The impact of blockchain technology on the cost of food traceability supply chain

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Abstract: The establishment of food traceability supply chain is an effective way to solve the problem of food safety. But the cost of operating traditional food traceability supply chain system is high. The enterprise on the chain are not willing to participate, and the data on the chain is easy to falsified, which leads to the existence of food traceability and the lack of consumers' willingness to buy for it. Based on this, solving the high cost in the technical point has become a feasible meaning. Introducing blockchain technology into food safety traceability can improve brand reputation, maintain market and consumer confidence, improve supply chain management, accelerate product and reduce liability risk. In this paper, from the compatibility of block technology and food traceability supply chain, it is concluded that the introduction of blockchain technology will reduce the transaction cost, quality cost, time cost, activity cost, and supply chain traceability additional cost in the food supply chain cost. By comparing with the application cost of block chain technology, this paper explores the cost control mechanism of food traceability supply chain based on block chain, so as to promote the development of food traceability supply chain. The application of blockchain technology in food traceability supply chain will improve the food traceability supply chain system.

1. Introduction

The procedures of food supply chain integrate and claim that individuals have been scattered in the supply chain to form a unified customer service industry. And an effective means to enhance consummate confidence. But at present, the application of food supply chain traceability system in China is not optimistic, one of the main reasons is the high cost. From the perspective of enterprises, the high cost of establishing traceability system leads to insufficient willingness of participants in the time and sustainability of system[1]. From the perspective of consumers, the cost generated by construction and management of traceability system is ultimately transferred to consumers, resulting in product prices and the reduction of consumption intention. From the perspective of technology, the current traceability system has a negative impact on the timeliness and sustainability of system construction Most of them are self built by enterprise. Enterprises modify or conceal the data out of self-interest behavior, which
leads to low accuracy of data, resulting in delays or misunderstanding of the supply chain, which includes in large cost of the supply chain, which includes the price and fees. At the same time, the traceability systems developed by different enterprises are difficult to sink and the data formats which makes it difficult to share the whole process of supply-chain system. Therefore, it is practical significance to study how to promote the application of food supply chain traceability system from the perspective of cost.

2. Literature review
Based on the relevant literature at home and abroad, the research on the cost of supply chain traceability mainly focuses on the following aspects: (1) the impact of establishing traceability system on transaction cost [2-3]. (2) Tracing the design of sharing quality cost among the main bodies in the supply chain [1,4-5]. (3) Participate in the cost-benefit analysis of the subjects involved in the traceability system [6-8]. (4) Trace the additional costs of the construction and implementation of the supply chain [9-11]. (5) Research on the application of blockchain in food safety traceability to reduce costs [12-14]. The above research shows that the application of food supply chain traceability system is closely related to the cost. The establishment and application of food traceability supply chain is a more complex system engineering, and the cost of supply chain traceability system is closely related to the Traceability Technology. Using blockchain as an emerging technology means to trace food safety will produce positive economic benefits in improving enterprise brand reputation, maintaining market and consumer confidence, improving supply chain management, accelerating product recall and reducing liability risk. What is the impact of the introduction of blockchain on the cost of food supply chain traceability? How to promote the establishment and application of food supply chain traceability system through cost control is worthy of further study. This paper intends to explore the cost control and mechanism of food supply chain traceability from the technical means of blockchain, in order to provide a new reference for food safety traceability cost management.

3. Applicability of blockchain in food traceability supply chain
According to the differences in the degree of information disclosure and central control, the blockchain is divided into public chain, alliance chain and private chain. Among them, the alliance chain has the characteristics of incomplete transaction, high transaction speed, low cost and strong controllability, which is suitable for the system of multiple institutions and organizations to participate in the management, which is also the most suitable blockchain for food traceability system. Therefore, the blockchain in this paper refers to the alliance blockchain.

