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## BLOCKCHAIN SMART CONTRACTS IN LOGISTICS INDUSTRY: A QUALITATIVE STUDY FOR ENHANCING LOGISTICS SERVICE QUALITY

**Abstract:** *This study seeks to fill a gap in the understanding of how blockchain smart contracts may improve logistics service quality and investigate the drivers of blockchain smart contracts. Semi-structured interviews were carried out with ten logistics professionals to collect data. According to the findings, the drivers of using blockchain smart contracts in the logistics industry comprised the strongest predictor amongst security, traceability, decentralization, transparency, efficient information sharing, and automation factors. The identified drivers of blockchain smart contracts could be used by logistics practitioners as a “road map” for the development of appropriate solutions to successfully strengthen logistics service quality within the logistics industry. The results indicate that blockchain smart contracts enhance payment transaction security, increase end-to-end visibility, and improve delivery timeliness. Moreover, this technology optimizes routing, advances fleet management, and reduces logistics costs. The existing literature focuses on the approaches to applying theoretical, technical, or operational benefits of blockchain smart contracts, but fails to propose a deep dive into logistics service quality. This research appraises blockchain smart contracts by assessing and suggesting how they can enhance logistics service quality.*

**Keywords:** *blockchain, smart contract, logistics service quality, logistics.*

### 1. Introduction

The actors of the global supply chain are seeking innovative solutions that will improve their speed, efficiency, and cost-effectiveness, encompassing a broad spectrum of internal and external stakeholders. The escalating complexity of these global supply networks primarily drives the growing interest in blockchain technology (Yang, 2019).

Many problems are due to poor data transparency and a lack of trust among stakeholders in the supply chain.

Nevertheless, this complexity often leads to challenges, including delayed, non-payment, and incomplete payments (Jain et al., 2020). Such inefficiencies escalate financing costs, as freight forwarders strive to mitigate supply chain risks, thereby increasing overall logistics expenditures. Furthermore, lack of transparency within these intricate supply chains jeopardizes trust and threatens payment security (Xie et al., 2020).

Blockchain-based smart contracts emerge as an up-and-coming tool and offer a potential solution to these challenges by addressing the limitations of traditional contract systems.

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This technology offers greater efficiency, lower costs, and enhanced security compared to SWIFT systems in facilitating cross-border payments in global supply chains (Yuan & Wang, 2016). Moreover, the evaluation, authorization, disbursement, and claims resolution related to freight forwarder insurance policies can be substantially accelerated through the implementation of smart contracts (Alnepak & Toraman, 2024).

Approximately 60% of logistics enterprises show supply chain transparency as a key priority. For instance, Trade Lens (Xu & He, 2024), Maersk (Jain et al., 2020), FedEx (Chang et al., 2019), and Deutsche Post DHL (Wang & Qu, 2019) have incorporated blockchain into their shipment tracking systems, notify in an 80% decrease in the time for processing paperwork.

Everledger has assessed the use of blockchain in logistics to enhance product authenticity, secure the movement of goods, and provide transparent documentation. Freight forwarders can create permanent and transparent records for each transaction using blockchain smart contracts (Alqarni et al., 2023), thereby strengthening trust and accountability among stakeholders in the supply chain (Alnepak & Toraman, 2024).

Another key advantage of blockchain in the logistics industry is its transformative impact on tracking shipments from origin to delivery (Xu & He, 2024). This technology eases real-time tracking, reducing both time and costs associated with manual processing (Choi, 2019). Blockchain smart contracts can streamline paper-based contract processes, find product sources, store data, and manage IoT devices on the blockchain (Ahmad et al., 2021).

This research is motivated by the increasing importance and widespread adoption of blockchain-based smart contracts in transforming logistics operations. The study aims to explore the key factors of driving blockchain smart contract use to improve logistics service quality. Moreover, it presents a comprehensive exploration of the critical

factors influencing blockchain smart contract adoption while linking the findings to relevant theoretical frameworks.

The rest of the study is structured as follows. The relevant literature regarding blockchain smart contracts and logistics service quality is reviewed in Section 2. Section 3 outlines the method. Section 4 presents the key findings and explores potential implementation for blockchain smart contracts, drawing insights from the logistics industry. Section 5 provides an interpretation of the outcomes, discusses avenues for future research, and presents limitations.

