

# Exploring the Application of Blockchain Technology in Logistics and Transportation System

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**Abstract:** This paper explores the application of blockchain technology in improving the management and efficiency of logistics and transportation systems. By leveraging blockchain technology, real-time recording, traceability, data sharing, security, and trustworthiness of logistics information can be achieved, thereby enhancing the efficiency and safety of logistics operations. The paper discusses the theoretical foundations of blockchain technology and logistics and transportation systems, highlighting key concepts such as decentralization, distributed ledger, consensus mechanisms, smart contracts, operations research, supply chain management, and transportation economics. Additionally, the literature review presents an overview of existing studies on logistics and transport systems and blockchain technology, illustrating various applications and benefits, such as sustainable transport frameworks, transportation and logistics management models, smart logistics systems, and supply chain traceability platforms. In conclusion, the exploration of blockchain technology's application in logistics and transportation systems offers comprehensive support for improving logistics efficiency, reliability, and safety, promising more efficient and reliable transportation services for the logistics industry in the future.

**Keywords:** Logistics, Blockchain, Transportation System.

## 1. Introduction

With the continuous expansion of global trade and the rapid development of the logistics and transport industry driven by economic recovery in the post epidemic era, the logistics and transport system is of great significance to the development of modern society in terms of economy, culture and society.

According to public data from the China Federation of Logistics and Purchasing (CFLP), China's total social logistics amounted to 352.4 trillion in 2023, a year-on-year increase of 1.38 per cent, which represents a further expansion in the scale of logistics demand. At the same time, total social logistics costs in 2023 will be \$18.2 trillion, up 2.3 per cent year-on-year from the previous year, occupying 14.4 per cent of China's GDP in 2023, 0.3 per cent lower than in 2022. In terms of the overall structure of costs, transport costs, storage costs, and management costs all increased to a certain extent from the previous year.

Blockchain technology, as a new type of decentralized, secure and trustworthy distributed ledger technology, provides new ideas and solutions to solve the problems faced by the logistics and transportation system at this stage. The design and realization of logistics and transportation system based on blockchain technology has become the current research hotspot in the field of logistics and transportation. By adopting blockchain technology, real-time recording, traceability, data sharing, security and trustworthiness of logistics information can be realized, so as to improve the efficiency and safety of logistics and transportation system.

The purpose of this paper is to analyze and summarize how to use blockchain technology to improve the management and efficiency of the logistics and transportation system, improve the operational efficiency and management level of the logistics and transportation system, reduce the cost of logistics and transportation, and help the logistics industry to seize the opportunity for development and upgrading, based on the combination of previous research.

## 2. Theoretical Foundations

### 2.1. Blockchain Technology Theory

#### 2.1.1. Decentralization

One of the core concepts of blockchain technology is decentralization. It eliminates the single point of control in traditional centralized systems through distributed networks and consensus mechanisms, making data and power more decentralized and equitable.

#### 2.1.2. Distributed Ledger

Blockchain is a distributed ledger technology that links transaction records in the form of blocks and guarantees their immutability through cryptographic methods. This distributed ledger allows for transparency, traceability and security of information.

#### 2.1.3. Consensus Mechanisms

Consensus mechanisms are rules and algorithms for the verification and validation of transactions and blocks by participants in a blockchain network. Common consensus mechanisms include Proof of Work, Proof of Stake, etc., which ensure that participants in the network reach consensus and maintain the consistency and security of the blockchain.

#### 2.1.4. Smart Contract

Smart contracts are self-executing contracts written in code. They run on the blockchain and automatically execute transactions and operations according to predefined rules and conditions without the intervention of a third party, increasing the reliability and efficiency of transactions.

### 2.2. Theory of Logistics and Transportation

#### 2.2.1. Operations Research Theory (ORT)

Operations research is the study of optimization problems and decision analysis, and its methods and techniques are widely used in the planning and optimization of logistics and transportation systems. The theory of operations research includes linear programming, integer programming, dynamic

programming, network flow and other methods, which are used to solve the problems of route selection, scheduling arrangement and resource allocation in logistics and transportation.

