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-RESEARCH ARTICLE-

EXPLORING BLOCKCHAIN ADOPTION IN MOROCCO'S FOREX MARKET: IMPLICATIONS FOR COST REDUCTION, VOLATILITY CONTROL, AND FINANCIAL INCLUSION

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—Abstract—

This study explores the transformative potential of blockchain technology within Morocco's foreign exchange (forex) market, emphasising its capacity to enhance cross-border transaction efficiency, promote financial stability, and advance financial inclusion. It evaluates the implications of integrating blockchain into Morocco's forex framework, particularly regarding transaction costs, exchange rate volatility, and inclusive access to financial services in the context of a developing African economy. Despite Morocco's regulatory restrictions on cryptocurrencies since 2017, blockchain's inherent advantages—such as reduced reliance on intermediaries, heightened transparency, and expedited international payments—are increasingly relevant to the country's evolving economic context. Drawing comparative insights from countries including Nigeria, Brazil, India, and Kenya, which have successfully incorporated blockchain in financial systems, the study quantifies potential benefits. These include an estimated 30% decline in transaction costs (from 5% to 3.5%), a 20% reduction in

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exchange rate volatility, and an annual increase of approximately 332,000 financial transactions. Employing quantitative tools such as the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model for volatility analysis and Monte Carlo simulations to forecast long-term scenarios, the findings highlight blockchain's significant potential in enhancing cost-effectiveness, stabilising currency exchange, and broadening financial access in Morocco. Nevertheless, the study also acknowledges persistent obstacles, including unclear regulatory frameworks, inadequate digital infrastructure, and limited public adoption of cryptocurrencies. These issues must be addressed through comprehensive regulatory reforms and public education initiatives to enable the effective integration of blockchain technology into Morocco's forex market.

Keywords: Blockchain Adoption, Foreign Exchange Market, Financial Inclusion, Exchange Rate Volatility, Cryptocurrencies.

INTRODUCTION

The incorporation of blockchain technology into the forex market holds considerable potential to reshape global financial systems by improving efficiency, security, and transparency in monetary transactions. As an open-source and secure innovation, blockchain has already revolutionised multiple sectors by offering notable advantages such as lower transaction fees, enhanced transparency, and rapid cross-border payments. Its implementation in Morocco's forex market could significantly advance the nation's financial operations, particularly in the context of an evolving financial landscape. However, the effective realisation of blockchain's benefits in Morocco is currently impeded by regulatory restrictions, an underdeveloped technological framework, and societal scepticism surrounding cryptocurrencies.

Recognised as one of the most ground-breaking financial innovations of the past decade, blockchain was initially associated primarily with digital currencies such as Bitcoin. Nonetheless, its decentralised and intermediary-free structure has attracted increasing attention from governments, financial institutions, and regulatory bodies. Countries including those within the European Union, as well as Switzerland and the United States, have progressively adopted blockchain within their financial sectors to cut costs and enhance transaction processing efficiency. These nations have simultaneously introduced favourable regulatory policies to facilitate blockchain integration while safeguarding financial system stability and security.

Contrastingly, emerging economies, including Morocco, have taken a more cautious approach towards blockchain adoption. Despite implementing strict prohibitions on cryptocurrencies since 2017, Morocco's financial sector is at a pivotal juncture. The forex market, a crucial component of international trade and financial equilibrium, continues to face numerous inefficiencies such as elevated transaction costs, delays in

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cross-border payment settlements, and frequent fluctuations in exchange rates. Although the advantages of blockchain are well documented, Morocco must first overcome major obstacles such as outdated regulatory frameworks, insufficient digital infrastructure, and widespread public distrust of blockchain technology. This research aims to assess the potential of blockchain technology to strengthen Morocco's forex market by reducing transaction costs, stabilising currency exchange rates, and improving access to financial services, particularly for unbanked populations. It also seeks to examine the structural and regulatory barriers hindering blockchain adoption and to propose viable policy recommendations tailored for Moroccan financial institutions and decision-makers.

Despite the evident opportunities blockchain presents, its adoption in Morocco remains limited due to several persistent challenges. Foremost among these is the lack of regulatory clarity, illustrated by the government's prohibition of cryptocurrency usage, which has hindered the development of blockchain-driven financial solutions. In addition, Morocco's underdeveloped digital infrastructure restricts the seamless deployment of blockchain systems. Public perception further compounds these difficulties, as blockchain technology is often linked with illicit activities and speculative ventures, thereby fuelling reluctance towards its adoption. These factors have collectively prevented Morocco from realising blockchain's transformative capacity within its forex sector.

