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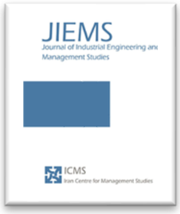

A Conceptual Model for Implementing Blockchain Technology in Manufacturing Supply Chain

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Abstract

This study aims to develop a comprehensive framework for integrating blockchain technology into the supply chain of Golrang Industrial Group. Employing a qualitative research approach, the study follows a data-driven theoretical methodology based on the Strauss and Corbin paradigm model. The research population consists of food industry factories affiliated with Golrang Industrial Group. Data collection was conducted through open interviews with ten industry experts and university professors, selected purposefully. The gathered data underwent analysis using the grounded theory method, comprising open coding, axial coding, and selective coding. The proposed model includes 54 indicators categorized into 19 concepts. The findings reveal that causal conditions for blockchain integration include strategic planning, blockchain structure design, inter-company collaboration, and financial infrastructure development. Industrial transformation, IoT, and artificial intelligence are key enablers, while employee training, continuous data updates, and skill-based selection of blockchain technology play essential roles in implementation. Effective background conditions involve transformational leadership, regulatory frameworks, and scaling mechanisms. The strategies identified include identity and access management, encryption, and secure data transmission. The study highlights blockchain's potential to enhance production security, corporate transparency, product traceability, and cost efficiency in transportation and maintenance. Path coefficient analysis indicates "intervening factors" have the highest impact on "strategies" (0.819), followed by "contextual conditions" (0.625) and "strategies" on "implications" (0.570). These findings provide valuable insights into both the opportunities and challenges of blockchain implementation in supply chain management.

Keywords: Technology, Blockchain, Supply Chain, Golrang Industrial Group, Grounded Theory.

Paper Type: Original Research

1. Introduction

Supply The supply chain encompasses a broad spectrum of entities, information flows, individuals, and activities that work collectively to coordinate planning, monitoring, engineering, and inventory control from the initial stage of production to final consumption (Asgharizadeh et al., 2023; Soltanifar et al., 2022). The fundamental goal of supply chain management is to establish a transparent, efficient, and collaborative environment among stakeholders, ensuring effective information exchange, cost reductions, operational security, and seamless engagement across all parties involved (Soufi et al., 2023; Yousefi et al., 2020; Yousefi et al., 2021). However, as supply chains continue to grow in scale and complexity, they become more susceptible to disruptions, particularly due to globalization, outsourcing, and demand fluctuations (Shashi et al., 2020). These challenges necessitate the adoption of advanced technologies to enhance supply chain resilience, transparency, and efficiency (Sharafi et al., 2021). Blockchain technology has emerged as a transformational tool for modern supply chains, offering an innovative solution to enhance data integrity, security, and transparency among supply chain participants (Attar et al., 2016; Rezaei-Kelidbari et al., 2016). Unlike traditional database systems, blockchain operates as a decentralized and tamper-resistant ledger, ensuring that all recorded transactions are immutable and traceable (Shao et al., 2018). This technology is particularly beneficial in addressing long-standing challenges such as fraud, counterfeit goods, inefficient record-keeping, and lack of real-time visibility (Gurtu & Johny, 2019). By integrating blockchain, supply chain networks can establish trust-based cooperation, enhance operational efficiency, and improve the accuracy of data

