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Application of blockchain technology in green logistics in Vietnam

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Abstract
As the frequency of logistics operations grows, their negative impacts on our natural environment and resources are escalating. The generation of waste, such as steel slag, industrial effluents, electronic scraps, and spent batteries, is on the rise, exerting significant environmental stress. One approach to mitigate these impacts is through the adoption of sustainable logistics practices. However, the implementation of these green logistics strategies faces obstacles due to the lack of real-time data exchange and transparency within the industry. The application of blockchain technology offers a promising solution to these challenges by facilitating data sharing among all parties involved. This paper proposes a conceptual framework for sustainable logistics operations that leverages blockchain technology, alongside the integration of the Internet of Things (IoT) and big data analytics. It further explores the potential applications, advantages, and challenges of employing blockchain technology for green logistics, particularly within the Vietnamese context, to operationalize this framework.

Keywords: Green logistics, blockchain, sustainability, traceability

1. Introduction
The movement towards eco-friendly practices in the logistics industry, often referred to as Green Logistics, plays a crucial role in minimizing the environmental footprint of logistic operations. By integrating sustainable practices, companies in the logistics sector can align with environmental standards, enhancing their market position and fostering enduring growth. The emphasis on developing and implementing strategies that support eco-friendly logistics underscores its significance in achieving sustainability over the long haul. This is supported by studies from Spencer and colleagues in 2018 [3], and Ren and their team in 2020 [4], highlighting the importance of adopting sustainable methods that not only conserve natural resources but also enhance the quality of life and promote economic advancement. For logistics companies, adopting a strategic approach to sustainability, with a focus on sustainable development as a core principle, is essential for success.

The genesis of blockchain technology in 2008, initially linked with the cryptocurrency Bitcoin, has broadened its applications significantly, influencing the logistics management sector among others. With its recent extension into manufacturing and the development of intelligent urban areas, blockchain technology presents a promising avenue for enhancing logistics operations. Its capacity for ensuring data integrity and transparency is particularly relevant in the logistics domain, offering a fertile ground for academic inquiry, especially within the Vietnamese context where research is gravitating towards identifying policy frameworks, opportunities, and challenges associated with blockchain's integration in Green Logistics. However, there's an observable gap in establishing a comprehensive research framework that optimizes the outcomes of blockchain applications in this area for Vietnam.

This study sets out to create a theoretical model that leverages blockchain technology, coupled with the Internet of Things (IoT) and big data, for refining logistics management. The IoT's role in transforming conventional items into intelligent devices capable of gathering and transmitting data in real-time is pivotal. Following this, blockchain technology is employed to facilitate the secure and immediate exchange of data. Utilizing big data analytics, the proposed model aims to design a suite of innovative applications to elevate Green Logistics services, catering to the needs of diverse stakeholders.

The subsequent sections of this document are structured in the following manner. Section 2 elaborates on two critical concepts: Green Logistics and Blockchain technology. Section 3 outlines a conceptual framework that utilizes blockchain technology to enhance green logistics services, highlighting its major applications for advancing green logistics within Vietnam. The fourth section explores the advantages, prospects, and hurdles associated with the application of this conceptual framework within the Vietnamese logistics sector. Finally, the fifth section summarizes the findings and contributions of this study and proposes avenues for further investigation.

2. Theoretical basis

2.1. Green logistics

Logistics management within the supply chain involves overseeing the movement of products from their creation to their final destination to satisfy customer needs. As depicted in a standard model, this chain comprises entities such as suppliers, manufacturers, distributors, and end-users, streamlining the process into a series of interactions between sellers and buyers. For instance, a producer acts as a seller to a distributor. The purchasing process encompasses at least two key activities: acquiring goods and distributing them. Once an order is confirmed, the seller arranges for a specialized third-party logistics (3PL) provider to handle the shipment, often utilizing a combination of transport methods. This encompasses long-haul transportation, storage solutions, and last-mile delivery, ensuring the product reaches the consumer, thereby concluding the transaction. Throughout this logistics journey, effective collaboration and coordination among all parties are crucial. This necessitates the use of up-to-the-minute data and information, enabling stakeholders to make informed decisions and implement strategies that support environmentally sustainable logistics practices.

