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Identification of Indicators for Blockchain-Based Supply Chain Management of Canned Food Using the Multi-Grounded Theory Method

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ABSTRACT

Providing and distributing high-quality, hygienic food in modern societies is vital. Despite the many potentials of blockchain, its adoption in the food supply chain and its performance in improving the management of canned food supply have not been investigated. It is evident that achieving key indicators for blockchain-based management of the canned food supply chain is crucial for designing a blockchain model for the canned food supply chain and for evaluating its performance. Using the qualitative method of multi-grounded theory, the dimensions and criteria influencing the management of the blockchain-based canned food supply chain were obtained. The final list includes ten main categories: transparency, immutability, decentralization (risk reduction), authentication, security, traceability, cost, support from senior management, complexity, and efficiency. These concepts and categories emerged from 172 codes identified during the open coding phase in the zigzag process of the literature review and interviews. The indicators obtained in this research will be used to design a blockchain model for the management of the canned food supply chain based on blockchain. They are also intended to improve the management of the canned food supply chain and introduce important criteria for employing blockchain technology in the management of the canned food supply chain.

Keywords: Food supply chain management, canned food supply chain, blockchain-based food supply chain, indicators of the canned food supply chain, Multi-Grounded Theory

Introduction

The global food supply chain has evolved into a highly complex, distributed, and interdependent system that plays a fundamental role in ensuring food security, economic stability, and public health. As one of the most critical infrastructures in modern economies, the food supply chain must continuously adapt to increasing consumer expectations, regulatory pressures, and technological advancements. In particular, the management of perishable goods such as canned food products requires precise coordination, efficient inventory control, and robust information systems to maintain quality and safety across all stages of production, processing, distribution, and consumption. The growing globalization of food systems has intensified challenges related to traceability,

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transparency, and coordination among supply chain actors, thereby necessitating innovative technological solutions to address these systemic inefficiencies {Min, 2019 #390646;Alabi, 2023 #390618;Heydari, 2024 #390626}. In this context, the emergence of digital technologies has significantly transformed supply chain management practices, enabling improved data collection, real-time monitoring, and enhanced decision-making capabilities.

Despite these advancements, traditional food supply chains continue to suffer from critical limitations, including fragmented information systems, lack of trust among stakeholders, and vulnerability to disruptions such as contamination, fraud, and inefficiencies in logistics operations. One of the most persistent issues in conventional supply chain systems is the lack of transparency and traceability, which hinders the ability to track products accurately from origin to final consumption. This limitation not only compromises food safety but also reduces consumer confidence and increases the risk of economic losses due to recalls and quality failures {Casino, 2019 #390612;Haleem, 2019 #390660;Bosona, 2023 #390640}. Furthermore, the bullwhip effect—caused by information asymmetry and poor coordination—continues to exacerbate inefficiencies in inventory management and demand forecasting, particularly in food supply chains characterized by perishability and demand volatility {Yang, 2021 #390621;Talukder, 2021 #390628}. These systemic challenges highlight the urgent need for advanced technological frameworks capable of enhancing visibility, trust, and coordination across supply chain networks.

Blockchain technology has emerged as a transformative innovation with the potential to address many of these longstanding challenges in supply chain management. As a decentralized and immutable distributed ledger, blockchain enables secure, transparent, and tamper-proof recording of transactions across multiple stakeholders without reliance on centralized authorities. This unique architecture facilitates real-time data sharing, enhances traceability, and reduces the risk of data manipulation, thereby significantly improving the reliability and integrity of supply chain information systems {Kshetri, 2018 #390619;Wang, 2019 #390632;Agarwal, 2024 #390614}. In food supply chains, blockchain applications have been particularly promising in ensuring product authenticity, preventing fraud, and enabling rapid identification of contamination sources, which are critical for maintaining food safety and quality standards {Feng, 2020 #390610;Duan, 2024 #390624;Giganti, 2024 #390625}. Additionally, blockchain integration with other emerging technologies such as the Internet of Things (IoT) and artificial intelligence (AI) has further enhanced its capabilities in monitoring, automation, and predictive analytics, thereby contributing to more intelligent and resilient supply chain systems {Tsolakis, 2023 #390615;Tang, 2024 #390608;Jin, 2025 #342005}.

In recent years, a growing body of literature has examined the role of blockchain in improving supply chain performance, particularly in the agri-food sector. Studies have demonstrated that blockchain can significantly enhance transparency, accountability, and efficiency by enabling end-to-end visibility of product flows and information exchanges {Kamilaris, 2019 #390639;Pandey, 2022 #390638;Bosona, 2023 #390640}. Moreover, blockchain-based traceability systems allow stakeholders to verify product origins, monitor processing conditions, and ensure compliance with regulatory standards, thereby addressing critical concerns related to food safety and sustainability {Galvez, 2018 #390636;Luna, 2024 #390627;Varavallo, 2022 #390643}. The integration of blockchain into supply chains has also been associated with improved collaboration among supply chain actors, reduced transaction costs, and enhanced trust among participants, which are essential for achieving sustainable and resilient supply chain operations {Rejeb, 2020 #390658;Philsoophian, 2022 #390611;Uvet, 2025 #359388}.

Despite its significant potential, the adoption of blockchain technology in supply chain management remains limited and faces several challenges. These include high implementation costs, technical complexity, scalability issues, lack of standardization, and resistance to organizational change. Additionally, the successful deployment of blockchain requires alignment with organizational capabilities, regulatory frameworks, and external environmental conditions, which vary across industries and regions {Pournader, 2020 #390635;Rahimi, 2022 #390650;Chittipaka, 2023 #390629}. The Technology–Organization–Environment (TOE) framework has been widely used to analyze the factors influencing blockchain adoption, highlighting the importance of technological readiness, organizational support, and environmental pressures in shaping adoption decisions {Malik, 2021 #390630;Park, 2022 #390631}. Similarly, the Diffusion of Innovation (DOI) theory provides valuable insights into how organizations adopt new technologies based on perceived benefits, compatibility, and risk tolerance, emphasizing the role of early adopters and innovation diffusion processes in accelerating technological transformation {Patil, 2023 #390645;Yontar, 2023 #390617}.