## **2. Literature Reviews**

### **2.1. Blockchain Smart Contracts in the Logistics Industry**

The foundational principle of blockchain was presented in 2008 by Satoshi Nakamoto, describing a decentralized, append-only digital ledger designed to be highly resistant to manipulation or unauthorized alterations (Nakamoto, 2008). Although the practical application of blockchain technology is a recent advancement, its fundamental concepts include cryptographic timestamping, verifiable records of transactions, consensus protocols such as proof-of-work, fault tolerance, asymmetric cryptography, and smart contract capabilities that have evolved over several decades (Mohanty et al., 2022).

Blockchain is a decentralized system for managing data that enables the replication, synchronization, and sharing of information across various locations involving organizations, countries, or operational units (Milicevic et al., 2023). One of the critical innovations built on blockchain is the concept of smart contracts, such as automated, self-executing agreements in which the contexts are accommodated directly into the code and deployed across the network (Zhou et al., 2020). These smart contracts are equipped to enforce contract conditions such as payment

conditions, regulatory compliance, and performance standards without the need for a middleman, decreasing the likelihood of both intentional and accidental errors (Nanayakkara et al., 2021). The primary aim of blockchain smart contracts is to eliminate the reliance on centralized trust authorities by helping secure, decentralized validation through specialized technical protocols (Younus & Raju, 2021).

Blockchain smart contracts resemble transparent ledgers, where transactions appear using alphanumeric identifiers and private keys in terms of functionality. Cryptographic mechanisms provide the secure and direct completion of transactions within a network, cutting the requirement for participants to trust each other (Liao & Wang, 2018). These technologies are collaborative, decentralized information systems in which

various entities collectively corroborate, record, and administrate shared data. Each node within the network ensures a synchronized copy of the ledger, which is updated only when consensus is reached among the participating nodes (Yuan & Wang, 2016).

Blockchain smart contract provides a transparent and secure protocol for arranging transactions and data between multiple participants (Chang et al., 2019). This structure increases operational efficiency, advances information integrity, and enhances visibility within supply chains (Natanelov et al., 2022). Table 1 presents a structured overview of the key studies in the blockchain smart contract literature, summarizing their sectors and study types, and highlighting their goals and objectives.

**Table 1.** Literature Reviews of Blockchain Smart Contact in Logistics Sector

Authors	Sectors	Study Type	Goals/ Objectives
Karamitsos et al. (2023)	Air Transportation	Case study (UK airports)	Introducing an innovative blockchain technology approach using smart contracts to resolve the existing inefficiency. They advocate for the adoption of smart contracts within the airside pass issuance workflow, aiming to streamline the process and minimize the time in air transportation.
Alqarni et al. (2023)	Logistics sectors	Review study	To explore the potential benefits and barriers associated with the adoption of smart contracts within the logistics industry. While smart contracts offer significant opportunities for enhancing automation, security, and efficiency, their implementation also brings challenges related to technology integration.
Yadav et al (2022)	Air Transportation	Empirical evaluation	To propose a decentralized framework to solve the problem of transparency and trust. Smart contracts are used to protect against malicious activity in air transportation.
Li and Zhou (2021)	Maritime transportation	Review study	Highlighting that the positions of ships and containers can be monitored in real-time, and their future locations can be expected using intelligent transportation systems powered by blockchain technology.
Jović et al. (2020)	Maritime transportation	Theoretical investigation	To accentuate the role of blockchain technology in promoting sustainability within logistics operations.
Xie et al. (2020)	Railway transportation	Empirical evaluation	To present an innovative design for a blockchain-integrated financial platform tailored to the logistics industry. Also, it offers comprehensive analysis to support the technological advancement of freight information systems.

Tsiulin et al. (2020)	Maritime transportation	Empirical evaluation	To reveal the difference between blockchain smart contracts and many current initiatives, such as the Port Community System. The Port Community System lacks the technical capability to achieve key principles such as transactional transparency, auditability, and real-time operational fairness.
Koh et al. (2020)	Logistics sector	Review study	To propose systematic approaches for naming, discovering, and analyzing business processes that are most effectively supported by blockchain technology in the logistics sector.
Issaoui et al. (2019)	Logistics sector	Case study	To clarify the importance of blockchain smart contracts, such as increasing sustainability and finding problems faster in logistics operations.
Philipp et al. (2019)	Maritime transportation	Survey study (21 expert interviews)	To declare significant potential for transforming traditional framework by confirming and recording each transaction within the integration of blockchain technology ledger in maritime transportation.

