Blockchain-Based Financial Control System

Tedan Lu

School of Business, Jiangxi Modern Polytechnic College, Nanchang 330095, China

Abstract—**In order to solve the problems of data security and low efficiency of information transmission in traditional financial control systems, this paper discusses in depth the application of blockchain technology in financial control systems. In order to optimize the performance of the traditional financial control system, this paper introduces blockchain technology into it and analyzes the structure and function of the financial control system. By constructing a blockchain-based financial data collection, information exchange and security consensus mechanism, a more efficient financial control system is designed, which can significantly improve the cost efficiency, shorten the audit cycle and enhance the data security. In the model, resource allocation within the financial control system is optimized, information exchange is more efficient, and a consensus mechanism is established. The experimental results prove that the model simplifies data entry and storage, reduces the workload of financial staff and improves transparency. The study bridges the gap between blockchain and traditional financial frameworks and advances the development of modern financial control systems.**

Keywords—*Blockchain technology; financial control system; resource allocation; information exchange; consensus mechanism*

I. INTRODUCTION

With the development of information technology, internet technology has been widely applied in various industries. As one of the important contents of internal management control in enterprises, financial data has a large number of human factors that affect the recording forms of accounting vouchers, books, and other records in traditional financial data entry methods [1-3]. Encrypting the original accounting vouchers is a necessary prerequisite to ensure the authenticity and completeness of accounting information [4]. As the size and complexity of enterprise financial data grows, traditional financial control systems are exposed to many limitations. It faces serious challenges in data recording accuracy, processing efficiency and security, and is difficult to adapt to the rapidly changing business environment. With the rise of blockchain technology, its decentralization, transparency, and tamperability have brought a new dawn to the field of financial control. However, blockchain still has many problems in integrating with existing financial infrastructure and meeting regulatory compliance. Therefore, this study aims to deeply analyze the shortcomings of the traditional financial control system, explore the optimization path of blockchain technology integration with it, and construct a new financial control model. This article provides a deep understanding of the decentralized structure and analyzes the development and application of blockchain technology based on existing literature, in order to establish a long-term development strategy for optimizing and improving the performance of traditional financial control systems.

Blockchain technology has obvious advantages in optimizing transmission architecture and improving system characteristics. Analyzing the application and development of blockchain technology in various fields is an important basis for studying its feasibility. The research on traditional blockchain has not been investigated from a technical and application perspective. Javaid conducted a comprehensive investigation into blockchain technology to fill this gap [5]. Xie explored the application theory of blockchain in the financial field, and designed a financial management control platform based on blockchain technology to better summarize the development direction of blockchain technology, providing a case study for analyzing the role of blockchain technology in the supply management process [6]. Zhang conducted research on financial control systems in the financial industry from three perspectives: data, rules, and applications, and provided constructive suggestions for promoting the development of blockchain technology in the field of financial control [7]. With the outdated performance of existing financial control systems and increasingly fierce market competition, Markos Zachariadis explored the process of building a distributed billing structure using blockchain technology and provided insights from a critical perspective [8]. Francesca Antonucci took advantage of the transparency and relatively low transaction costs of blockchain technology to construct control systems in an encrypted and distributed form to achieve new optimization solutions [9]. The above plan analyzes the feasibility of blockchain technology application in various fields, opening up new directions for the optimization and development of control systems.

The quality of financial control systems is influenced by many factors. In order to determine the reasons for the insufficient performance of traditional financial control systems and the effective improvement of advanced information technology in financial control systems, it is necessary to explore them. Ratmi Dewi studied the impact of the use of internal financial control systems on the quality of financial statements and reflected on the application of advanced information technology in financial control systems [10]. With the advancement of information technology stimulating the relevant advantages of financial systems in the financial industry, Ulrich Bindseil reviewed the impact of effective control of financial systems on the financial system, and compared and discussed the development direction and optimization trend of financial control systems [11]. Javad Oradi summarized the internal weaknesses of financial control systems, providing a research case for reducing audit costs and improving accounting efficiency [12]. In the process of examining the internal control strength of financial control systems, SAPUTRA Komang Adi Kurniawan found that organizational culture and human resource capabilities are one

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*Corresponding Author

of the key factors affecting the performance of financial control systems [13]. In the process of traditional access to financial control systems, a large amount of private data is generated. Due to the inability of traditional access control methods to ensure the security of financial data transmission, the current system optimization trend has made prospects for the development and application of blockchain technology in financial systems [14-16]. The above research only provides a brief analysis of the factors that affect financial control systems and the direction in which information technology can improve financial systems, and further research is needed.

In order to improve the performance of financial control systems and enhance the confidentiality and convenience of financial information data transmission, this article studied the architecture and workflow of traditional financial control systems, and analyzed the factors that affect the operational mode of financial control systems. In response to the shortcomings and shortcomings of traditional financial control systems, improvement suggestions were proposed. Based on blockchain technology, an anonymous financial control credit mechanism was constructed, and a decentralized financial control system was established by combining consensus algorithms. In this optimized financial control system, point-to-point information exchange can greatly improve system efficiency, and distributed data storage can reduce information acquisition costs while also improving the security and objectivity of financial data.

Compared with other existing solutions, the financial control system constructed based on blockchain technology in this paper shows significant advantages in many aspects. It solves the problems of the traditional financial control system, such as difficult to distinguish the subject, easy to tamper with information, and limited resource allocation, etc. By optimizing the structure and functions, such as establishing an anonymous crediting mechanism, adopting distributed storage and encryption technology, it achieves a significant increase in cost efficiency, which can significantly reduce the cost of cross-border transactions; significantly shortens the auditing cycle and reduces the risk of accounting fraud; and enhances the security of data and effectively prevents the tampering of data.

Main Contributions:

The main contributions of this paper can be summarized as follows:

1) Significant improvement in cost efficiency: The blockchain-based financial control model constructed in this paper has made a breakthrough in cost efficiency. Through experimental verification, the model can significantly reduce cross-border transaction costs and save a lot of money for enterprises.

2) Significant reduction in audit cycle: By optimizing the audit process, the model in this paper significantly reduces the audit cycle of transactions, improves the efficiency of financial data processing, and reduces the risk of accounting fraud.

3) Enhanced data security: Using the distributed storage and encryption technology of blockchain, the model in this

paper enhances the security of financial data. Through comparative experiments, its excellent performance in preventing data tampering and improving data storage security is verified.

4) Combination of theory and practice: This paper not only theoretically analyzes the application of blockchain technology in the field of financial control, but also verifies the effectiveness of the model through actual cases and experiments, providing practical guidance for the application of blockchain technology in financial control systems.

II. Defects in Traditional Financial Control Systems

The financial control system is an important control component in the business process of an enterprise, which is a program that adjusts and constrains the financial activities of the enterprise to achieve commercial value. Traditional financial control systems have key functions such as financial prediction, financial decision-making, financial analysis, and financial evaluation to process and manage financial data, and have smooth and systematic operation. If the financial control system of an enterprise falls into chaos and cannot effectively control and manage financial data, it would reduce the management efficiency of the enterprise and leave the entire business in a disorderly state [17-19]. In short, financial control systems play a crucial role in curbing fraudulent economic activities and ensuring the safety and integrity of economic assets. Analyzing and summarizing the shortcomings of traditional financial control systems is the foundation for building a scientific and efficient financial control system.

A. Main Body of Financial Control System

In the application process of traditional financial control systems, reasonable control is based on the financial flow information, goods transaction information, and raw material procurement information generated in enterprise economic activities. Financial decisions in economic activities are comprehensively determined by various stakeholders, regulating the relationships between various operating entities in the economic plan, and forming a complete functional network. However, this makes it difficult to distinguish the controlling entities of the financial system [20]. In order to strengthen the information management of the financial control system, this article analyzes the control subjects of the financial system, hoping to make a unified plan for the control subjects of the financial system, and arrange and process financial information and economic processes.

The control subject of traditional financial systems should have the functions of financial departments and work arrangements, and should be in a central position in the governance structure of enterprises, with absolute discourse power in decision-making on financial conditions and economic activities. Faced with complex sources of financial information, the information management capabilities of traditional financial control systems are limited. Therefore, the subject of financial control should exist in the system as a multi-level state, in order to manage and process financial data with higher efficiency in modern enterprise economic activities.

B. Financial Control System Structure

With the rapid development of technology, the form of capital flow in the enterprise economy is also undergoing a huge transformation, and the transformation process from the real economy to the digital economy is breathtaking. Electronic vouchers are more convenient and easier to manage compared to paper vouchers. However, the digital form of currency has led to an explosive growth of information in financial control systems. Compared to traditional forms of currency, data in financial information management is prone to tampering, and data storage and transmission processes are no longer reliable [21-23]. In the new situation of modern capital flow, the establishment of a comprehensive financial control system cannot only be limited to plans and considerations.

With the changes and development of capital flow forms, the management philosophy of the financial control system should be updated, and ultimately implemented in the structural transformation of the financial control system [24-25]. Due to the inability of traditional financial control systems to ensure the confidentiality and objectivity of financial information storage and transmission processes, this article tentatively utilizes blockchain technology to optimize its structure, such as constructing a reasonable anonymous credit mechanism and decentralized system structure, and efficiently handling problems throughout the entire production and operation process with a sounder financial control system structure. The structure of the financial control system constructed in this paper is shown in Fig. 1:
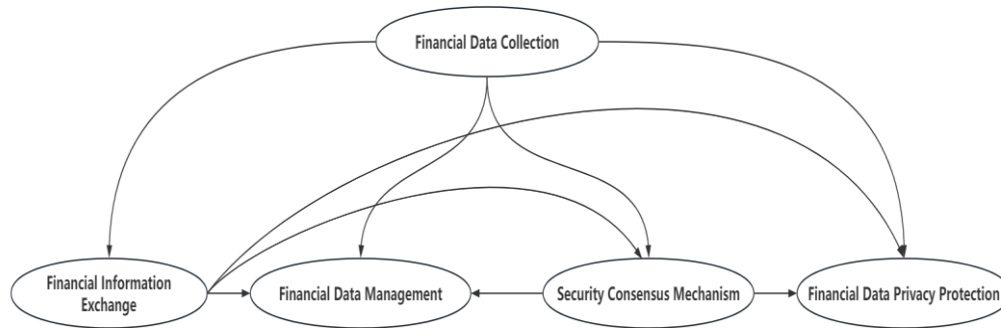
C. Resource Allocation of Financial Control System

From the perspective of system resource allocation, the financial control system should solve problems encountered in financial information processing difficulties, risk response, and business models with more economical and reasonable resource allocation plans [26]. The resource allocation plan for the financial control system must include all levels of participation in enterprise economic activities to achieve the initial goal of integrating resources and covering the entire company. Under the influence of a comprehensive financial control system resource allocation plan, the means of financial control are no longer limited to a single audit and inspection in traditional financial control systems.

With the advancement of modern economic construction, financial control systems have put forward higher performance requirements. A financial control system with principles, competitiveness, and objectivity is conducive to the healthy development of the economic market and the integration of the financial field and control system. Analyzing the workflow and structural characteristics of traditional financial control systems can effectively identify the application deficiencies of traditional financial control systems in modern economic activities. This article summarizes the shortcomings of traditional financial control systems and proposes effective solutions to address these shortcomings. This innovation and development have been made to achieve efficient management of financial information in financial control systems and promote the progress of modern financial information management work.

Fig. 1. System structure diagram.

III. BASIC SCHEME OF FINANCIAL CONTROL SYSTEM

In order to achieve the goal of optimizing traditional financial control systems, this article tentatively combines blockchain technology to analyze the structure and functions of financial control systems. The financial control system not only has accounting and bookkeeping functions, but also assists leaders in decision-making and management. It can also analyze financial data through financial information processing software to generate financial statements that reflect the operation of enterprise economic activities. A more reasonable and scientific financial control system structure can better collect, analyze, and predict financial information.

A. Financial Data Collection

The collection of financial data by the financial control system is a prerequisite for its operation. Good data collection capabilities can provide raw data support to the financial control system and ensure its normal operation. This article is based on blockchain technology to encrypt and save financial data, enabling timely generation of corresponding timestamps and authentication signatures during the process of uploading and downloading financial data in the system. Before extracting financial data, proof of work must be provided for the financial data in the blockchain. The financial data collection function based on blockchain makes the operation of the financial control system more transparent and secure. Each system operator can be recorded in real-time while performing any operation on financial data, including various commercial transaction data and daily operational flow information, as well as transaction records of enterprises, distributors, and even individuals, which can be stored in encrypted form in the blockchain, providing necessary technical support for the normal operation of the financial control system.

B. Financial Information Exchange

In the financial control system, the main purpose of constructing an interaction layer is to process various financial information generated in enterprise economic activities. While funds flow, the financial control system based on blockchain technology abandons the traditional form of paper currency transactions and instead uses encrypted digital currencies similar to Bitcoin for transactions on the blockchain. Every process of financial information interaction reflects a real enterprise economic transaction, and the initiation and end of each transaction are recorded in encrypted form in the blockchain. This ensures the security of financial information while also ensuring the objectivity of financial information, and records various details and processes of the transaction in detail.

C. Financial Data Management

In the enterprise's economic activities, the management is responsible for the interactive operation of recording the capital flow and financial data in the form of cryptocurrency, and assisting the financial information interaction layer to process and manage the relevant financial data while recording the main economic transaction records. In an optimized financial control system based on blockchain technology, management can apply corresponding types of cryptocurrency systems to different types of transactions, enabling enterprises to record and manage all processes related to economic activities from the beginning to the end. Due to the fact that all fund transfer records in the financial control system are stored on the blockchain, it ensures that the financial data during the transaction process and fund flow conversion cannot be tampered with by third parties, ensuring the reliability of encrypted financial data storage and greatly enhancing the company's ability to control financial data. The working interface of the financial control system is shown in Fig. 2.

D. Security Consensus Mechanism

Based on the application of blockchain technology, a security consensus mechanism is established in the financial control system. Due to the susceptibility to network latency during peer-to-peer network access, it is common for nodes in the blockchain to receive financial data at different times. Therefore, this article applies a randomly parallel blockchain security consensus algorithm to establish a security consensus mechanism, which unifies the receiving time of each node in the blockchain during transactions. The member who first completes the transaction using the consensus algorithm records the transaction time, thereby obtaining the identity of the bookkeeper and receiving accounting rewards.

E. Financial Data Privacy Protection

In order to improve the privacy of financial data, the optimized financial control system in this paper tentatively refers to blockchain homomorphic encryption technology to optimize it. In the practical application of optimizing financial control systems, each node in the blockchain has the same copy of financial data, thus achieving a balanced treatment of the objectivity and privacy of the transaction process in the entire enterprise's economic activities. In the process of point to point transactions, it is not necessary to fully read financial data to ensure the objectivity and privacy of the transaction, while also preventing illegal hackers from invading and stealing.

In the face of increasingly complex economic transaction activities, this article analyzes the workflow and infrastructure of the financial control system in order to build a more reliable financial control system and achieve more efficient control of financial data for companies. The working structure diagram of the optimized financial control system is shown in Fig. 3. The above section introduces the basic scheme and functions of a financial control system designed based on blockchain technology in this article. However, further experiments are needed to verify the working performance and application effectiveness of the optimized financial control system.

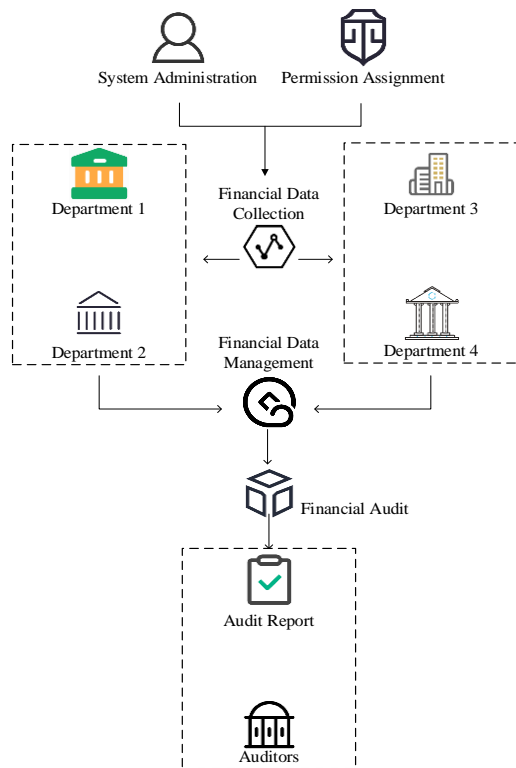Fig. 2. Financial control system work interface.

Fig. 3. Optimizing the work structure of financial control system.

IV. PERFORMANCE COMPARISON EXPERIMENT OF FINANCIAL CONTROL SYSTEM

A. Cross Border Transaction Cost Comparison

The coordination of financial information is an important function of financial control systems, and improving the information coordination performance of financial control systems is the key to enhancing the competitiveness of enterprises. Cost control in cross-border transactions is an important indicator of a company's strength. Low cost capital operation often provides enormous convenience for enterprises. How to open up a broader economic market with more efficient cost control is a serious challenge to the information coordination ability of financial control systems. The indicators for cost calculation by the control center are shown in Table I.

To explore the impact of blockchain technology on financial control systems and verify that optimizing financial control systems can reduce the cost of cross-border transactions by coordinating financial information, this article conducted an application experiment on a financial control system in a certain e-commerce enterprise. 60 e-commerce transaction orders in the same batch were randomly sampled as experimental data and divided into two groups, with 20 transaction orders for children's toys, mother and baby products, and women's and men's clothing. The experiments that applied traditional financial control systems and optimized financial control systems were divided into a control group and an experimental group, and the average transaction costs of 60 transaction orders in the two groups of experiments were compared. Fig. 4(a) and Fig. 4(b) are comparative analyses of transaction costs between traditional and optimized system applications.

Enterprises often face high capital operating costs when facing overseas markets, and the operational processes in economic transactions are complex and have high transaction fees. Efficient and cleverly structured financial control systems can help simplify the complex process of economic transactions, making transactions that originally required multiple stages simpler. This article is based on the blockchain network to optimize the financial control system. In practical applications, it crosses the clearing process of import and export banks and intermediate third parties, and directly conducts point-to-point transactions in the blockchain network. Fund transfer is carried out in the form of encrypted digital currency, reducing the complexity of transactions and improving the operational efficiency of funds. As shown in Fig. 4(a), the average cost of transaction orders for children's toys, mother and baby products, and women's and men's clothing in the control group with traditional financial control systems was 60000, 70000, and 70000 yuan, respectively. As shown in Fig. 4(b), the average cost of transaction orders for children's toys, mother and baby products, and women's and men's clothing in the experimental group with the application of the optimized financial control system was 50000 yuan, 50000 yuan, and 40000 yuan, respectively. Compared to the transaction orders with the application of traditional financial control systems, the transaction orders with the optimized financial control system had significantly reduced costs.

TABLE I. INDICATORS INVOLVED IN COST COORDINATION RESPONSIBILITY REPORT

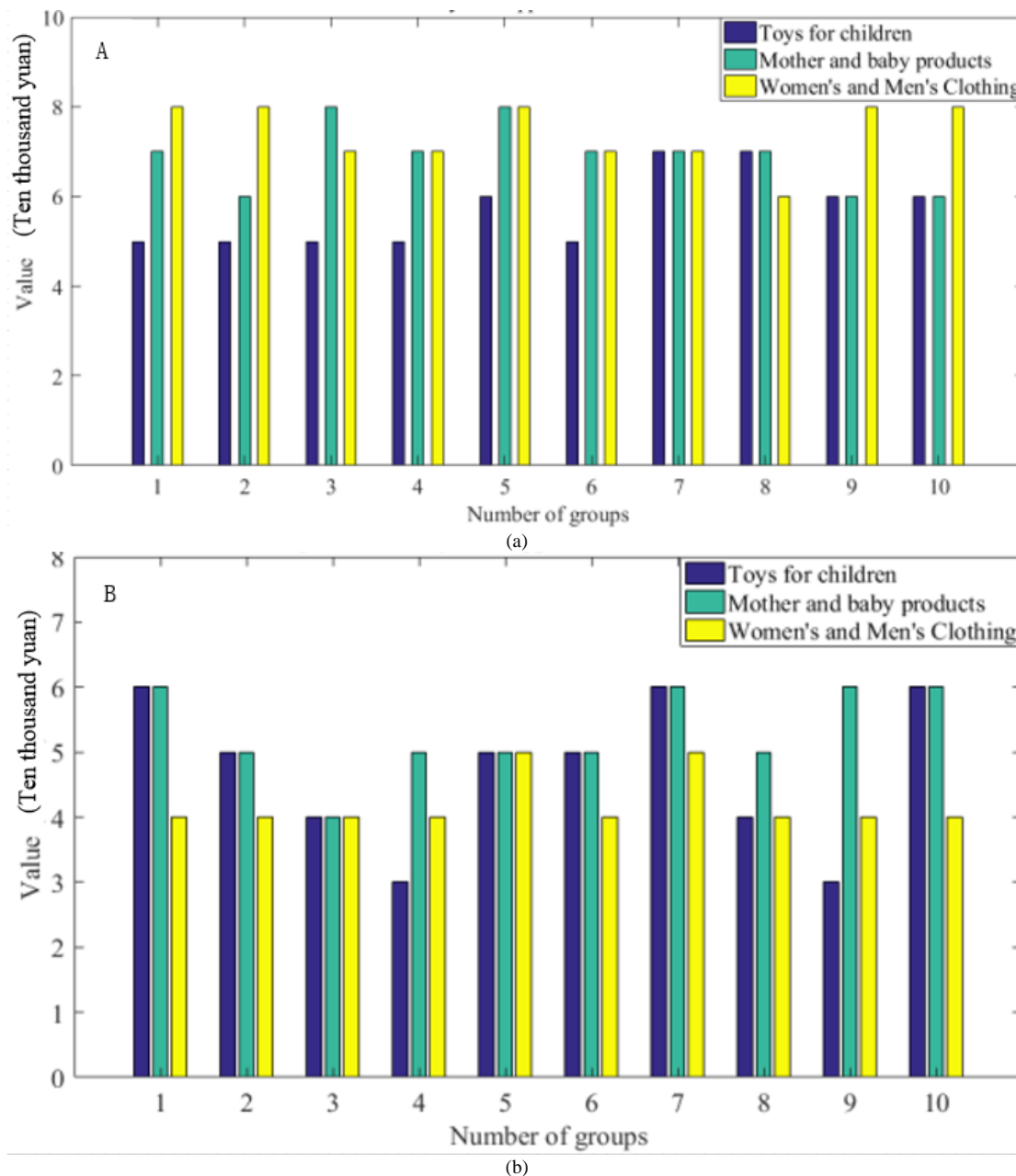| Projects	Indicators			Projects	Indicators		
Material Costs	Budget	Actual	Differences	Uncontrollable costs	Budget	Actual	Differences
Labor Costs	Budget	Actual	Differences	Depreciation of equipment	Budget	Actual	Differences
Variable Costs	Budget	Actual	Differences	Other	Budget	Actual	Differences

Fig. 4. (a) Traditional transaction cost diagram, (b) Optimized system transaction cost diagram.

B. Comparison of Audit Process Cycles

Traditional financial control systems have complex transaction processes for enterprise economic activities, such as counterparty confirmation, financial data analysis, information registration, system auditing, etc. The efficiency of decision-making plans for economic activities is not high, and the audit process of accounting bookkeeping, confirmation, and final generation of accounting reports after transactions are completed increases the risk of accounting fraud. To verify the positive role of optimizing financial control systems in the audit process cycle, this article conducted a comparative experiment. 80 transactions were divided into control and experimental groups, with 40 orders for children's toys and 40 orders for mother and baby products. The experiment using traditional financial control systems was set as the control group, while the experiment using optimized financial control systems was set as the experimental group. The audit cycles of transactions in two sets of experiments were recorded and compared. As shown in Fig. 5, a comparative analysis of audit cycles between traditional and optimized systems is presented.
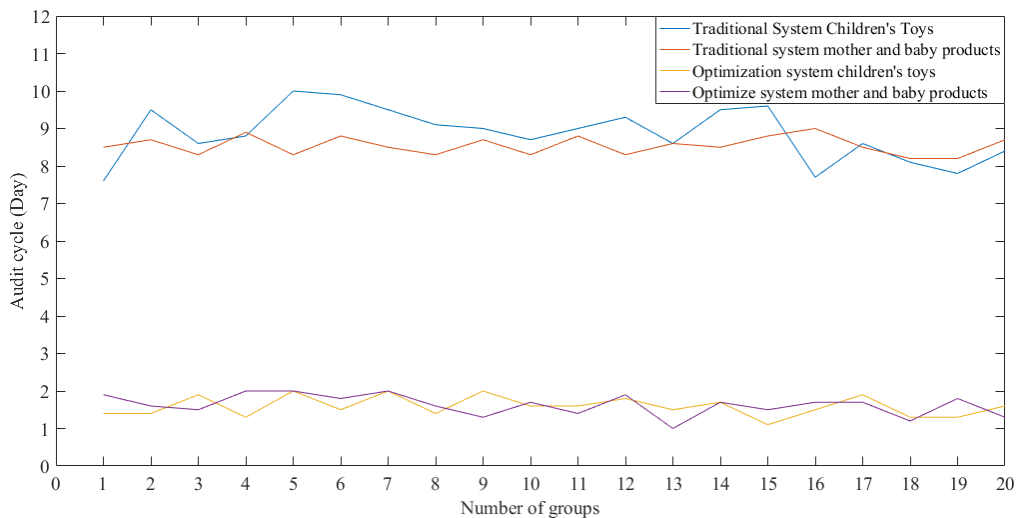
Fig. 5. Comparison of audit cycles between traditional and optimized systems.

As can be seen from the image in Fig. 5, in the traditional financial control systems, transactions of economic activities of enterprises must be reviewed and approved by central institutions. Without the allocation and supervision of control centers, transaction chaos can easily occur in complex audit processes. Due to the overly complex audit process of traditional financial control systems, errors in financial information exchange often occur, such as duplicate payments, which can cause varying degrees of confusion in the transaction records of both parties. The optimized financial control system based on blockchain technology architecture in this article can record transaction information in real-time, and the arrangement of blocks in the blockchain network can be sequentially recorded. Only then can the initial audit information be recognized by other nodes in the network, and there is no risk of confusion in the process of auditing financial information. As shown in Fig. 4, in the control group with the application of traditional financial control systems, the average audit period for children's toy type transaction orders was 8.9 days, and the average audit period for mother and baby product type transaction orders was 8.6 days. In the experimental group that applied the optimized financial control system, the average audit period for children's toy type transaction orders and mother and baby product type transaction orders was 1.6 days. From the comparison of data in Fig. 4, it can be seen that the optimized financial control system based on blockchain technology has greatly improved the audit process compared to traditional financial control systems, greatly refining important links in the audit process, skipping or even removing the process of relative shortcomings, greatly increasing the efficiency of the financial data audit process.

C. Comparison of Financial Data Security

As a financial control system, ensuring the security of financial data storage is crucial. The process of managing and controlling financial data in traditional financial control systems is uniformly planned by the control center, and the top management formulates a rough process to process and store financial data in a top-down structure. In the complex financial data processing process, the security of financial data cannot be fully guaranteed. The security protection of financial data is not comprehensive, leading to difficulties in perfect handover

between various departments in the enterprise during accounting and auditing, and even causing huge commercial loopholes and economic losses. The optimized financial control system based on blockchain technology in this article adopts a distributed encrypted storage method for financial data, greatly improving the security of financial data. In order to verify the positive effect of blockchain technology on financial data storage security performance, security comparison experiments were conducted. This article simulated hackers invading and tampering with the financial data storage modules of traditional and optimized financial control systems, in order to verify the security level of financial control system storage of financial data. Establishing a logically rigorous security evaluation standard is the prerequisite and foundation for verifying the security of financial control systems. In each intrusion experiment, the security of the financial control system was evaluated, with an upper limit of 12, 1-3 being poor, 4-6 being average, 7-9 being good, and 10-12 being excellent. The results of each intrusion were recorded as the evaluation basis. The recorded results of 15 intrusion experiments are shown in Table II.

The blockchain network adopts decentralized auditing and accounting, with each node in the network participating together and copying financial data separately. Each node only determines the ownership of accounting rights based on whether the transaction was completed first and recorded, which is recognized by all nodes. The optimized financial control system based on blockchain network is different from the traditional classified accounting structure of financial control systems, but adopts a distributed accounting structure. Each node in the fully running blockchain network can access transaction data that has been confirmed to exist, and can independently check and verify the integrity of the branch chain. Due to the immutability and persistence of the optimized financial control system based on blockchain technology, the financial data stored in the optimized financial control system is also more secure. As shown in Table 2, after 15 simulated intrusion experiments, in the control group experiment that applied the traditional financial control system, the intrusion was successful twice with an average evaluation index of 7. In the experimental group experiment that applied the optimized financial control system, all simulated intrusions

failed with an average evaluation index of 11. According to data comparison, the optimized financial control system based on blockchain technology architecture has an improved security performance evaluation index of four compared to traditional financial control systems in terms of financial data storage.

TABLE II.   RECORD ANALYSIS OF INTRUSION EXPERIMENTS

Number of experiments	Traditional Financial Control System		Optimize financial control systems	
	Evaluation Index	Intrusion results	Evaluation Index	Intrusion results
1 time	7	Failed	12	Failed
2 time	5	Succeed	9	Failed
3 time	7	Failed	12	Failed
4 time	8	Failed	11	Failed
5 time	8	Failed	12	Failed
6 time	9	Failed	10	Failed
7 time	7	Failed	11	Failed
8 time	8	Failed	10	Failed
9 time	5	Succeed	12	Failed
10 time	7	Failed	9	Failed
11 time	8	Failed	12	Failed
12 time	7	Failed	12	Failed
13 time	6	Failed	11	Failed
14 time	9	Failed	10	Failed
15 time	8	Failed	11	Failed

V. RESULT AND DISCUSSION

Compared with traditional systems, the blockchain based financial control system proposed in this article has achieved significant improvements in all aspects. Through experimental verification, the model can effectively reduce cross-border transaction costs. In the e-commerce enterprise experiment, after applying the optimized system, the average cost of different product transaction orders significantly decreased. In terms of audit cycle, the optimization system based on blockchain technology greatly shortens the audit process. The traditional system has a relatively long review cycle for different types of transactions, while the optimized system greatly shortens the review cycle and improves the efficiency of financial data processing. In terms of data security, optimizing the distributed encrypted storage method of the system makes financial data more secure. After multiple intrusion experiments, traditional systems have a certain success rate of intrusion with a low average evaluation index, while optimized systems can effectively resist all simulated intrusions with a high average evaluation index. These results demonstrate the effectiveness and superiority of the proposed model.

With the vigorous development of the digital economy, blockchain technology has gradually entered the social perspective and played an important role in multiple fields, especially in the economic field, where there is an urgent need for strong support from advanced technology. The management system and classified accounting structure of traditional financial control systems are difficult to enable rapid interaction

and transmission of financial information between relevant departments, and traditional system solutions are prone to hacker intrusion and tampering, leading to frequent examples of major economic accidents. Due to the advantages of distributed data storage structure and immutability, blockchain technology can achieve secure and efficient processing of financial data, ensure the authenticity of financial data and the transparency of economic transaction processes, and promote the work efficiency and management level of financial control systems.

This article analyzed the workflow and structural architecture of traditional financial control systems, tentatively applied blockchain technology to optimize the financial control system, and designed a more excellent financial control system. The performance and application effectiveness of the optimized financial control system were verified through comparative experiments. The results showed that the optimized financial control system in this article had more precise cost control and a safer financial data storage structure, ensuring the normal progress of enterprise economic activities while saving a lot of time and costs. In the future, this paper will conduct in-depth research on the compatibility issues that the current system may face with existing financial infrastructure, explore effective integration strategies, and ensure that the system can smoothly integrate into the current financial ecosystem. Thus promoting the application and popularization of blockchain financial control systems in a wider range of fields, providing more efficient, secure, and intelligent solutions for enterprise financial control.

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