In the context of the canned food supply chain, the application of blockchain technology presents unique opportunities and challenges. Canned food products, while having longer shelf lives compared to fresh produce, still require stringent quality control, efficient logistics, and reliable traceability systems to ensure product safety and compliance with regulatory standards. The complexity of canned food supply chains, which involve multiple stakeholders such as suppliers, manufacturers, distributors, and retailers, necessitates robust coordination mechanisms and transparent information sharing to optimize performance and reduce inefficiencies {Noble, 2023 #390607;Granillo-Macias, 2024 #390648}. Blockchain technology can play a critical role in addressing these challenges by enabling secure and transparent data exchange, improving inventory management, and facilitating real-time monitoring of supply chain activities {Raja, 2025 #371533;Fang, 2025 #286125}. Furthermore, blockchain-based systems can enhance sustainability by reducing food waste, improving resource utilization, and supporting environmentally responsible practices in supply chain operations {Giganti, 2024 #390625;Heydari, 2024 #390626}.

Another important dimension of blockchain adoption in supply chain management is its impact on risk management and resilience. The increasing frequency of disruptions such as pandemics, geopolitical conflicts, and climate-related events has exposed the vulnerabilities of traditional supply chains and underscored the need for more resilient systems. Blockchain technology, with its decentralized architecture and real-time data capabilities, can enhance supply chain resilience by improving visibility, enabling proactive risk identification, and facilitating rapid response to disruptions {Gholami-Zanjani, 2021 #390605;Chen, 2025 #377535;Zhang, 2025 #371527}. Additionally, blockchain-based financial solutions such as supply chain financing can improve liquidity and reduce financial risks for small and medium-sized enterprises (SMEs), thereby strengthening the overall stability of supply chain networks {Asante Boakye, 2025 #286113;Danylov, 2024 #390656}.

From a strategic perspective, the integration of blockchain into supply chain management aligns with the broader paradigm of Industry 4.0 and digital transformation. The convergence of digital technologies, including blockchain, IoT, big data analytics, and cloud computing, is reshaping supply chain ecosystems and enabling more agile, adaptive, and data-driven operations {Basl, 2019 #390665;Surucu-Balci, 2024 #390623}. In this digital era, organizations must develop new capabilities and adopt innovative business models to remain competitive and responsive to changing market conditions. Blockchain technology, as a foundational component of digital supply chains, offers significant potential to create value through enhanced transparency, efficiency, and trust among stakeholders {Cole, 2019 #390667;Agnola, 2025 #371529}. However, realizing these benefits requires a comprehensive understanding of the key indicators and factors that influence blockchain-based supply chain management.

The identification of these indicators is particularly important for designing effective blockchain-based supply chain models and evaluating their performance. Indicators such as transparency, traceability, security, cost efficiency, and organizational readiness play a crucial role in determining the success of blockchain implementation in supply chain management {Yadav, 2020 #390666;Varavallo, 2022 #390643;Haldive, 2025 #217983}. Moreover, organizational factors such as management support, training, and cultural readiness, as well as environmental factors such as regulatory frameworks and market dynamics, significantly influence the adoption and effectiveness of blockchain technology {Chittipaka, 2023 #390629;Gulen, 2024 #390649}. Understanding these multidimensional factors requires a holistic analytical approach that integrates theoretical frameworks with empirical insights.

The present study builds upon this growing body of knowledge by focusing specifically on the identification of key indicators for blockchain-based supply chain management in the canned food industry using a multi-grounded theory approach. This approach combines theoretical grounding, empirical data, and iterative analysis to develop a comprehensive and context-specific understanding of the factors influencing blockchain adoption and performance. By integrating insights from existing literature and expert perspectives, the study aims to provide a robust framework for analyzing and optimizing blockchain-based supply chain systems. The research contributes to the literature by addressing a critical gap in understanding the specific indicators and dimensions that shape blockchain-enabled supply chain management in the canned food sector, as highlighted in prior studies {Duan, 2020 #390647;Pandey, 2022 #390638;Khan, 2023 #390606}. Additionally, it offers practical implications for policymakers, managers, and industry stakeholders seeking to leverage blockchain technology for improving supply chain efficiency, transparency, and sustainability.

Given the increasing importance of digital transformation and the growing demand for safe, transparent, and sustainable food systems, the need for systematic and evidence-based research on blockchain applications in supply chain management has become more critical than ever. The insights generated from this study are expected to support the development of innovative strategies and frameworks for enhancing supply chain performance and resilience in the canned food industry. Furthermore, by identifying the key indicators and dimensions of blockchain-based supply chain management, the study provides a foundation for future research and practical implementation of blockchain technologies in complex supply chain environments. The relevance of this research is further underscored by the findings of prior work emphasizing the importance of integrating technological, organizational, and environmental perspectives in understanding blockchain adoption and its impact on supply chain performance {Xu, 2025 #266992;Iftikhar, 2025 #277251;Zhang, 2025 #371527}.

Accordingly, the aim of this study is to identify the key indicators influencing blockchain-based supply chain management in the canned food industry and to develop a comprehensive model for improving its performance using a multi-grounded theory approach.

