



A Blockchain Technology-Enabled Audit Governance: The State of Art, Remaining Challenges and Future Perspective

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Abstract. The blockchain is developing gradually and its development and application in the governance of audit have won great concerns. This paper points out the key features of the blockchain, such as the advantages in the governance of audit including automation, data security and transparency as well as the cost decreasing. Based on the practical applications of home and abroad, it can verify the use of the technology in improving the efficiency, reducing the cost, and increasing the data accuracy under different auditing scenarios, but the application of the technology also confronts the problems such as low maturity of technology, incomplete regulation system, protection of personal information data. Finally, we put forward the countermeasures for above problems, including optimizing the blockchain performance and scaling up, enhancing the security development of the data privacy protection technology, formulating an unified regulatory frame, and advancing the industry standardization, etc., and put forward some prospect in this paper, i.e. the blockchain will promote the audit governance transform traditional behind auditing to real-time ahead auditing, which will change the ecosystem of audit industry. The theoretical analysis and the work examples of this study also gave theoretical evidence and work directions of digitalizing work in audit field and helped to achieve the healthy and harmonious development of the social economy.

Keywords: Blockchain Technology; Audit Governance; Potential Advantages; Application Challenges; Coping Strategies; Development Trends

1 Introduction

Recently years, as an innovative distributed ledging technology, block chain technology has gradually become a hotspot of research in both academia and industry because of its prominent merits in security, transparency and efficiency. Blockchain has

first attracted attention thanks to Cryptocurrencies such as Bitcoin, but it has been quickly embraced in the whole spectrum of applications from finance, healthcare, agriculture to supply chain[1]. Due to its attributes of decentralization, immutability and record keeping in real time, a wealth of potential has been released in the realm of audit governance [2].

Conventional audit governance presents issues of inefficient, asymmetry, fraudulent information and risk management challenges. This inefficiency can be improved through the automation and accuracy of audit processes provided by block chain technology. Smart contracts application also improves audit governance, which automatizes and confirms audits automatically, and execution does not depend on human [2]. Secondly, the immutability of blockchain makes data integrity and authenticity with auditing evidence [1], making the data and record processed by the blockchain with high reliability for auditors. The features of blockchain technology hence exhibits enormous potential in the audit governance. The problems such as inefficiency, information asymmetry, and fraudulent risks in auditing were be well resolved, and new ideas and methods can be provided in innovating audit governance mode.

Despite the obvious benefits that blockchain provides in terms of audit governance, its adoption is still considered challenging from both a technical and managerial perspective. Blockchain scalability and performance constraints can inhibit its adoption as a mean to handle large volumes of transactions [1]. A managerial obstacle, resides in the fact that there is no standard regulation in place and there is no unity over several common issues [2]. Thus, the exploratory studies about blockchain application innovation in audit governance and its problems in application deserve a depth of discussion for the promotion of its application.

The research in this paper intends to discuss the new applications of blockchain technology in audit governance, discuss its possibility and prospects of helping on internal control, risk management and flexibility, and put forward the relevant implementation suggestions. Literature and case reading are used to provide theory and application guidance for the digitalization of auditing field.

2 Theoretical Foundation

A block chain is a kind of distributed ledger technology that can realize data security, sharing, transparency, immutability and other features with cryptographic technologies and consensus algorithm. Block chain enables several parties to share transaction information and verify it. Transactions are verified without needing to trust any central authority. Decentralization, real time update and non-changing feature are among the main features of block chain which grant it enormous scope of applications in different areas [3]. Nonetheless, there are also limitations in the technologies for the usage of CBR, for instance, high energy cost, high technical thresholds and technical approaches, all to a certain extent restrict large-scale promotion.

Audit governance is an important procedure used to guarantee the accuracy and reliability of an organization's financial report. Aiming at increasing stakeholder trust

(e.g., stockholders, creditors, and regulators), it is an independent procedure to review the authenticity and reliability of financial report. In traditional auditing methods, which are time-consuming and costly, the risks include information asymmetry, the situation of human error[4].

Therefore, the application of blockchain and governance of audit provide solutions to the pain points of traditional audit:

Transparency and Traceability: The distributed ledger characteristics of blockchain ensure that all transaction records are transparent to public auditing parties and can be viewed in real time and information asymmetry are decreased.

Data Security: The cryptographic technologies and immutability feature of the Blockchain provide evidence of authentic and secure audit data by providing a minimal chance for data tampering.

Improving Effectiveness: Through the use of blockchain, auditing work can achieve automation to save labor and improve the speed of the audit and reduce the cost.