### 2.2.2. Supply Chain Management Theory

Supply chain management is a management theory that studies coordination and cooperation among enterprises, focusing on logistics processes, information flows and financial flows throughout the supply chain. Supply chain management theory includes concepts such as supply and demand matching, inventory management, and coordination mechanisms for optimizing supply chain coordination and resource integration in logistics and transportation systems.

### 2.2.3. Theory of Transportation Economics

Transportation economics is an economic theory that studies transportation markets and transportation costs. It involves the study of transportation demand and supply, transportation prices and costs, and the structure of the transportation market, and provides a theoretical basis for the assessment of the economic efficiency of logistics and transportation systems and the formulation of transportation policies.

## 3. Literature Review

### 3.1. Overview of logistics and transport systems

Logistics and transport system is a system that plans, implements, controls and manages the transport process of goods from the place of production to the place of consumption through a series of logistics activities. Logistics and transportation system usually includes suppliers, transporters, distribution centres, warehousing centres and other links, through logistics information technology, to achieve intelligent, automated and visual management of logistics and transportation process, improve logistics efficiency and reduce logistics costs. Overseas studies started earlier and covered a wider range of topics. These studies cover a wide range of topics, such as logistics network design, transportation planning and management, vehicle routing and scheduling, inventory management and supply chain optimization. Many of these studies use various technologies, including blockchain, to improve the efficiency and effectiveness of logistics and transportation systems.

Stephen Okyere et al. introduced a logistics framework for cargo transportation to advance sustainable multimodal transport in inland transportation and formulated an optimization model to integrate existing logistics system models with the help of an adaptive genetic algorithm (GA) to mitigate some of the current problems<sup>[1]</sup>. Zubkov et al. present a conceptual model for the management of transportation and logistics systems and an ontology formation methodology for the creation of information and intelligence models for the management of transportation and logistics systems<sup>[2]</sup>. M V Kolesnikov et al. proposed to consider the effectiveness of logistics and transportation complexes from multiple perspectives, such as financial and production, and demonstrated the need to harmonize the interests of the participants in the logistics process in order to ensure the internal integrity and security of logistics and transportation complexes<sup>[3]</sup>. JUDITH AMOGOLA proposes an automated transportation management system covering route planning and optimization, yard management, order

visibility and load optimization, freight auditing and payment as a way to achieve logistics optimization for third party logistics service providers<sup>[4]</sup>. Marcella Anjanit proposed a new supply chain system based on a customized network that assigns the most suitable transportation network to each supplier to obtain more inventory space and thus achieve cost efficiency<sup>[5]</sup>. Schafer and Sarah E both found through their research that improvements in transportation system intelligence and integrated information sharing positively impacted transportation outcomes<sup>[6]</sup>. Péter Veres et al. proposed an integrated engineering optimization algorithm for solving the vehicle allocation and scheduling problem in an intelligent transportation system and combined this algorithm with an algorithm for the global supply chain transportation process<sup>[7]</sup>. A G Nekrasov and A S Sinitsyna suggested the creation of a digital Transportation and Logistics System (TLS) to provide efficient support to the global transportation system through the use of digital technologies, using logistics engineering methods<sup>[8]</sup>. Amitabh Bhargava et al. proposed an IIoT model for integrated smart logistics to optimize the transportation management structure of logistics by studying the optimal path identification for logistics scheduling, real-time monitoring of logistics vehicle parameters such as fuel, axle, and engine vibration, temperature monitoring, and optimal scheduling of the logistics distribution system to improve the customer experience and customer satisfaction, and thus minimize the transportation cost<sup>[9]</sup>. Zhao et al. proposed a remote monitoring system for logistics and transportation vehicles based on the Internet of Things (IoT) for the development of logistics and transportation industry and the development needs of intelligent transportation. The system integrates scheduling, monitoring, and management, and is characterized by good real-time performance, high transmission rate, high collection frequency, large data storage, and ease of use, which provides a strong technical support for the development of intelligent transportation system<sup>[10]</sup>.

