Application of Blockchain Technology in Emergency Supply Chains

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Abstract: COVID-19 has brought great challenges to the word. As an important part of emergency supplies support, the information sharing level of the Emergency Supply Chain(ESC) plays an important role in its rapid response capability. Firstly, this paper analyzes some problems existing in China's ESC during the epidemic. Then, the emergency supply chain is divided into four stages. Finally, the paper conducts a coupled analysis of the problems within each phase and the integration of blockchain technology. In conclusion, the application of blockchain technology can realize information transparency, which could improve China's ability to supply emergency supplies under public health emergencies.

Keywords: Emergency Supply Chain; COVID-19; Blockchain; Information Sharing

1. Introduction

The COVID-19 pandemic emerged in China at the end of December 2019 and erupted globally in 2020[1]. The assurance of emergency medical supplies is fundamental to logistical support for frontline medical forces, with the Emergency Supply Chain(ESC) representing a crucial link in securing these supplies. This significance was particularly highlighted during this unprecedented global health crisis[2]. The ESC during this pandemic exhibited characteristics of multiple participating entities, strong systemic requirements, intricate processes, extensive frontline operations, widespread geographical coverage, and close interlinking of various stages. However, the lack of transparency, asymmetry, and non-disclosure of information at different stages became the primary issues within the ESC, resulting in mismatches between supply and demand, delayed responses, and untraceable donated supplies[3]. Despite efforts by governmental bodies to coordinate multiple resources to ensure the supply of emergency materials[4], the lack of swift establishment of a collaborative mechanism within the ESC persisted, leading to issues of non-transparency and hampering the response speed of the ESC.

Blockchain technology, characterized by its decentralized, tamper-proof, and transparent nature, offers a secure and efficient solution for information sharing[5]. Presently, blockchain applications span various domains such as financial services , big data services, and the Internet of Things. This paper, through a thorough analysis of the actual impact of the COVID-19 pandemic on the ESC and its existing problems, coupled with an analysis of the characteristics of blockchain technology, aims to ensure the public disclosure, transparency, and immutability of supply and demand data after public health incidents. The goal is to achieve supply chain traceability for emergency supplies, enhance the response speed of the ESC, and ensure the rational allocation of emergency materials.

2. Problems in the Emergency Supply Chain

2.1 Inaccurate Emergency Supplies Demand

During the COVID-19 outbreak, shortages in emergency supplies arose due to insufficient local reserves to match the rapid spread of the virus. The unpredictability of the outbreak's duration and scope increased uncertainty in estimating emergency supply needs, causing significant discrepancies between estimated and actual demands. This inaccuracy hindered decision-making for supply procurement and allocation, challenging the central coordination of emergency supplies.

2.2 Unreasonable Procurement Plans

Panic caused by the pandemic led to mismatches between supply and demand, prompting urgent and excessive procurement of emergency supplies in various regions. This rush led to hoarding even in less affected areas, complicating supply distribution to severely affected

regions. Lack of transparent demand information, delayed monitoring, and information dissemination contributed to these challenges.

2.3 Non-disclosure of Available Emergency Stock i

The lack of comprehensive national emergency supply information made it hard to prioritize supplies based on epidemic severity. Regional governments hesitated to share available stock, leading to gaming behaviors among regions and difficulties in efficiently distributing supplies to high-risk areas, despite later central government supervision.

2.4 Opacity in the Allocation and Direction of Donated Supplies

Amidst the outbreak, donations poured in, but logistical issues emerged. Donated supplies often didn't meet medical standards and faced allocation chaos and unclear destinations. Existing platforms for donation information lacked scale and comprehensive functionality.

2.5 Delayed Information Sharing

Delays in emergency supplies reaching regions due to procurement, shipment, and transportation timeframes caused ineffective regulation and resource wastage, increasing logistics and storage costs.

2.6 Information Asymmetry Between Supply and Demand Parties

China's lack of a real-time platform for crucial emergency supply-demand data led to delayed updates on demand information. This delay caused surplus supplies due to production delays in reducing output, incurring substantial storage costs and wastage.

2.7 Incomplete and Insecure of the Existing Emergency Supplies System

Existing systems lacked efficient interdepartmental and interregional information sharing. These top-down managed systems operated independently from demand information, hindering supply-demand matching. Additionally, storing most information in main nodes posed risks of information loss due to node issues or cyberattacks.

3. Coupling Analysis with Blockchain Technology

This paper defines the ESC as a demand-driven dynamic supply-demand network established for rapid response and delivery of emergency materials in an epidemic environment caused by the spread of viruses or bacteria with the core objectives of rapid treatment implementation and early prevention and control. The ESC is divided into four phases: procurement planning, material supply, distribution, and material reception. After the outbreak, based on information released by the National Health Commission regarding epidemic levels, infection numbers, and material reserves, rapid responses were initiated for material procurement. The central government and relevant institutions engaged in procurement, production, and reasonable allocation of emergency materials. The distribution center facilitated supply-demand matching, ensuring timely delivery of these emergency materials to the required regions. Subsequent responses were adjusted based on the epidemic level, infection numbers, and updated demand in the recipient regions, creating a dynamic process for emergency material allocation. Information sharing plays a pivotal role in coordinating supply chain businesses, forming an integral part of business coordination. Despite partial reliance on information management systems like ERP in the current ESC, there remains a lack of comprehensive integration and coordination across all stages. This leads to varying degrees of information asymmetry among entities, escalating coordination costs. Blockchain technology, with its decentralized ledger utilizing encryption, hash algorithms, digital signatures, and consensus mechanisms, addresses this issue. It ensures transparency, data authenticity, and immutability in the ESC, eliminating asymmetry, enabling information sharing, and maintaining data integrity across all stages.

Blockchain's application enhances the ESC's response speed and reliability. It secures data on fund flow, logistics, and information flow in each stage, cutting coordination and management costs. This guarantees the efficient allocation and use of emergency materials. The study conducted a coupling analysis between the issues in the COVID-19 ESC and blockchain technology:

Firstly, a blockchain-based ESC enables real-time sharing of procurement, supply, distribution, and epidemic information. Through information sharing, various participating entities can effectively formulate procurement, scheduling, transportation, and production plans to

match supply and demand, thereby enhancing the utilization of emergency materials. In the later stages of the epidemic, symmetrical supply and demand information will reduce the bullwhip effect. Manufacturers and local governments can timely adjust production and procurement plans to avoid overcapacity and material waste.

Secondly, by applying blockchain, the correctness and integrity of information are ensured. Entities can only add new information within each block of the blockchain, without the ability to modify or delete existing information. This guarantees the reliability of data at each stage of the ESC, making inventory and logistics information immutable, thereby improving the security and reliability of the supply chain.

Thirdly, in cases where information errors or data tampering occur during information sharing in the supply chain, hash function pointers can quickly locate the storage position of erroneous information, enabling data traceability. This helps ensure the reliability of all data related to the movement of emergency materials, avoiding situations where the dynamics of donated materials are unclear.

Fourthly, blockchain's distributed ledger system decentralizes supply chain data storage, spreading it across the blockchain. Accessible by authorized participants, this ensures transparency, enabling coordinated information flow across the ESC. It minimizes information disparities, allowing efficient material allocation and rapid responses. Moreover, this method offers heightened data security compared to traditional databases, enabling data recovery through other nodes in case of a node or block issue

4. Conclusion

The ESC forms the foundation for ensuring the availability of emergency materials. The sharing and exchange of information among various entities at each stage of this chain facilitate both horizontal and vertical coordination of all information. This integration fosters unified management, providing the fundamental groundwork for coordinated efforts in combating epidemic situations. This paper, through coupling analysis, has demonstrated that the application of blockchain technology in the ESC effectively resolves issues such as information asymmetry, inaccuracies, and delays during information transmission. It ensures that all participating entities in the ESC can access data information in real-time with precision, reducing the impact of the bullwhip effect, accelerating the responsiveness of the ESC, supporting traceable and controllable emergency logistics. Ultimately, it achieves a scientific, efficient, and precise process for the production, procurement, scheduling, and distribution of emergency materials, thereby enhancing the management level of the ESC.

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