Methods and Materials

To identify the criteria affecting the management of the canned food supply chain based on blockchain, a multi-grounded analysis method has been employed. The multi-grounded theory is an analytical approach used to address complex and multi-criteria issues. Grounded theory, in simple terms, is a qualitative research design in which the researcher seeks to understand the indicators, categories, and subcategories of a specific and main field. In the canned food supply chain, this method can facilitate the improvement and optimization of management processes and decision-making. Generally, the multi-grounded theory method includes three processes: theoretical grounding, empirical grounding, and internal grounding. For this purpose, this study's multi-grounded theory includes the meta-synthesis method of Barroso and Sandelowski and grounded theory. Figure 1 illustrates the implementation process of the adopted method in this research.

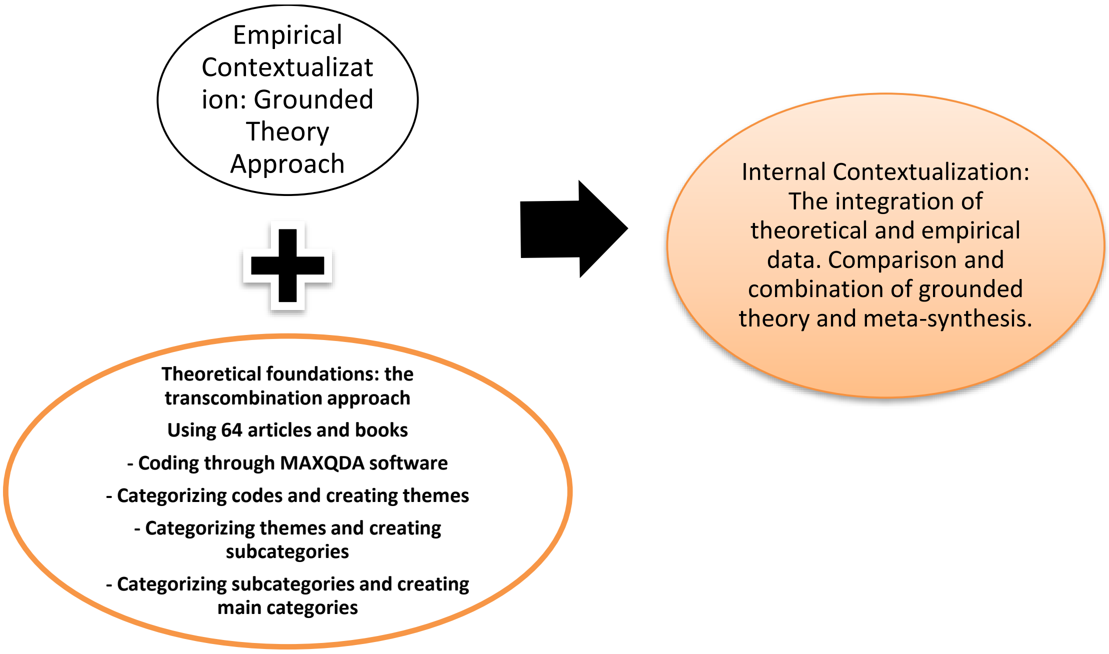

Figure 1: Multi-Grounded Theory Process

Findings and Results

Review of Background and Meta-Synthesis

The background review aims to identify criteria and initial concepts from previous research. In this study, during the theoretical groundwork phase, the meta-synthesis method, which is an exploratory research method, is employed. This method can be considered a systematic study and examination of past research. A common reference framework has been extracted from the results of previous studies. Meta-synthesis is used to integrate various studies to create interpretive and comprehensive findings. The result of this method provides a clear and precise picture of the processes of finding, selecting, evaluating, and combining the results of initial research.

Collection of Articles Related to Supply Chain Management and Blockchain

In this model, the first step for the researcher is to focus on the main research question. The main question is: What are the factors affecting the management of canned food supply chains based on blockchain? In fact, the research aims to identify the indicators of supply chain management for canned food based on blockchain and to design a necessary model for utilizing blockchain technology to improve the management of canned food supply chains. Blockchain, supply chain, supply chain management, blockchain food supply chain, and canned food supply chain are terminologies used in external databases such as https://www.sciencedirect.com/, https://www.emerald.com/insight/, and https://www.springer.com/de. The process of searching and selecting articles was conducted based on the PRISMA protocol. Accordingly, 258 studies and texts related to the topic were initially identified. Based on qualitative criteria such as publication date, thematic relevance, and credibility, a total of 64 studies were ultimately selected.

After determining the relevant databases, key information from the articles is extracted. By examining the selected texts in the MAXQDA software environment, codes are identified. Then, the selected articles are qualitatively analyzed to identify research contexts, key topics, and research gaps. Thus, after classifying the codes, themes (concepts) are created, and based on the obtained concepts and their related definitions, subcategories and finally main categories are formed. The basis for categorizing these codes is based on the degree of similarity between different codes. The logic of analysis in this research is based on relational diagrams. In this approach, categorization is performed based on the researcher's intuition and understanding of the subject under investigation. To this end, themes are created according to the researcher's discretion from the concepts. This process continues until all concepts are allocated to subcategories and subcategories to relevant categories. It is noteworthy that in the final stage, the researcher has analyzed the subcategories and the categorization of the examined codes several times to create a foundational understanding of the existing concepts and criteria.

Empirical Grounding Section - Gathering New Data (Classic Grounded Theory Stage)

This section aims to validate and enrich initial concepts with empirical data. In the empirical grounding section, data were collected using the grounded theory method, employing open coding, axial coding, and selective coding to identify and categorize the data.