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sharing across multiple stakeholders. The increasing adoption of globalized supply chains has resulted in heightened competition, evolving consumer expectations, and the need for faster decision-making (Tavakol et al., 2023a,b; Bahadoran et al., 2022). Additionally, disruptions such as power outages, system failures, network breakdowns, or unforeseen global events can create cascading effects, leading to supply shortages, financial losses, and compromised service quality (Salahi et al., 2023; Kazemi et al., 2024a,b). These vulnerabilities emphasize the necessity for real-time tracking, improved coordination, and enhanced risk mitigation—all of which blockchain technology can effectively address (Slalahi et al., 2021). In parallel, the manufacturing industry is experiencing a digital transformation driven by Industry 4.0, which integrates blockchain, the Internet of Things (IoT), artificial intelligence (AI), and automation to optimize production processes (Ghane et al., 2016; Yadav et al., 2024). These technologies collectively enable decentralized decision-making, predictive analytics, enhanced energy efficiency, and seamless production monitoring (Shen et al., 2022). A key aspect of this transformation is supply chain transparency, which has become a growing concern for both enterprises and regulatory bodies (Casado-Vara et al., 2018). On one hand, the demand for greater supply chain flexibility and agility has forced companies to enhance their operational visibility (Schuitemaker & Xu, 2020). On the other hand, governments and consumers are increasingly demanding insights into product origins and ethical sourcing practices, further emphasizing the need for traceable and verifiable supply chain operations (Liu et al., 2024). Over the last decade, blockchain technology has been increasingly integrated into supply chain management systems, primarily to enhance operational efficiency and data security (Pilkington, 2016). The core advantages of blockchain include decentralization, traceability, and tamper resistance, all of which help mitigate risks associated with fraudulent transactions, unauthorized data modifications, and supply chain opacity (Homayounfar et al., 2018 ,b). Additionally, smart contract functionalities embedded within blockchain networks enable automated and self-executing agreements, eliminating the need for intermediaries and reducing administrative complexities (Gurtu & Johny, 2019). Blockchain operates on a blockchain network architecture, where each transaction is recorded in a series of interconnected blocks (Kim & Shin, 2019). Each block consists of a header and a body, with every new block referencing the preceding one, thus forming a continuous and secure chain of records. The Genesis block serves as the initial foundation of the blockchain, and subsequent transactions are added through a process known as mining. This unique structure ensures data integrity, consistency, and security across the entire supply chain. Despite the growing significance of blockchain technology in supply chain management, there is still a lack of empirical research focusing on the specific organizational and technological factors influencing its adoption (Saberifard et al., 2024). Given the transformative potential of blockchain, it is crucial to examine its implementation patterns, benefits, and challenges within real-world supply chain networks. In light of these considerations, this research aims to explore the implementation pattern of blockchain technology within the supply chain of Golrang Industrial Group. Through an in-depth investigation of the theoretical framework, technological applications, and organizational impacts, this study seeks to provide valuable insights into the adoption dynamics and strategic advantages of blockchain in modern supply chains. The research will further discuss the findings, implications, and potential future applications of blockchain, offering a comprehensive understanding of its role in transforming supply chain operations.