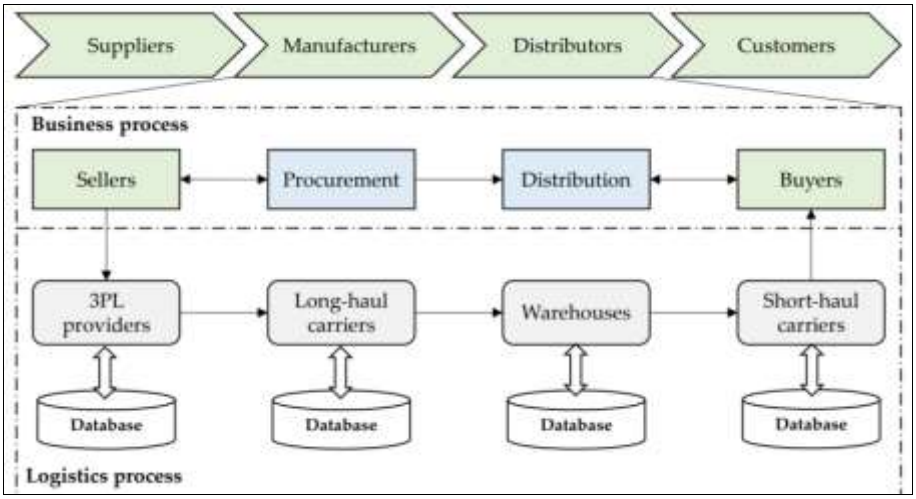

Fig 1: Logistics in the supply chain (Li *et al*., 2014)

In recent times, Vietnam's Logistics sector has witnessed robust growth as numerous enterprises have started to understand the pivotal role of Logistics in enhancing competitive advantage, efficiency, and overall quality. Serving as a crucial component of international trade, the Logistics sector continues to expand, contributing significantly to both the global economy and that of Vietnam. Presently, Vietnam's logistics services market is estimated to be between 20 to 22 billion USD annually, representing about 20.9% of the nation's GDP. The Logistics industry has enjoyed an annual growth rate of approximately 16 to 20% in recent years. Particularly, in alignment with global sustainable development trends, Vietnam is focusing on promoting green logistics practices. These practices offer several advantages, including cost reduction, energy conservation, and minimizing environmental damage amid current climate change challenges.

2.2 Blockchain technology

Blockchain represents a flawless digital ledger for recording economic activities, extending beyond mere financial transactions to virtually anything of significant value. This innovation merges cryptography, peer-to-peer networks, and game theory to foster trust and record transaction histories among network participants, based on a consensus-driven approach for uniformly storing data.

The evolution of Blockchain technology is categorized into three distinct phases: the initial phase focuses on currencies and payments; the second phase expands into finance and markets; and the third phase encompasses the monitoring of design and operations. Recognized as a revolutionary technology, Blockchain has made significant strides in various fields including supply chain management, business processes, healthcare, manufacturing, and data management. Four principal attributes distinguish Blockchain from traditional centralized management software: transparency of data, enhanced security measures, digital asset management, and the implementation of smart contracts. These features collectively contribute to Blockchain's potential to transform a wide array of sectors by providing a secure, transparent, and decentralized framework for conducting transactions and managing data.

3. Blockchain model in logistics

Figure 2 shows an overview of the proposed framework consisting of seven layers: physical layer, cognitive layer, network layer, blockchain layer, management layer, application layer, and user layer.