Conducting In-Depth Interviews with Experts, Supply Chain Managers, and Blockchain

Specialists Selecting expert professors and staff is one of the most critical stages of such research, as the credibility of the results depends on the competence and knowledge of these individuals, and typically, the selection of experts is done through non-probability sampling. One of the methods used in this context is purposive sampling. Interviewees were selected using a snowball sampling method. Before conducting the interviews, the researcher explained the topic and purpose of the research to the interviewees. Some interviews were conducted face-to-face, while others were conducted via phone or using social media platforms like Skype, WhatsApp, etc. Each interview lasted approximately 90-120 minutes. The interviews were semi-structured, meaning that the initial questions were designed based on the codes, themes, and categories derived from the meta-synthesis phase, and new questions were posed based on the responses given. The characteristics of the interviewees are shown in Table 1. Sample members were selected based on specific conditions and criteria, including theoretical mastery, practical experience, willingness and ability to participate in the research, and accessibility. Given the nature of the grounded theory method, the sample size is not predetermined. Instead, it begins with purposive sampling and then progresses to theoretical sampling until theoretical saturation is reached. Therefore, in this section, an analysis of the content of each interview showed that from the sixteenth interview onwards, the repetition of the obtained data was increasing. In this situation, another interview was conducted. Thus, in the seventeenth interview, we reached theoretical saturation, meaning that conducting new interviews does not add anything new to the content of the research. Consequently, after saturation, the number of experts (sample members) was 17. The characteristics of the experts are provided in the table.

Table 1: Characteristics of individuals Interviewees

Job Title	Expert Code	Work Experience	Education	Job Title	Job Title	Expert Code	Work Experience	Education
CEO	I	25	PhD	Lecturer and Supply Chain Expert	Lecturer and Supply Chain Expert	XI	10	PhD
Production Manager	II	14	Master's	Supply Chain Management Lecturer	Supply Chain Management Lecturer	XII	11	Master's
Technical Manager	III	18	PhD	R&D Manager	R&D Manager	XIII	22	PhD
Quality Control Manager	IV	27	Master's	Commercial Deputy	Commercial Deputy	XIV	16	PhD
Group Deputy	V	16	PhD	Warehouse Manager	Warehouse Manager	XV	18	Master's
Warehouse Manager	VI	17	Master's	Operations Deputy	Operations Deputy	XVI	12	PhD
Factory Manager	VII	12	PhD	Sales Supervisor	Sales Supervisor	XVII	13	Master's
Warehouse Supervisor	VIII	19	Master's	Food Supply Chain Specialist	Food Supply Chain Specialist	X	15	PhD
Production Planning Manager	IX	10	Master's					

Analysis of Collected Data Using Coding (Open, Axial, and Selective)

In this section, after each interview, the researcher used MAXQDA software to conduct a thorough study of the interview text, comparing, naming, conceptualizing, and categorizing the data. In open coding, the process of breaking down, comparing, naming, conceptualizing, and categorizing the data takes place. Initially, the data is divided into separate sections. This is done through line-by-line examination of sentences extracted from the literature and the interviewees' responses to identify key words. The similarities and differences among the broken-down data are analyzed, and similar data that carry the same semantic weight are coded under common codes. Subsequently, concepts corresponding to each code are assigned. Through these processes, categorization is achieved. In summary, open coding represents a collection of conceptual categories created after examining the data. In the axial coding stage, the relationships between the categories are determined. In this way, one of the open coding categories is selected as the main category or phenomenon and placed at the center of the process. Other categories (subcategories) are then related to it, and the development of concepts and models is based on new data.

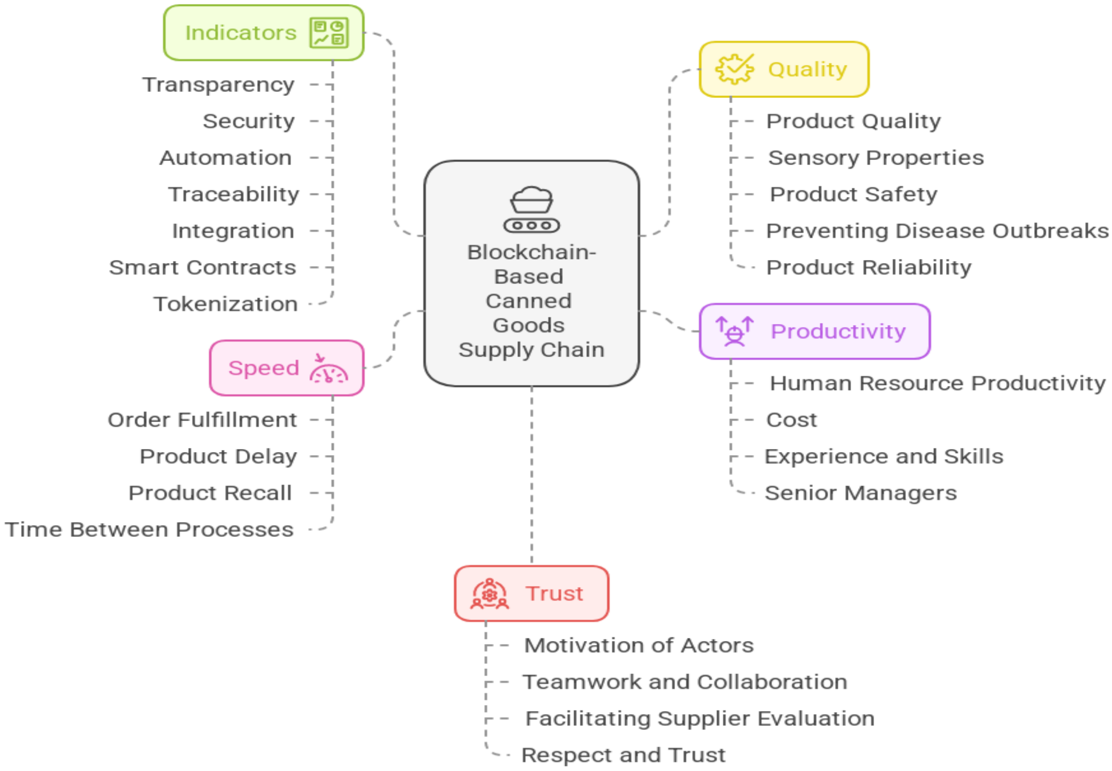

Figure 2:Summary of Extracted Factors Affecting the Management of Canned Food Supply Chains Based on Blockchain Using Meta-Synthesis and Grounded Theory

The governing platform in the organization are factors that, by creating stable conditions, provides a suitable platform for implementing more optimal management of the canned food supply chain. Based on the research literature and the opinions of the interviewees, the factor of the blockchain-based canned food supply chain management platform is the organization's policy regarding the implementation of canned food supply chain management in Iran's one and one factories, which includes the indices of "budget allocation", "organizational culture", and "organizational structure". It should be noted that the concepts and propositions of this section have been produced from 30 codes that were determined during the zigzag process of studying research literature and interviews in the open coding stage. Table 3: Extracted factors related to laws, education, participation, and acceptance using meta synthesis and grounded theory

Table 2: Extracted factors related to rules, education, participation, and acceptance using metasynthesis and grounded theory

Category	Subcategory	Outcome	Open Codes
Rules, education, participation and acceptance	organization	Organizational structure	Organizational levels/Decision level/Fundamental changes//Network organization/Technology adoption/Vertical structure/Organization/Organizational options/Delegation of duties/Multiple communications/
		Organizational training	learning/training/expertise/skill/technical skill/expert
		Budget allocation	Acceptance of technology/cost for creativity/systemization/synchronization with the fourth industrial revolution/budget allocation/financing/risk control costs/financial resources/financial strength of the organization
	outside environment	Rules	Business Laws/Health Laws/Food and Drug Organization/Global Supervision/International Trade/Government Laws/Suppliers/Agricultural Trustees/Indigenization of Technology

Table 3: Factors Related to the Outcomes of Blockchain-Based Food SupplyChain Management for Canned Products Using Meta-Synthesis and Grounded Theory

Category	Subcategory	Outcome	Open Codes
Goals	Outcomes	Increasing speed, greater collaboration, better performance, and cost reduction	Increasing supply chain management speed / Transparent tracking / Reasonable pricing / Tracking from farm to fork / Increased collaboration among actors / ....
		Increasing quality and hygiene, and reducing diseases	Maintaining product quality / Quantitative control / Quality of delivery services / No damage to the product / Transparent tracking / Better supervision by competent authorities / ...
		Customer orientation and support from an overall perspective, and tracking changes	On-time delivery / Delivery at the right place / Timely delivery / Original high-quality product / Easy access / Multiple distribution centers / No congestion at distribution centers / Inspection of the distribution process / Fast delivery / Gamification / ...
		Accountability, Environment	Better and more transparent supervision / Eliminating intermediaries / Minimum pollution / Compliance with green supply chain / ....

Presentation of the Conceptual Model for Blockchain-Based Canned Food Supply Chain Management (Multi-Grounded Theory)

The purpose of this stage is to construct a robust and practical theoretical model. Therefore, the final results of the meta-synthesis and grounded theory data are combined, and the final framework of blockchain-based supply chain management criteria is presented. In this stage, internal grounding is conducted, and the results of grounded theory and empirical grounding are compared. Where no discrepancies exist, the results are integrated. Given that the multi-grounded theory process is an iterative process that flows between existing theories and empirical data, this process continues until data saturation is achieved, thereby enriching the research.

In the final stage, two files from the previous stages are combined, thus integrating the results of the previous stages (internal grounding).

After evaluation by two experts and confirmation of the coherence and integrity of the results, the conceptual model of the research, resulting from a combination of theoretical and empirical foundations, is presented in Figure 3:

