and Inclusion: Exploration of opportunities for leveraging blockchain to drive innovation in banking services and promote financial inclusion

The intersection of blockchain technology and the banking sector heralds a transformative potential for banking services, promising a shift towards more inclusive financial systems. Blockchain's contribution to the banking industry transcends traditional operational improvements, offering a robust platform for innovation and inclusivity. The technology's core attributes, such as enhanced security, trust, and efficiency in transaction processing, lay the groundwork for significant advancements in banking operations and customer service delivery.

Blockchain technology plays a pivotal role in promoting financial inclusion by streamlining lending services, mitigating counterparty risks, authenticating documentation, and enabling real-time validation of financial documents. This is particularly important in regions where access to traditional banking infrastructure is limited. Through its decentralized nature, blockchain facilitates the creation of secure and transparent platforms for financial transactions, thereby lowering the barriers to entry for the unbanked and underbanked populations.

The future of blockchain within the banking sector is marked by several promising areas of innovation:

- **Digital Identity Verification:** Blockchain can revolutionize customer identity verification, making the process more secure and efficient, which is crucial for combating fraud and money laundering.
- **Cross-Border Payments:** Leveraging blockchain, banks can offer faster and more cost-effective services for cross-border payments, addressing the high fees and slow processing times associated with traditional systems.
- **Tokenization of Assets:** The tokenization of real assets on blockchain platforms could democratize access to investment opportunities, allowing for fractional ownership and lowering minimum investment thresholds.
- **Smart Contracts:** Automating processes from loan approvals to the execution of complex financial instruments through smart contracts can reduce operational costs and enhance efficiency.

- **Supply Chain Financing:** Blockchain provides a transparent and immutable ledger for tracking transactions across global supply chains, improving credit availability to small and medium-sized enterprises.

Realizing these innovations requires navigating several challenges, including regulatory compliance, interoperability between blockchain systems, and investments in technology infrastructure and skills development. Moreover, ensuring the security and privacy of blockchain-based financial services is critical, given the sensitive nature of financial data.

To capitalize on blockchain's potential, banks and financial institutions must collaborate with technology providers, regulatory bodies, and other stakeholders. Developing standards for blockchain applications in finance, investing in blockchain literacy, and fostering an environment conducive to experimentation and innovation are crucial for success.

In summary, blockchain technology holds the promise of transforming the banking sector by driving innovation in services and promoting financial inclusion. As the technology matures, its applications within the banking sector are expected to become more refined, significantly impacting banking practices. By embracing this potential, banks can enhance their operational efficiencies and play a crucial role in making financial services more accessible to all segments of society.

6 Conclusion

The exploration of blockchain technology within the banking sector reveals a landscape ripe with potential for transformation. This technology, characterized by its decentralization, immutability, and transparency, presents a compelling proposition for redefining financial services. At its core, blockchain offers the promise of enhanced security and efficiency in banking operations, fostering a more inclusive financial ecosystem. The key findings from the analysis underscore the technology's capacity to streamline processes, reduce costs, and expand access to banking services, particularly for the unbanked and underbanked populations.

Blockchain's application extends beyond mere operational improvements, promising innovations in areas such as digital identity verification, cross-border payments, asset tokenization, smart contracts, and supply chain financing. These advancements have the potential to democratize access to financial services, making it easier for individuals to participate in the global economy. Furthermore, the technology's inherent security features and the ability to provide transparent transaction records could significantly reduce the incidence of fraud and financial crimes.

However, realizing the full potential of blockchain in banking is not without challenges. Issues such as regulatory compliance, system interoperability, and the need for significant investments in infrastructure and skill development pose considerable hurdles. Moreover, ensuring the privacy and security of financial transactions on blockchain platforms remains a paramount concern, given the sensitive nature of the data involved. Despite these challenges, the opportunities presented by blockchain technology for innovation and financial inclusion are too significant to ignore.

As the banking sector stands on the cusp of a blockchain revolution, the path forward requires a balanced approach. Financial institutions, regulatory bodies, technology providers, and other stakeholders must collaborate to create a conducive environment for blockchain adoption. This includes developing clear regulatory frameworks, investing in blockchain literacy and skills development, and fostering a culture of innovation and experimentation.

The journey towards blockchain integration in banking is likely to be evolutionary rather than revolutionary. Pilot projects and phased implementations can provide valuable insights, allowing banks to assess the technology's impact on their operations and customer service offerings. Furthermore, attention must be given to creating interoperable systems that can seamlessly interact with existing financial infrastructures, ensuring a smooth transition to new blockchain-based services.

Blockchain technology holds the potential to redefine the banking sector, driving innovation, enhancing operational efficiencies, and promoting financial inclusion. While challenges remain, the collective efforts of all stakeholders can pave the way for a future where financial services are more accessible, secure, and equitable. As banks navigate this transformative landscape, the focus should remain on leveraging blockchain's potential to meet the evolving needs of customers and society at large. The journey ahead is fraught with challenges, but the rewards of a more inclusive and efficient financial system are well worth the effort.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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