The core issue lies in determining how blockchain can be effectively integrated into Morocco's forex market to enhance operational efficiency, reduce volatility, and foster financial inclusion, while also addressing barriers such as regulatory rigidity, infrastructural shortcomings, and public hesitancy. Although substantial research has examined blockchain integration in the financial systems of developed economies, limited attention has been paid to its implementation within the forex markets of emerging economies, and particularly in contexts like Morocco. Prior studies have primarily evaluated blockchain's ability to reduce transaction costs and enhance market stability in advanced economies but have largely overlooked the distinctive regulatory, infrastructural, and socio-cultural complexities confronting developing countries. Furthermore, there is a notable scarcity of literature examining how public attitudes and educational outreach influence blockchain adoption in such settings.

To bridge these gaps, the present study investigates the specific prospects and impediments to adopting blockchain in Morocco's forex market. By selecting Morocco as the focal point, the research contributes original insights to the literature on blockchain adoption in emerging markets and proposes actionable strategies to address integration challenges. The principal objective is to analyse the integration of blockchain into Morocco's forex operations and assess its potential impact on reducing transaction expenses, lowering exchange rate volatility, and combating financial exclusion. Specifically, the study evaluates blockchain's capacity to simplify financial

transactions by diminishing intermediary reliance and associated costs. Additionally, it investigates the influence of blockchain on exchange rate fluctuations and broader market stability, aiming to establish whether the technology can facilitate a more stable environment for forex trading.

A further objective is to assess blockchain's role in enhancing financial inclusion, especially by extending access to financial services for Morocco's largely unbanked population, thereby encouraging broader economic engagement. Finally, the study identifies the primary barriers to blockchain adoption in Morocco's forex market and addresses regulatory, technological, and social challenges that could impede its integration. Ultimately, the research is intended to provide evidence-based policy recommendations to support the successful adoption of blockchain within Morocco's financial infrastructure, maximise the technology's benefits, and mitigate existing constraints.

The strategic integration of blockchain is of critical importance to Morocco's financial system and overall economic progression. With a focus on the forex market, which is central to Morocco's participation in global financial transactions, this research offers valuable insights into how the application of blockchain could fortify and optimise the country's financial architecture. The findings will serve as a resource for policymakers, financial stakeholders, and technological innovators, offering guidance on the effective adoption of blockchain and identifying the obstacles that must be addressed for successful implementation. Moreover, the study contributes to the academic discourse on blockchain adoption in emerging economies generally, and within the North African region specifically. It identifies Morocco's unique regulatory, infrastructural, and societal challenges and considers how the nation's response can inform other regional governments considering similar technological integration.

The structure of this study is as follows: Section Two presents a review of the existing literature on blockchain use in forex markets, discussing the advantages and limitations encountered in both developed and developing economies, along with the theoretical framework underpinning the research. Section Three outlines the study's methodology, detailing the research design, data collection processes, and the analytical models employed to estimate blockchain's effect on transaction costs, exchange rate volatility, and financial inclusion. Section Four reports the key findings and explores their implications for Morocco's forex sector and broader financial landscape. The final section concludes the study by summarising its principal outcomes and outlining policy recommendations for the successful implementation of blockchain in Morocco's forex market.

LITERATURE REVIEW

Blockchain technology has significantly reshaped multiple industries, and its emerging

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application within the foreign exchange (forex) sector signals a major step towards the modernisation of financial markets on a global scale. Due to its decentralised architecture, transparency, and irreversible record-keeping, blockchain has proven particularly effective in reducing transaction-related expenses. These features have become central to the growing global reliance on blockchain for foreign exchange settlements (Al-Jaroodi & Mohamed, 2019; Catalini & Gans, 2016). By eliminating the need for conventional intermediaries such as banks and payment processing entities, blockchain enables rapid, direct fund transfers, offering a remedy to the traditionally high costs and lengthy settlement periods associated with forex operations (Tapscott & Tapscott, 2017; Yermack, 2017). This decentralised mechanism, coupled with reduced intermediary involvement and improved transparency, enhances the overall cost-effectiveness and operational efficiency of cross-border forex transactions (Tasca & Tessone, 2019; Xu et al., 2019).

Globally, several economies have experienced meaningful reductions in transaction fees by incorporating blockchain within their forex systems. Switzerland stands out as a pioneer, where the financial sector has successfully integrated blockchain to streamline settlement processes, eliminate transaction charges, and reduce dependency on intermediaries during currency exchange procedures (Zheng et al., 2018; Hub & SNB, 2022). Likewise, the European Union has embraced blockchain as part of its broader regulatory initiatives, such as the Markets in Crypto-Assets (MiCA) framework, mandating blockchain integration across financial services to lower exchange costs and facilitate efficient international transfers. The regulatory structure has contributed to a more transparent, legally secures, and streamlined financial environment, thereby simplifying cross-border processing. One of blockchain's most valued contributions is its elimination of intermediaries, traditionally responsible for transaction delays and added costs in the forex ecosystem. Through peer-to-peer mechanisms validated via consensus protocols, blockchain removes the need for brokers and financial intermediaries, enabling faster and more affordable transactions (Catalini & Gans, 2016). Blockchain platforms such as Ripple and Stellar have demonstrated the capacity to facilitate rapid and low-cost international payments and remittances. Ripple, for instance, has managed to reduce transaction fees for cross-border forex payments from 6% to approximately 2–3% (Bank, 2021).

In developing economies, the ability of blockchain to lower transaction costs carries particular significance. High fees and delayed cross-border settlements are often barriers to financial inclusion, especially for low-income populations dependent on remittances. In many regions, remittance charges range between 5% and 10%, placing a burden on recipients who often rely on these funds for essential living expenses (Khan et al., 2024; Mani & Ngigi, 2024). Blockchain provides a viable solution by facilitating low-cost, peer-to-peer forex settlements that drastically reduce these charges. Platforms such as Ripple and Stellar have successfully lowered remittance costs and enhanced the reliability of international settlement systems (Shariff et al., 2025). As adoption

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increases, forex markets in emerging nations are expected to benefit from improved transaction efficiency and reduced costs, ultimately enhancing global market access for underserved populations (Josyula, 2024; Thong, 2025).

In Morocco, the implementation of blockchain could result in considerable improvements in foreign exchange operations by reducing transaction expenses, particularly for cross-border payments. At present, Morocco experiences elevated costs in forex transactions, which hinder financial development and reduce inclusiveness. Blockchain could alleviate these constraints by lowering fees and increasing payment efficiency, thereby promoting broader engagement in international trade and remittances for both individuals and enterprises. Technologies such as Ripple can facilitate secure and expedient cross-border transactions, enhancing the Moroccan financial system and bolstering the nation's global economic competitiveness (Abdallah-Ou-Moussa et al., 2025). Moreover, reduced transaction fees could attract increased foreign investment into Morocco's financial markets by offering efficient and affordable trading solutions (Sule et al., 2024).

Blockchain's advantages extend beyond cost savings; it also improves transparency and enables traceability of financial flows. Each transaction recorded on a blockchain is immutable and publicly verifiable, allowing all parties to access real-time data. This transparency minimises the risks of fraud, conflict, and human error, issues frequently associated with conventional forex transactions (Papadaki & Karamitsos, 2021). By establishing a unified and tamper-proof ledger, blockchain enhances trust among market participants and reduces the operational costs related to verification and reconciliation processes (Grossman, 2022).

Another critical advantage of blockchain lies in its capacity for near-instantaneous settlements. Traditional forex settlements can take several hours or even days, particularly in cross-border contexts. Blockchain enables near-real-time transaction clearance, reducing the risk of losses caused by exchange rate volatility during settlement delays (Soufaih, 2020). This feature is particularly vital in forex markets, where price fluctuations occur rapidly and unpredictably. The quick settlement ability of blockchain significantly reduces transaction costs and ensures operational efficiency in time-sensitive market environments (Owolabi et al., 2024). In Morocco's context, blockchain adoption has the potential to modernise its financial sector by improving the operational performance of the forex market, lowering costs, and fostering financial inclusion. Large corporations and small to medium-sized enterprises alike could benefit from lower barriers to entry in international markets due to reduced forex charges (Dzidzikashvili & Kheladze, 2022). Enhanced transaction efficiency would create growth opportunities for Moroccan enterprises, especially in the area of cross-border trade. The global success of blockchain in reducing fees and accelerating settlements is widely acknowledged. Countries such as Switzerland and regulatory frameworks like the EU's MiCA, as well as platforms like Ripple, serve as models of successful

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blockchain integration in forex markets (Hossain, 2023). In Morocco, the same technology could yield transformative results by reducing transaction fees, enhancing market competitiveness, and stimulating increased economic participation and foreign investment.

Blockchain's traceability is central to its cost-reduction capabilities in forex trading. With each transaction permanently recorded and publicly accessible, blockchain fosters an environment of openness and accountability. This mitigates the risks associated with fraud, conflict, or mismanagement in conventional forex settlements. As all stakeholders share access to a common ledger, the requirement for extensive oversight, audits, and reconciliation procedures is significantly reduced, thus lowering transaction costs (Adeoye et al., 2025). These features improve market functionality and benefit both institutional and individual participants (Sule et al., 2024). By curtailing the secrecy often associated with traditional settlement systems, blockchain also serves as a deterrent against financial malpractices (Ayodele et al., 2025).

The speed of blockchain-enabled transactions is another major advantage in forex markets. Given the time-sensitive nature of these markets, even minor delays can incur substantial financial losses. Traditional systems often require several hours or days for settlement, especially across borders. Blockchain, however, facilitates swift transactions through smart contracts and automated protocols, thereby reducing both the time and cost associated with forex trading (Min, 2025). Rapid settlement capabilities mitigate exposure to market volatility during the processing window and offer traders a strategic edge in deploying funds quickly for subsequent trades (Sule et al., 2024). In highly liquid markets where margins are thin, these time savings translate directly into financial advantage (Min, 2025).

Blockchain also enhances liquidity within forex markets. Liquidity is a vital feature of any stable financial system, and blockchain's capacity for instantaneous settlement supports this by eliminating delays and enabling constant fund circulation. This increased liquidity contributes to reduced volatility and smoother market operations (Eyo-Udo et al., 2024; Owolabi et al., 2024). Traders benefit from being able to transact quickly with limited exposure to risk, thus enhancing the market's overall operational efficiency (Adeoye et al., 2025). In the case of Morocco, blockchain offers a promising solution to longstanding inefficiencies such as high transaction fees and slow cross-border payment processes. Given the country's move towards digitalisation, blockchain presents a viable path toward faster and more cost-effective trade and remittance systems (Soufaih, 2020). By increasing transparency and lowering transaction fees, Morocco can become a more appealing destination for domestic and international investors. Small and medium-sized enterprises, often hindered by high forex charges, would particularly benefit from blockchain adoption, enabling improved access to international markets and competitiveness (Soufaih, 2020).

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Moreover, blockchain's ability to reduce transaction costs and speed up settlements could play a crucial role in enhancing financial inclusion in Morocco. With approximately 44% of the adult population remaining unbanked, blockchain offers a transparent, secure, and affordable alternative to conventional banking systems (Abdallah-Ou-Moussa et al., 2025). By removing financial barriers, blockchain can enable broader participation in the economy through low-cost, cross-border payments (Attia & Fund, 2020). As adoption expands, blockchain is poised to be a transformative tool for building inclusive financial infrastructures in countries such as Morocco (Maleh et al., 2024).

Increased adoption of blockchain within Morocco's forex system may also drive innovation in financial technologies. The Moroccan government has already expressed interest in exploring digital currency initiatives, for which blockchain could serve as a foundational infrastructure (Nach, 2024). This transition could reduce dependence on legacy banking systems and promote a decentralised and inclusive financial model that supports individuals, businesses, and the economy at large (Abdallah-Ou-Moussa et al., 2025). By leveraging blockchain to reduce transaction costs, enhance market functionality, and promote inclusivity, Morocco can align its financial sector with broader strategic goals for competitiveness and innovation (Maleh et al., 2024). As global trends favour blockchain integration, Morocco has the opportunity to establish itself as a regional leader in financial technology by embracing this innovation to strengthen its forex market and unlock new avenues for economic development (Nach, 2024).

METHODS

The central aim of this study is to examine the potential benefits and limitations associated with the integration of blockchain technology into Morocco's foreign exchange market, with particular focus on three fundamental aspects: exchange rate volatility, transaction costs, and financial inclusion. The analysis is grounded in advanced econometric approaches, specifically employing the GARCH model to assess fluctuations in exchange rates, alongside Monte Carlo simulations to project long-term scenarios. These methodologies are applied to empirical data drawn from financial markets where blockchain has already been adopted for settlement purposes, notably in the contexts of Nigeria, Brazil, India, and Kenya.

Data Description and Variables

Data Sources

The data utilised in this report are drawn from several authoritative sources. Bank Al-Maghrib provides key economic and financial indicators for Morocco, including historical exchange rate records. Supplementary insights on blockchain adoption and

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broader global economic developments are obtained from publications by the World Bank and the International Monetary Fund. Additionally, international case studies feature prominently, particularly those of Nigeria, Brazil, India, and Kenya. These countries were purposefully selected due to their relevant experience in integrating blockchain into foreign exchange operations and cross-border payment systems.

Measured Variables

Transaction Costs

Transaction costs are assessed as the proportion of fees associated with foreign exchange payments. These costs are evaluated both prior to and following the implementation of blockchain technology in order to determine its effect on reducing expenses related to intermediary services.

Exchange Rate Volatility

Exchange rate volatility is defined as the conditional variance within the exchange rate time series and is quantified using the GARCH model.

Financial Inclusion

Financial inclusion is evaluated by examining the proportion of the population without access to formal banking services and the associated expenses of utilising conventional financial institutions. These costs are then compared with projected figures under a blockchain-based system, which are expected to be lower due to the removal of intermediary entities.

Data Collection Period

The dataset employed in this analysis spans a five-year period from 2019 to 2024, ensuring the inclusion of recent developments and reflecting the current economic dynamics at both national and regional levels in Morocco and the selected comparator countries.

Applied Econometric Models

GARCH Model for Exchange Rate Volatility

The volatility of exchange rates is estimated using the GARCH model, which serves as a key indicator of foreign exchange market stability. This model is particularly well-suited for analysing financial time series characterised by time-dependent fluctuations in volatility, such as those observed in exchange rates.

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

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The GARCH model is specified using the following set of parameters:

- σ_t^2 is the volatility (conditional variance) at time t.
- σ_{t-1} is the forecast error of time t−1.
- α_0, α_1, β_1 are the estimated coefficients from historical exchange rate data.

Specific Application of the Model

The parameters α_0, α_1, and β_1 are derived through calibration using historical exchange rate data for the Moroccan dirham. The projected impact of blockchain adoption is assessed by examining how the technology contributes to reduced volatility, primarily by influencing key drivers such as unanticipated market disturbances and broader economic shocks.

Monte Carlo Simulations

These parameters are utilised to construct a range of plausible scenarios informed by critical economic indicators, including transaction costs, exchange rate volatility, and the proportion of the unbanked population. This approach supports the simulation of the long-term effects of blockchain adoption within Morocco's foreign exchange market.

Simulation Process

- A total of 1,000 distinct scenarios will be simulated, each based on the probabilistic distribution of the most influential economic variables.
- Within each scenario, forecasts for transaction costs and exchange rate volatility will be generated, and the average projected values for each variable will be computed accordingly.

Objective of the Simulations

The simulation results will yield a set of long-term forecasts, enabling the evaluation of multiple economic scenarios to assess potential reductions in transaction costs, decreases in exchange rate volatility, and improvements in financial inclusion within the Moroccan context.

Measurement Methods

Transaction Costs Reduction

Transaction costs are expressed as a percentage of the fees associated with foreign exchange operations. The following equation is applied to estimate the extent of fee reduction resulting from the implementation of blockchain technology.

$C_{new} = C_{initial}$ x (1-R)

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Where:

- C_{new} is the transaction cost after implementing blockchain.
- $C_{initial}$ is the transaction cost before adoption.
- R is the rate of cost reduction.

Exchange Rate Volatility Reduction

Exchange rate volatility will be assessed through the GARCH model by estimating the conditional variance of exchange rate movements. The anticipated decline in volatility following the adoption of blockchain will be evaluated by tracking reductions in variance over time, taking into account the technology's influence on enhancing market stability.

Improvement in Financial Inclusion

Financial inclusion is evaluated by tracking the rise in transaction volumes conducted by previously unbanked individuals following the implementation of blockchain technology. The subsequent formula is applied to quantify blockchain's effect on expanding access to financial services.

Financial Inclusion = (Target Population x Traditional Cost) – (Target Population x Blockchain Cost)

Where:

- Target population refers to the group of individuals who do not have access to traditional financial services.
- Traditional cost represents the usual expenses associated with using conventional financial services, such as transfer fees and commissions.
- Blockchain cost indicates the estimated expenditure for accessing services through blockchain platforms, expected to be lower due to the exclusion of intermediary parties.

Data Validation and Methodology Robustness

The data employed in this study are verified through cross-referencing with several credible sources, including official reports issued by the central banks of the countries under review and peer-reviewed academic literature. To ensure the reliability of the findings, sensitivity analyses will be conducted to evaluate the consistency of long-term projections across varying economic conditions. Outcomes derived from the Monte Carlo simulations will be compared against real-world evidence drawn from case studies in nations that have already integrated blockchain technology. This comparative approach supports the validation and contextual relevance of the results within the Moroccan foreign exchange market.

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RESULTS

The adoption of blockchain technology within Morocco's foreign exchange market presents considerable prospects for reshaping the nation's financial framework. This research investigates the economic and financial implications of blockchain implementation by drawing comparisons with countries such as Nigeria, Brazil, India, and Kenya, where blockchain has already been incorporated into financial systems. The analysis centres on three primary dimensions: transaction costs, exchange rate volatility, and financial inclusion. The following sections offer a detailed examination of the results in each area, assess their broader significance, and align the outcomes with insights from existing scholarly literature.

Transaction Costs Reduction

A key outcome of this research is the marked decrease in transaction costs attributed to the integration of blockchain technology. Presently, foreign exchange transaction fees in Morocco are estimated at approximately 5%. With the introduction of blockchain, these costs are projected to decline by around 30%, resulting in an estimated fee of 3.5%. This decline is particularly noteworthy given that high transaction fees have long posed challenges to the efficiency of Morocco's international trade and cross-border financial operations. Figure 1 illustrates a comparative analysis of transaction fees before and after the adoption of blockchain in Morocco, alongside the four comparator nations: Nigeria, Brazil, India, and Kenya. Prior to blockchain implementation, transaction costs in these countries ranged between 4% and 6%, with India experiencing the highest and Nigeria the lowest fees. Post-adoption, all countries recorded significant reductions, with Nigeria registering a fee of 2.8% and Kenya achieving a post-blockchain rate of 3.15%.

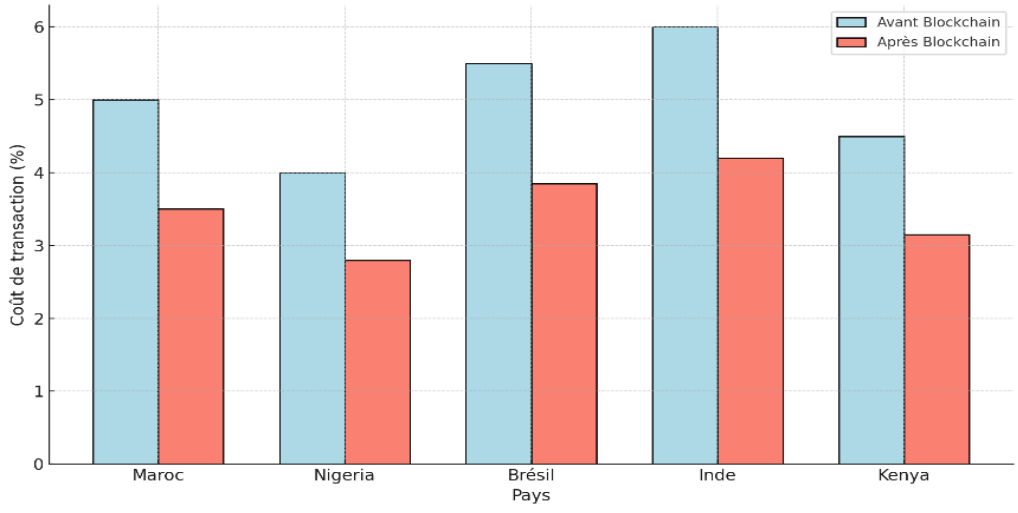

Figure 1: Comparison of Pre-and-Post Blockchain Adoption of Transaction Costs

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The decline in transaction costs observed across the examined countries is largely attributable to the elimination of intermediary entities such as banks and payment processors, along with the inherent transparency of blockchain-enabled transactions. This outcome is consistent with earlier research findings, including those of Ríos (2024) and Zhang (2020), which highlight how blockchain reduces reliance on intermediaries and facilitates more straightforward cross-border payments, thereby directly lowering transaction fees. In the context of the European Union, for example, the implementation of the MiCA regulatory framework has contributed to a noticeable decline in the cost of international financial transfers (Divissenko, 2023). In Morocco, such a reduction in transaction fees is anticipated to enhance the competitiveness of foreign exchange operations, offering tangible benefits to both businesses and consumers through more affordable currency exchange. Additionally, these improvements could encourage broader engagement in international trade and cross-border financial activities, contributing positively to the nation's overall economic growth.

Exchange Rate Volatility

An essential focus of this study is the prospective influence of blockchain technology on exchange rate volatility. At present, Morocco maintains a relatively stable exchange rate volatility of 2%. However, the analysis reveals that nations which have adopted blockchain have experienced a notable decline in volatility levels. Specifically, Nigeria, Brazil, India, and Kenya—originally recording volatility rates of 3%, 2.5%, 4%, and 2% respectively—each registered a 20% reduction following the integration of blockchain technology. Figure 2 illustrates the changes in exchange rate volatility before and after the introduction of blockchain in these countries. Post-adoption, volatility declined to 2.4% in Nigeria, 1.6% in Kenya, and 3.2% in India. Morocco's volatility remains at 2%, as the country has yet to adopt blockchain within its financial system.

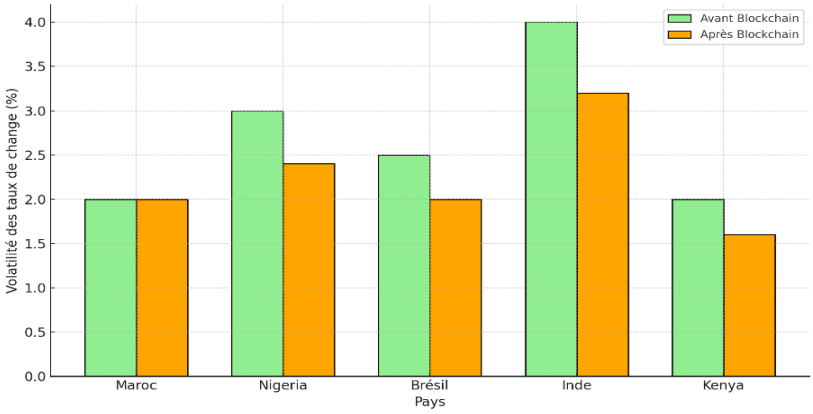

Figure 2: Pre and Post Blockchain Adoption Exchange Rate Volatility Comparison

The reduction in exchange rate volatility is largely attributed to the enhanced transparency and efficiency introduced by blockchain technology, which diminishes

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speculative activity and helps to moderate market fluctuations. Blockchain's capacity to facilitate real-time settlement and reduce reliance on intermediaries contributes significantly to the increased predictability of currency movements. This stabilising effect is supported by prior studies, such as Eyo-Udo et al. (2024) and He (2021), who demonstrated that blockchain-based cross-border payments tend to exhibit lower volatility due to more streamlined and transparent exchange processes. In the context of Morocco, adopting blockchain could yield considerable economic benefits. Greater exchange rate stability would lessen uncertainty for businesses, investors, and consumers, thereby fostering a more predictable environment for foreign exchange operations. Such predictability could encourage increased foreign direct investment (FDI) and support broader economic development, as suggested by the findings of Caton (2020) and Owolabi et al. (2024), who linked stable exchange rates with improved economic resilience and growth potential.

Financial Inclusion Impact

Another important outcome of this study is the positive influence of blockchain technology on enhancing financial inclusion within Morocco. At present, accessing traditional financial services in the country remains costly, with an average charge of 3% per transaction. The integration of blockchain could reduce this cost to approximately 1%, thereby improving the affordability and accessibility of financial services, particularly for the unbanked population. According to the World Bank's Global Findex, 44% of Morocco's adult population—equating to nearly 16.6 million individuals—remains outside the formal banking system. Figure 3 illustrates the potential of blockchain to facilitate an increase of roughly 332,000 additional financial transactions annually. This growth in transaction volume would represent a substantial step forward in broadening financial inclusion and advancing economic participation for previously unbanked segments of the population.

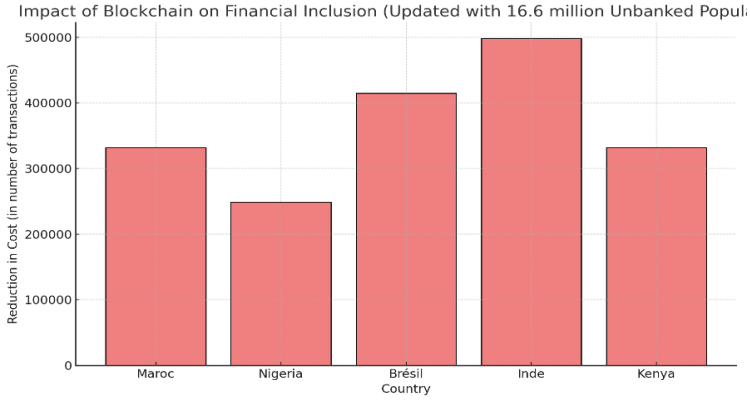

Figure 3: Impact of Blockchain on Financial Inclusion

Financial inclusion is expected to improve as the cost of accessing services declines and financial processes become more streamlined through the use of blockchain technology. By employing blockchain, financial institutions can offer cost-effective and reliable

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alternatives, particularly in remote and marginalised areas where underserved populations are concentrated. This emphasised that blockchain significantly lowers transaction costs, thereby making financial services more accessible to unbanked and low-income individuals.

Moreover, increased access to financial services can empower small enterprises and entrepreneurs in underserved regions, enabling them to participate more actively in the economy. By removing traditional barriers to service provision, blockchain has the potential to reduce financial exclusion and foster more inclusive economic development. This is consistent with the broader literature on financial inclusion, particularly the work of Adegbite (2024) and Mhlanga (2023), who underscored the capacity of blockchain to close financial access gaps among marginalised communities.

Monte Carlo Simulations and Long-Term Projections

To evaluate the long-term implications of blockchain implementation, Monte Carlo simulations were employed to estimate its influence on transaction costs and exchange rate volatility. A total of 1,000 scenarios were generated, each reflecting different future economic conditions. In assessing transaction costs, the simulations incorporated an assumed 30% reduction from the baseline rate of 5%. The results indicated that the average transaction cost could decline to 3.5%, with most simulated values clustering near the mean, suggesting a consistent downward trend across various projections. For exchange rate volatility, the simulation applied a 20% decrease from the baseline level of 2%. The resulting output confirmed the potential of blockchain to stabilise currency fluctuations, with volatility estimates falling to approximately 1.6%. These findings reinforce the view that blockchain adoption can enhance the predictability and resilience of Morocco's foreign exchange market over time. Figure 4 illustrates the projected long-term effects of blockchain adoption on both exchange rate volatility and transaction costs.

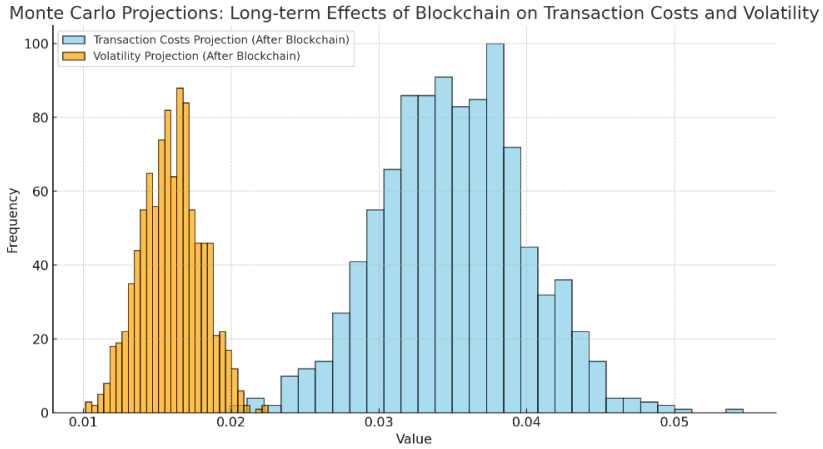

Figure 4: Long-term Projections of Blockchain Effect

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The results derived from the Monte Carlo simulations underscore the reliability and consistency of blockchain's anticipated impact on Morocco's foreign exchange market. The long-term projections suggest that the adoption of blockchain would contribute to reduced exchange rate volatility and lower transaction costs, ultimately fostering a more efficient, transparent, and stable forex environment. These conclusions are in line with previous scholarly findings, including those of Li (2023), whose analysis demonstrated that the integration of blockchain into financial systems enhances market stability and supports more accurate long-range forecasting. Similar perspectives are echoed by Caton (2020) and Dhaygude et al. (2024), who highlight blockchain's role in improving prediction accuracy, reducing volatility, and increasing efficiency in complex financial markets.

CONCLUSION

The integration of blockchain technology into Morocco's foreign exchange market presents a considerable opportunity to modernise and enhance the nation's financial system. This analysis has shown that blockchain adoption can lead to several critical improvements, notably the reduction of transaction fees, the mitigation of exchange rate volatility, and the promotion of broader financial inclusion. These anticipated benefits are consistent with the positive outcomes already observed in countries such as Nigeria, Brazil, India, and Kenya, which have successfully incorporated blockchain into their financial sectors. With respect to transaction costs, blockchain implementation in Morocco is projected to reduce forex fees by approximately 30%, lowering them from 5% to around 3.5%. This reduction would enhance the competitiveness of Morocco's forex sector by making currency exchanges more affordable and encouraging greater involvement in international trade and cross-border financial activities. In terms of exchange rate stability, blockchain could contribute to a 20% decline in volatility, fostering a more stable and predictable environment for foreign exchange operations and potentially strengthening investor confidence. Furthermore, the reduction in the cost of accessing financial services is expected to improve inclusion among Morocco's unbanked population, which currently accounts for 44% of adults. The technology is estimated to support an additional 332,000 financial transactions annually, thereby broadening access to essential services for economically marginalised groups and supporting inclusive economic participation.

Despite these advantages, Morocco must address several longstanding barriers before blockchain can be successfully integrated. These include an underdeveloped regulatory framework, inadequate digital infrastructure, and widespread public scepticism toward blockchain and cryptocurrencies. To overcome these challenges, clear and supportive regulations are necessary—ones that encourage technological innovation while safeguarding financial integrity and consumer protections. Exploring mechanisms such as Central Bank Digital Currencies (CBDCs) could offer a balanced route, combining the technological benefits of blockchain with the oversight of central authorities.

Morocco's gradual embrace of blockchain, accompanied by investments in digital infrastructure and public education, could position the country as a regional leader in financial innovation. Furthermore, adopting progressive regulatory strategies, such as regulatory sandboxes inspired by those in Switzerland and the European Union, would provide a controlled environment for testing and refining blockchain applications in the forex market.

Although obstacles remain, the long-term advantages of blockchain adoption for Morocco's forex market and the wider economy are substantial. Addressing these challenges could not only result in a more efficient currency exchange system but also foster deeper financial inclusion and strengthen the country's position in the global financial landscape. Blockchain adoption has the potential to act as a catalyst for Morocco's economic development. Future research should focus on empirical validation through pilot implementations and explore the potential interplay between CBDCs and blockchain. Additionally, examining the extended economic implications—such as effects on growth, investment, and employment—could further clarify the broader relevance of blockchain within Morocco's economic context.

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