

Application Of Blockchain Technology in Product Supply Chain

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Abstract. Nowadays, people's consumption level continues to increase, and the industrial supply chain needs to be continuously upgraded and improved to cater to market demand. This process has also gradually exposed some shortcomings of the traditional industrial chain, such as opaque information, non-traceable product sources, and difficulty in inventory management by enterprises. , the market is flooded with a large number of substandard products, making it difficult for consumers to protect their legitimate rights and interests, etc. However, when the emerging blockchain technology is applied to traditional industrial chains, people find that it solves many pain points in traditional industrial chains. Blockchain is a distributed ledger technology with multiple nodes distributed in the network. Each node records the same data and jointly maintains and records transaction records. Through blockchain technology, consumers can trace the source of products, companies can trade goods more safely, factories can manage inventory more conveniently, and prosecutors can also supervise the industrial chain more conveniently.

Keywords: Supply chain; Transparency; Blockchain.

1. Introduction

Today, product productivity continues to develop, and transportation levels continue to improve, stimulating people's purchasing power to soar. As a result, the global product supply chain is developing rapidly. However, many problems have gradually been exposed in the product supply chain, such as the lack of transparency of product information in the supply chain and the difficulty of traceability. Many product supply chains are complex, involving multiple stakeholders and information silos. A lack of transparency can lead to difficulties in tracking and verifying the movement of goods and services. It can also create opportunities for fraud and counterfeiting. Secondly, there are frauds and irregularities. Some companies evade product quality requirements to seek profits. Third, forecasting is inaccurate: Accurate demand forecasting is critical to maintaining optimal inventory levels. However, traditional supply chains often face the problem of inaccurate demand forecasts, leading to excess or insufficient inventory, which may lead to a waste of resources and high business operating costs. Fourth, data sharing is inefficient: Sharing critical information among supply chain partners is often inefficient and relies on manual processes, paper documents, or legacy systems. This inefficiency can lead to delays and errors in the supply chain. Fifth, counterfeit products: Supply chains are vulnerable to counterfeit products entering the system, especially when the source of goods is not well documented. Counterfeit products can damage brand reputation and jeopardize consumer safety. Fifth, compliance and regulations: Navigating a web of international and local regulations is challenging for global supply chains. Ensuring compliance with different legal requirements can be expensive and time-consuming.

The above problems will have a serious impact. For enterprises, the enterprise's reputation is damaged, which causes a waste of funds and increases the operating cost of the enterprise. For consumers, the product quality is not up to standard. It does not comply with relevant regulations, which affects If consumers use it normally, it may even affect their health in severe cases. Blockchain technology has the advantages of decentralization, anonymity, and tamper resistance. These features effectively solve a large part of the problems in the current supply chain.

2. Blockchain Concept

Blockchain is a distributed ledger technology with multiple nodes distributed in the network. Each node records the same data and jointly maintains and records transaction records. A block is a recording unit that stores transaction data. Each block has a unique identifier, which includes the hash value of the previous block, creation timestamp, and transaction data. The hash function used in the blockchain is an algorithm that converts data into a fixed-length string.

Fig 1 shows that Blockchain is divided into six layers according to different functions, including the data layer, network layer, consensus layer, incentive layer, contract layer, and application layer. The physical layer can store transaction data and securely trade accounts. The network layer is a distributed network architecture that allows nodes to communicate with each other. The consensus layer uses consensus algorithms, transaction packaging, and block chaining. The function of the incentive layer is mainly an issuance and distribution mechanism to provide rewards to each node participating in the blockchain security verification work. The contract layer functions are mainly smart contracts and script codes to make the ledger programmable. Smart contracts are immutable digital contracts. To ensure that the results of each node are the same, they are completed jointly on multiple nodes [1]. The application layer mainly includes various application scenarios of blockchain, such as services in medical, intelligent transportation, energy issues, and other fields and cases [2].