## 2.2. Logistics Service Quality

The concept of logistics service quality (LSQ) has its roots in the work of Perreault Jr. and Russ (1976), who argue that logistics activities contribute to time, place, and form utility, thus adding value to products. Logistics service quality is defined a process, starting from the order placement and continuing through service completion, with customers prioritizing different aspects of service quality (Limbourg et al., 2016). This approach is subsequently characterized as a collection of performance indicators, evaluated based on the capacity to deliver products in alignment with customer expectations (Yang et al., 2010).

Mentzer et al. (2001) propose a model encompassing nine variables: information quality, ordering process, release quantity of orders, timeliness, accuracy of orders, quality of orders, condition of orders, handling of order discrepancies, and the quality of personnel interactions. According Arabelen and Kaya (2021), the LSQ framework was categorized with five key dimensions: customer-centric quality, order fulfillment quality, timeliness, information quality, and corporate image along with social responsibility.

This framework is further detailed by twenty-four specific factors. Vu et al. (2020) identify

fourteen critical variables, with delivery time and shipment condition ranked as the most important. While human factor-related variables were emphasized by customers, they were not deemed significant by logistics service providers, thereby shedding light on the logistics service quality dynamics in a developing country with lower logistics maturity. A high standard of logistics service quality substantially fortifies logistics provider's competitive position within dynamic business environments. The delivery of superior service quality contributes to advanced customer satisfaction, thereby fostering customer loyalty toward the service provider (Baki et al., 2009).

Logistics service providers need to make certain that their information tools are both user-friendly and valuable to customers, as this is crucial for encouraging both the initial adoption and ongoing usage. If customers find these tools easy to use but not beneficial, or if the tools don't provide tangible value (such as accurate order tracking or real-time updates), they are unlikely to continue using them. Therefore, it's important to strike a balance between usability and usefulness to foster long-term customer satisfaction and engagement (Bienstock et al., 2008).

Customer perception of logistics service quality is influenced by both the service capacity and the quality of information.

Fernandes et al., (2018) find that the link between logistics capabilities and customer satisfaction is mediated by the overall quality of logistics services in Brazil.

Limbourg et al., (2016) point out that logistics service providers should address weaknesses in areas like shipping, claims, and freight. Moreover, they should focus on strengthening research and establish customer care programs in Vietnam. Thai, (2013) suggests that logistics service providers can gain valuable insights into areas needing improvement by using the proposed model to collect customer feedback. The logistics service quality factors can serve as a checklist for benchmarking service quality, allowing providers in Singapore to compare their performance.

### 3. Methodology

The logistics service quality and blockchain smart contract variables identified through a comprehensive review of existing literature, selected as the basis for our study enabled us to develop the research questions. This empirical study was carried out through the theoretical framework proven by existing research on blockchain smart contracts, as discussed in Section 2. Due to the limited exploration of this subject in the Türkiye context, the research took an exploratory approach, aiming to assess the significance and interconnections of the relevant factors.

A qualitative approach was adopted to acquire perspectives and rich insights through semi-structured interviews. This method is particularly effective in combining the findings related to the dimensions of logistics service quality shown in the systematic literature review, as it is widely regarded as one of the most frequently utilized interview techniques (DiCicco-Bloom & Crabtree, 2006).

Semi-structured interview questions have been constructed according to the outcome of the systematic literature review. The semi-structured interview approach is considered most appropriate, given the lack of consensus regarding the precise dimensions of logistics service quality and blockchain smart contract in the logistics industry. As it allows participants the flexibility to express their perspectives in a comprehensive and detailed manner.

Open-ended questions were designed to allow participants to expand on the topic and provide in-depth responses. Each set of questions was specifically tailored to the participants and their organizations to address the research goals. The study adopted an exploratory qualitative method, involving recorded, detailed interviews with 10 logistics managers from Türkiye. The interviews were conducted between January and April 2025. The demographic profile of the interviewees reflects diversity in terms of title and experience, supporting the credibility of the qualitative findings (Table 2).

**Table 2.** Demographics of the Interviewees

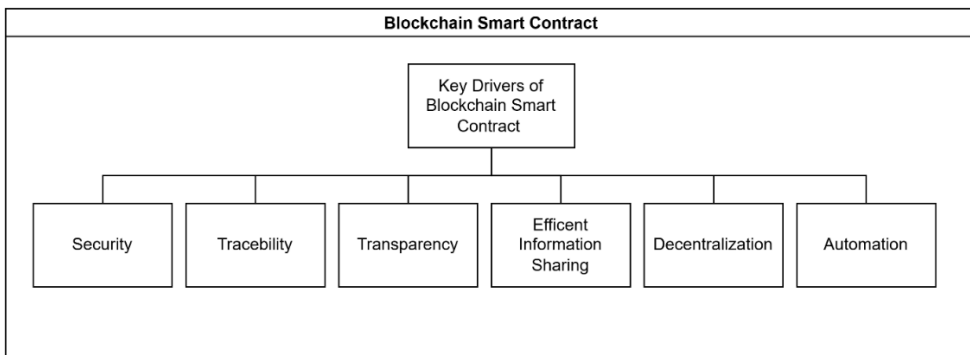
Logistics Experts no	Title	Experience
1	Logistics Coordinator	12 years
2	Inventory Control Analyst	7 years
3	Warehouse Manager	16 years
4	Logistics Routing Planner	4 years
5	Regional Logistics Manager	24 years
6	Customs Compliance Specialist	6 years
7	Director of Multimodal Transportation	18 years
8	Freight Documentation Executive	8 years
9	Distribution Center Manager	20 years
10	Executive of Exporting and Importing Division	9 years

#### 4. Results

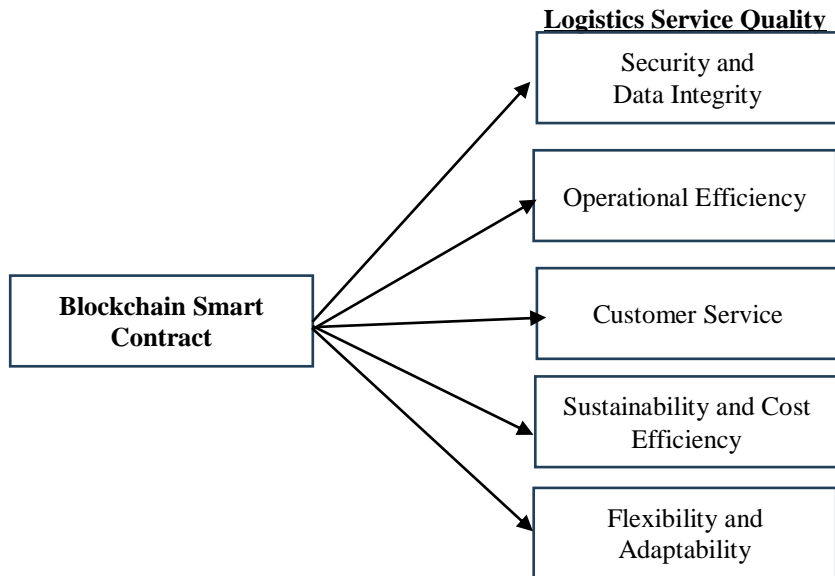
The results of the ten interviews present that the key drivers of blockchain smart contract in the logistics industry extracted from the literature are acknowledged by the interviewees.

Besides, several key drivers were proposed by the logistics experts apart from the literature. Blockchain smart contract frameworks offer great flexibility within the

logistics sector (Aleksieva et al., 2023). It can be customized by choosing different consensus protocols, cryptographic methods, and smart contract structures. This adaptability allows participants to join a blockchain network with minimal need for trust and reduced risk (Mthimkhulu & Jokonya, 2022), thanks to the inherent security features of the technology (Orji et al., 2020). Figure 1 visualizes the key drivers of blockchain-based smart contract adoption in the logistics industry.



**Figure 1.** A Key Driver of Blockchain Smart Contracts in the Logistics Industry



**Figure 2.** Logistics Service Quality Dimensions Improved by Blockchain Smart Contracts

Based on the interview findings, Figure 2 provides an overview of the logistics service quality dimensions that are enhanced through the use of blockchain-based smart contracts. Blockchain smart contract automatically updates the blockchain ledger, ensuring accountability and real-time enforcement of agreements (Sinha and Roy Chowdhury, 2021). For instance, freight forwarders may collaboratively design smart contracts to define and regulate service-level standards and product quality requirements (Hasan et al., 2019).