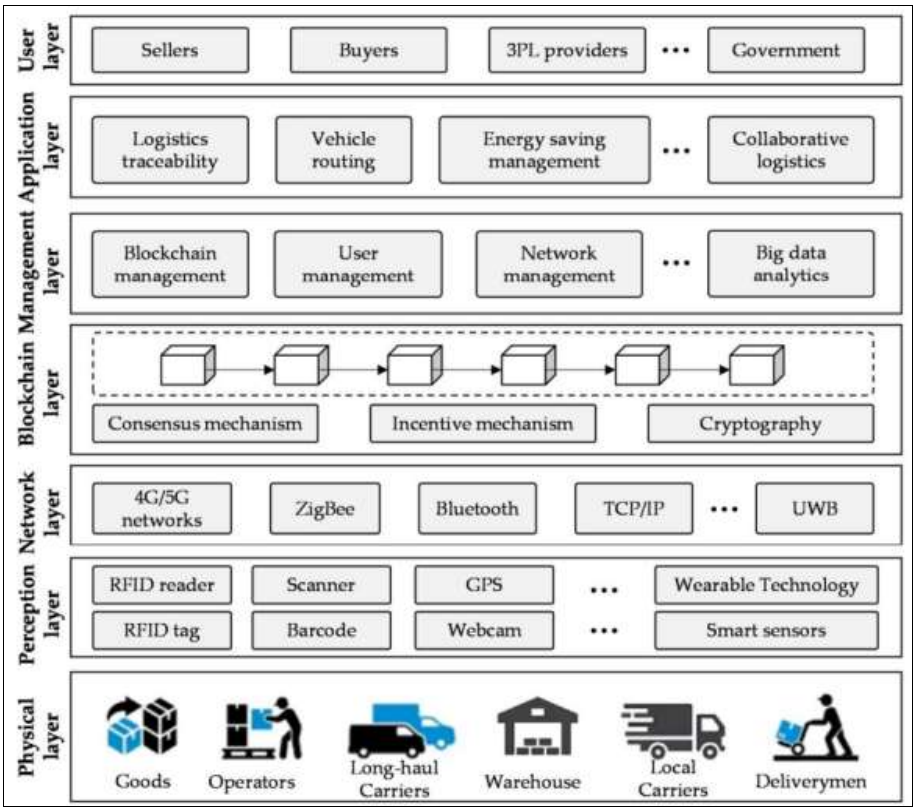

Fig 2: Theoretical framework for applying blockchain in Green Logistics (Bing Qing Tan *et al*., 2020)

The foundational layer, known as the physical layer, encompasses all varieties of logistical assets involved in the logistical workflow, serving as the primary support for logistical activities. These assets fall into three categories: goods requiring transport from the seller to the buyer, logistical personnel who facilitate the transport of goods, and logistical machinery and infrastructure, including trucks, forklifts, and storage facilities.

At the perception layer, the focus shifts to tracking and monitoring the condition of logistical assets using diverse sensory equipment. Technologies such as RFID systems facilitate the identification of goods with the help of readers, tags, scanners, and barcodes. Surveillance cameras ensure the security and integrity of the workplace, while GPS technology installed in vehicles offers real-time tracking of their locations. The adoption of wearable tech in logistics not only boosts efficiency and lightens the load on workers but is also seen as a move towards sustainable social development. Additionally, the deployment of intelligent sensors for utilities like electricity, water, and gas helps in the early detection of resource usage patterns.

The network layer establishes the communication pathways necessary for data exchange. Information gleaned from the perception layer can be sent over to the blockchain layer via various communication technologies, including 4G/5G networks and others, facilitating swift and secure data sharing in real-time.

In the blockchain layer, data is compiled into blocks linked sequentially to create a blockchain. Each block consists of a header with meta information and a body that houses a Merkle tree containing verified datasets and cryptographic hashes. The creation of a blockchain hinges on three pivotal components: a consensus mechanism ensuring data integrity across the network, an incentive model encouraging participation, and cryptographic methods for data protection.

The management layer comprises various tools designed to facilitate the functioning of this conceptual framework, covering aspects like blockchain oversight, user analytics, network supervision, and big data processing. These tools are pivotal in maintaining the blockchain, analyzing user interaction within the supply chain, managing network communications, and leveraging blockchain data for practical applications.

Finally, the application layer offers a variety of tools and services, such as supply chain visibility, environmental impact assessments, smart contracts, and cooperative logistics solutions to the end users within the supply chain, denoted as the user layer. These applications aim to enhance the efficiency and transparency of logistics operations for all stakeholders involved.