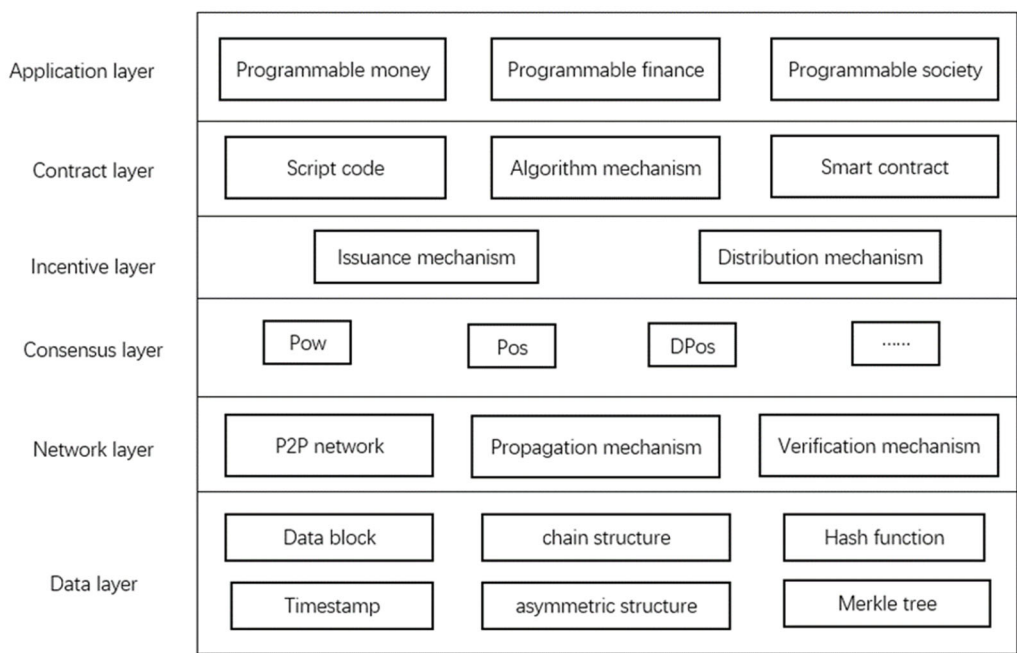


Fig. 1 Blockchain structure

3. Problems and Negative Impacts in the Supply Chain

3.1. Not Traceable

The following reasons lead to opaque information and untraceable products. First, there are information islands in the traditional product supply chain. In the traditional product supply chain, various parts such as factories, transportation companies, and retailers usually use their information systems, making it difficult to share data and exchange information, which results in opaque information. At the same time, when the supply chain spans multiple countries and regions, it involves multiple participants, making the supply chain more complex. Second, many traditional supply chains still use manual operations and paper documents, which leads to possible errors in data entry and high delays, making it difficult to keep up with the speed of transactions. Moreover, administrators may tamper with data at will to seek benefits, which makes the data unreal [3].

Opaque product information can have adverse effects on both companies and consumers. For consumers, it is difficult to obtain the true source and quality information of their products, and they may purchase counterfeit or substandard products, posing a threat to their health and safety. In addition, the lack of transparency in information leads to trust issues, making it difficult for consumers to trust product labels and promotional information. For sellers, opacity increases the difficulty in managing inventory and logistics, which may lead to excessive or insufficient inventory and increase costs. In addition, the opacity of information in the supply chain also increases the risk of fraud and counterfeiting, affecting the reputation of sellers. Solving this problem requires adopting new technologies, such as blockchain, to improve the transparency and traceability of the supply chain.

3.2. Fraud and Breaches

There are fraud and compliance issues in the supply chain, mainly due to insufficient government regulation and corporate exploitation. For the government, there are regulatory deficiencies or unclear regulations in some regions, which allow some companies to evade compliance requirements, such as environmental regulations, labor regulations, or quality standards. Government departments need stronger regulations to ensure supply chain compliance. In the pharmaceutical industry, drug supervision is mainly based on random inspection, with consumer complaints and reports as auxiliary supervision [4]. To a certain extent, this approach can play some role, but consumers' health cannot be threatened in any way. This kind of supervision is not enough.

Enterprises, are often under pressure to reduce costs and increase profits and may seek ways to reduce costs, including using cheap illegal labor, avoiding taxes, and complying with non-compliant standards. These practices may lead to fraud and compliance issues in the supply chain.

These issues have had adverse effects on multiple aspects: firstly, corporate reputation is damaged: fraud and non-compliance in the supply chain may lead to corporate reputation damage, reducing consumer trust in their products and brands. This may lead to a decrease in sales and a loss of market share.

Secondly, legal liability: Noncompliant behavior may lead to legal litigation and fines, further increasing the cost and legal risk of the enterprise.

Thirdly, consumer victimization: Consumers may purchase non-compliant or counterfeit products, endangering their health and safety. They may also unknowingly support unethical or illegal practices.

Fourth, the stability of the supply chain is threatened: Fraud and non-compliance issues can lead to supply chain instability. Because some products do not meet specifications, the government may take action to investigate and punish relevant departments, and the company may lose reliable suppliers, affecting the supply of the entire industry chain.