Simultaneous document processing and process tracking can be achieved, promoting

greater transparency throughout the entire operation (Dolgui et al., 2020). This mechanism reduces reliance on manual processes and fosters greater trust among participants in multi-party logistics network (Hamidi et al., 2024). By integrating IoT applications, it becomes possible to track cargo movement and generate the necessary data for smart contract applications. Access to real-time data within the global supply chain can significantly accelerate the overall logistics process (Alqarni et al., 2023). Drawing on senior executive interviews, Table 3 highlights the logistics service quality dimensions improved through blockchain smart contract implementation.

**Table 3.** Identifying the Key Dimensions of Logistics Service Quality in the Blockchain Smart Contract Context: Evidence from Senior Executive Interviews

<b>Improving Logistics Service Quality through Blockchain-Based Smart Contracts</b>				
<b>Security and Data Integrity</b>	<b>Operational Efficiency</b>	<b>Customer Service</b>	<b>Sustainability and Cost Efficiency</b>	<b>Flexibility and Adaptability</b>
Data integrity and tamper-proof records	Enhancing forecasting and demand planning	Customer Personalized experience	Reduction in carbon footprint	Standardization of processes and protocols
Enhanced cybersecurity	Efficient inventory management	Faster issue resolution	Optimized resource usage	Adaptability of new technologies
Authentication and access control	Reducing human error	Real-time customer feedback	Lower energy consumption	Flexibility in managing seasonal demand
End-to-end visibility	Predictive maintenance for equipment	Enhanced customer trust and satisfaction	Waste reduction	Compliance with international standards and regulations
Smart contracts for secure transactions	Automation of repetitive tasks	Reduced errors in order fulfillment	Sustainable packaging solutions	Ability to adapt to market changes and customer demands
Prevention of fraudulent activities	Real-time data access and analysis	On-time deliveries	Reduction in logistics costs	
Data encryption for confidentiality	Faster transaction processing	Proactive customer support	Cost savings from automation	
Securing payment transactions	Optimized routing and fleet management	Customer-centric logistics solutions	Transparency in environmental reporting	
Dispute resolution mechanisms	Order accuracy	Accurate condition reporting	Sustainable logistics implementation	

Audit trails and compliance	Decreasing lead times		Compliance with environmental regulations	
Continuous monitoring and risk management	Avoiding the middleman		Competitive price of logistics service	
Resilience and system redundancy	Reducing red tape			
Regulatory compliance assurance				

Note: The dimensions of logistics service quality presented in this table were derived from in-depth interviews with senior logistics executives, focusing specifically on the impacts of blockchain-based smart contract applications.

## 5. Conclusion and Discussion

Blockchain technology has the potential to revolutionize logistics service quality by improving operational efficiency, enhancing security, supporting sustainability, and fostering customer-centric solutions. These findings highlight the critical role of blockchain smart contracts in driving innovation and providing a competitive advantage in the logistics industry. From an international commerce and logistics policy perspective, it is essential for policymakers to develop targeted initiatives that encourage freight forwarders to adopt blockchain-based smart contract technologies, thereby cultivating an environment conducive to blockchain integration in the logistics sector. Regulatory frameworks and legal guidelines concerning the use of blockchain smart contracts in the logistics sector should be clarified and made more accessible, ensuring freight forwarders can adopt the technology. Furthermore, governments could distribute additional funding and subsidies to research

initiatives focused on blockchain smart contracts, aiming to tailor the technology more effectively to the specific needs of the logistics industry.

This paper will be a comprehensive procurement framework for the logistics industry based on blockchain and smart contract. It presents that finding from a semi-structured interview with 10 logistics professionals in Türkiye.

The results can be used in future studies to develop scientific or practical in blockchain smart contract implementation for improving logistics service quality. Despite its findings and contributions, this research is an exploratory study that followed a qualitative approach to principally investigate to explore the key drivers of blockchain-based smart contracts for improving logistics service quality in Türkiye. While considered valid, these results and implications lack generalizability and should be tested through empirical quantitative research of a larger sample size such as Germany, France, Spain to confirm and apply them.

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