Timely Auditing: With real-time updating ability of blockchain, the auditor can obtain the most recent accounting data at any moment in time and achieve a timely auditing and on-line supervision [3][4].

This integration as presented in Figure 1 improves not only the efficiency and reliability of audit governance but also give the organization more powerful transparency and integrity and lay the solid theoretical foundation for the future audit practices.

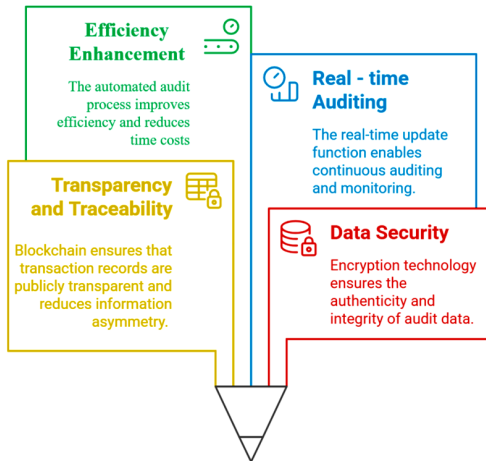


Fig. 1. Integration of Blockchain in Auditing

3 The Current Application Status of Blockchain Technology in Audit Governance

3.1 Case Studies at Home and Abroad

- UAE Supply Chain Audit: Smart Contract Auditing

In some UAE supply chain audits, the use of smart contracts highly optimized the audit effectiveness in the transaction verification process.¹ For example, a logistics company automated the transaction execution based on smart contracts, cutting the amount of human participation as well as errors in the process and made a remarkable advancement in audit efficiency.²⁴⁻²⁶ The time used for verifying transaction dropped from the average 48 hours to 34 hours (about 30% in overall efficiency improvement). Furthermore, smart contracts reduced audit expenses by around 20% [5].

- **Ukraine's Digital Transformation—Supply Chain Audit**

In 2021, Ukraine deployed 94 digital initiatives, among which 2 digital blockchain projects were used for supply chain management. This means the supply chain was traceable (i.e., from procurement, transportation, and storage) with data integrity and transparency. After the implementation of the supply chain management project, the sharing efficiency in the supply chain increased by 40%, while the audit cost decreased by 25%[6].

- **Kangmei Pharmaceutical Inventory Audit—Financial Data Auditing**

Literature [7] takes Kangmei Pharmaceutical as a sample to analyze the limitations of auditing process with the application of Blockchain technology in the pharmaceutical industry. Kangmei Pharmaceutical's inventory goods include a huge inventory of traditional Chinese medicine materials and biological assets, and traditional auditing procedures find it difficult to reasonably ascertain the value and flow of it. By using the blockchain technology, all transaction data were saved in a real-time way and encrypted for safekeeping so that auditors can access the correct and available data anytime during audits, thus making the audits less risky. By using the blockchain technology, the inventories audited at Kangmei Pharmaceutical were correct at 70% before adopting the blockchain technology and rose to 95% after blockchain technology adopted. Audit time has been cut down roughly 40%.

3.2 Technical Advantages and Innovations

- **Networked Auditing for Petrochemical Enterprises—Real-Time Auditing**

Literature [8] states that blockchain's distributed ledger technology allows auditors to monitor enterprises' economic activities in real time, thereby improving audit efficiency and accuracy. For example, a petrochemical enterprise achieved real-time auditing through blockchain technology, increasing its audit coverage from 60% to 90% and enhancing audit efficiency by 40%.

- **Audit Practices in the Middle East—Smart Contract Auditing**

Literature [5] points out that smart contracts can automatically verify the compliance of transactions and generate immutable audit evidence, reducing audit costs and improving audit quality. For instance, in an audit project in the Middle East, the application of smart contracts reduced audit costs by approximately 20%.

• Kangmei Pharmaceutical Financial Data Audit—Data Immutability

After adopting blockchain technology, all transaction records of Kangmei Pharmaceutical are permanently stored and tamper-proof, reducing the financial data tampering rate from 5% to 0%, thus effectively preventing financial fraud [7].

As is recorded in Table 1, blockchain technology has greatly improved the efficiency and lowered the cost as well as improve accuracy and transparency of the data in various audit scenarios.

Table 1. Comparison of Blockchain Technology Applications in Audit Governance

Case Name	Application Scenario	Core	Main Improvements	Efficiency	Cost	Data
		Technolo- gy		Improve- ment (%)	Reduction (%)	Accuracy Im- prove- ment (%)
UAE Supply Chain Audit	Supply Chain	Smart	Automated transaction verification, reduced manual intervention	30	20	-
	Management	Contracts				
Ukraine Supply Chain Audit	Supply Chain	Distributed	Real-time data tracking, improved transparency	40	25	-
	Management	Ledger				
Kangmei Pharmaceuticals Inventory Audit	Financial Data Audit	Blockchain	Improved inventory audit accuracy, reduced audit risks	-	-	From 70% to 95%
		Encryption				
		Storage				
Petrochemical Enterprise Network Audit	Real-time Audit	Distributed Ledger	Real-time monitoring of economic activities, improved audit coverage	40	-	-

3.3 Existing Issues and Limitations

• Kazakhstan’s Digital Transformation—Insufficient Technical Maturity

Implementing blockchain technology during Kazakhstan’s digital transformation still remains technically challenging and costly. For instance, a blockchain project of a Kazakhstani company had \$5 million implementation costs which cost \$2 millions over the project’s estimated budget, an amount 40% over budget [6].

• Egypt’s Audit Environment—Lagging Regulatory Frameworks

With regards to application of blockchain, we believe that there will be a trade off for data integrity and confidentiality in Egypt’s audit industry. To name one instance, an Egyptian auditors firm abandoned a blockchain audit project due to the absence of clear legal backings, which made the project’s schedule delayed by six months [9].

- Audit Practices in the Middle East—Data Privacy Issues

While the openness and transparency of blockchain enhance data credibility, they also pose challenges to data privacy. In a Middle Eastern audit project, for example, customer information leakage due to data privacy issues led to a \$1 million compensation claim against the audit firm [5].

In order to make the problems in the use of blockchain technology in audit governance and the countermeasures more clear, table 2 lists the problems and the countermeasures in detail.

Table 2. Challenges and Countermeasures of Blockchain Technology in Audit Governance

Challenge Type	Specific Issue	Response Strategy
Technological Immaturity	High implementation costs, high technical complexity	Enhance blockchain performance and scalability, optimize consensus algorithms
Lagging Regulations	Lack of clear legal support	Establish a unified regulatory framework, promote industry standardization
Data Privacy Issues	Conflict between data transparency and privacy protection	Strengthen data privacy protection technology development (e.g., homomorphic encryption, zero-knowledge proof)

3.4 In-Depth Analysis of Innovations

- Smart Contract-Driven Automation in Audit Processes

Smart contracts are the important application scenarios of blockchain technology in audit. Based on UAE supply chain audits and Middle East audits, smart contracts audit carries out the terms of contracts and determines whether the relevant provisions of audit transactions are in line with the pre-set rules. They can not only reduce manpower factors but improve audit efficiency, from manual verification to automated validation. Conventional auditing mainly depends on audit clerks to review and confirm transactions through manpower, which is time-consuming and subjective to errors. Smart contracts make transactions processed and recorded in time, with automatically produced audit evidence. Audit clerks directly access them, realizing the time-consuming and standardized audit work, that is to say, to construct audit business logic.

- Distributed Ledger-Driven Innovation in Audit Data Management

Blockchain's distributed ledger technology has brought unprecedented changes to the field of audit data management. In Ukraine's supply chain audits and petrochemical networked auditing enterprises, distributed ledger not only can synchronize all the transaction data storage at different nodes and update in real time, which guarantees

high transparency and traceability of data. Through which auditors obtain all genuine data in time, the information island breaking and the problem of unconsolidation and difficult verifiability of traditional audit scattered information are solved, at the same time, the authenticity and integrity of data cannot be falsified by themselves, and the data foundation is solid and reliable to audit work, audit evidence is credible and convincing. The new data source acquisition mode, data storage mode, and data verifiability model are created.

- **Real-Time Auditing and Continuous Monitoring Model Innovation**

By using the update attribute of blockchain in time real-time auditing and ongoing supervision has become a practical issue. The model of audit is greatly innovated. Petrochemical enterprises have been able to expand the audit coverage extensively through the blockchain technology, breaking away from the traditional periodic audit and realizing the real-time supervision of corporate economic activities. It allows the auditors to acquire the most updated financial data instantaneously to catch the risks and anomalies in business with more comprehensive information, and change the audit model that is conducted after the events into instant supervision that is executed during the process. In addition, by applying this auditing model, the auditing could become a prospective and proactive model, thus to prevent the finance risk that the enterprises bear and guard the enterprise economic activities according to regulations and stability, providing better services to the internal control and risks of enterprise management in a timely and targeted manner.

4 Strategies to Address Challenges of Blockchain Technology in Audit Governance

4.1 Technical Improvement Strategies

4.1.1 Enhancing Blockchain Performance and Scalability.

More investment in the R&D of blockchain's underlying technologies, incentivizing synergy among academia, university and companies. Best consensus algorithm—researching the newer Proof of Stake (PoS) and Practical Byzantine Fault Tolerance (PBFT), which could lessen the communication load between nodes and increasing the speed of handling transactions. Take the PoS algorithm optimization, for instance, PoS algorithm optimization will effectively reduce blockchain network energy consumption, enhance transaction throughput capacity. Moreover, combining the blockchain technology and artificial intelligence (AI) and big data will further enhance audit intelligence and supply technical support for the audit governance from another aspect. By using the sharding technology to divide the blockchain network as shards and process transactions of multiple shards in parallel, it can improve the ability of the blockchain to process a large amount of transactions, which conforms to the development of increasing data volume and diverse business processes in audit governance.

4.1.2 Strengthening R&D for Data Privacy Protection Technologies.

Integrating specialized methods, such as homomorphic encryption and zero-knowledge proofs, to secure critical information but at the same time making audit/verification transparent. Homomorphic encryption enables certain computations on encrypted data without decryption and the auditors to access the information without making the privacy leaks. Zk proof. In the audit scenario, since there are participants or organizations, including the transferor and the transferee, besides the blockchain platform, they don't want to disclose any extra information to verify a transaction is compliant or not. Zk proof is capable of fulfilling this demand.

4.2 Management and Regulatory Optimization Strategies

4.2.1 Establishing a Unified Regulatory Framework.

The regulatory authority and government should build the unified regulatory mechanism for the application of blockchain technology in audit governance, indicating the access criteria, operating rules, and supervision measures for blockchain-based audit services, so as to control the activities of enterprises and audit organizations. For instance, learning from the European Union's (GDPR), where a rigid legal guidance system exists for data privacy, China can develop its domestic blockchain auditing regulations based on China's unique context. From an international perspective, the auditing standards can also be revised as to include blockchain features (e.g., through the introduction of the professional auditing guideline on blockchain for the better provision of clear operational guidance to the auditing practice). Also qualification checks (qualification review) should be done on such blockchain audit service companies who are authorized for this services are equipped with proper technical standards and have security in place. Data flow data storage, data utilization, and data sharing standards should be defined to enable data flow within the legal framework in a more compliant manner.

4.2.2 Promoting Industry Standardization.

Industrial organizations need to step forward to combine with enterprises and research organizations to set forth industry standard for blockchain audit, including data format standard, smart contract programming standards, audit process standard. Integrate data format for promoting data exchange and sharing between various platforms; standardized smart contract program code for reducing the probability of counterparty and legal risks; standardized audit process for improving the auditable result comparability and trustworthiness and being conducive to blockchain audit business development.

4.3 Talent Development Strategies

4.3.1 Reform of University Professional Education.

Accounting colleges, audit colleges with their related majors should modify their professional courses by adding some "Blockchain and Audit Innovation" and other

related courses in blockchain, like principles, technical architecture, smart contract development, cases in audit governance, training students' interdisciplinary knowledge and skills. Through the course allowing students not only to learn blockchain skills but also enable students to put blockchain technology to real application scenarios of audit to resolve real audits issues. The universities can cooperate with the enterprises to set up blockchain audit internship bases for students to let students have practice opportunities. Meanwhile, industry associations are capable of organizing blockchain audit skills competitions to arouse students' interests in learning and potential creative abilities. As blockchain technology has been widely used in audit industry, the need for blockchain tech-savvy professional talents that have knowledge on both audit procedures and blockchain-related technical skills, will grow rapidly, over 30% in the following 5 years.

4.3.2 Training and Continuing Education for In-Service Professionals.

Various training and continuing training programs should be provided for professional accountants and auditors working on the job. A variety of hybrid online and offline measures (e.g. through blockchain audit technology education and seminar sessions), including feedback from industry experts and technical experts, sharing practical experience and the most cutting edge technology, aiming to keep professionals' technology updated and boost their blockchain environment auditing capabilities, to fit into the digital transformation in audit.

5 Future Prospects for Blockchain Technology-Driven Innovation in Audit Governance

5.1 Trends in Technological Integration and Innovation

The blockchain will be tightly combined with advanced technologies such as artificial intelligence (AI) and big data. AI is used to explore audit risks and abnormal trend by analysis the large-scale audit data on blockchains, which improves the intelligent level of audit; Big data technology provides big data resources for blockchain, and helps improve the accuracy and integrity of audit analysis. For instance, machine learning algorithms in AI can categorize and predict transaction data stored on the blockchain so as to capture the risk of fraud quickly. Big data technology can incorporate multi-source audit data so as to provide stronger bases for audit decisionmaking.

Innovation blockchain application models will arise, e.g., distributed audit platforms based on blockchain technology can realize the worldwide sharing of audit resources and collaborative auditing, which is free from the geographical and organizational barriers to improve the audit efficiency and level. By integrating with IoT, it can realize audit of physical assets and conduct automatic auditing in real time, thereby further promoting the authenticity and reliability of audit.

5.2 Transformation of Audit Governance Models

Blockchain will bring the audit governance change from passive posthoc auditing to on-line, timely, and proactive audit. On-line audit allows auditors to monitor enterprise economic actions in real time, discover problems in time, propose corrective suggestions, and bring down risks in an effective way. Based on the in-depth mining of blockchain information, proactive auditing can pre-emptively identify potential risks and proactively give enterprises risk management and optimization recommendations of internal control so as to make auditors from a simple supervisor and controller to enterprises' value producers, for instance, distributed audit platform on blockchain will facilitate global sharing and auditing, breaking through the geographical and organizational barrier. The integration of IoT and blockchain technology will endow the physical asset real-time monitoring and automated auditing functions, so that the audit integrity and credibility will be improved. All these technological evolutions are bound to alter the audit industry ecosystem where auditing's supervisory function in economic activities and its service value will become much more conspicuous.

From a perspective of audit organizational, a kind of virtual audit teams is also supposed to be widespread in the future, in which audit members come from various regions and departments, and the cooperation via the blockchain platform makes them efficient working together across various organizational boundaries, and enhances the flexibility and adaptation ability of audit work.

5.3 Impact on the Audit Industry

Blockchain technology's extensive implementation will influence the ecosystem of auditing industry. On the one hand, it will improve the auditing industry in terms of efficiency and overall quality and improve the reliability of auditing by effectively meeting people's audit supervisory and service demand in economic activities. In the other hand, it will also reshape the auditor industry's staff structure, elevating the requirement of comprehensive capabilities for auditors—the interdisciplinary talents with profound audit practice knowledge and blockchain knowledge will be the scarce resource for the auditor industry.

With the development of blockchain auditing technology, the competitive environment in the auditing market will be reshaped. The auditing institutions that have learned the advanced blockchain auditing technology are bound to have a competitive advantage to offer better-quality and more-effective service to clients, speeding up the development pace of the auditing industry to professionalism and informatization.

While blockchain technology can open up huge possibilities to audit governance innovations, it will encounter the same hurdles. With the effective measures for the technological innovation, management and control as well as talent cultivation, the blockchain technology will play a greater part in audit management, and the audit industry will enter a new stage of the digital development, and provide powerful support for economic society's healthy and stable development.

6 Conclusion

This paper probes the innovative usages, the challenges, coping measures and possible directions of development of blockchain technology in audit governance. Blockchain technology based on such characteristics as decentralization, immutability and real-time recording presents considerable merits to audit governance, which successfully alleviates the aforementioned problems with audit carried out by convention, such as the auditing inefficiency, information asymmetry and fraud-risk in auditees. Furthermore, in practice, the situation in the UAE with supply chain audits at the blockchain smart contracts layer that increase the efficiency of transaction verification and audit, Ukraine's real-time supply chain information collection, and Kangmei Pharmaceutical improving audit results by strengthening supply chain inventory audit control, all indicate the practical feasibility and value of the audit governance mode using blockchain technology.

At the same time, applying blockchain technology to audit governance, limited technical maturity, immature regulations and data privacy are also encountered. As an example, for the former, high blockchain project implementation expenses in Kazakhstani companies, the suspension of an Egyptian audit firm's project because of regulations uncertainties, and leaking of data privacy in a Middle East audit project, among others. With the above being identified, there exists both the need for, and numerous strategies that can be undertaken to meet, these challenges. The study suggests high-level R&D spending to achieve technical performance and data privacy protection optimization, a single regulation framework and industry standardization, as well as innovation on universities' education and in-service training to develop interdisciplinary talents.

In the future, blockchain technology will be widely integrated with AI, big data, IoT and other emerging technologies, and will further drive audit governance change from past-hoc audit to real-time and active audit and revise the audit industry ecosystem. This study provides several contributions: 1) Our analysis about the innovative implementation of blockchain and its challenges in audit governance; 2) Our proposed measures on how to apply and solve these challenges. Moreover, the future research may explore the deep combination between blockchain and other hot technologies (such as AI, big data, IoT) and its special applications in various fields, offering a more systematic theoretical basis and practical guidance for the digital revolution of audit governance. Although there exists the above difficulties, under the impetus of incessant technological innovation and the utility of coping measures, the blockchain technology is very likely to bring the audit industry to a new age of digital economy, playing a powerful role to promote the economic society on a healthy and stable development.

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