3.3. Poor Inventory Management

Inventory management issues in the supply chain often stem from multiple reasons. Firstly, opaque information and inaccurate demand forecasting make it difficult for enterprises to accurately estimate customer demand, resulting in excessive or insufficient inventory. Secondly, delays and opacity in production and logistics processes can make it difficult for enterprises to accurately track the real-time status of inventory. This opacity and unreasonable distribution of inventory can have different impacts on companies, consumers, and other populations.

For companies, unreasonable inventory management may result in capital being trapped in inventory and unable to be used for other important activities. This will increase costs as inventory management requires additional warehousing and management expenses. In addition, excessive inventory may lead to product obsolescence and waste.

For consumers, inventory management issues may lead to product shortages and prevent customers from obtaining the required products. This may lead to customer dissatisfaction, damage brand reputation, and even lead to customer loss.

Therefore, solving inventory management issues in the supply chain is crucial for enterprises, consumers, and the entire supply chain ecosystem. Blockchain technology can provide more

transparency and real-time performance, helping to improve demand forecasting, inventory management, and overall supply chain efficiency.

4. Blockchain Advantages

4.1. Traceability

Blockchain is a decentralized ledger, which means it is not controlled by a single entity. Instead, it is maintained by a network of computers (nodes) spread throughout the supply chain. This decentralized structure ensures that no one party has undue control over the data, thereby increasing transparency. Once a transaction is added to the blockchain, it becomes virtually immutable. This means it cannot be changed or deleted. Immutability ensures that historical data remains intact and trustworthy. Once a transaction is added to the blockchain, it becomes virtually immutable. This means it cannot be changed or deleted. Immutability ensures that historical data remains intact and trustworthy. All participants in the supply chain network have access to the blockchain. Everyone can view and verify recorded transactions. This openness provides transparency because no information is hidden. Every product or asset on the blockchain is assigned a unique identifier. This identifier goes back to its origins. From the manufacturing process, material procurement, and quality inspection to final delivery, every stage is documented. Participants have a copy of the chain at the end and can track product location and quantity at any time [5]. Fig 2 shows that the product traceability process can be divided into forward tracking and reverse tracking according to different directions [6]. Forward tracking starts from product production and records a series of processes from production to processing, storage, transportation, and sales. It allows the person in charge of the company to understand the specific situation of the product and manage it in real-time. Reverse traceability can help consumers understand product details and assist consumers in making purchase decisions [7]. At the same time, reverse traceability can also make it easier for product supervision departments to inspect product materials and quality and standardize market behavior.

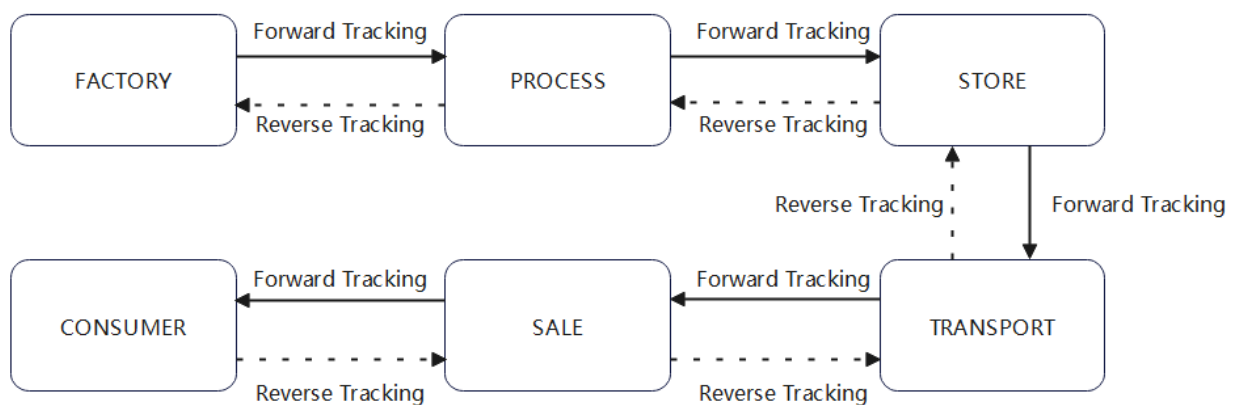


Fig. 2 Forward and reverse tracking

4.2. Convenient Supervision

In the context of the supply chain, fraud and compliance issues can arise due to various factors, including the complexity of global supply chains, lack of transparency, and difficulties in verifying the authenticity and ethical practices of suppliers. These issues can have detrimental effects on companies' reputations and legal liabilities. To address these challenges, blockchain technology offers several key solutions. Various merchants participating in relevant supply chains can interact on the logistics financing blockchain platform, which brings traceability of activity transactions to logistics companies [8]. Blockchain's transparency and immutability simplify the auditing process. Regulatory bodies and third-party auditors can efficiently review supply chain data and confirm regulation compliance. Blockchain's decentralized nature enables end-to-end traceability, making it easier to track the origin of products and monitor the conditions under which they were produced. This feature

is essential for ensuring ethical sourcing and compliance with labor laws. Smart contracts are self-executing agreements that automatically enforce predefined rules. They can be used to ensure compliance with regulatory standards and ethical practices throughout the supply chain. For example, payments can be automatically released upon the successful verification of compliance.

By implementing blockchain technology, companies can strengthen their supply chain's integrity, reduce the risk of fraud and non-compliance, and protect their reputation. Consumers and regulatory authorities can also benefit from increased trust in the supply chain, knowing that ethical and legal standards are being upheld.

4.3. Efficient Inventory Management

Blockchain has great potential for managing supply chain inventory and provides solutions to challenging problems [9]. Real-time Data Sharing. Blockchain enables real-time data sharing among supply chain participants. Every transaction, including changes in inventory levels, is recorded instantly and visible to all authorized parties. This eliminates delays in data updates and ensures that all stakeholders have access to the most current inventory information.

Once data is recorded on the blockchain, it becomes virtually immutable. This means that past inventory records cannot be tampered with or altered. This feature ensures data integrity and prevents unauthorized changes, enhancing trust in the accuracy of inventory information.

And, each product or batch of goods can be assigned a unique identifier, linked to its history from manufacturing to delivery. This detailed traceability allows companies to track inventory movements with precision. It aids in pinpointing the exact location of goods in the supply chain, reducing the risk of overstocking or stockouts.

Smart contracts, which are self-executing agreements, can be integrated into the blockchain to automate inventory management processes. For example, when inventory falls below a predetermined threshold, a smart contract can trigger an automatic reorder, optimizing stock levels.

Blockchain fosters better communication and cooperation among supply chain participants. The shared ledger promotes efficient collaboration and reduces the likelihood of discrepancies between different records held by various parties. Table 1 shows the current problems and corresponding solutions in the industrial chain mentioned above.

Table 1. Problems and Solutions

Problems	Solutions
Not Traceable	Decentralized structure ensures that no one party has undue control over the data, thereby increasing transparency; It cannot be changed or deleted; Everyone can view and verify recorded transactions
Fraud and Breaches	Blockchain's transparency and immutability simplify the auditing process; Smart contracts ensure compliance with regulatory standards and ethical practices throughout the supply chain
Poor Inventory Management	Real-time Data Sharing: Once data is recorded on the blockchain, it becomes virtually immutable; Each good will be assigned a unique identifier

5. Drawbacks

At the same time, even if blockchain technology has developed to this day, there are still many shortcomings. First, energy consumption is huge. Some blockchain processing requires a lot of computing power, which undoubtedly requires a large amount of energy consumption, and then inevitably Hurts the environment. Second, it requires a large investment of capital. Blockchain technology is still a high-tech technology and a long-term way for enterprises to cut costs. Much money is invested in the early stages to establish smart contracts and implement blockchain protocols [10]. The development and use costs are huge and some small businesses cannot afford it, nor is it suitable for processing large amounts of small transactions. At the same time, for non-professionals, a lot of professional knowledge training is required to use and maintain the blockchain proficiently—

third, legal, and regulatory issues. The current legal system and regulatory standards have not kept up with the development of blockchain technology, and the legal system is not complete and mature enough, which makes it difficult for subsequent problems to be resolved fairly and effectively.

6. Conclusion

This article introduces the related concepts of blockchain, and then introduces a series of problems existing in today's industrial chain, such as opaque product information, corporate violations, poor internal inventory management, etc., and then introduces the blockchain to address these problems. How does the chain improve the problem?

It is believed that with the expansion of research and development of blockchain in the supply chain, more and more companies will apply blockchain in product supply chains, which has greatly improved operating costs and enhanced corporate credibility. The government has strict control over product supply chain production, transportation continued attention to sales and other links, continuous improvement of relevant laws and regulations, and vigorous efforts to rectify corporate violations, there will be fewer and fewer product substandard problems in the product supply chain, and people's product experience will be better and better.

At the same time, the current development of blockchain technology is becoming more and more mature, but there is still a lot of room for development. Among them, the application of blockchain in product supply chains still has a long way to go: 1. Blockchain technology calculations still consume a lot of energy. In the future, we can try to reduce redundant computing processes and reduce energy waste. 2. At the same time, the application and maintenance of blockchain technology requires professionally trained personnel, which undoubtedly raises the entry threshold. In the future, we can try to reduce the difficulty.

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