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RESEARCH ARTICLE

Understanding the Financial Transaction Security through Blockchain and Machine Learning for Fraud Detection in Data Privacy and Security

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ABSTRACT

This study examines the integration of blockchain technology and machine learning (ML) to enhance financial transaction security, with a focus on fraud detection, data privacy, and operational transparency. The study explores the combined capabilities of blockchain's decentralized ledger and ML's predictive analytics in securing financial transactions. A systematic review was conducted, sourcing relevant studies from academic databases where literature resources are stored, such as IEEE Xplore, Google Scholar, Scopus, Web of Science, DOAJ, and SCImago. 3037 study papers were collected from those academic databases. After screening and testing eligibility, 137 papers were selected to conduct this study. Studies covering blockchain, ML, and their collaborative impact on financial security were selected, classified, and analyzed. Comparative analysis methods highlighted both the strengths and limitations of this dual-technology approach. Results indicate that blockchain's immutability and transparency, alongside ML's data-driven fraud detection capabilities, create a robust framework for transaction security. Blockchain effectively ensures data integrity and transparency, while ML algorithms improve fraud detection and decision-making through real-time data analysis. However, challenges such as scalability, high energy consumption, and high implementation costs persist, limiting adoption in small and medium-sized institutions. The combined application of blockchain and ML presents a transformative potential for financial sectors, particularly in enhancing transaction integrity, regulatory compliance, and risk management. This framework can serve as a model across various industries beyond finance, including government and non-financial organizations, to foster a secure transaction environment. This study primarily relies on qualitative data and lacks empirical validation through quantitative measures. Further, blockchain's energy-intensive nature and ML's data dependency pose obstacles to widespread implementation, especially in resource-constrained settings. Future research should aim at developing cost-effective and energy-efficient blockchain and ML solutions to support broader adoption. Additionally, advancements in quantum computing and AI-driven blockchain could address existing security vulnerabilities, making the technology more accessible and scalable.

1. INTRODUCTION

The decentralized, secured, and immutable transaction technology known as blockchain technology makes transactions secure across the network (Monga et al., 2024). Besides, machine learning algorithms have the capability of analyzing a large amount of data and detecting patterns amount the data to identify fraudulent activity in financial transactions eventually creating a safe environment for financial transactions (Amiri et al., 2024). According to Paramesha et al. (2024), the integration of blockchain technology and machine learning algorithms in securing financial transactions has developed a promising shift from traditional financial transaction transactions operations (Islam et al., 2024).

Blockchain technology, initially hypothesized as the fundamental context for cryptocurrencies like Bitcoin, has grown into a robust podium for secure and transparent digital transactions (Kumar & Rani, 2024). At its center, blockchain is a decentralized ledger that archives transactions in an unalterable method, safeguarding transparency and immutability (Tuomi, 2024). By abolishing the need for mediators and fundamental authorities, blockchain fundamentally modifies the dynamics of belief and answerability in financial transactions (Pflueger et al., 2022). Smart contracts, programmable self-executing contracts arranged on blockchain webs, further improve the efficiency and reliability of financial contracts by mechanizing indenture implementation (Mansouri et al., 2024).

Instantaneously, machine learning algorithms have flourished across various fields, contributing advanced proficiencies for data analysis, pattern acknowledgment, and decision-making (Faraji et al., 2024). In financial transactions, machine learning predictive analytics tools have become crucial for mining tortious insights from vast amounts of data (Martin, 2024). From predicting weather to detecting fraudulent actions, machine learning algorithms empower financial establishments to make up-to-date decisions and boost effective efficiency (Amin et al., 2024).

The connection of blockchain technology and machine learning algorithms offers a convincing opportunity to crack new competencies and proficiencies in financial transactions (Khan et al., 2024). By mixing machine learning algorithms with blockchain technology, financial foundations can influence predictive analytics to enhance investment policies, accomplish risks, and automate monotonous responsibilities (Ressi et al., 2024). The incorporation of blockchain and machine learning embodies an archetype modification in the way financial transactions are directed (Soana, 2024). By connecting the mutual supremacy of these technologies, financial organizations can reveal novel competencies, boost security, and substitute superior transparency in the worldwide financial network (Bhuiyan, 2024). According to Bhuiyan et al. (2024), as authors research profoundly into the details of this junction, they board a voyage near the future where finance is more available, well-organized, and comprehensive for all sponsors.

This research paper pursues discovering the transformative potential of the co-operation between blockchain and machine learning in terms of financial transactions (Christodoulou et al., 2024). Through an inclusive review of prevailing literature, case studies, and experimental evidence, it aims to explain the key topographies, aids, encounters, and insinuations of this junction. By analyzing authentic specimens and developing trends, this article grants appreciated insights for stakeholders circumnavigating the composite scenery of technology-driven revolution in finance.