2. Theoretical Foundations

Blockchain technology (BCT) is a form of distributed ledger technology, meaning copies of the ledger are stored across multiple nodes within a network. This decentralized system ensures that records are tamper-proof, reducing the need for a central authority while promoting transparency and trust in data exchanges. One of BCT's most significant advantages is that all network members have access to a shared ledger, fostering trust and accountability (Zheng et al., 2018). Beyond its well-known application in cryptocurrencies, BCT has expanded into areas such as digital identity verification, smart contracts, and supply chain management (De Giovanni, 2020), offering a revolutionary approach to secure and efficient data management (Hariyani et al., 2025). Blockchain technology has undergone several evolutionary phases, each broadening its scope and capabilities. Initially introduced in 2008 by Satoshi Nakamoto as the foundation for Bitcoin, blockchain was designed to be a decentralized, immutable ledger for cryptocurrency transactions. This first-generation BCT removed the need for third-party intermediaries, ensuring security and transparency in digital currency exchanges (Hariyani et al., 2025). The technology's trustless structure set the foundation for broader applications beyond cryptocurrency. The second generation of BCT emerged with the launch of Ethereum in 2015, which introduced smart contracts—self-executing agreements with predefined conditions embedded in software code (Zheng et al., 2020; Fadaei Eshkiki and Homayounfar, 2024). Unlike Bitcoin's blockchain, which was primarily designed for digital transactions, Ethereum enabled automated contract execution without intermediaries, significantly broadening BCT's use cases (Khan et al., 2021). Ethereum also supports decentralized applications, providing an environment for developing financial services, supply chain solutions, and other innovative business models (Tyagi, 2023). This advancement positioned blockchain as a dynamic tool for digital transformation (Massaro, 2023). Blockchain networks can be categorized into permissioned and permissionless types. Permissionless blockchains allow unrestricted participation, promoting transparency, while permissioned blockchains require authorization to access or validate transactions, often preferred in enterprise applications (Kharaghani et al., 2023). Additionally, blockchains can be classified as public, private, consortium, or hybrid (). Public blockchains, like Bitcoin and Ethereum, allow open participation, whereas private blockchains restrict access to authorized users. Consortium blockchains involve multiple organizations managing the network, ensuring a balance between decentralization and control. Hybrid blockchains combine elements of public and private models, providing a tailored approach to different use cases (Zheng et al., 2018). Blockchain technology has the potential to revolutionize supply chain management (SCM) by enhancing procurement, logistics, inventory control, and supplier selection (Blagojevic et al., 2016). One of BCT's most significant advantages is its ability to reduce reliance on intermediaries, leading to cost reductions and improved efficiency. Real-time tracking and monitoring of goods ensure an unprecedented level of transparency and traceability, enabling organizations to respond swiftly to market changes and demand fluctuations. A key benefit of blockchain in SCM is its capability to eliminate counterfeiting by providing end-to-end product traceability (Mackey & Nayyar, 2017). Traditional supply chains often suffer from data inconsistencies and errors during manual entry, but blockchain minimizes these issues by offering a single source of truth shared across all participants (Verhoeven et al., 2018). Moreover, BCT helps businesses predict demand more accurately, manage disruptions effectively, and optimize inventory costs. The decentralized nature of blockchain enhances security within the supply chain by preventing fraud and ensuring data integrity. A significant issue in traditional supply chains is the challenge of maintaining transparency while protecting sensitive business information. Blockchain addresses this by enabling selective data access through encryption, ensuring that only authorized participants can view certain details (Ivanov & Sokolov, 2018). The integration of blockchain with supply chain operations is expected to continue growing, driven by the need for enhanced traceability, efficiency, and sustainability. Companies are increasingly exploring hybrid blockchain models to balance transparency with data security, ensuring that sensitive business information remains protected while maintaining visibility for key stakeholders (Korpela et al., 2017). Blockchain's ability to address identity management issues also presents opportunities for improving authentication and fraud prevention across industries. As digital transactions become more prevalent, blockchain-based identity verification solutions can provide secure and verifiable credentials, reducing risks associated with identity theft and unauthorized access (Casado-Vara et al., 2018). Additionally, blockchain is set to play a pivotal role in sustainability initiatives. Many companies are leveraging blockchain to track carbon footprints, verify ethical sourcing practices, and ensure compliance with environmental regulations (Ivanov & Dolgui, 2020). By providing an immutable record of sustainability-related data, blockchain helps organizations demonstrate accountability and meet evolving consumer expectations for responsible business practices. Blockchain technology has increasingly been integrated into supply chain management (SCM) to enhance security, transparency, traceability, and efficiency. Several studies have explored its applications across various industries, identifying both its advantages and challenges. For example: Jayashri et al. (2023) proposed the Trust Chain, a three-layer blockchain-based system that monitors trust relationships among supply chain participants. This system assigns trust and reputation scores to both products and supply chain members, ensuring transparency. Their model integrates smart contracts to calculate reputation ratings securely and automatically, distinguishing between different participants and services. Irfan Khan et al. (2023) investigated the impact of blockchain on inventory management, demonstrating how it reduces operational costs, improves product traceability, and enhances communication among supply chain actors. The study highlighted blockchain's ability to provide real-time visibility into inventory status, reducing errors and delays. In fraud prevention and supply chain transparency, Susheelamma et al. (2023) focused on how blockchain can revolutionize supply chain management beyond cryptocurrencies. Their research showed that blockchain minimizes errors, prevents fraud, reduces product delays, and enhances transparency. By improving supplier-consumer relationships and eliminating counterfeit risks, blockchain fosters greater supply chain integrity. In agricultural and food supply chains, Srivastava and Dashora (2022) explored blockchain applications in agricultural supply chains, identifying its role in food safety, traceability, transparency, and integration with IoT. Their study, which reviewed 89 research papers, emphasized blockchain's potential in ensuring product authenticity and reducing inefficiencies in food distribution. Henrichs et al. (2025) conducted a systematic review of blockchain applications in food and pharmaceutical supply chains, analyzing 74 studies. Their findings highlighted the dominance of permissioned blockchain networks such as Ethereum and Hyperledger Fabric, which rely on off-chain data storage and restricted access models. Smart contracts were identified as key enablers of supply chain automation, though regulatory and standardization challenges remain major barriers to widespread adoption. In the field of supply chain competitiveness and efficiency, Al-Yassin et al. (2023) examined blockchain's role in enhancing supply chain enterprises and boosting competitive advantages. Their findings showed that investment in blockchain technology leads to significant efficiency improvements across supply chain operations, reducing manual processing time, errors, and administrative costs.