The characteristics of blockchain and it’s applicability in food traceability supply chain are as follows: (1) technical applicability. Traditional Internet of things uses centralized server to store, transmit and share data, while blockchain technology uses multi-to-peer distributed network, which is difficult to be attacked. The principle of consensus is used to establish a consensus mechanism to ensure the authenticity and effectiveness of data, which increases the integrity and security of transaction data. Through the establishment of food traceability supply chain based on blockchain, it can provide consumers with complete transaction information and reliable channels to track the source of products, and realize the sharing of data on the supply chain. (2) Applicability of data collections and transmission. First of all, blockchain technology allows participants to upload transaction information anonymously, so as to protect the data privacy of participating enterprises and focus only on the transaction itself. Secondly, blockchain technology can prevent databases. The data on the supply chain based on blockchain is maintained by all noises in the chain, which breaks away from the traditional supply chain traceability technology on the central platform. Finally, when the blockchain is combined with the Internet of things devices, it can prevent all parties from creating wrong records and tampering with the data source. (3) Management applicability. Firstly, the introduction of blockchain can recognize the transparent management of supply chain. Blockchain can ensure the openness and transparency of information on the chain. All nodes at all levels of the chain can see the relevant information about transactions on the chain. At the same time, transparent data management provides a credible way for
audit, operation records, logistics tracking and other activities. Secondly, the introduction of blockchain can recognize the traceability of supply chain information. In order to solve the problems of food safety and quality, improve the transparency, safety, persistence and integrity of traceability; moreover, blockchain helps to improve supply chain cooperation and trust, especially for cross organizational business processes, the distributed and heterogeneous services of blockchain can well adapt to the trust building between cross regional organizations, and have a profound impact on the relationship and governance structure in the supply chain influence.

**Food traceability supply chain system based on blockchain**

![Food traceability supply chain system based on blockchain](image)

**Figure 1 Food traceability supply chain system based on blockchain**

4. Cost division of food traceability supply chain

4.1. Cost division of food supply chain

The current research has not yet formed a complete system for the cost division of food supply chain, which should be considered in many aspects. First of all, we should fully combine the development experience of supply chain management in recent years, and integrate information cost, time cost, transaction cost and supply chain cost control into the research system; secondly, we should embody the thought of supply chain management, that is, we should have more systematic concept and pay more attention to the construction of new relationship between enterprises; thirdly, we should introduce the relationship dimension into the cost division system. The transaction cost caused by the complex relationship between node enterprises is taken into account, so as to build a more comprehensive cost evaluation system.

Based on this, according to Fuquan Xie's research on cost division of food supply chain in "Supply chain cost management - Research on category cost and operation", this paper starts from three dimensions: cost dimension, relationship dimension and production dimension. The cost dimension includes transaction attribute cost and activity attribute cost. Transaction attribute cost consists of search cost, negotiation cost and performance cost; activity-based cost includes quality cost, time cost and...
activity cost. The relationship dimension mainly focuses on the government and the group. Production dimension mainly includes raw material supply, quality inspection and production, storage and transportation, finished product sales, etc. This paper focuses on the change of cost dimension under the influence of relationship dimension under the premise of introducing blockchain technology.

4.2. Additional cost of food supply chain traceability

After the introduction of traceability system, no matter what technology is adopted, there will be additional costs, including hardware cost, software cost, operation cost and labor cost. Among them, the hardware cost mainly includes the purchase of relevant systems, computer hardware, terminal query equipment, labels, and the purchase of various bar codes; the software cost includes the computer equipment and equipment maintenance, system equipment depreciation, supply chain communication and coordination fees, water and electricity site rental fees, etc.; the human cost includes technical development personnel, label printing personnel, information input personnel and other staff Recruitment costs and salary expenses. Operation cost refers to the cost that should be generated in order to maintain the normal operation of the whole system in addition to the above costs, including recall cost of defective products, marketing and publicity expenses of products and company image, and communication and coordination expenses with other parties in the system.

![Figure 2 Composition of food supply traceability cost](image)

5. Influence of introducing blockchain on cost control of food traceability supply chain

5.1. The impact of the introduction of blockchain on the cost of food supply chain

5.1.1. The impact of the introduction of blockchain on transaction cost.

Blockchain can effectively reduce search costs. It is mainly reflected in the following aspects: (1) the introduction of blockchain helps to reduce opportunistic behavior. By collecting system information, the blockchain constructs a permanent record and tamper-proof system for past transactions, uses its intelligent contract function to determine exchange parameters and enforce them, which can largely limit the opportunistic behavior in the transaction relationship. (2) The introduction of blockchain is conducive to reducing the transaction costs caused by information collection and verification. First of all, blockchain can reduce the uncertainty of external environment by providing reliable historical and real-time data, and create a safe and transparent business environment for enterprises; by providing massive market data, blockchain can help enterprises improve decision-making efficiency, optimize decision-making process, improve supply chain flexibility and reduce supply-demand differences Bullwhip effect; by improving the flow efficiency of goods, services, finance and other information in the supply chain, the blockchain weakens the boundaries between enterprises, reduces the uncertainty of supply and demand, and flexibly matches the supply and demand sides, thus saving time and money.
Compared with other supply chains, the food supply chain is faced with more uncertainties and risks, which will cause people's doubts about life, environment and social governance. Blockchain technology is used to monitor the food circulation on the chain in real-time to make the risk visible, thus effectively reducing the transaction cost between the main bodies in the chain. Secondly, blockchain reduces the uncertainty of behavior. Blockchain provides a method to gather initial information at the beginning of a transaction relationship, and the available records of past behaviors enable suppliers and sellers to show their reputation and product quality to potential business partners. Through information sharing, the governance cost of reviewing and selecting suitable supply chain partners can be reduced, so that improper behaviors can be seen and tracked; sufficient information can be realized through blockchain Depth, including product source, production process, and other permanent and immutable records related to products, provides a solid foundation for performance evaluation, benchmarking and auditing; transparent product sources can prevent fraud and counterfeiting, thus saving the cost of monitoring, controlling existing suppliers and ensuring the quality of products and services. Finally, with the gradual expansion of the supply chain to the supply network, the number of participants increases, the total information collection cost increases, and the transaction cost increases. The introduction of blockchain will greatly reduce the cost of information collection.

Blockchain can effectively reduce the cost of negotiation and signing. First of all, blockchain provides a more market-oriented governance structure for transactions with high environmental uncertainty, enabling companies to reach trust and sign contracts without establishing long-term relationships, and reduce the transaction costs in uncertain environments, such as complete contract design costs, and contract continuation and renegotiation costs. Secondly, there is a great correlation between the negotiation and signing cost and the specific assets involved in the transaction. The degree of asset specificity is directly proportional to the requirement of contract continuity. The introduction of blockchain will make both parties of the transaction match the supply and demand resources without establishing trust relationships under the blockchain constraint, thus increasing the opportunity of seamless contract docking, reducing the risk of investment in specific assets and reducing the negotiation and signing Cost.

Blockchain can effectively reduce the performance cost. Through the introduction of blockchain to improve the infrastructure, information and communication technology of traceability supply chain, enhance the degree of information assurance, strengthen the trust relationship, to save the cost of product quality inspection in the later stage. At the same time, by providing more comprehensive information, the blockchain improves the reaction sensitivity of the main body on the chain and promotes the communication and negotiation between the main bodies on the chain. Blockchain can encourage participants to perform their contracts and reduce the possibility of transaction change.

5.1.2. The impact of the introduction of blockchain on quality cost.

The introduction of blockchain is conducive to the formation of a reasonable quality cost-sharing system. The traditional food traceability supply chain cannot provide all the information about the source of the product. When the safety accident occurs, the product seller will be unable to determine the responsible person in the chain, which will lead to the "black pot" phenomenon. After the introduction of retroactive supply chain based on blockchain, the main body in the chain can determine the responsibility subject through the blockchain, and the buyer can realize the transfer of all internal losses and external losses according to the responsibility, to realize the responsibility sharing of the quality cost of the supply chain and achieve the common optimization of the whole supply chain and the Department.

The application of blockchain can effectively reduce the quality cost. First of all, reduce the identification cost of the main body in the chain. By introducing blockchain and using the reliable data provided by blockchain to form a trust mechanism, it can reduce the identification costs such as on-site inspection of suppliers, verification of suppliers' ability, production process, and product quality, and inspection of goods sources. Secondly, the internal loss cost is reduced. The blockchain provides the whole chain traceable product information, which will greatly reduce the opportunistic motivation of suppliers, ensure the product quality, and reduce the defective rate of products from the source, to reduce.
the return cost and internal loss. Finally, reduce the cost of external losses. The introduction of blockchain makes the responsibilities between the major bodies in the chain clear. When food quality and safety accidents occur, it can realize the accountability and proof, reduce the disputes in the process of responsibility shifting, and at the same time, it has a positive effect on maintaining the image of the industry and reducing the external loss cost caused by accident.

5.1.3. The impact of the introduction of blockchain on time cost.
When food safety accidents occur, it is an important measure to calm down the accidents and reduce the negative impact of enterprises to give consumers a reasonable explanation in time. First of all, the introduction of blockchain can realize the rapid positioning of information on the chain. On the one hand, it can determine the link where the product may have defects, on the other hand, it can quickly determine the responsible subject when there is a defect, to reduce the negative impact of continuous fermentation of quality and safety events, to reduce the time cost. Secondly, the introduction of blockchain will save a lot of transaction time. The enterprises on the chain can attract customers by transmitting their information, eliminate the management costs and intermediary costs, and achieve the purpose of saving time and cost.

5.1.4. The impact of the introduction of blockchain on activity-based costing.
Supply chain activity-based cost management can be divided into supplier cost management, distributor cost management, and customer cost management. First of all, due to the complexity of food types, the food production and sales chain has developed from the traditional supply chain to the supply and demand network. Through the introduction of blockchain, we can find the suppliers who meet the requirements at home, and calculate the procurement costs of different suppliers and select the suppliers with low comprehensive cost, to reduce the supplier management cost. Secondly, the introduction of blockchain, the use of transparent information on the chain, manufacturers can get customer information directly over distributors, reduce the management and maintenance costs of distributors. Finally, the blockchain can retain the product destination information, establish a customer database, facilitate the analysis of customer needs, thereby reducing customer maintenance costs.

5.2. The impact of the introduction of blockchain on supply chain traceability additional cost
The role of blockchain in reducing the additional cost is mainly reflected in the following aspects: (1) the decentralization of blockchain is conducive to saving the cost of information and data storage of core enterprises, improving its operation efficiency, and reducing the cost of hardware and software in the additional cost. At present, the traditional information and data storage mode depend on the data storage center, and the pressure of the data center storage system increases infinitely with the increase of the amount of data. Under the blockchain system, each participant exists independently and follows the same rules and mechanisms. When each node writes and reads data, it does not need to be tested by the central database, which is more efficient; (2) it can be reduced Low system maintenance cost. The decentralized characteristics of blockchain can make each participant in the supply chain system an independent individual to jointly maintain the blockchain network. Taking the alliance chain as an example, core enterprises no longer assume the responsibility of system maintenance as the initiator of the supply chain. Instead, the members of the alliance act as the creators of the blockchain network, dynamically manage the flow of members, and allocate the corresponding permissions through the voting, election and other means. The participation and mutual supervision of alliance members can prevent the supply chain from being controlled by one party, which can not only enhance the cohesion within the alliance, but also reduce the unilateral maintenance cost of the blockchain by core enterprises.

5.3. The increased cost of blockchain introduction
The introduction of blockchain can reduce the cost of supply chain traceability, but it will also increase other costs. First of all, the introduction of blockchain will increase the cost of product quality identification and evaluation. Blockchain is essentially a database, which does not have the function of
verifying whether the initial information is true or false. Before the information is uploaded to the blockchain, the blockchain cannot guarantee the authenticity and effectiveness of the data. Therefore, before the information is entered into the blockchain, there are still opportunistc behaviors, and the error information generated during this period will enlarge the impact with the extension of the chain, thus enlarging the governance cost. In order to avoid the irreparable loss of wrong information in the future, the participants in the food supply chain must strengthen the quality monitoring before the information is put on the chain, which leads to the increase of the cost of product quality identification and evaluation. Secondly, the introduction of blockchain to the existing traceability system will generate conversion costs. The food traceability system has formed a complex food traceability system including the Internet of things, two-dimensional code and other technologies. To introduce blockchain technology into the existing traceability system is bound to face conversion costs. At the same time, with the continuous maturity of blockchain technology, there will be more technology investment. Finally, the introduction of blockchain technology will also face the rise of human resource costs. In order to realize the effective diffusion of blockchain technology in the food supply chain, strong technical talents are needed to promote the blockchain program and maintain the blockchain ecosystem, and talent training will also increase the cost of human resources.

Figure 3. Cost control mechanism of food traceability supply chain based on blockchain

6. Conclusion
This paper analyzes the impact of the introduction of blockchain on the cost control of the food traceability supply chain. The introduction of blockchain can greatly reduce the transaction cost, quality cost, and activity cost between the main bodies on the chain, and generate additional economic benefits in time. However, as an emerging technology, the technical defects of blockchain also increase the traceability cost to a certain extent. The use of blockchain technology requires strict control of data
sources to ensure the authenticity and accuracy of data sources. The traceability scheme based on the blockchain can ensure that once the data is input into the system, once the data is modified in violation of the consensus mechanism and design principles, it will be recognized by the real integrity verification mechanism. Too much data can't be guaranteed from the source. At the same time, increasing product quality control will also increase the traceability cost of the whole supply chain. In the future research process, we can investigate the extent of cost control on industrial departments and node enterprises, and establish a model to quantify the effect of cost control. Finally, since building a food traceability supply chain system based on the blockchain requires a lot of early-stage technical investment, how the government, enterprises, and industry associations play a role in promoting the construction of the system, and what measures should be taken to promote the application and effectiveness of the blockchain are the focus of the follow-up research.

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