4. Application of blockchain technology in green logistics in Vietnam

In Vietnam's market, verifying the authenticity of products poses a significant challenge to consumers, especially due to the prevalence of counterfeit items that often appear indistinguishable from the real ones. This issue is particularly acute in the food sector. As a basic yet crucial use of blockchain technology in Vietnam, a specific application has emerged to address this concern. It equips various parties with the tools to verify and monitor products using a blockchain network, as depicted in Figure 3. The implementation of this technology significantly enhances the effectiveness of the logistics system, ensuring the safety of products and optimizing delivery schedules. Blockchain-enabled logistics tracking offers stakeholders access to uniform and dependable data regarding the logistics journey

of goods. Utilizing such reliable data allows stakeholders to optimize the use of resources and materials, yielding notable economic benefits for companies. Furthermore, this approach contributes to the advancement of Green Logistics by promoting the comprehensive, efficient, and effective management of products and materials across their lifecycle, as noted by Srivastava, S.K. in 2007.

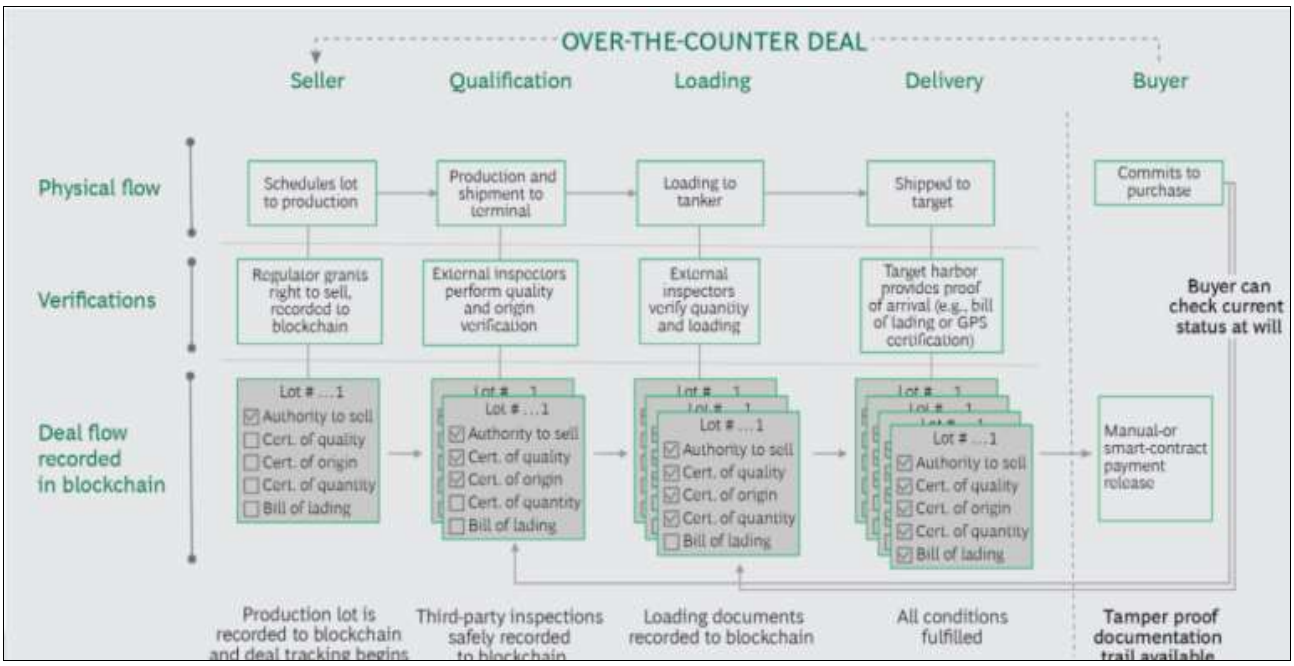

Fig 3: Operating model of a centralized retrieval system applying Blockchain technology

Working together, logistics companies can lower energy use and carbon output while also boosting their profits. Typically, a shared logistics marketplace exists, populated by numerous entities eager to trade their logistics assets or duties. Owing to fluctuating supply and demand dynamics, traditional systems for sharing logistics often struggle with efficient distribution of resources and tasks. The introduction of blockchain technology can pave the way for peer-to-peer (P2P) collaborative logistics markets, offering a platform for unrestricted trading, as depicted in Figure 4. Such an approach not only optimizes the use of resources but also cuts down on the consumption of raw materials, thus benefiting the environment, fostering sustainable growth, and contributing to the creation of eco-friendly supply chains. In these blockchain-supported P2P marketplaces, smart contracts play a key role in streamlining the transaction process.