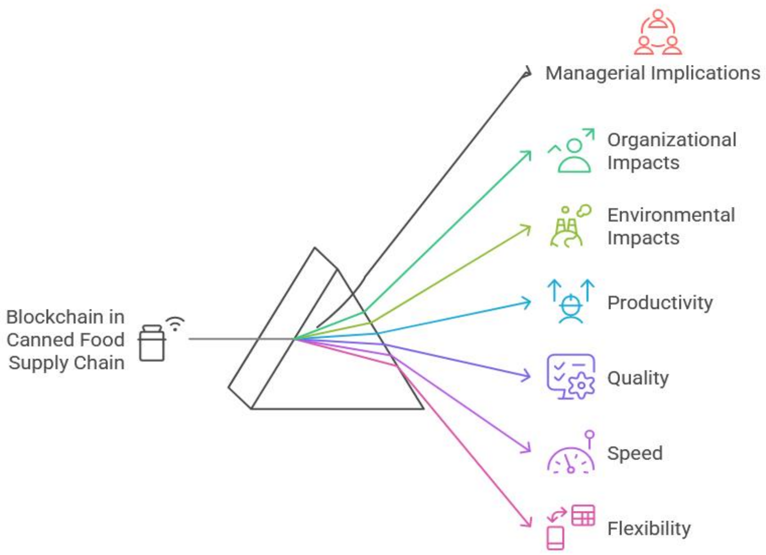

Figure 3: The impact of blockchain in canned food supply chain management

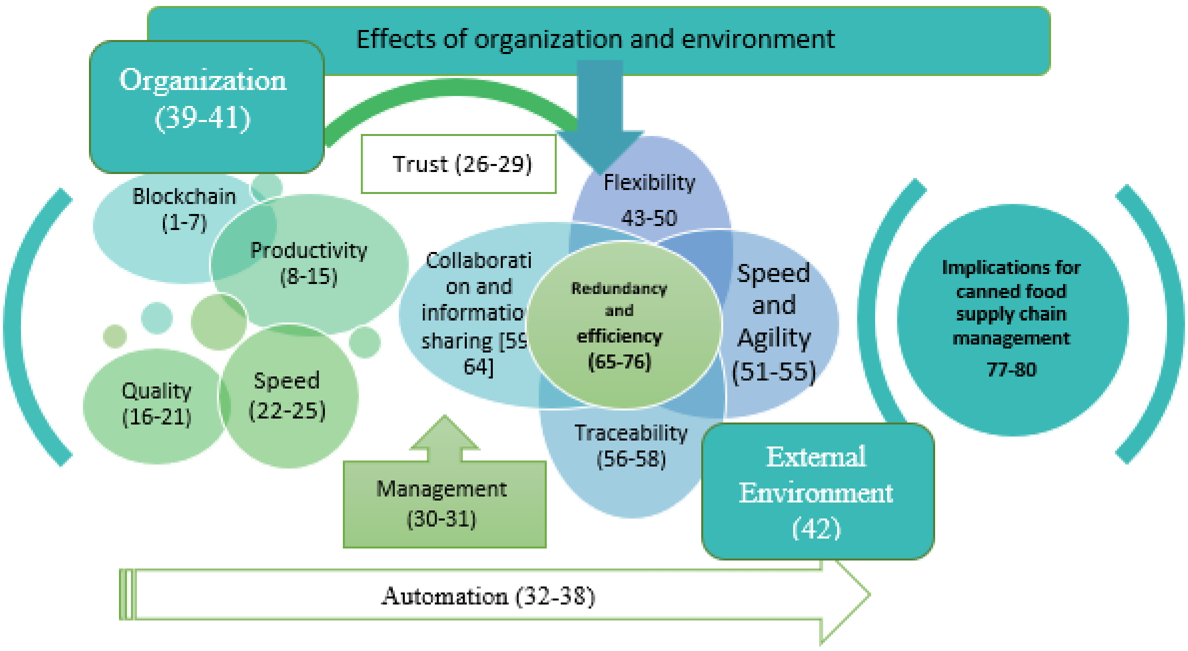

Figure 4: Conceptual Model of the Research

Quality Control of the Model

The purpose of this stage is to evaluate the operational feasibility and accuracy of the final conceptual framework. After coding and obtaining the concepts, internal validity and reliability were assessed to evaluate the results. To assess validity, opinions from two experts were obtained, and the alignment of the study's results and findings with the set objectives was confirmed. For internal reliability assessment, Cohen's kappa coefficient was used. The kappa coefficient determines whether the results and findings have been correctly coded. To monitor the analysis and synthesis results, a supply chain management and meta-synthesis expert was asked to review the output results and provide their perspective using the paired comparison method. The comparison of the expert's views with the findings was evaluated using the kappa index. According to Table 4, the kappa index range of $0.61 \leq k \leq 0.80$ indicates the appropriateness of the analysis and synthesis results.

The calculation of the kappa index in this research was performed as follows: Parameters A and D indicate agreement between two coders, while parameters B and C indicate disagreement between two coders.

$$\text{Observed Agreements} = \frac{A+D}{N} = \frac{11+0}{14} = 0/786$$

$$\text{Random Agreements} = \frac{A+B}{N} * \frac{A+C}{N} * \frac{C+D}{N} * \frac{B+D}{N} = \frac{13}{14} * \frac{13}{14} * \frac{2}{14} * \frac{2}{14} = 0/017$$

$$K = \frac{\cdot/786 - \cdot/017}{1 - \cdot/017} = 0/782$$

Table 4. Kappa Results

Expert's View/ Researcher's View	Yes	No	Total
Yes	A= 11	B= 2	13
No	C= 2	D= 0	1
Total	13	1	N= 14

The kappa index obtained was 0.782, which falls within the range of 0.61 ≤ k ≤ 0.80, indicating the appropriateness of the analysis and synthesis results.

In summary:

- The indices of blockchain speed and agility, blockchain flexibility, traceability, collaboration among actors, and secure information sharing in blockchain technology significantly improve the performance of canned food supply chain management.
- The use of blockchain technology enhances the speed, efficiency, and quality indices in canned food supply chain management.
- Organizational factors such as the type of structure, organizational culture, management support, training of personnel and managers, and allocation of necessary budget impact the application of blockchain in improving canned food supply chain management.
- Regulations related to supervisory organizations, general production laws, transportation, environmental regulations, and safety laws should be considered in blockchain-based canned food supply chain management.
- The application of blockchain in canned food supply chain management results in increased speed, enhanced collaboration, better performance, reduced costs, customer orientation, support for a comprehensive view, and tracking of changes in the supply chain, as well as faster and more responsive environmental preservation components.
- Management implications assist managers and decision-makers in the canned goods industry to improve their supply chain performance by leveraging blockchain technology.

Discussion and Conclusion

The findings of this study indicate that blockchain-based supply chain management can substantially improve the management of canned food supply chains through several interrelated mechanisms, including enhanced speed and agility, improved traceability, stronger collaboration among actors, secure information sharing, and better overall operational performance. These results are consistent with the broader literature that positions blockchain as a foundational technology for reconfiguring supply chain processes around transparency, immutability, decentralization, and data integrity. In the context of canned food, these capabilities are particularly important because the sector depends on reliable quality control, product tracking, inventory visibility, and regulatory compliance across multiple organizational boundaries. The identification of indicators such as transparency, security, traceability, efficiency, cost, managerial support, and complexity in this study also aligns with the dimensions extracted in the underlying qualitative model of the article and is broadly supported by previous studies emphasizing that blockchain adoption in food supply chains should be evaluated not only by technical performance but also by organizational and environmental readiness {Wang, 2019 #390632;Pandey, 2022 #390638;Agarwal, 2024 #390614;Duan, 2020 #390647}.

A central result of the study is that blockchain improves the speed and agility of canned food supply chain management. This finding can be interpreted through the capacity of blockchain to reduce information delays, eliminate redundant verification processes, and allow real-time or near-real-time access to trusted records among distributed actors. In conventional food chains, delays in documentation, fragmented records, and low interoperability often slow response times and increase administrative friction. By contrast, a shared ledger environment allows participants to access a synchronized version of events and transactions, which accelerates decision-making and reduces process bottlenecks. This result is supported by prior research showing that blockchain can improve operational responsiveness and streamline coordination in supply chains, particularly where product integrity and timing are critical {Kshetri, 2018 #390619;Cole, 2019 #390667;Raja, 2025 #371533}. In addition, the integration of blockchain with intelligent tools and IoT-based infrastructures can further strengthen inventory synchronization and dynamic decision-making, which helps explain why the present study identified agility and speed as prominent outcome indicators {Tang, 2024 #390608;Jin, 2025 #342005;Xu, 2025 #266992}.

Another key finding is the importance of traceability as one of the most influential indicators in blockchain-based canned food supply chain management. This result is strongly consistent with the dominant stream of blockchain research in agri-food systems, where traceability is often treated as the most visible and immediate value proposition of blockchain adoption. In food systems, traceability is not merely a technical convenience; it is directly related to food safety, recall efficiency, fraud prevention, product authenticity, and consumer trust. The present findings suggest that blockchain can support more reliable tracking of canned food products across the chain, making it easier to verify origin, monitor handling conditions, and identify responsibility at each stage. Prior empirical and conceptual studies have reached similar conclusions, showing that blockchain-based traceability can reduce the opacity of food supply chains and provide more robust audit trails than traditional centralized systems {Caro, 2018 #390604;Casino, 2019 #390612;Feng, 2020 #390610;Bosona, 2023 #390640}. The same pattern has been observed in sector-specific applications such as dairy, olive oil, aquaculture, and organic food chains, suggesting that the traceability function identified in this study is not an isolated phenomenon but part of a wider structural advantage of blockchain in food systems {Arena, 2019 #390642;Baralla, 2019 #390641;Varavallo, 2022 #390643;van Hilten, 2020 #390644;Luna, 2024 #390627}.

The study also found that secure information sharing and collaboration among supply chain actors significantly enhance supply chain management performance. This is theoretically and practically important because food supply chains often suffer from fragmented communication, low trust, and selective data disclosure across suppliers, processors, warehouses, distributors, and retailers. Blockchain helps address these issues by enabling tamper-resistant and shared information environments in which stakeholders can exchange validated data with lower risk of manipulation. This, in turn, improves coordination and reduces disputes regarding product status, transaction histories, and compliance requirements. Previous studies have similarly highlighted the role of blockchain in fostering inter-organizational trust, information visibility, and collaborative performance {Philsoophian, 2022 #390611;Rejeb, 2020 #390658;Uvet, 2025 #359388}. Moreover, studies on blockchain adoption in supply chains emphasize that transparency is not just a technical attribute but a relational mechanism that strengthens stakeholder confidence and enables more integrated supply chain governance {Zhu, 2018 #390622;Yontar, 2023 #390617;Agnola, 2025 #371529}.

The results concerning efficiency improvement and cost reduction are also highly meaningful. The study suggests that blockchain can improve operational quality while reducing wasteful practices and inefficiencies in the canned food supply chain. This conclusion is consistent with the argument that blockchain reduces duplication of records, automates validation processes, improves data accuracy, and decreases reconciliation costs across organizational boundaries. Especially in food systems, where errors in tracking, expiration monitoring, and supplier verification can create financial and reputational damage, such efficiencies are strategically important. Previous literature has shown that blockchain can contribute to better cost performance through process optimization, fraud mitigation, and lower transaction complexity {Kshetri, 2018 #390619;Yadav, 2020 #390666;Fang, 2025 #286125}. In parallel, recent reviews in the agri-food domain have linked blockchain adoption to broader sustainability and resource-efficiency gains, which further supports the present study's identification of efficiency as a major outcome category {Giganti, 2024 #390625;Heydari, 2024 #390626;Tsolakis, 2023 #390615}.

At the same time, the findings show that blockchain adoption is not determined by technological features alone. Organizational factors such as structure, culture, management support, budget allocation, and training emerged as major influences on implementation success. This result is fully consistent with the TOE framework and with prior blockchain adoption studies demonstrating that firms adopt emerging technologies when technical usefulness is matched by organizational readiness and leadership commitment. In many cases, blockchain projects fail not because the technology lacks potential, but because organizations lack the capabilities, internal alignment, and change-management capacity to deploy it effectively. The emphasis placed in this study on managerial support and organizational preparation therefore reflects a mature understanding of technology adoption as a socio-technical process. Previous empirical research has shown that top-management support, organizational innovativeness, resource availability, and employee capabilities are significant determinants of blockchain uptake in supply chains and related sectors {Chittipaka, 2023 #390629;Malik, 2021 #390630;Asante Boakye, 2025 #286113}. Likewise, studies informed by DOI logic suggest that firms differ in adoption timing depending on their innovation orientation, perceived relative advantage, and tolerance for implementation uncertainty {Park, 2022 #390631;Patil, 2023 #390645}.

The study's identification of complexity as a relevant indicator is equally important, because it prevents an overly optimistic reading of blockchain adoption. While blockchain offers substantial benefits, its implementation often involves technical integration challenges, governance questions, interoperability issues, and uncertainty about standards and platform design. In the food supply chain context, these barriers may be intensified by the heterogeneity of actors, the digital maturity gap across firms, and the need to connect physical product flows with digital records. The literature has repeatedly identified complexity, scalability, and technical readiness as major barriers to blockchain diffusion {Khan, 2023 #390606;Rahimi, 2022 #390650;Pournader, 2020 #390635}. Platform architecture and system openness also matter, because the effectiveness of blockchain ecosystems depends on the rules of participation, validation, access, and integration among stakeholders {Androulaki, 2018 #390657;Kwon, 2019 #390655;Boelsmand, 2020 #390653}. Thus, the present study's findings are valuable precisely because they balance enabling and constraining indicators rather than treating blockchain as a universally frictionless solution.

The role of external regulations and supervisory laws, highlighted in the study, also deserves special attention. Food supply chains are subject to health, transport, environmental, and product-quality regulations, and any blockchain-based management system must operate within these formal institutional constraints. The finding that legal and regulatory conditions affect blockchain-based canned food supply chain management is well aligned with the environmental dimension of the TOE framework and with broader evidence that institutional pressure, compliance requirements, and policy support shape digital technology adoption. In regulated food environments, blockchain may help firms meet compliance demands more efficiently by improving documentation accuracy and auditability, but implementation still depends on legal acceptance, governance alignment, and stakeholder coordination {Danylov, 2024 #390656;Surucu-Balci, 2024 #390623;Luna, 2024 #390627}. This becomes even more relevant as blockchain increasingly intersects with sustainable trade, digital trade infrastructure, and global value chain governance {Gulen, 2024 #390649;Chen, 2025 #377535;Uvet, 2025 #359388}.

Another important contribution of the findings is their connection to supply chain resilience and disruption management. Although the study mainly focused on management indicators, the identified dimensions of transparency, traceability, secure information sharing, and coordination are also critical antecedents of resilience. In recent years, food supply chains have been exposed to severe shocks, including pandemics, inflationary pressures, and sustainability disruptions. Under such conditions, blockchain-enabled visibility and data integrity can help firms identify vulnerabilities earlier, coordinate responses more effectively, and maintain continuity across complex networks. This interpretation is consistent with research on resilient food supply chain design and smart food systems, which emphasizes the importance of digital information infrastructures for coping with volatility and systemic disruption {Gholami-Zanjani, 2021 #390605;Alabi, 2023 #390618;Damoska Sekuloska, 2022 #390637}. The present study therefore adds practical value by showing that blockchain indicators in canned food chains are tied not only to routine efficiency but also to adaptive capacity under uncertainty.

Overall, the discussion of the findings suggests that blockchain-based canned food supply chain management is best understood as a multidimensional capability system rather than a single technological intervention. Its effectiveness depends on the interaction among technical attributes such as transparency, immutability, security, and traceability; organizational conditions such as managerial support, budget, culture, and training; and environmental influences such as regulation, market expectations, and industry pressures. This is consistent with the broader evolution of supply chain management toward digitally enabled, sustainability-oriented, and knowledge-intensive systems {Min, 2019 #390646;Kamilaris, 2019 #390639;Wamba, 2018 #390664}. The contribution of the study lies in contextualizing these dimensions within the canned food sector and in demonstrating, through a multi-grounded theory approach, that meaningful blockchain adoption requires alignment between technological potential and implementation realities. In this sense, the results extend prior reviews and conceptual studies by offering an empirically grounded indicator framework for a specific food subsector while remaining consistent with wider blockchain and agri-food scholarship {Galvez, 2018 #390636;Pandey, 2022 #390638;Giganti, 2024 #390625;Zhang, 2025 #371527}.

One limitation of the study is that it focused specifically on the canned food supply chain, which may reduce the direct generalizability of the findings to other agri-food sectors with different perishability profiles, governance structures, and distribution logics. In addition, the research was qualitative and based on expert interviews and multi-grounded analysis, which provided strong interpretive depth but did not allow statistical testing of the identified relationships or measurement of effect sizes across broader samples. Another limitation is that although important organizational and regulatory dimensions were identified, cross-country institutional differences and platform-level technical heterogeneity were not examined in detail.

Future research should test the proposed indicators quantitatively in larger samples of firms operating in different food and non-food supply chains in order to assess the strength and direction of relationships among blockchain capabilities, organizational readiness, and supply chain performance. Comparative studies across industries, countries, and firm sizes would also be valuable for determining which indicators are context-specific and which are more universal. It would further be useful to examine how blockchain interacts with AI, IoT, predictive analytics, and supply chain finance tools in integrated digital ecosystems, and whether these combinations generate stronger improvements in resilience, transparency, and sustainability than blockchain alone.

From a practical standpoint, managers in the canned food industry should avoid approaching blockchain merely as a fashionable digital tool and instead treat it as a strategic infrastructure that requires process redesign, staff training, governance rules, and long-term commitment. Implementation efforts should begin with high-value use cases such as traceability, inventory visibility, quality assurance, and compliance reporting, then expand gradually as organizational maturity increases. Policymakers and industry associations can support this transition by developing technical standards, encouraging interoperable platforms, and reducing implementation uncertainty for smaller firms. Successful adoption will depend not only on software deployment but also on shared trust, cross-organizational collaboration, and the willingness of stakeholders to institutionalize transparent data practices across the supply chain.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

All ethical principles were adheried in conducting and writing this article.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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