### 3.2. Overview of blockchain technology research

Alara Altay et al. discuss the latest and future applications of combining sensors with blockchain technology for decentralized healthcare, storage and quality control in the food or pharmaceutical supply chain. Using blockchain technology to transform healthcare and supply chain management by eliminating the need for trusted third-party centralized labs/institutions to conduct testing<sup>[11]</sup>. Zhou et al. proposed a blockchain-based logistics information system aimed at solving the problems of lack of trust and concentration of rights in the existing logistics system using the LGBM algorithm to recommend the matching of vehicles and goods in the transportation process. Finally, the constructed algorithm model is simulated and analyzed<sup>[12]</sup>. Elnaz Irannezhad discusses the potential of blockchain to improve inefficiencies in the maritime supply chain and logistics, as well as limitations and challenges<sup>[13]</sup>. Lenny Koh et al. reconfigured the entire transportation system process by combining blockchain technology with artificial intelligence technology and machine learning technology, the actual delivery scheduling of flow information in the logistics and transportation system may acquire, store, and deliver commodities in different ways over time<sup>[14]</sup>. Zvonko Merkaš et al. combine blockchain technology with IoT

elements in logistics and transportation to optimize business processes, increase supply chain traceability and transparency, and bring about larger cost reductions [15]. Mamoon Humayun et al. proposed a layered framework combining smart logistics and transportation, integrating IoT and blockchain for the purpose of providing a smart logistics and transportation system. The effectiveness of the system was also verified in conjunction with an empirical study [16]. Chen et al. proposed an intelligent logistics system based on IoT and blockchain technology to track the transportation progress of products in the supply chain, and the use of blockchain technology features enables enterprises to have a more intuitive understanding of the current status of inventories and transportation of goods, which leads to a better control of enterprise resources [17]. Anuj Batta et al. analyze the actual level of implementation and proliferation of blockchain technology within the logistics and transportation industry and envision future applications by examining the collective wisdom of the academic literature and the industry practice of implementing blockchain in logistics and transportation [18]. Hassan SM et al. introduced a reliable, logistically friendly and cost-effective crude oil trading platform (PTS platform) powered by blockchain that complies with Industry 4.0 standards. The PTS saves costs by matching the product to the customer's required location and desired quality thereby reducing the time and distance traveled [19].

#### 4. Summary

The exploration of the application of blockchain technology in logistics and transportation systems covers a wide range of aspects, providing all-round support for improving logistics efficiency, reliability and safety.

First, by establishing a decentralized and traceable supply chain management system, blockchain technology ensures the transparency and authenticity of logistics information, reduces information asymmetry and risk, and improves the credibility of the supply chain.

Secondly, the use of smart contract technology realizes the automation and programmability of the transportation cooperative relationship, which improves the trust and efficiency between the cooperating parties and reduces disputes and controversies in the process of cooperation. In addition, blockchain technology can be used for cargo traceability and quality management, and consumers can inquire about the production, transportation and storage of goods through blockchain to ensure the quality and safety of the goods and enhance consumer trust and satisfaction.

Meanwhile, by monitoring and optimizing transportation routes in real time, blockchain technology can help identify and respond to safety hazards and risks on the routes to ensure the safe transportation of goods.

Finally, through data sharing and collaborative management, blockchain technology promotes information sharing and resource optimization among all participants in the logistics and transportation system, and improves the efficiency and synergy of the whole logistics and transportation system. In summary, the application of blockchain technology in logistics and transportation system will bring more efficient, safer and more reliable transportation services to the logistics industry in the future.

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