Many studies have been conducted on blockchain technology that can bring secure decentralized and transparent transactions in financial sectors (Azubuko et al., 2024). Besides, machine learning algorithms can learn from huge amounts of data, and from that data, it can detect the fraudulent activities that make financial transactions secure (Faraji et al., 2024). According to Ahmed & Alabi. (2024), Blockchain-based Federated Learning (BCFL) can sluggish the exponential development of cryptocurrency fraud. Besides, Blockchain and smart contract-based tactics can attain vigorous Machine Learning (ML) algorithms (Bhuiyan, 2024) for e-commerce fraud detection (Bhuiyan et al., 2024). Additionally, A secure fraud detection model based on machine learning and blockchain can crack the difficulties of fraud and incongruities in the Bitcoin network (Ashfaq et al., 2022). Federated learning (FL) and Blockchain technology can deliver extra assurance and defenses as well as transparency (Rabbani et al., 2024), allowing financial organizations to cooperate on machine learning (ML) models while upholding the privacy and honesty of their data (Sudharsanam et al., 2022). Moreover, hybrid consensus algorithms that syndicate machine learning (ML) techniques to discourse the encounters and susceptibilities in blockchain networks (Liu et al., 2020). Also, according to Mohammad et al. (2023), the combination of blockchain and machine learning in finance can secure fintech (Alam et al., 2022). However, very few studies have been clearly shown on both blockchain technology and machine learning algorithms integration in securing financial transactions and data privacy (George, 2023). These gaps mentioned areas where further research and development are essential to fully harness the potential of blockchain and machine learning in enhancing the security of financial transactions (Odeyemi et al., 2024). This paper is mainly about filling the gaps in financial transaction security and data privacy in organizations.

To help guide the exploration of enhancing financial transaction security using block chain technology and machine learning. Authors outlined three key questions that can serve as objectives. These questions will help shape the research development or project strategy (Venkatesan & Rahayu, 2024).

RO (1): How block chain technology can be integrated into existing financial systems to enhance transaction security and how can consensus mechanisms be leveraged for secure financial transaction processing?

RO (2): How does the combination of block-chain and machine learning improve real time fraud detection in financial transactions?

RO (3): What are the security and privacy implications of using block chain and machine learning?

2.0 LITERATURE REVIEW

Blockchain has grown in popularity as a result of Bitcoin's success (Hashemi Joo et al., 2020). However, this technology is not limited to the banking industry (Huang & Tan, 2024). Blocks of cryptocurrencies joined by chains were the original definition of a blockchain (Ogbaisi et al., 2024). FinTech has focused a lot of attention on this new concept (Chang et al., 2020). The core ideas and enabling technologies that have transformed the methods for storing, validating and sharing have led to a major improvement in security transparency and efficiency (Tariq, 2024). Blockchain and machine learning is an autonomous, reliable, decentralized database system that stands out for its ability to maintain an unchangeable record of transactions (Bhuiyan, 2023). The decentralized nature of blockchain is apart from traditional centralized systems and offers a fresh perspective for data management and security (Bhuiyan et al., 2024). The system is based on a distributed ledger where each blockchain contains a number of transactions. Every time a transaction occurs (Metha et al., 2023). Here are eight main points that outline key components. A framework that enhances financial transaction security using blockchain technology and machine learning, blockchain technology has grown to become a vital instrument in the digital world, particularly in the accounting sector. Authors will look at some of the important processes below in a figure showing their relationship.

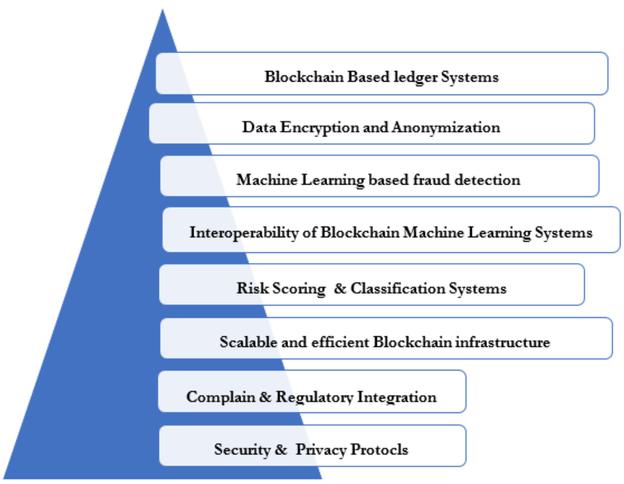

Figure (1): Block chain fundamentals essential ideas & tools.

Source: Author's Work

2.1 Block-chain based ledger systems

Blockchain machine learning is radically different by offering innovative solutions that raise productivity, accuracy and client happiness across the board. Managing investment in one important application machine learning, Artificial intelligence in the financial sector. Financial advisors and investors can make better decisions by using (AI) (ML) algorithms that analyze large information to identify patterns and trends. These algorithms can evaluate complex financial data more quickly and accurately than people, which eventually enhances risk assessment, predicting analytics, and portfolio management (Fischer, 2018). Financial institution's approaches to risk management and regulatory compliance are engaging as a result of (ML)(AI) artificial intelligence & Machine learning used by regulatory technology, or RegTech to expedite compliance procedures, to expedite compliance procedures, monitor transactions for anomalies, and confirm adherence to regulatory requirements (paramesha et al., 2024).