Ranjbar Malekshah et al. (2022) investigated blockchain's application in the vegetable oil supply chain, highlighting key benefits such as improved order fulfillment, supplier communication, and transparency in transactions. Their study found that blockchain significantly reduces lead times and operational inefficiencies. Liu et al. (2024) developed a Blockchain-based Event-driven Tracking (BET) framework, specifically designed to help small and medium enterprises (SMEs) implement customized cooperation tracking systems. Their model includes a blockchain data structure and smart contracts to improve event-driven tracking mechanisms, ensuring real-time visibility and accountability in supply chains. Gurtu and Johny (2019) reviewed 299 research papers on blockchain's role in SCM. Their study identified key trends, industry applications, and emerging challenges. They emphasized that blockchain is eliminating intermediaries, reducing inefficiencies, and fostering greater transparency in global supply chains. Hariyani et al. (2025) conducted a meta-analysis of 480 peer-reviewed papers from the Scopus database, examining blockchain's impact on manufacturing and industrial engineering. Their findings revealed that blockchain enhances automation, transparency, trust, and sustainability by improving real-time traceability and smart contract implementation. Finaly in the sustainability area, Jasrotia et al. (2024) analyzed the relationship between blockchain adoption and environmental performance in green supply chains. Their research, conducted on medium-sized manufacturing enterprises in India, used PLS-based structural equation modeling to establish a positive correlation between blockchain and sustainability initiatives. Liao et al. (2024) applied game theory models to analyze blockchain adoption in green supply chains. Their study examined revenue-sharing and cost-sharing contracts between manufacturers and retailers, showing that while blockchain benefits both parties, consumer privacy concerns and cost implications hinder full adoption. Wang et al. (2023) explored how blockchain influences carbon emission policies and cost asymmetries. Their findings suggested that benchmarking policies encourage manufacturers to reduce emissions, but higher blockchain costs can sometimes lower total emissions, creating a complex relationship between environmental performance and blockchain adoption. While existing research has extensively examined blockchain applications in supply chains, most studies focus on specific sectors (e.g., agriculture, food safety, inventory management, and sustainability) without addressing comprehensive industrial integration. This study bridges this gap by investigating the implementation of blockchain technology in Golrang Industrial Group's supply chain, a large-scale manufacturing and consumer goods enterprise. Unlike prior studies that primarily analyze technical frameworks, environmental impacts, or theoretical models, this research empirically evaluates blockchain's real-world effectiveness in enhancing security, transparency, product traceability, and cost efficiency within a large industrial ecosystem. By employing Grounded Theory methodology and qualitative research techniques, this study identifies key organizational challenges, financial feasibility, and operational constraints associated with blockchain implementation.

3. Research Methodology

This study adopted a qualitative research strategy and employed the Grounded Theory method. Grounded Theory focuses on identifying behavioral patterns derived from everyday experiences, offering valuable insights into research methodologies and guiding future studies. Given the complexities surrounding theoretical frameworks in literature and the evolving nature of data collection techniques, further exploration is warranted (Mackey et al., 2020). Strauss and Corbin (1990) also emphasized that Grounded Theory provides a deeper understanding of human behavior. To collect data, a semi-structured interview method was utilized, consisting of six carefully designed questions. These questions were developed based on an extensive review of relevant literature and refined under the supervision of academic advisors and experts. The interviews were conducted in an open-ended format, either in person or via telephone, with a purposefully selected sample of 10 participants. This group comprised food industry experts, specialists, university professors, and other professionals with relevant expertise.
The data analysis process followed the three main coding phases of Grounded Theory:

1. Open Coding – Identifying concepts, along with their properties and dimensions, within the collected data. Events and occurrences were labeled with conceptual tags, forming initial codes.
2. Axial Coding – Establishing relationships between categories and subcategories along specific dimensions and characteristics. As per Strauss and Corbin's (1998) systematic approach, the derived categories were structured through axial coding.
3. Selective Coding – Developing higher-level abstract categories by making analytical comparisons to highlight similarities and differences. These refined categories served as the building blocks for constructing theories.

Following Strauss and Corbin's (1998) model, this research was conducted in the following steps:

1. Formulating research questions
2. Collecting data
3. Conducting three-stage coding
4. Writing analytical notes to document interpretations and insights
5. Developing and compiling the final theoretical framework
6. Checking the model's validity

The study sample included 10 participants (7 men and 3 women). As shown in the table (1).

Table 1. Demographic characteristics of participants

GROUP	Number	Average age (years)	Average work experience (years)	Education	
				MSe	Ph.D
Golrang Industrial Group food industry managers	3	52.33	25	66.67 %	33.33
Golrang Industrial Group food industry experts	3	41.66	14.33	100%	-
Supply chain specialists	2	46.5	19.5	50%	50%
University professors and experts	2	56	23.5	-	100%

All interviews have been recorded and the audio file has been thoroughly processed. Theoretical saturation was achieved during the eighth interview, nevertheless, interviews were conducted until the tenth sample to ensure the sufficiency of data. To obtain the desired information, the research focused on enriching the interviews. Sample analysis was conducted incrementally after each interview. Written transcripts were generated post-interview, and further key topics and categories were identified during the conceptualization process.

