

Research on Food Security Audit Based on Blockchain Technology

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Abstract. Based on the characteristics of blockchain such as decentralization, independence, security and anonymity, audit entities can explore the feasibility and application logic of its application in food security audits by leveraging technologies such as smart contracts, consensus mechanisms, asymmetric encryption and distributed ledgers. The article first analyzes the current situation and problems of food security auditing at both the practical and theoretical levels. Then, it constructs a logical framework for the application of blockchain technology in food security auditing by combining the advantages of blockchain technology, and specifically elaborates on the food security auditing process under blockchain technology. Finally, fully consider the problems faced by blockchain technology in its application and make prospects for its future development.

Keywords: Blockchain Technology, Food Security Audit, Framework Construction, Audit Process.

1. Introduction

The demand for grain has been continuously increasing, showing a rigid feature. Meanwhile, the contradictions in the grain supply structure have become increasingly prominent, leading to a tight balance in food security. This pattern is expected to be difficult to undergo fundamental changes in the short term. In addition, the continuous rise in the cost of domestic grain production, coupled with increasingly severe constraints on resources and the environment, all these factors have put forward higher requirements for the stability and sustainability of grain production.

Auditing is an important component of the security system. It has always played an indispensable governance role in ensuring the effective implementation of major strategic deployments and in preventing and curbing any behavior that may harm the interests of people. The smooth implementation of the food security strategy is even more inseparable from audit supervision. Ensuring the stability and security of grain production has always been an indispensable and continuously focused key area of audit work. However, the implementation of food security audits requires higher efficiency and more advanced methods. Therefore, this article analyzes from the perspective of blockchain how to better promote food security audits, which is conducive to further consolidating the position of auditing in governance and also builds a solid technical support and improvement direction for food security guarantee strategies in the new era.

2. The current situation of food security audits

In practice, auditing has become an important force in implementing the overall outlook on food security, safeguarding food security and ensuring social stability. In recent years, auditing authorities in various regions have carried out a large amount of auditing work centered on food security. In 2022, the Audit Office of Sichuan Province organized a special audit covering 75 counties in 10 cities, with a focus on the implementation of policies and measures for farmland protection, the advancement of key tasks, the management and use of funds for grain production subsidies, and the construction of farmland water conservancy facilities. In 2024, the Audit Department of Gansu Province conducted on-site inspections of the rotation and release ledgers of policy-based reserve grain, investment plans for work-for-relief projects, and related project construction materials. They also inspected the progress of project construction and verified whether the storage quantity of policy-based reserve grain was consistent with the actual situation and whether its quality met the standards.

These auditing practices not only exposed existing problems and potential risks, but also promoted relevant departments and units to strengthen management and improve their work, playing a positive role in ensuring food security. It is evident that the achievements of auditing in ensuring food security have been tested by reality. However, in the current food security audit work, the audit objects mainly focus on large enterprises or large farmlands. There are still problems such as insufficient audits of small and medium-sized enterprises, unclear audit basis standards, insecure and unreliable audit data, and deficiencies in professional audit talents and methods. Therefore, the introduction and application of new technologies and methods are urgently needed.

In the theoretical circle, with the development of blockchain technology, scholars have also carried out research on its application in many fields and scenarios. Blockchain technology, with its decentralized, immutable and traceable features, has provided new solutions for the auditing field and gradually become a hot topic in academic research and practical exploration[1]. The related achievements cover multiple scenarios such as financial auditing, education and medical data management, supply chain tracking, and environmental governance, effectively addressing issues like data tampering, insufficient transparency, and low efficiency in traditional auditing[2]. Feng Yu et al. (2024) proposed a blockchain-based educational data auditing scheme, which randomly selects AI detection modules through smart contracts for data compliance checks and combines certificateless aggregation signature technology to achieve batch verification, reducing storage and computing overhead[3]. Sarode et al. (2023) designed a blockchain-based audit management system to meet the audit requirements of electronic health records. The audit logs are stored in an immutable form on the blockchain, enabling medical personnel to trace patients' diagnosis and treatment records along the timeline. In supply chain and cross-chain data sharing scenarios, blockchain is used to solve the problems of dynamic data updates and source audits[4]. Chenting Li et al. (2024) proposed a dual auditing scheme for the integrity issue of cross-chain data sharing, combining message-locking encryption technology to protect data privacy, supporting batch updates of dynamic data through an improved Merkle tree, and reducing on-chain computing overhead by using smart contracts and homomorphic label algorithms[5]. However, there are currently no papers on the combination of food security auditing and blockchain technology.

Based on the gap between practice and theory, the article first constructs a logical framework for the application of blockchain technology in food security auditing in five levels according to the working principle and advantages of blockchain technology. Secondly, by integrating traditional auditing work and through technological substitution, the general process of food security auditing under blockchain technology is further elaborated. Finally, fully considering some of the problems currently faced by blockchain technology in its application, relevant suggestions and prospects for future development are put forward.

3. The construction of a food security audit application framework based on blockchain technology

The construction of the food security audit application framework based on blockchain technology is shown in Figure 1, which includes a total of five levels. Specifically, they are the data layer, network layer, consensus layer, contract layer and application layer.

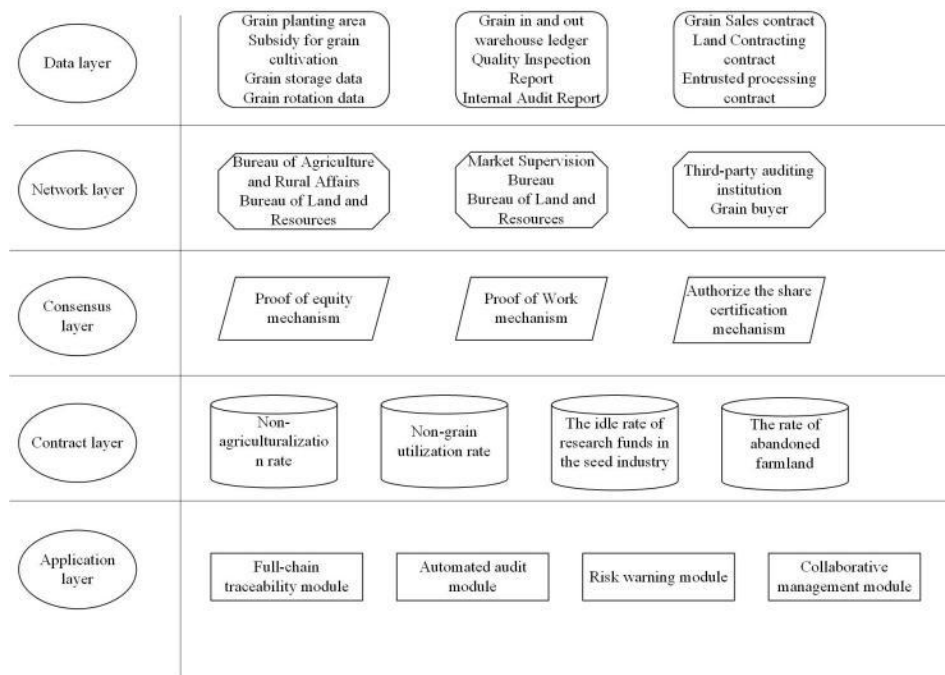


Figure 1.An application framework for food security auditing based on blockchain technology

The core function of the data layer is to store various types of data related to grain production and circulation, including grain planting area, rotation data, agricultural subsidy distribution situation and other related information. By leveraging the technologies of blockchain such as timestamps and smart contracts, the data related to food security activities are orderly connected in chronological order, thereby building the basic structure of the blockchain and enabling rapid temporal positioning of the required data. On this basis, through the application of Hash algorithms, distributed data storage and asymmetric encryption technologies, these data related to food security activities are transmitted to the entire blockchain. At this point, all network nodes on the blockchain take on the responsibility of data management and protection, replacing the traditional model where only a few people are responsible for food security data management, and further strengthening the decentralized feature. This mechanism to a certain extent ensures the authenticity and security of food security data, not only providing support for the smooth progress of food security auditing work, but also effectively enhancing the supervision efficiency of stakeholders over the production and circulation links of food.

The core function of the network layer is to build a network platform to connect the audited entity with various stakeholders, as shown in Figure 2. Each stakeholder has the node permission on the blockchain, which enables them to more conveniently access and obtain information related to food production and circulation activities within their permission scope. Under the premise of ensuring data security, this setting has, to a certain extent, enhanced the transparency and sharing of data on grain production and circulation. These stakeholders can be divided into internal and external categories. Among them, the internal stakeholders mainly consist of various departments that generate data on grain production and circulation, such as the agricultural and rural affairs bureau, grain depots and storage enterprises, etc. With the granted node permissions, these departments can automatically input the relevant data generated during the grain production and circulation process into the blockchain. This helps simplify the data collection process for food security audits and, to a certain extent, enhances the transparency of grain-related data. External stakeholders mainly include other enterprises or institutions that have business dealings with the audited entity in grain production and circulation activities, such as banks, schools and hospitals with grain purchase demands, etc. In addition, it also covers departments that supervise the food security information of the audited units and auditing authorities that carry out food auditing work, etc. This setting can to a certain extent enhance the authenticity and transparency of grain data, reduce the possibility of data tampering by humans, facilitate information transmission between enterprises and stakeholders, and make it easier for departments and other stakeholders to supervise grain production and circulation activities,

thereby better regulating the behavior of producers and reducing the occurrence of illegal acts by related organizations.

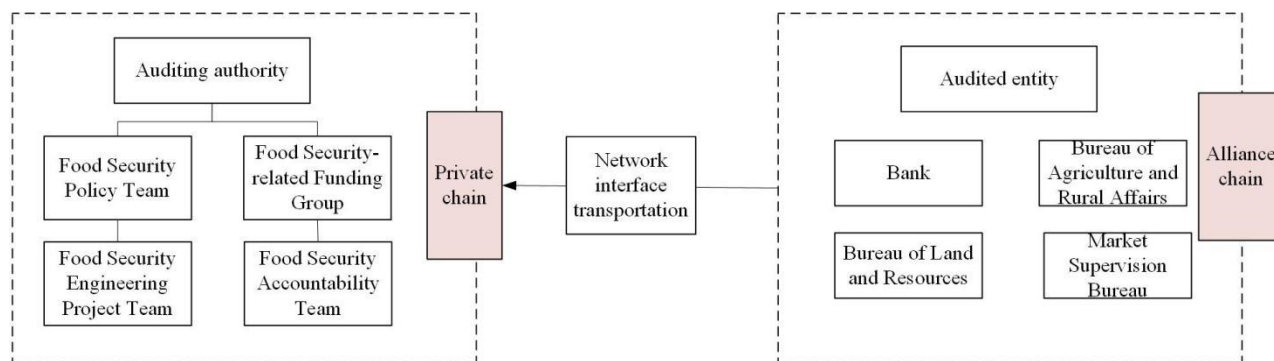


Figure 2.Network Platform Construction

The consensus layer is composed of multiple consensus mechanisms, such as the proof of work mechanism and the authorized share proof mechanism, all of which are included. Under the collaborative effect of these consensus mechanisms, each node in the blockchain network can quickly verify newly entered data. This not only better guarantees the authenticity of the data of each node but also enhances the reliability of the data. For data to be officially stored in the blockchain, it must be verified by at least 51% of the nodes. This requirement largely reduces the possibility of human tampering with data, and thereby enhances the security of data to a certain extent.

The contract layer mainly includes smart contracts, script codes, and various algorithm mechanisms, etc. These technologies form the foundation for the application of blockchain in food security auditing work, providing a solid guarantee for the smooth progress of the auditing work. With the help of blockchain technology, the non-agricultural utilization rate, non-grain utilization rate, idle rate of seed industry research funds, and abandoned farmland rate can all be processed automatically. After the data of grain production and circulation is entered, the calculation and conversion can be completed automatically. To a certain extent, this simplifies the auditing process and effectively improves the efficiency of auditing work. In addition, in the food security audit contract layer based on blockchain technology, pre-setting emission early warning rules related to grain production and circulation activities helps the audited units and relevant leading cadres to promptly identify and rectify problems existing in the grain production and circulation links, thereby avoiding greater losses to consumers.

The application layer is an interactive interface directly facing users (farmers, enterprises, regulatory authorities, consumers), providing functions such as full-chain traceability, automated auditing, risk early warning, and collaborative management, to support the practical implementation of food security auditing. Among them, in the full-chain traceability query system module, users can query the full-process data of grain from planting to sales through the product identification code. The intelligent audit platform module automatically generates audit reports based on smart contracts and marks high-risk links. Auditors can initiate manual reviews of the risk batches marked by smart contracts by regulatory authorities, and the review results will be recorded on the chain for evidence. The risk early warning and decision support module can issue real-time early warnings. Through on-chain data monitoring, smart contracts trigger early warnings and notify the responsible parties via text messages and APP push notifications. Trend analysis can also be conducted, generating visual reports based on historical data on the chain to assist regulatory authorities in formulating policies. The collaboration management platform module enables data sharing. Growers, processing enterprises, logistics providers, etc. can upload data from their respective links through the platform, and regulatory authorities can view and coordinate in real time. When disputes arise among multiple parties regarding data, the platform automatically arbitrates by calling on the on-chain evidence data and smart contract rules. The result is recorded on the chain and cannot be tampered with.

4. The food security audit process based on blockchain technology

According to the characteristics of auditing work, the process of food security auditing can be divided into the auditing preparation stage, the auditing implementation stage and the auditing report stage. The combination with blockchain technology is shown in Figures 3 to 5.

4.1. Audit preparation stage

(1) Determine the audit objectives and scope

Blockchain provides a shared, single-source data ledger. Auditors can access historical and real-time data streams on the chain, such as temperature and humidity sensors and quality inspection reports on the chain, to quickly understand the overall operation of the entire grain supply chain. Based on the analysis of on-chain data, such as batch circulation speed, frequency of abnormal temperature records, and changes in quality inspection pass rates, auditors can more accurately identify high-risk links, such as specific warehouses, certain transportation routes, and certain suppliers, as well as high-risk batches, thereby more scientifically determining the focus and scope of audits.

(2) Develop an audit plan

Audit plans can be formulated based on real-time and near real-time data on the chain, making them more timely and targeted. In the blockchain, audit trigger rules based on specific conditions can be preset, such as when the temperature of a certain batch exceeds the threshold or when the inventory of a certain warehouse changes abnormally. Through smart contracts, audit instructions can be automatically issued or the priority of the plan can be adjusted to achieve “event-driven”.

(3) Obtain relevant basic information

Key data such as origin certificates, pesticide residue test reports, temperature and humidity records, and transfer documents are uploaded to the blockchain when they are generated or occur. They are verified and recorded by multiple nodes, which naturally have higher credibility and significantly reduce the workload of data verification in the audit preparation stage. Auditors can directly access the structured data on the chain through authorization without repeatedly requesting and organizing paper or electronic documents, improving the efficiency of preparation.

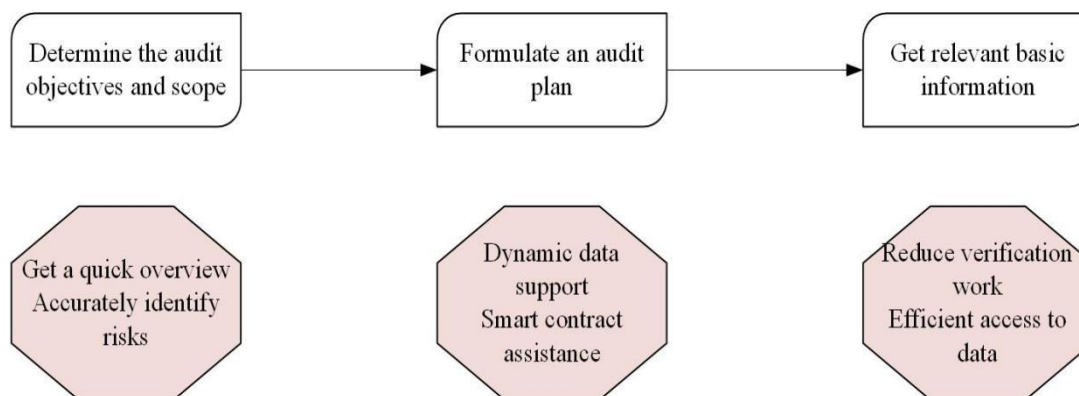


Figure 3. The preparation stage of food security audit based on blockchain technology

4.2. Audit implementation stage

(1) Internal control testing and evaluation

Many internal control rules can be solidified and executed on the chain through smart contract coding. Auditors can directly verify the logic and execution records of smart contracts, confirm whether the control is enforced or automatically executed, and achieve nearly full control testing. All operations related to internal control, such as the signatures of quality inspectors and the confirmation of outbound by warehouse managers, are recorded on the chain and cannot be tampered with, facilitating auditors to trace the complete process of control execution.

(2) Substantive procedures

Auditors can easily trace the full chain information of any batch of grain from the field to the dining table. For instance, quickly verify the authenticity of a certain batch of inventory, the legality of its source, the compliance of storage conditions, and the rationality of its circulation path. It greatly reduces the need for manual review of vouchers and on-site inventory checks. Smart contracts can be used to automatically execute some verification procedures, such as automatically comparing the logistics records on the chain with the inventory change records to see if they are consistent, and automatically checking the validity period and results of the quality inspection reports.

(3)Data analysis

Auditors can also use more powerful data analysis tools to conduct in-depth mining of on-chain data, identify abnormal patterns, potential risk points and improvement opportunities, such as identifying transport vehicles that frequently experience temperature control anomalies and predicting changes in loss rates under specific warehousing conditions. Such analysis results are more reliable and insightful.

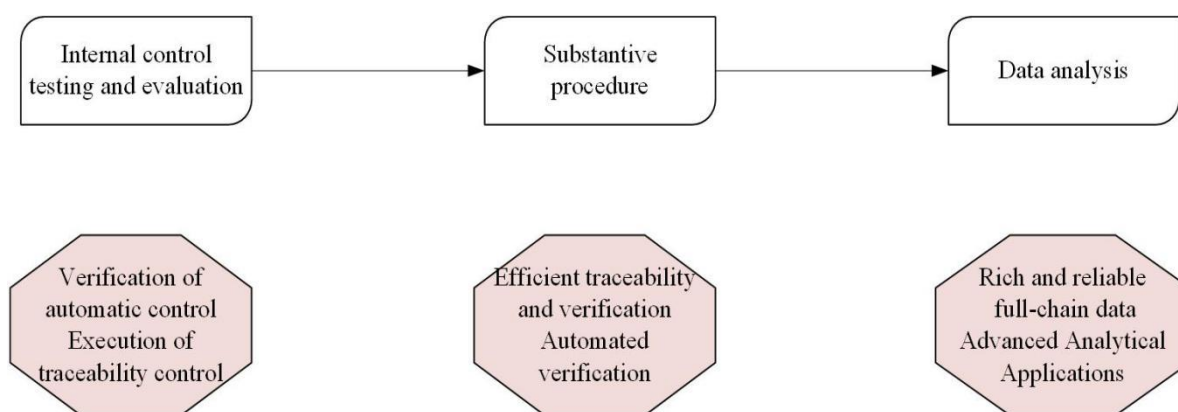


Figure 4.The implementation stage of food security audit based on blockchain technology

4.3. Audit report stage

(1)Summary and communication of audit findings

All audit findings can be directly linked to the original unalterable transaction records, status data and operation logs on the chain. The audited entity can promptly and transparently verify the authenticity and completeness of the audit evidence, reducing disputes. Thanks to the real-time on-chain data and the automated monitoring of smart contracts, for some key risks, such as major quality accidents and serious violations of operations, it is theoretically possible to achieve near-real-time abnormal reporting and early warning, which is much faster than the traditional regular audit reports.

(2)Preparation of audit reports

Auditors can develop report templates based on blockchain data, automatically extract and summarize qualified data and analysis results using smart contracts or reporting tools, generate initial drafts or core parts of reports, and improve the efficiency and standardization of report preparation. Auditors can also utilize on-chain data to generate more intuitive and dynamic visual charts (such as batch flow chart, temperature control curve and standard comparison chart, quality pass rate dashboard), making the report clearer and more convincing.

(3)Subsequent tracking and rectification verification

The audited entity can upload rectification measures, such as equipment maintenance records, process update documents, and personnel training certificates, to the blockchain. Auditors can remotely and in real time monitor the progress of rectification and verify the effect of rectification. For rectification points that require continuous monitoring, such as ensuring that the temperature consistently meets the standards, smart contracts can be set up for automated continuous monitoring, and relevant parties and auditors can be automatically notified when the conditions are met or violated.

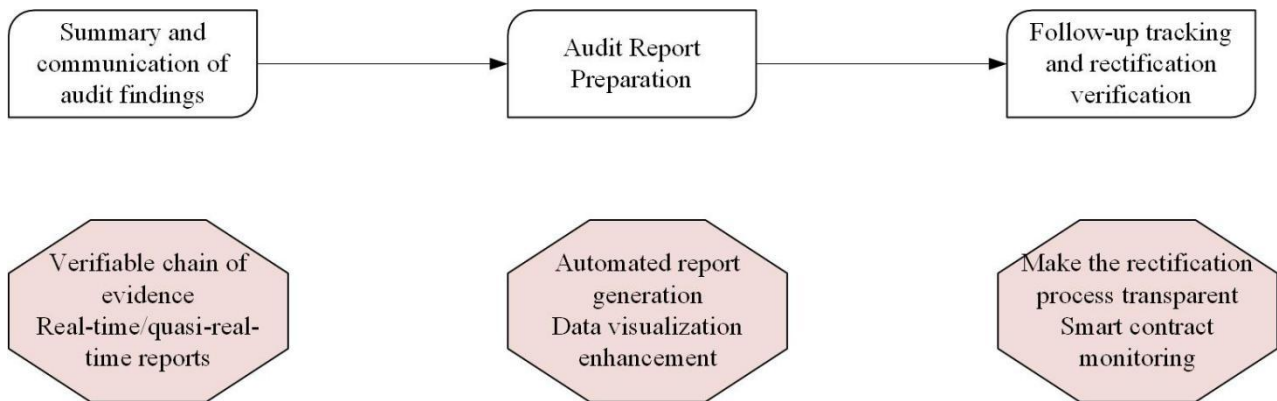


Figure 5.The stage of food security audit reports based on blockchain technology

5. Conclusion

Blockchain auditing technology is an open and inclusive technical model. It can enhance the efficiency of food security audits, ensure the effectiveness of audits, improve the independence of auditing institutions and auditors, and better implement the policy of full coverage of audits. However, when implementing blockchain auditing technology, we should also pay attention to some possible issues. As a new technology emerging in the information age, the relevant laws and regulations are still not perfect. We should explore and formulate laws and regulations to ensure the security of blockchain. Blockchain auditing technology places higher demands on the professional capabilities of auditors. Through training, every auditor can master blockchain auditing methods and apply them to various related auditing fields, completing the transformation from traditional auditing to blockchain auditing, keeping up with The Times and conforming to the trend of new technological development.

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