Table (1): Impact site of Block-chain based Ledger systems.

Impact site of Block-chain based Ledger systems	Parameter
Decentralization	Implement a distributed ledger to eliminate the need for a centralized power ensuring that all transaction records are immutable and tamper resistant (Hashemi Joo et al., 2019).
Transaction Transparency	Each transaction is recorded on a block-chain, ensuring that all parties can verify transaction authenticity while preserving the security of data (Gosh et al., 2020).
Smart Contract	Automate transaction process through secure, self—execution smart content, reducing human error and potential fraud (Al-Zubaidie & Jebbar, 2024).

2.2 Data Encryption and Anonymous

The process of converting plaintext data into an anonymous, unintelligible format(ciphertext) using an algorithm and key is known as data encryption (Salam et al., 2024). Only authorized individuals with the required key are able to decode the data and restore it to its original format. The process of removing or altering personally identifying information (PII) from dataset to make it more difficult to identify particular individuals is known as data anonymization. This preserves privacy while allowing data to be used for analysis (Pratoma et al., 2023).

Table (2): Methods of Data encryption and Anonymous.

Methods of (DE&DA)	Parameter	Reference
Symmetric Encryption (DE)	Encrypts & Decrypts data using the same key. AES (Advanced Encryption Standard) & DES (Data Encryption Standards) are two examples.	(Vardalachakis et al., 2023) (SWEENEY, 2002; Zeadally et al., 2021)
Asymmetric Encryption (DE)	Utilizes a pair of keys: public key for encryption and private key for decryption. RSA (Rivest Shamir-Adleman) is a widely used asymmetric algorithm.	
Data Masking (DA)	Replaces sensitive data with fictitious values.	(Majeed & Lee, 2021) (Zeadally et al., 2021)
Aggregation (DA)	Summarizes data to prevent the identification of individual records.	

Pseudonym (DA)	Replaces (PII) with pseudonyms, which can be reserved with additional information stored separately.	

2.3 Machine Learning based fraud detection

Algorithm's training is a component of Machine Learning on historical data to recognize patterns and make predictions. In fraud detection, ML models evaluate transaction data to find irregularities that might point to fraud (Alsoufi et al., 2022).

Supervised Learning: Models are trained on labeled datasets where transactions are marked as either legitimate or fraudulent. Support vector machines, Decision trees and neural networks (Fathima et al., 2023).

Unsupervised learning; Models detect patterns in unlabeled data, identifying anomalies without prior knowledge of fraud. Clustering, Anomaly Detection, etc techniques (Alsoufi et al., 2022). Semi–supervised learning: Increase the accuracy of directions by combining labeled & unlabeled data. Particularly labeled data is limited (Alsoufi et al., 2022).

2.4 Interoperability of Block-chain Machine Learning Systems

Author have evaluated of entity's software, procedures, systems, business units and financial units' capacity for interoperability (Bhuiyan et al., 2024). A protocol for general communication is suggested as an alternative to the "point to point" blockchain interoperability strategy because the problem depends on promoting coordination, collaboration and communication among entities. Interoperability is defined as the semantic reliance across different ledgers to exchange or transfer data or values in order to directly modify the state of other blockchain systems (Belchior et al., 2021).

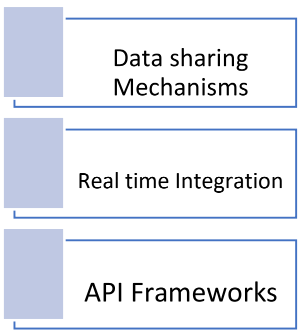

Figure (2): Interoperability of Block-chain Machine Learning Systems

Data sharing mechanisms create systems that securely allow block-chain stored data to be accessed by machine learning models, ensuring seamless data interoperability. Real-time integration enables real-time communication between blockchain systems and machine learning models for instant fraud detection and risk mitigation. API framework developed APIs to facilitate interaction between different blockchain platforms ensuring flexibility and scalability (Bcoghaci & Alkhawaldeh, 2020).

2.5 Risk Scoring & Classification Systems

A number of scoring systems have been put forth as a training tool in an effort to direct resources to those who would perhaps gain the most from clinical interventions (Brabrand et al., 2010).

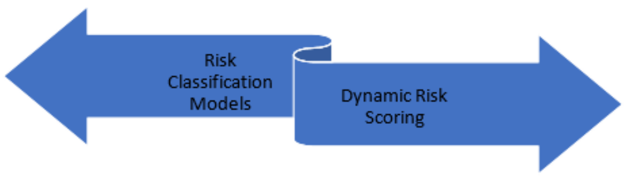

Figure (3): Risk scoring classification systems
Sources: (Shung et al., 2020)

Risk classification models use machine learning models to classify transactions based on risk levels. Helping prioritize high risk transactions for further scrutiny. Dynamic Risk Scoring continuously updates risk scores based on transaction behavior and emerging fraud patterns, allowing for adaptive fraud prevention (Malik et al., 2023).

2.6 Scalable and efficient-chain infrastructure

BlockLayer-2 solutions Implement layer-2 scaling solutions, such as side chains or cost channels to reduce transaction costs and improve processing speeds (Bhuiyan et al., 2024). Consensus mechanism optimization uses energy-efficient consensus mechanisms to minimize the computational overhead and make the systems more sustainable. Cross-chain interoperability allows interaction between different blockchain networks to improve flexibility in transaction security across financial ecosystems.

2.7 Complain & Regulatory Integration

Blockchain & Machine Learning framework compliance with financial regulations including the General Data protection regulations (GDPR) Anti Money Laundering (AML) & and know your customer (KYC) is ensured by regulatory alignment (khan et al., 2021). Auditing mechanisms develop blockchain-based auditing tools that provide regulators with real-time access to transaction records for compliance verification without compromising data privacy (Belchior et al., 2021).

2.8 Security and privacy Protocols

Multi-factor authentication (MFA) is incorporated to ensure that only authorized individuals can initiate and approve transactions. Secure Data Sharing uses blockchain-native encryption techniques and privacy-preserving machine learning methods to securely share financial data between parties without exposing sensitive information (Bhuiyan et al., 2024). Cyber security measures implement cyber security best practices such as distributed denial of service protection firewalls and regular security audits to protect both the blockchain and machine learning system (Verduyn & Hutten, 2023).

There are all-point frameworks that provide a comprehensive approach to integrating blockchain technology and machine learning to enhance the security of financial transactions. It covers critical areas from encryption and fraud to scalability, compliance, and interoperability.

3.0 Methodology

In order to construct this research paper, the researcher used previously published research papers, renowned and credible journal articles, and research reports that have been published within 10 years (Bhuiyan et al., 2024). From paper collection to the construction of the framework researchers divided the work fellow into five stages (Çetin et al., 2023). Each stage has its own purpose for tasks.

3.1 Search and Data collection

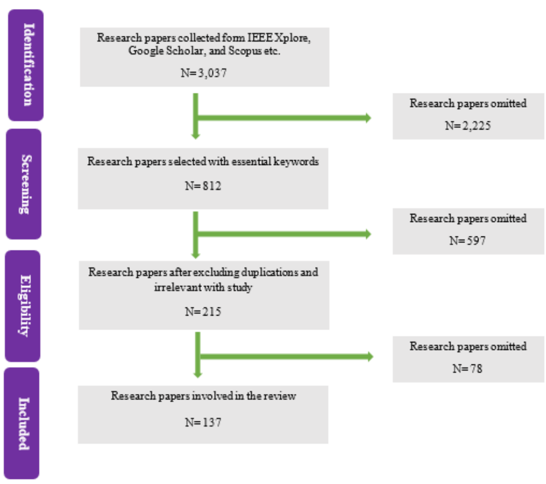

Figure (4): Data accumulation flowchart

To accumulate relevant information, 3,037 papers have been collected from academic databases such as IEEE Xplore, Google Scholar, Scopus, Web of Science, DOAJ, and SCImago (Serey et al., 2023). Keywords such as Blockchain and cybersecurity, machine learning and financial fraud detection, blockchain in financial transactions, and machine learning in secure financial transactions have been used to screen papers while excluding 2,225 documents. (Odeyemi et al., 2024). Studies combined with blockchain and machine learning, blockchain and financial transaction security, machine learning, and financial transaction security are included, whereas duplicate, irrelevant, and papers not focused on financial transaction security are excluded (Akrami et al., 2023), which is 597 papers. After reviewing the abstract, documents that don't specifically fit the research topic are omitted, which is 78 papers (Yigitbas et al., 2023). Then, the authors conducted research based on 137 previously published research papers (Degli-Innocenti, 2024).

3.2 Categorization and Classification of papers

To study the collected papers in-depth, studies are classified into relevant categories such as machine learning, and blockchain, and combined with machine learning and blockchain (Valencia-Arias et al., 2024). In the blockchain category, benefits, challenges, and limitations have been examined whereas in the machine learning category how it works (Shafay et al., 2023), types of machine learning, and how it can be implemented in securing financial transactions have been studied (Wang et al., 2024). Besides in the combination category, combination effect, benefits, and possibility have been learned (Zhao et al., 2024).

3.3 Comparison

Comparative analysis is adopted to evaluate their category how well machine learning algorithms and blockchain technology can secure financial transactions (Yang et al., 2024), their ability to handle huge-scale of financial data, and their ability to prevent fraud and various cyber-attacks (Ting et al., 2024).

3.4 Research gap identification

By classifying and comparing, the unaddressed and non-discussed areas of research have been extracted. Then, authors have filled the gap by adopting comprehensive research studies (Márquez et al., 2024).

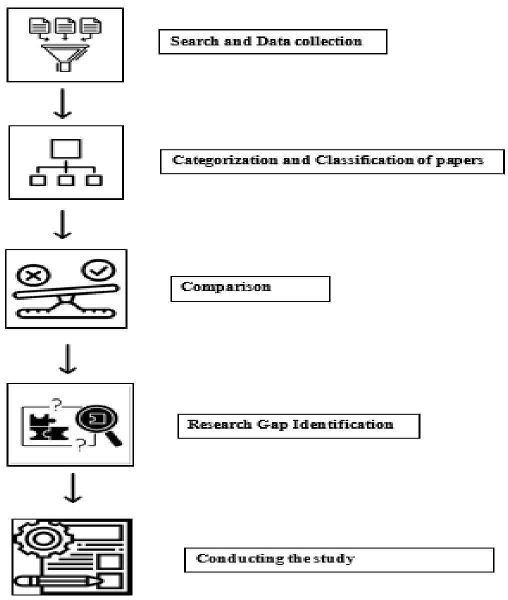

Figure (5): Research conducting algorithms.

3.5 Conducting the study

Based on the extracted research gap, a comprehensive study is developed by the authors (Karunarathna et al., 2024). The research is combining machine learning & blockchain technology algorithms for enhancing financial transaction security (Alenizi et al., 2024).

4.0 DISCUSSION

The main focus of the conversation when it comes to utilizing blockchain technology and using machine learning to make financial transactions safer is how these technologies can work in tandem to solve present safety issues in the financial industry. These are the main topics of conversations.

Blockchain software is an allocated ledger that offers a decentralized, transparent. Its numerous features might significantly increase the security of financial transactions (Pratomo et al., 2024). The application of blockchain technology has had a significant impact on the enhancement of integrity and transparency in a number of sectors (Nifise et al., 2024). The impact is particularly apparent in supply chain management (SCM) governmental organizations and data-sharing protocols. SCM has been transformed by blockchain technology, especially in the areas of transparency and security. The features of blockchains, such as decentralization, immutability, and transparency, have mitigated the tension between supply chain security and transparency. Even though confidentiality may limit supply chain transparency, blockchain's availability and integrity promote transparency. Blockchain's ability to preserve security while boosting openness makes it a significant advancement over traditional methods. The way this technology is applied and developed inside the supply chain environment will be determined (Xu et al., 2024). The perception of block chain technology and its impact on government agency transparency have also been studied. Research 9indigate that the majority of individuals view block chain favorably and are aware of its potential benefits. The perception of block chain and its impact on institutional information transparency are closely related. This correction suggests that as blockchain technology gains popularity and awareness, transparency in public organizations increases. Blockchain's tamperproof, timestamp, and reversibility features aid in these organizations' management and transparency (Zamudio Garcia et al., 2022).

The impact of adopting blockchain for data sharing, especially leveraging cryptographic technology, on throughput and transparency has been studied (Bhuiyan et al., 2024). Blockchain's cryptographic technology ensures the legitimacy and integrity of data, which promotes transaction confidence and transparency (Bhuiyan et al., 2023). This approach offers credentials and automates secure and intelligent evaluations using improved cryptographic algorithms. The optimal setting for boosting throughput has been determined by block-chain network research on standard block intervals. This understanding is crucial for enhancing financial transaction security using blockchain technology and machine learning for non-crypto processes like election voting, where transparency is important (Ahmed et al., 2022).

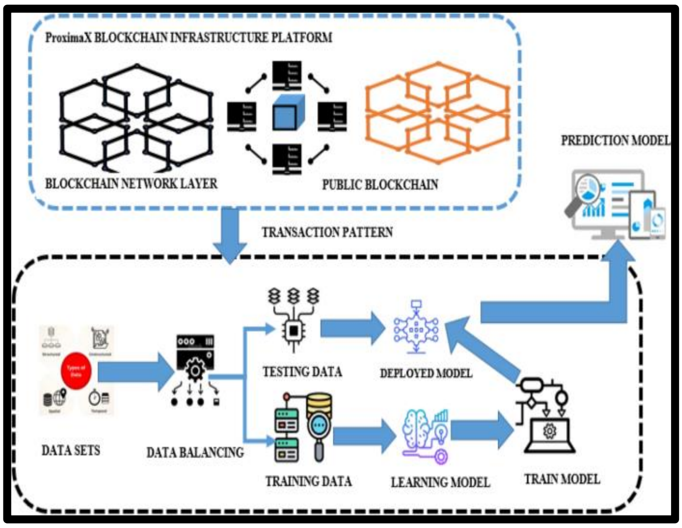

Figure (6): Block-chain's potential in Transparency and Honesty
Source: (Venkatesan & Rahayu, 2024)

Consequence for financial, technological, and ethical the use of blockchain technology across businesses has significantly enhanced ethical, financial, and technological. These effects include reshaping industries, altering legal frameworks, and shifting economic situations. Blockchain & other emerging technologies are evaluating quickly & have the potential to revolutionize Verity of financial sector. However, this rapid pace of innovation usually outpaces the regulatory capacity, leading to ambiguities and holes in the legal framework. The complex interplay between technological advancement and the flexibility of legal structures highlights conflicts between moral and business objectives. Businesses that employ blockchain technology while emphasizing moral conduct gain the trust of customers and enhance their standing in the industry. Laws are being changed globally to priorities data privacy, cyber-security, and the development of moral blockchain and machine learning (Bhuiyan et al., 2023). Even if the technology sector's anticipated growth indicates enormous economic potential, competent handling of these complexities needs an adaptable legal framework in enhancing financial transaction security using blockchain technology and machine learning (Derrvishiet et al., 2022).

Block-chain technology raises significant ethical, legal, sociological and economic issues. The controversy surrounding driverless cars, a topic closely linked to block chain, artificial intelligence & machine learning is one illustration of the moral implications of technological advancement. The incapacity to keep up with the rapid changes in technology or culture known as "future shock" might result from technological breakthroughs even while they make life easier. This highlights the need for an ethical framework to guide the development and use of technologies like block-chain ensuring that their benefits are shared equitably and that laws are established to support those affected by technological advancements (Banerjee et al., 2020).

The development of blockchain technology in these industries also has important political and economic repercussions (Bhuiyan et al., 2023). Because of its tamperproof, timestamp, and reversibility features, blockchain technology is revolutionizing data management and transactions. Building traceable data processing systems and decentralized storage is necessary due to the blockchain's integration in a number of industries (Faraji et al., 2024). Which is transforming human-machine interaction into an intelligent mode. This integration also necessitates heuristic thinking in areas such as the creation of harmonization of laws and regulations related to blockchain-based systems. Significant repercussions for society provide insights into corporate applications focused on the healthcare sector (Rodrigues, 2021).).

4.1 Addressing Obstacles & Restrictions in the Adoption Block-chain & Machine Learning

The adoption of blockchain technology across different businesses must overcome a variety of barriers and limitations in order to reach its full potential (Hossain et al., 2024). Because these issues are very across different businesses and regions, tailored solutions are needed. Transparency and reliable energy access are two problems that the African energy sector is now confronting, and blockchain technology provides a workable solution. Blockchain technology enables financial access, safe and transaction platforms, and peer-to-peer energy trading. However, it is challenging to implement because of barriers like imprecise legislation, inadequate infrastructure, and a lack of technology expertise. Establishing industry standards for interoperability, creating a transparent regulatory environment, and supporting educational and training programs to improve technical expertise are some suggested treatments (Chime, 2023). Blockchain & Machine Learning application in the Bangladeshi healthcare sector presents comparable difficulties. Among the challenges are a lack of experience and expertise. High-cost and high-risk technological challenges, unclear laws opposition, to reform, & lack of support from higher authorities. The lack of government initiatives is one of the primary reasons behind these challenges, according to an integrated multicriteria decision-making process. A comprehensive strategy involving stakeholders, service provider research, and legislation is required to address these issues and advance blockchain use in healthcare (Dhingra et al., 2023). The automobile industry in the UK faces significant opportunities as well as challenges in implementing blockchain for operational improvement. A methodical review of academic literature reveals technical and management problems from the perspective of the technological organizational environmental (TOE) paradigm (Hossain et al., 2024). The paper emphasizes the importance of fully understanding these opportunities and obstacles for companies aiming to use blockchain for operational excellence. The results show that in order to address these problems, a collaborative approach including several stakeholders and a focus on technology and management is necessary (Upadhyay et al., 2020).

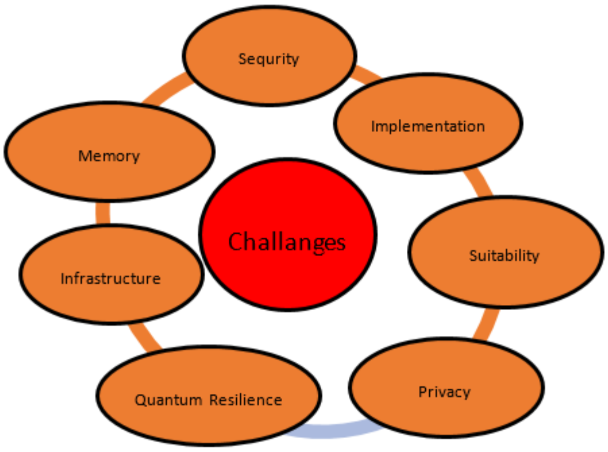

Figure (7): Challenges of Block-chain & Machine learning adoption
Source: (Tanwar et al., 2022).

4.1.1 Suitability

Blockchain is a viable solution when there are several entities in a distributed environment and the data is unreliable. Its performance is a must; a simple database is the better option. Therefore, before using blockchain in any application, it is imperative to understand its architecture (Salah et al., 2019).

Infrastructure: Network infrastructure and blockchain-specific technology improve the performance of many blockchain-based apps. These cloud services include network administration, mining equipment, decentralized storage, and communication protocols (Velanka et al., 2018).

4.1.2 Privacy

The data generated by the device and stored on the blockchain nodes, which present privacy issues for information must be kept secret or private. To solve such issues. Private blockchain encryption and restricted access may be employed (Chawathe, 2018).

Memory: As more blocks are uploaded, the blockchain continues to expand in size because of this, every node must store the entire chain, which puts a significant strain on the device's memory (Tanwar et al., 2020).

4.1.3 Implementation

A similarly massive number of transactions will be needed for a large scale blockchain network, problems could arise with implementing blockchain. This big for example transaction would strain the network and there is a huge demand for internet bandwidth that is difficult to decrease (Javaid et al., 2022).

4.1.3 Security

Due to their decentralized nature, block-chains are vulnerable to security breaches. The most common concern is that the agreement protocols might be undermined as a result of attacks (Tanwar et al., 2018).

4.1.4 Quantum Resilience

Quantum computers might soon be able to decipher a block chain's vulnerability to this issue because it uses one encryption. Which only protects digital signatures. As a result, blockchain performance and security (Hossain et al., 2024).. Quantum cryptography has the potential to improve the security of the block-chain network since quantum communication is automatic. (Users cannot mimic another user.) In the blockchain network, it can encrypt all P2P communication and replace conventional digital signatures. Research is underway on the use of quantum computing to create a blockchain (Fedrov et al., 2018).

4.2 Developments in the Future Block-chain's Potential to secure Financial Transaction

A comprehensive review of the blockchain literature in accounting identifies recent advancements and patterns in this emerging field (Hossen et al., 2025). This approach combines citation analysis. Machine Learning based subject modeling combined with a manual examination of a few chosen pieces (Shahriare Satu et al., 2023). The evolving function of accountants, new difficulties for auditors & the potential difficulties of blockchain technology are the main research topics. The regulation of vital currencies. The analysis indicates that although blockchain is anticipated to disrupt accounting and auditing, these disciplines will still require attention (Hossen, 2024). These professions might shift toward more prominent advisory roles as a result of the volume of data kept on blockchain aligning competitive intelligence and business strategy (Garanina et al., 2021). Interest in blockchain technology for safe financial technology and accounting management is growing, according to an analysis of research trends in this field. The evaluation of publication patterns between 2013 and 2024 shows a quadratic increase in research effort. Among the key areas of concentration that have been identified are block-chain network security, digital storage, information management, commerce, edge computing and the internet of things. By providing information on past and upcoming axes in this emerging subject, the study assists research funding programs in making decisions (Abad segura et al., 2021).

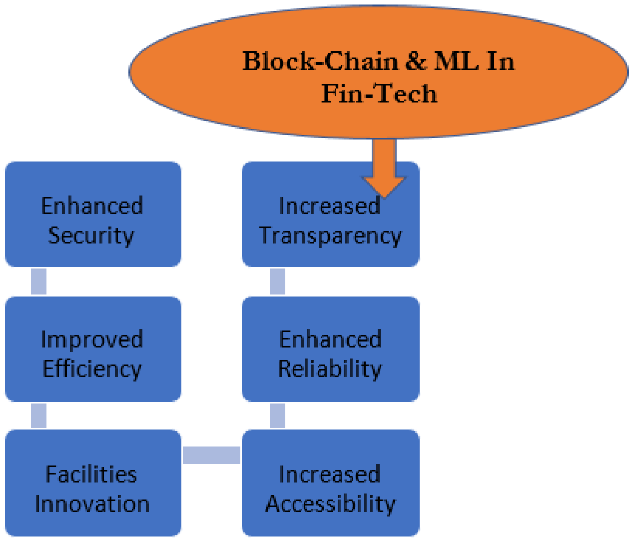

Figure (8): Block-chain & Machine Learning (ML) implication in FinTech.

Blockchain's increasing significance in accounting is demonstrated by the predictive insight that significant changes in accounting, auditing, and financial transaction practices (Islam & Bhuiyan, 2022). This disclosure shows how blockchain technology may create a new framework and revolutionize traditional methods (Azad et al., 2022). A thorough analysis of scholarly discussions around the integration of blockchain technology into accounting and financial transactions, enhancing financial reporting systems, and guiding auditing and valuing cryptocurrencies (Sheela et al., 2023). Blockchain technology might assist supply chain finance in overcoming challenges in FinTech (Islam et al., 2024). Blockchain technology can be used to tackle supply chain financial accounting issues such as validity verification, smart contracts, automation, and president data on trade transactions (Uddin et al., 2024). The costs and risks of using blockchain and machine learning must be considered. These include operational code development, enhanced security, improved efficiency, facility innovation, increased transparency, enhanced reliability, and increased accessibility, as well as implementation of technological, educational, and integration costs. This study demonstrates the current application of blockchain technology and machine learning in supply chain finance and makes forecasts on its future direction and impact on accounting practice (Rijiaanto, 2024).

5.0 Implication

Enhancing financial transactions through blockchain and machine learning has significant implications across various domains such as security, efficiency, transparency and innovation. Breakdown the potential impacts implication (Rahman et al., 2024). Regulatory Challenges & Solution: Regulatory frameworks may need to evolve to adapt to decentralized technologies, but machine learning can offer a pathway to enhanced regulatory oversight without stifling innovation (Venkatesan & Rahayu, 2024) Decentralized Finance (DeF) & innovation: new finance products and services will emerge, democratizing access to financial services globally especially in under-banked or unbanked regions. Machine Learning can help navigate these new ecosystems with enhanced decision making and prediction tools (Abdukhakaeem & Hu, 2021). Reduced Costs and Intermediaries Blockchain: Together blockchain & Machine learning can significantly reduce operational and transaction costs making financial services more accessible particularly for underserved markets ((Paramesh et al., 2024)). Efficiency in Financial operations blockchain Technology: Financial institutions and business can streamline operations, reduce costs, and speed up transaction processes by leveraging the combined power of blockchain & ML ((Boughaci & Alkhawaldeh, 2020). Enhance Transparency & Accountability: Enhanced transparency fosters trust among stakeholders, while machine learning provides tools for auditing and monitoring in real time potentially reducing the need for manual intervention (Efunniyi et al., 2024).

CONCLUSION

This study encourages the complementary use of blockchain technology with machine learning to enhance fraud detection or overall financial transaction security (Rahman et al., 2024). According to Guzman et al. (2024), despite challenges, stakeholders must work together to fully realize the promise of this innovative approach to bolster financial stability (Rahman et al., 2024). The study's conclusion also highlights how crucial it is to keep researching, developing, and fusing blockchain and machine learning with cutting-edge innovations like blockchain and quantum computing (Khang et al., 2024). According to Hossain et al. (2024), marketing intelligent use of machine learning and blockchain will be essential to addressing impending challenges and grasping new opportunities as financial transaction security grows (Rahman et al., 2024). The continuous development of blockchain and machine learning in financial transaction security is not only changing financial procedures but also laying the groundwork for a more robust, driver-driven, and dynamic financial system (Paramesha et al., 2024). An important advancement in IoT security is represented by our research (Alnumay, 2024). Together blockchain technology, machine learning models, and the iOS app have a comprehensive architecture that tackles a variety of security issues (Nazir et al., 2024).

Limitation

Despite explaining tough security standards in financial transactions where blockchain technology and machine learning algorithms are implemented, this research paper has some limitations. This research is based on qualitative data, no quantitative data have been analyzed to ensure how much blockchain and machine learning secure the financial transaction. Additionally, implementing both technologies in an organization is expensive, and it is not feasible to implement this technology in small and medium intuitions (Kayikci & Khoshgoftaar, 2024). Furthermore, blockchain technology cannot handle large amounts of data simultaneously which makes this system slow also consumes too much energy (Haque et al., 2024). The lack of talent who know actually how to handle blockchain makes implementing it costly and tedious (Azhar, 2024). On the other side, machine learning highly depends on statistical data to predict any threat, and also machine learning performs outstandingly in large amounts of familiar data sets but gives obscure results when a new data set is presented which makes machine learning (Knapp, 2024) vulnerable against ever-evolving new methods cyber-attacks (Patni et al., 2024). According to Barbierato & Gatti., (2024), machine learning lacks creativity and biases on biased data sets and deep learning of machine learning is very complex to understand and manage.

Future research direction

As technologies are evolving more and more sophisticated attacks and threats are also evolving to deter security systems (Faraji et al., 2024). It's like a thief and police game. So, research on secure financial transactional technology should be continued and need to be up to date (Albshaier et al., 2024). One of the most noteworthy developments would be if blockchain and machine learning technology's costs were reduced in the future (Valencia-Arias et al., 2024). Further research needs to be conducted on how to cut the cost of these technologies and make them more available because machine learning algorithms can get better and better if it more exposed to large amount of data (Kamath et al., 2024). Availability will give it more experience to treat detection which will eventually improve the financial security (Chatterjee et al., 2024). More research needs to be conducted on how to reduce blockchain manning energy consumption which will be less costly and more favorable for the environment (Jellason et al., 2024).

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Conflict of Interest

Authors declare there is no conflict of interest or any argument between them.

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