4. Research Findings

4.1. Open Coding

The open coding process consists of three key phases. First, significant excerpts from the text are assigned codes. In the second phase, different open codes that represent the same underlying concept are grouped together to form broader conceptual categories. Finally, in the third phase, these concepts are further organized into overarching categories (Strauss & Corbin, 1998). Given the extensive length of the interview transcripts, Table 2 presents a sample of extracted texts along with their corresponding initial codes.

Table 2. Conceptualization of Verbal Evidence

Open Coding	Verbal Evidence
Agreement and cooperation with supply chain partners	Supply chain protocols establish regulations and norms for engaging with other supply chain members, ensuring effective collaboration.
Compliance with data structure	Blockchain functionality relies on its specific data structure. Selecting a compatible technology enables seamless information storage and transfer through interconnected blocks, ensuring accuracy and verifiability.
Development of IoT usage	IoT technology allows employees to collect and share supply chain data through connected devices, enhancing real-time monitoring and decision-making.
Awareness of challenges and limitations	Organizations must train employees on blockchain-related challenges and limitations to anticipate obstacles early and develop effective implementation strategies.
Strengthening security and data protection	Blockchain enhances data security through strong cryptography and digital signatures. Encrypted data within blocks remains protected, with unauthorized changes promptly detected by the network.
Utilizing the right data coding system	Secure data management in blockchain relies on advanced cryptography and digital signatures. Any unauthorized modifications are flagged, ensuring data integrity.
Enhancing blockchain speed and efficiency	Implementing effective design patterns in blockchain technology improves its operational speed and efficiency, optimizing supply chain performance.

The next phase of open coding involves presenting tables that illustrate the concepts derived from secondary codes and the categories formed from these concepts. Through data collection and interviews, this study has identified 19 components and 54 indicators, systematically organized for analysis.

- **Causal Conditions**

This research aims to identify the causal conditions influencing the implementation of blockchain technology in the manufacturing supply chain. These conditions include strategy design and goal setting, blockchain structure design, fostering inter-company cooperation and standardization, and establishing the necessary financial and economic infrastructures. Table 3 provides a detailed overview of these conditions.

Table 3. Classification of causal conditions

Category	Component	Indicator
Causal conditions	Strategy design and goal setting	Analyzing the company's environment and needs, developing suitable strategies for blockchain implementation, and monitoring and evaluating the implemented model.
	Block chain structure design	Selecting the appropriate blockchain type, defining its scope and limitations, and choosing the right supporting technology.
	Development of inter-organizational cooperation and coordination	Enhancing transparency and trust among supply chain members, fostering shared interests, and establishing common standards and regulations between companies.
	Providing appropriate financial and economic infrastructure	Implementing systematic financial changes, developing a viable technological business model, and allocating a dedicated budget for blockchain adoption.

The successful implementation of blockchain technology in the supply chain of **Golrang Industrial Group** requires several essential causal conditions:

1. **Strategy Design and Goal Setting:** This process involves assessing the organization's environment and requirements, formulating effective strategies for blockchain integration, and establishing systems to monitor and evaluate the implementation framework.
2. **Blockchain Structure Design:** This phase includes selecting the appropriate blockchain type, defining its scope and limitations, and identifying the optimal technological infrastructure to support the blockchain solution.
3. **Development of Inter-Company Cooperation and Coordination:** Ensuring transparency and trust among supply chain stakeholders is crucial. This process fosters mutual interests, establishes standardized regulations, and promotes collaboration between firms to enhance coordination and efficiency.
4. **Provision of Financial and Economic Infrastructure:** Effective blockchain adoption necessitates systematic financial adjustments, the development of a sustainable business model, and the allocation of dedicated funding for blockchain initiatives.

The establishment of these causal conditions is fundamental to creating a robust foundation for the seamless integration of blockchain technology within Golrang Industrial Group's supply chain. By addressing strategic planning, technological considerations, inter-company relationships, and financial infrastructure, the organization can ensure a structured and efficient implementation process.

Moreover, the successful integration of blockchain technology requires a specialized team equipped with the necessary expertise to manage risks and oversee operations. Continuous training and education programs are also essential to keep employees updated on the latest advancements in blockchain technology and its applications in the supply chain. By fostering a culture of innovation and continuous improvement, Golrang Industrial Group can ensure the long-term success of its blockchain adoption efforts.

- **Contextual Conditions**

The contextual conditions outlined in Table 4 for this study encompass utilizing a transformational leadership approach, establishing norms and legal frameworks, and implementing a scaling method within the organization.

Table 4. Classification of contextual conditions

Category	Component	Indicator
Contextual Conditions	Using a transformational leadership style	Development of transformational leadership and appropriate organizational commitment, appropriate management of knowledge, use of successfully implemented models
	Providing standards and legal settings	Providing data protection laws and regulations, providing security standards, providing standards related to inter-company information sharing
	Development of scaling procedure in the company	Development of chain technology sustainability, creating a suitable technological networking between supply chain members, providing flexible technological architecture

The successful implementation of blockchain technology in the supply chain of Golrang Industrial Group depends on several key conditions:

1. Adopting a Transformational Leadership Style: This involves fostering transformational leadership, cultivating strong organizational commitment, implementing effective knowledge management practices, and leveraging successful models for blockchain adoption.
2. Establishing Standards and Legal Frameworks: Ensuring compliance with legal and regulatory requirements requires enforcing data protection laws, implementing robust security protocols, and defining clear criteria for intercompany information exchange.
3. Developing Scalability Procedures: To sustain blockchain technology over time, it is essential to enhance its scalability, establish a reliable technology network among supply chain members, and implement a flexible technological architecture that supports the expansion of blockchain solutions.

These contextual conditions serve as the foundation for a conducive environment within Golrang Industrial Group, facilitating the effective integration of blockchain technology into its supply chain. By addressing leadership, regulatory compliance, and scalability, the organization can create a structured and adaptable framework for blockchain adoption.

- **Intervening Conditions**

In addition to these foundational requirements, this study identifies several intervening conditions that influence blockchain implementation. These include:

1. Providing Necessary Training to Employees: This process involves enhancing employees' knowledge of blockchain technology, familiarizing them with associated technologies, and conducting case studies and practical experiments to test blockchain applications.
2. Updating Company's Dataset: Successful implementation requires the development of technology policies and procedures for efficient information dissemination. Additionally, innovative approaches should be adopted to gather and incorporate employee feedback on blockchain technology, ensuring continuous improvement and adaptation.

3. Developing Skill-Based Procedures for Blockchain Selection: This involves integrating blockchain technology with supply chain processes while enhancing the company's technological capabilities to ensure that the selected blockchain aligns with specific supply chain requirements and protocols.

Table 5 presents a detailed breakdown of these intervening conditions, which play a crucial role in ensuring a smooth and sustainable blockchain integration process.

Table 5. Classification of intervening conditions

Category	Component	Indicator
Intervening conditions	Providing necessary training to employees	Developing awareness of blockchain technology, developing employees' familiarity with technologies related to blockchain, conducting case studies and practical tests in the form of a pilot.
	Updating company's dataset	Providing technological policies and procedures in the dissemination of information, using new methods in collecting and communicating employee opinions about blockchain technology.
	Development of skill-based procedures in block chain selection	Coordination of blockchain technology with supply chain protocols, development of technological capabilities of the company

These intervention conditions are crucial for preparing Golrang Industrial Group—its workforce, organization, and technological infrastructure—for seamless blockchain integration. By prioritizing transparency, traceability, and efficiency, the company can establish itself as a leader in blockchain adoption. Focusing on employee training, continuous information updates, and technological alignment will enable a smooth and effective implementation of blockchain solutions.

- **Strategic Conditions**

In this study, the strategic conditions for blockchain implementation include: effective management of identity and access to ensure data security, Utilization of robust security measures and data encryption techniques, and prioritization of secure data transmission to protect sensitive information. Table 6 provides a detailed overview of these strategic conditions, which play a vital role in ensuring the secure and efficient deployment of blockchain technology.

Table 6. Classification of strategic conditions

Category	Component	Indicator
Strategic Conditions	Appropriate management of identity and access	Accurate and unique identification for different corporate entities, use of appropriate authentication system, development of proofs and approvals methods.
	Using appropriate data security and encryption methods	Use of appropriate cryptographic algorithm, proper management of cryptographic keys, use of appropriate digital signature mechanisms
	Emphasis on the safe transfer of data and information	Using the right system for data coding, developing information network security, providing physical block chain security guarantees

This section introduces various strategies designed to safeguard the security and integrity of data and information during the adoption and implementation of **blockchain technology** within **Golrang Industrial Group's supply chain**. These strategies include:

1. **Proper Management of Identity and Access:** This involves the rigorous verification of unique and precise identities for corporate entities. Implementing robust authentication systems and establishing standardized procedures for documentation and approval processes are essential to ensure secure access control.
2. **Utilizing Advanced Security and Data Encryption Methods:** This strategy emphasizes the importance of implementing **effective encryption algorithms**, managing **encryption keys securely**, and leveraging **digital signature mechanisms** to protect data integrity and confidentiality.
3. **Ensuring Secure Data and Information Transmission:** The adoption of **strong encryption protocols**, enhancement of **network security**, and implementation of **physical security measures** are critical for safeguarding blockchain data.

These strategies address key aspects of data security, including identity management, encryption, and secure data transfer. Their primary objective is to protect sensitive company information while ensuring its reliability and confidentiality. Organizations must prioritize these security measures to mitigate risks, prevent data breaches, and eliminate unauthorized access. By implementing these strategies, companies can establish a secure and resilient blockchain framework, reinforcing stakeholder trust and ensuring compliance with regulatory and industry standards. Ultimately, a robust security infrastructure enhances business flexibility and competitiveness, positioning organizations for sustainable success.

- Core Phenomenon

The core requirements identified in Table 7 focus on factors related to the Industrial Revolution, alongside the advancement of IoT and artificial intelligence (AI) implementation within the organization. These elements serve as the central category for this research, providing a foundation for understanding blockchain adoption within Golrang Industrial Group.

Table 7. Classification of the core category

Category	Component	Indicator
Core phenomenon	Industrial-oriented transformation	Supplying skilled human resources, appropriate technological changes in the company structure, providing suitable mechanisms for solving inter-company disputes
	Development of IoT and artificial intelligence	Paying attention to employee innovation in the field of IoT and artificial intelligence, developing cooperation with knowledge-based companies

The core phenomenon pertains to the fundamental components required for industrial transformation within a corporation including human resources, technological advancements, conflict resolution, and the strategic development of IoT and AI capabilities. These include:

1. **Industrial-Oriented Transformation:** This encompasses the provision of skilled manpower, the implementation of technological advancements in the company's infrastructure, and the establishment of procedures for resolving inter-company conflicts.
2. **Development of IoT and Artificial Intelligence:** The primary focus of this component is on the development and utilization of IoT and AI in the corporate sector. It involves fostering innovation among employees in the fields of IoT and AI, as well as enhancing collaboration with knowledge-based companies specializing in these fields.

Effectively implementing these fundamental components is essential to securing a competitive edge for the company in an industry that is rapidly evolving. By focusing on enhancing the capabilities of the workforce and embracing technological progress, the company can improve its operational efficiency and flexibility. Moreover, implementing efficient conflict resolution strategies promotes a cohesive workplace atmosphere and streamlines decision-making and teamwork. Adopting IoT and AI technologies propels the company to the forefront of innovation, empowering it to leverage new opportunities and stay ahead of industry trends.

- Implications

Finally, the implications reflect the results derived from the execution of the proposed plans. This study categorizes the findings into several key areas:

Table 8. Classification of implications

Category	Component	Indicator
Implications	Improving the security of production and trade	Proof of authenticity and falsifiability, transaction verification, and enhancement of transfer information security.
	Development of corporate transparency	Transparency in financial transactions, business activities, and monitoring and inspection processes.
	Improved tracking and tracing of company products	Accurate product tracking, identity verification, fraud prevention, and increased trust capabilities.
	Reducing transportation and maintenance costs	Reduction of costs related to product failures and errors, elimination of intermediaries and executive actions, and decreased security costs for product preservation.

1. **Impacts on Enhancing Production and Trade Security:** The incorporation of blockchain technology significantly improves the security of production and trade by ensuring the authenticity and falsifiability of products and transactions. Additionally, it strengthens the security of transfer information, making it more difficult for malicious actors to compromise the system.
2. **Effects on Promoting Corporate Transparency:** Blockchain enhances corporate transparency by providing real-time access to transparent financial transactions, business activities, and monitoring and inspection processes. This transparency builds trust and accountability across all levels of the organization and with external stakeholders.
3. **Outcomes of Improving Product Tracking and Tracing:** Blockchain facilitates more accurate tracking and tracing of products, offering proof of identity and helping prevent fraud. This improvement increases customer trust and ensures greater confidence in the authenticity and quality of products.
4. **Consequences of Reducing Transfer Costs:** The integration of blockchain reduces transportation and maintenance costs by minimizing errors, eliminating intermediaries, and cutting down on enforcement actions. Moreover, it lowers security costs related to product preservation, resulting in more efficient and cost-effective operations.

Briefly, the adoption of blockchain technology in Golrang Industrial Group's supply chain has the ability to improve various aspects of the supply chain, including security, transparency, traceability, and cost-effectiveness. This has the potential to create a more streamlined and dependable supply chain ecosystem.

4.2. Selective coding

The final phase in the grounded theory method is known as the selective coding stage. This phase involves selecting the main category, establishing systematic connections between this main category and other categories, validating these connections, and refining and developing categories that require additional attention. Taking into account the preliminary studies, opinions of the interviewed individuals, and the analysis of data collected using the foundational data theory method, the present research establishes a proposed model. This model is derived by calculating the main concepts and is depicted in Figure 1.

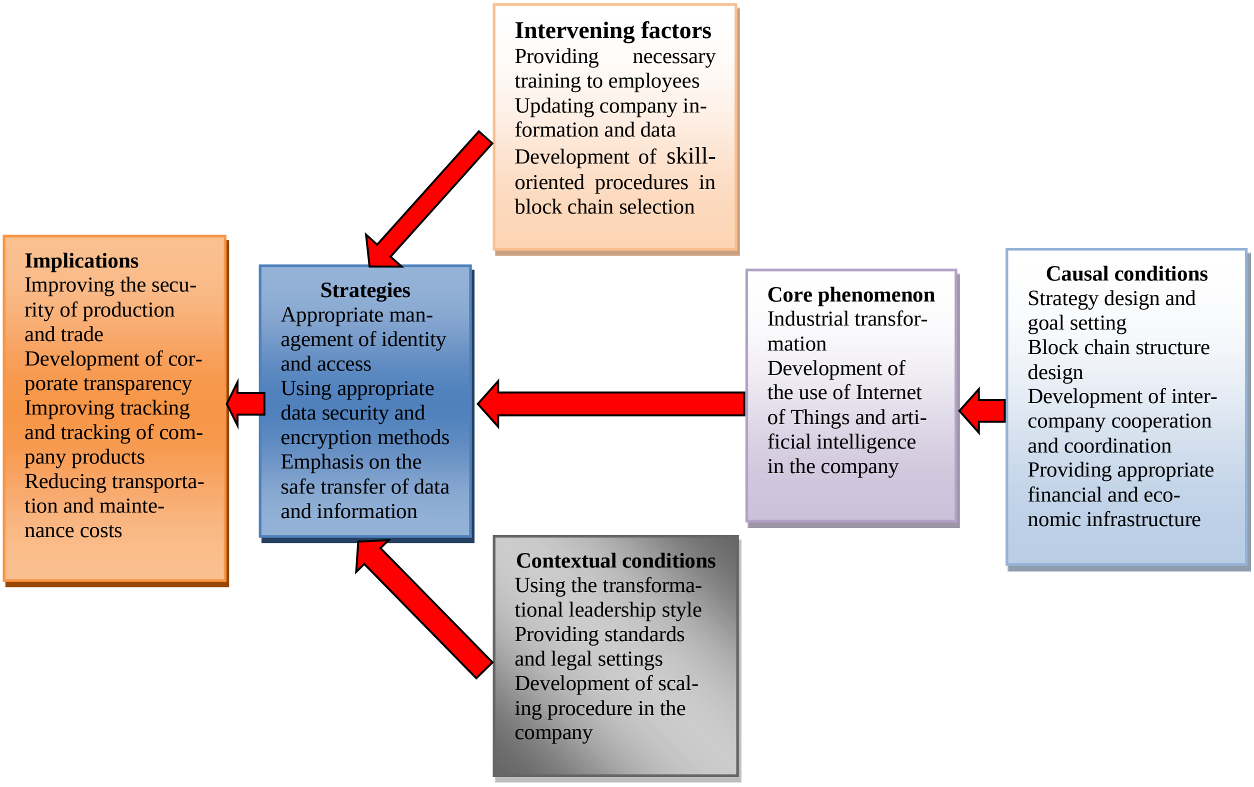

Figure 1. Research conceptual model

4.3. Analysis of the Conceptual Model Relationships

In this section, in order to analyze the data gathered in the quantitative section, first the variables were described through statistical parameters, and then the relationships of the conceptual model (SEM) were tested using the structural equation modeling method. It is obvious that prior to testing the model and examining the significance of its relationships, it is necessary to assess the variables of the model in terms of statistical parameters.

4.4. Evaluation of Distribution of Variables and Model Fit

In order to determine the approach used for data analysis (variance-based or covariance-based), the result of the Kolmogorov-Smirnov test (the last column of Table 4) was used. Since the significance level of model variables is less than 5%, Therefore, at the 95% confidence level, all research variables have a non-normal distribution. thus, the partial least squares (PLS) using Smart PLS3 is applied. A two-step approach has been used to implement SEM: First, the measurement model is explored to ensure the appropriate reliability and validity, and then the results of the structural model are presented. