

## Current Situation and Trend of Research on Application of Blockchain Technology in Logistics Field

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**Keywords:** blockchain technology, logistics field, application research, current situation and trend

**Abstract:** The research on application of blockchain technology in logistics field is of great significance and practical value. From the existing academic ideas, the applied logistics category can be roughly divided into three directions including comprehensive logistics, partial logistics and supply chain logistics. At present, domestic research is more active in academic exploration and theoretical analysis than research abroad, but it lagged behind in application innovation and empirical study. In the future, the research on application of blockchain technology in logistics field should be focused on combination with smart logistics & national strategy, empirical study of comprehensive application and the block supply chain.

### 1. Introduction

In the new normal background of economic development in recent years, logistics industry has shifted from pursuing speed scale growth to pursuing efficiency quality growth while accelerating industry transformation and business upgrading, and technological innovation is the core support for the transformation and development of traditional logistics to modern logistics. At present, new technologies such as the Internet of Things, big data, and cloud computing are deeply integrated with the logistics industry, ushering in new changes. In recent years, application of blockchain technology, an emerging cutting-edge technology, in the field of logistics has been initially studied and practiced by academic circles and industries at home and abroad. New technologies represent non-exhausted source for sustainable development of the logistics industry. It is of great significance and practical value to combine blockchain technology with the logistics field in frontier exploration and application research.

### 2. Blockchain Technology and Related Research Overview

Blockchain technology originated from a founding paper “Bitcoin: A Peer-to-Peer E-Cash System” published by the scholar “Satoshi nakamoto” in the cryptography mailing group in 2008 [1], but a recognized blockchain definition has not yet been formed. The narrow blockchain technology refers to the combination of data blocks into specific data structures by chain in a chronological order, and cryptographically guaranteed decentralized sharing of general ledgers for counterfeiting and tampering prevention. Generalized blockchain technology refers to a distributed computing paradigm and decentralized infrastructure frame for data generation and update using distributed node consensus algorithm, data validation and storage using encrypted chain block structure, and data manipulation and programming using automated script code (smart contract).

The core strengths of blockchain technology include decentralization, collective maintenance, security and trustworthiness, time series data and programmable. (1) Decentralization: Based on the distributed structure, the process of accounting, verification, storage, maintenance and transmission of data is completed. Instead of relying on the central organization, mathematical methods are taken to establish the trust relationship between distributed nodes to form a trustworthy decentralized distributed system; (2) Collective maintenance: a special economic incentive mechanism is used to ensure that all nodes in the distributed system can participate in the verification process of the data

block (bitcoin “mining” is a typical example), and consensus algorithm is adopted to select a specific node to link the new block with the blockchain; (3) Security and trustworthiness: the data is encrypted by the principle of asymmetric cryptography, and powerful computing force formed by the consensus algorithm is used to defend against attacks from outside to guarantee that blockchain data cannot be forged and tampered; (4) Time series data: data storage is completed through time-stamped chain block structure, generating time series for data and thus featuring traceability and verifiability; (5) Programmable: flexible scripting code system is provided for users to develop advanced smart contracts, currency and a variety of other decentralized applications [2]. Blockchain technology is a universal underlying technical framework that can bring profound changes to all sectors of the industry.

Relevant academic research on blockchain technology lags behind. Before 2016, if Chinese literature was searched using Wanfang Data Knowledge Service Platform as data source, and English literature was searched using Web of Science and EI Village as data source, the results showed that there were only 2 Chinese literatures [3,4] and 8 English literatures [5-12] containing keyword “blockchain” in titles, but basically with no direct relationship with the logistics field. After that, relevant literatures combining blockchain with logistics field have emerged one after another, but still in the initial stage of research in general. Although the academic and business circles have paid widespread attention to blockchain in the past two years, and proposed some models, strategies and schemes for applying blockchain technology in the logistics field, the research results are fragmented, lacking systematic combining. Therefore, this paper analyzes the relevant research status of blockchain technology application in logistics field mainly from the three application directions of integrated logistics, partial logistics and supply chain logistics, sorts out domestic and foreign research results, and analyzes the possible direction for future research.

### **3. Blockchain and Integrated Logistics Related Research**

Some scholars in the early related research first proposed the important idea of applying blockchain technology to the field of logistics. Wu Sijin [13] proposed to actively promote the extensive application of blockchain technology in the field of logistics, believing that application of blockchain technology can effectively simplify the logistics process. With bulk commodities as example, private key of blockchain only for individuals can effectively prevent others’ counterfeit, the owner can change or authorize the ownership of the bulk commodity, and the resulting high transparency allows mortgage financing of warehouse receipt on the blockchain to be successful even on the way, and makes split resale easy. Finally, it introduces the exploration activities of the author’s institution after joining blockchain alliance hyperledger. Zhao Gang [14] believed that logistics industry is a typical application field of blockchain technology. The application scenarios such as non-tamperable circulation records, product traceability, notarization and anti-counterfeiting, and multi-participation confirmation are representative, which will greatly improve logistics efficiency and reduce logistics cost. Borodin K.S. and Lipai V.A. [15] believed that blockchain application in the logistics field can effectively improve visibility of goods, enhance information reliability, save the cost of commodity verification, allow accurate demand prediction, dynamically process orders in real time and improve inventory management. Zhang Xiaohua [16] believed that current application of blockchain has gradually expanded from the single application mode of digital currency to various fields of economic society, and its application in logistics field has gained initial development. Blockchain technology enjoys good development prospects in supply chain management, cost decreasing and benefit increasing in cross-border logistics, retrospection of consumer goods, logistics safety monitoring strengthening of dangerous goods, and financing of logistics enterprises, etc.

After that, other scholars discussed how to specifically apply blockchain technology to integrated logistics, and initially proposed some ideas and implementation paths, but the research focus is scattered. Through in-depth investigation and interviews in the logistics industry, Xu Xiang [17] demonstrated that application of blockchain technology can make goods have asset characteristics, so that the goods in the logistics chain is traceable, non-counterfeiting, non-tampering, which can

effectively prevent the loss of goods, wrong claim accidents, and promote the implementation of real-name system. In addition, blockchain platform construction can make funds quickly integrate into logistics enterprises to improve the business environment. Luo Xingling [18] discussed the application of blockchain technology in logistics transportation, logistics finance and logistics platforms, believing that blockchain technology can help realize intelligence, transparency and traceable logistics information in logistics transportation process, significantly reduce logistics accidents and improve logistics efficiency; application to logistics finance can enable commodity capitalization, and solve financing problems of small and medium small and micro-sized enterprises in the supply chain. The blockchain-based logistics platform can optimize resource utilization, reduce intermediate links, and enhance the overall logistics industry effectiveness. Hao Yukun and Zhang Jiyuan [19] designed a smart container operation platform based on blockchain technology, which gives play to the technical advantages of blockchain in efficient information sharing and self-credibility, significantly reduces logistics costs, simplifies cumbersome processes, and monitors logistics in real time throughout the process by combining Internet of Things technology to enhance logistics safety guarantee. Wu Jun [20] believed that blockchain technology is particularly suitable for cross-domain multi-party cooperation, especially for scenarios with high credit costs, such as logistics industry with long transaction chains, multiple participants and high credit costs, holding that blockchain technology advantages exactly solve the pain points, which can effectively reduce the cost of logistics credit and improve operational efficiency.

#### **4. Blockchain and Partial Logistics Related Research**

In the past two years, research on blockchain technology and partial logistics has appeared successively, mainly in the fields of port and shipping, aviation logistics and freight, express logistics, cold chain logistics and procurement logistics. Yu Bin, Wei Weijian, et al. [21] followed the concept of open security documents, introduced blockchain technology into the field of safety supervision of marine bulk liquid chemical transportation, and proposed decentralized, open and transparent, traceable record platform with easier operation for relevant parties to improve shipping safety supervision level of bulk chemicals. Xu Kai [22] analyzed the application value of blockchain technology for port and shipping information platform from the perspective of information platform technology development in port and shipping. The development trend of blockchain in application scenarios such as port, shipping and international supply chain management has been systematically analyzed, and the impact of blockchain on the trading patterns of ports and shipping industry has been expounded. M Francisconi [23] took cross-organizational information system of the famous port Rotterdam as an example, empirically studied the use and advantages of blockchain technology in port logistics, adapted various functions provided by information systems to various uses of blockchains, analyzed practical application cases of blockchain technology by combining various strategies, evaluated the benefits of blockchain technology application as well as its technical adverse effects on the port information system, and proposed solutions for potential problems in decentralization. Wen Xuefeng [24] analyzed the application prospects of blockchain technology in shipping field from shipping data, shipping communication, asset certification, logistics management, etc., and discussed the problems and challenges in the application process. Han Yu [25] proposed the integration application mode of EDI system and blockchain technology in container transportation, made quantitative assessment using analytic hierarchy process and expounded the application advantages and possible problems of blockchain technology in container transportation.

Meanwhile, documents related to aviation logistics and freight transportation have also appeared [26]. Studies believe that blockchain is an infrastructure for enterprises. This technology can make air freight resources more open, enhance transparency of freight process, and reduce manual work mistakes. For temperature-sensitive goods such as food, flowers and medicines, blockchain technology can record data throughout the freight transport in detail for reference by relevant parties at any time, so that freight safety is more secure. Secondly, container air transport involves complex handover procedures and errors are inevitable, the “General Ledger” function of blockchain

technology can avoid errors from the beginning. In addition, blockchain has both web server hosting and virtual currency settlement functions, so there will be broader application in the field in the future. Tian Yishun, Zhao Guanghui, et al. [27] proposed using the trust creation function of blockchain technology to solve the problem of honesty mechanism between transaction entities, solve the dilemma in freight logistics market, and meanwhile, exerting the efficient trading advantage of the technology in the payment system to effectively improve the transaction efficiency of freight logistics market and promote cost saving and profit increasing in logistics industry by combining the advantages of freight logistics network; and finally, improving the supervision ability and governance level of freight logistics market by taking advantage of distributed storage characteristics of this technology.

In addition, some scholars also explored the application of blockchain technology in the fields of partial logistics such as express delivery, cold chain and procurement. Wang Miaojuan [28] analyzed the problems of blockchain in terms of safety, efficiency, game, etc., and proposed to establish a blockchain system exclusive for express logistics industry. Based on the blockchain design concept of issuing tokens, research and development of logistics tokens should be carried out so that express delivery achieves three-in-one digital management of information flow, physical flow and capital flow. Through the application of blockchain system, realize the whole process block chaining of mailing, receiving, originating, transshipment, dispatching and signing, thus ensuring open, transparent express process, enhancing traceability of goods, information and funds, effectively solving service accidents such as false claim, wrong claim and vicarious inventory, and promoting the implementation of express real-name system. Ning Zhuo, Li Muiyang, et al. [29] found that application of blockchain technology in express delivery industry has unique advantages, and believed that blockchain technology is expected to become the golden key to solve the pain points of logistics industry and reshape operating mode of the industry. X Sun, HW Wang [30] discussed the application of blockchain technology in preventing financial risks in cold chain logistics, analyzed the evolution process and characteristics of cold chain logistics financial credit, proposed cold chain logistics financial credit system framework using blockchain technology, and provided solution to credit problem based on the framework. Yang Wenfeng, Weng Weijie et al. [31] proposed to save contract amount, contract content, contract signing time and digital identity of both parties in the procurement process in the blockchain technology-based smart contract to create decentralized and non-tamperable, non-cancelable social enterprise credit system, and build a collaborative procurement cloud platform by integrating information technology such as big data and cloud computing to help enterprises improve the level of procurement logistics management.

## **5. Blockchain and Supply Chain Logistics Related Research**

Although there are few foreign literatures in the fields of integrated logistics and partial logistics applications, in the application research of blockchain technology in the field of supply chain logistics, foreign literature has increased significantly, approaching domestic research in number. Hackius N. and Petersen M. [32] conducted an online survey of logistics professionals' assessment on the application prospects of blockchain technology in logistics and supply chain management. The results show that most participants are quite optimistic about the new technology of blockchain and its value. Meanwhile, it was found that blockchain application level, technology, experience and industry differences also have significant impact on the assessment results. Therefore, combining IT-level solutions, efforts should be made to deeply analyze the application advantages and values of blockchain technology, further explore specific application innovation cases to effectively promote the application of blockchain technology in logistics and supply chain. K Sadouskaya [33] analyzed the technological innovation and application potential of blockchain, expounded blockchain's technical characteristics in response to various challenges in the supply chain logistics field and solution of various problems, investigated innovation practice of blockchain technology application in enterprises, analyzed the advantages and effects of the application of blockchain technology and proposed main potential problems. M Petersen and N Hackius et al. [34] revealed the value expectations of logistics professionals for blockchain

technology and the challenges it brings, classified blockchain application systems in the current supply chain logistics business field, considering that enterprise selection of the system type should be based on its actual needs and first-hand materials should be grasped through hands-on experiments to give full play to the application potential of blockchain technology. Dujak and D. Sajter et al. [35] analyzed the current application status of blockchain technology in logistics chain and supply network, believed that blockchain technology has an overwhelming advantage in solving trust problems, which can effectively enhance function of logistics and supply chain systems in certification, trust, information exchange security, etc.. The latest practice is to develop blockchain to broader application in distributed general ledger technology, which establishes a theoretical basis for the future application of blockchain technology in supply chain logistics. I. Britchenko and T. Cherniavska et al. [36] took flower supply chain logistics as an example to empirically study the application of blockchain technology in flower container transportation from Kenya to Rotterdam and found that the main advantages in application of blockchain technology in the field of supply chain logistics include: consistency of all participants and high transparency of the participation process, smart contracting, complete documentation and non- tampering of document handling and cargo handling information, minimization of export agency approval and payment errors, effective prevention of fraud, enhanced confidence of participants and customers, participants' information feedback in real time, problem response in time and improved operation, etc. Then, the bottleneck problems demanding attention in application of blockchain technology in supply chain logistics are analyzed, including the doubts of traditional logistics mode advocates on the innovation technology, complexity of coordination among supply chain participants, standardization of business processes and high requirements for employee qualifications. It is believed that blockchain technology has important application potential and prospects in various fields of economy, but the most important fields of concern are supply chain and logistics. In summary, current foreign research focuses on multi-perspective, multi-faceted discussion and illustration on application advantages and values, application potential and prospects of blockchain technology in the field of supply chain logistics, introduces some specific application innovation cases, analyzes the faced application bottlenecks and challenges, and proposes implementation path for improving blockchain technology application in the field of supply chain logistics.

In China, the research on blockchain technology application in supply chain logistics is still in its infancy. Guo Shanshan [37] proposed a method of applying blockchain technology to realize trusted traceability in supply chain logistics, and constructed a three-level blockchain structure: First, in the P2P network at the bottom of the blockchain, each transaction role performs and verifies transaction under the premise of registration as consensus node; second, verified block information is stored in each transaction node in the storage layer; third, provide an interactive interface in the application layer, verify the transaction information to prevent tampering to achieve trusted traceability query. Ran Yelan [38] believed that application of blockchain technology in the field of supply chain logistics will make logistics more transparent, large-scale synergy will be easier, role of the chain owner will gradually weaken, and shift from “chain owner-driven” to “demand-driven” will truly occur. Cai Jinhua and Hu Jiamu [39] analyzed the possibility and rationality of applying blockchain technology to the construction of cigarette supply chain logistics system, and considered that blockchain technical advantages of decentration, high fault tolerance, traceability and intelligence helps to solve the core problems of high cost, low efficiency and high risk in the existing cigarette supply chain system. Based on blockchain architecture model and key technologies, Wang Chuanlei and Wan Yidi [40] studied the coupling relationship between blockchain and supply chain logistics information resources in the main body, trading mechanism and smart contract, and constructed blockchain-based supply chain logistics information ecosystem model based on dimensional analysis on objects, attributes and functions to improve the supply chain logistics information ecology. Cao Feng [41] believed that non-tampering of blockchain and high transparency and multi-access capability provided by shared ledger can be used to track ownership variation of goods in the supply chain so that interaction efficiency and accuracy of supply chain logistics is significantly improved. Combining technical characteristics of blockchain, Lu Weiwei [42]

analyzed the problems existing in traditional supply chain logistics management, and discussed the technical advantages and application value of blockchain technology in solving related problems. Li Xiao and Liu Zhenggang [43] believed that to solve the opportunistic risk and trust problem of supply chain governance in the new environment, we can learn from decentralized blockchain Internet governance system and develop supply chain intelligent governance mechanism. Ye Xiaoying, Shao Qing, et al. [44] designed supply chain logistics prototype system by integrating blockchain technology, smart contract and Internet of Things, realized automatic uploading of main body data of the supply chain by virtue of two-dimensional code, RFID and NFC in the Internet of Things, completely preserved the main body data of the entire supply chain using blockchain and smart contract, which ensures that the data is transparent, traceable and non-tamperable, while taking into account the encryption protection of private data. Different levels of data query are provided for different users, so that the supply chain logistics system is more automated, safer and more reliable, and facilitates regulatory traceability. In summary, the domestic research results at this stage are mainly theoretical discussions, with temporarily less empirical analysis and practical case introduction.

## **6. Conclusions and Research Prospects**

### **6.1. Conclusions**

This paper studies and summarizes the hot issue of logistics- the application of blockchain technology in the field of logistics. It can be seen that the proposal of blockchain concept and the development of blockchain technology relatively lag behind. Therefore, the idea of applying blockchain technology in the field of logistics sprouts late, with a number of relevant research literatures recently shown at home and abroad. At present, domestic research is more active than foreign research in academic discussion and theoretical analysis, but slightly inferior to foreign research in application innovation and empirical research. Judging from the existing academic ideas, application of blockchain technology in the field of logistics is roughly divided into three application directions of integrated logistics, partial logistics and supply chain logistics according to the logistics category where it is applied.

First, the direction of integrated logistics. Some scholars in the early related research first proposed the idea of applying blockchain technology widely in the field of logistics. After that, other scholars discussed how to apply blockchain technology to integrated logistics, and some ideas and implementation paths were initially proposed, but the research focus is scattered.

Second, the direction of partial logistics. In the past two years, the research on blockchain technology application to partial logistics has successively emerged, mainly in the fields of port and shipping, aviation logistics and freight, cold chain logistics, procurement, express logistics, etc. Various ideas, strategy framework and technical route for practical application are put forward, with some practical cases introduced, but research depth, operability and systematicness need to be strengthened as a whole.

Third, the direction of supply chain logistics. At present, foreign research focuses on multi-perspective, multi-faceted discussion and illustration on application advantages and values, application potential and prospects of blockchain technology in the field of supply chain logistics, introduces some specific application innovation cases, deeply analyzes the faced application bottlenecks and challenges, and proposes models and implementation path for improving blockchain technology application in the field of supply chain logistics. The domestic research on blockchain technology application to supply chain logistics is still in its infancy, and the research results are mainly theoretical discussions, with temporarily less empirical analysis and practical case introduction. The existing literature mainly discusses how to apply blockchain technology to enhance traceability, transparency and credibility of supply chain logistics, improve supply chain intelligence and logistics information management, improve supply chain logistics efficiency and safety and reduce overall costs and risks.

## 6.2. Future Research Directions

Based on the classification of the above research, this paper proposes the possible future research directions for the application of blockchain technology in the logistics field as follows:

(1) The integration of blockchain technology application and smart logistics. Smart Logistics attaches great importance to integrating the Internet of Things, sensor network and existing Internet, and realizes intelligent, networked, visualized and controllable logistics through fine, dynamic and scientific management. Blockchain technology can combine IoT technology to realize real-time and effective monitoring of logistics processes and enhance logistics security. Meanwhile, it combines artificial intelligence, big data, robotics technologies etc. to interactively develop smart logistics with intelligent manufacturing to promote the injection of new kinetic energy to real economy growth. Smart logistics represents a future development direction. “Blockchain + Smart Logistics” may become a new research hotspot, but there are currently few relevant research literatures in this area.

(2) Empirical research on overall application of blockchain technology to the field of logistics. The characteristics of blockchain technology itself determine the broad application prospects of blockchain, but the research on logistics field application focuses on the analysis of technology application mode, application advantages and prospects, and the application scope is temporarily relatively narrow and unitary, mainly in theoretical discussions, the breadth and depth of application, practical cases and empirical research need to be strengthened. As the innovation and practice of blockchain technology in the field of logistics is increasingly active, empirical research results related to this will increase significantly.

(3) Integration with national strategies. At present, China is in the new stage of implementing “One Belt, One Road” strategy. Logistics is the bottleneck for the construction of countries and regions along the “One Belt, One Road”, also the core engine for launching future development. Some scholars have made important progress in combining blockchain technology with “One Belt, One Road” regional logistics. For example, Wang Juanjuan and Liu Ping [45] believed that economic cooperation has widened the gap between supply and demand of “One Belt, One Road” regional logistics services. To alleviate this contradiction, exploratory study is made on applicability of blockchain technology to this field. The result shows that blockchain technology helps “One Belt, One Road” regions to improve logistics service transparency and build an efficient logistics mechanism. Also, construction of government-led logistics security mechanism is proposed. However, so far, there are few relevant research results combining national strategies.

(4) “Blockchain + Logistics” transition to block supply chain. With the increasing maturity of blockchain technology application in the supply chain, there will be innovative research on in-depth integration of blockchain and supply chain. Some scholars have proposed the concept of “block supply chain” and its application scenarios. All parties involved in the supply chain are registered in the blockchain. Using decentralized and distributed coexistence characteristics of the network, each transaction is continuously verified and a unique, continuous chain is constructed in the public block according to time series, forming a “block supply chain”. Its typical application scenarios mainly include procurement process, delivery process, recycling process, etc. The application scenarios integrate key elements such as intelligent property rights and smart contracts to fully guarantee uniqueness, whole-process traceability of the transaction process on the block supply chain. These characteristics will enable block supply chain to have broad development prospects. In October 2017, the “Guiding Opinions of the General Office of the State Council on Actively Promoting Supply Chain Innovation and Application” was released. With the implementation of the first supply chain national policy, supply chain innovation and application that deeply integrates the disruptive technology of blockchain will be increasingly active, and block supply chain and related fields are expected to become new research hotspots.

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