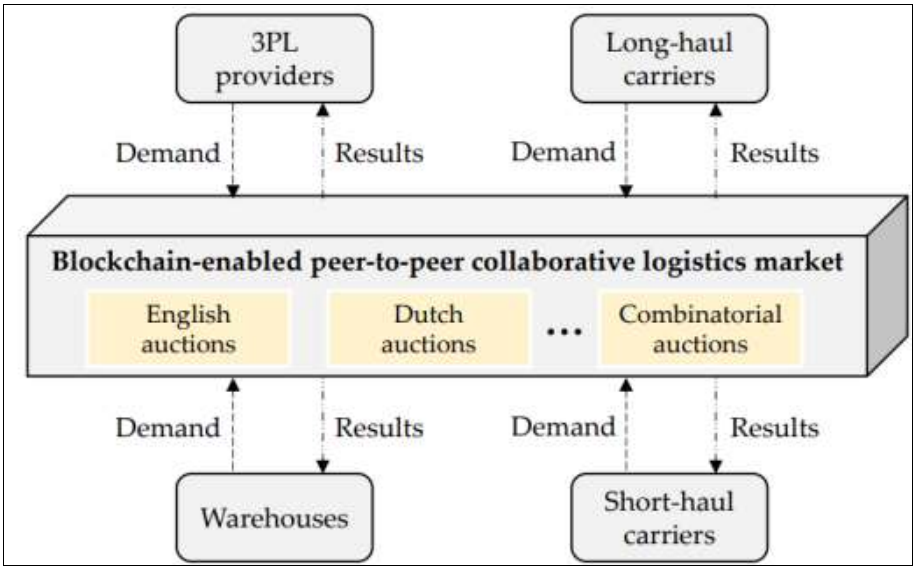

Fig 4: Collaborative Logistics Market (Bing Qing Tan *et al*., 2020)

In the Vietnamese logistics sector, the discrepancy between the size and capabilities of logistics firms results in collaboration within the industry emerging as a future concern. This scenario presents both significant challenges and substantial opportunities for trailblazing companies to engage in partnerships.

Broadly speaking, the implementation of theoretical models rooted in blockchain technology for green logistics in Vietnam is relatively novel. Therefore, it's crucial to examine the advantages, opportunities, and obstacles associated with this approach.

5. Conclusion

Amid the rapid advancements of the fourth industrial revolution, blockchain technology has emerged as a key trend with potential positive effects across various socio-economic sectors. This study introduces a theoretical model for enhancing Green Logistics through the incorporation of blockchain, IoT, and big data technologies. The significance of this work is multifaceted. Initially, it evaluates the logistics operations within supply chains, pinpointing prevalent issues that hinder the logistics sector in Vietnam from achieving Green Logistics. Following this, it advocates for a comprehensive seven-tier framework driven by blockchain technology. This framework is designed to transition the logistics sector from conventional methodologies to blockchain-based practices, thereby facilitating significant applications that aim to lower operational and managerial expenses while boosting efficiency and profitability in Vietnamese enterprises. Furthermore, it thoroughly discusses the advantages and challenges faced in Vietnam, enabling logistics professionals to perform a thorough cost-benefit analysis.

Additionally, this paper outlines potential areas for future research, addressing critical inquiries such as streamlining the seven-tier model for easier business adoption, devising effective incentive schemes to propel Vietnamese logistics firms towards sustainable practices with blockchain, and tackling the financial implications of blockchain implementation for these enterprises.

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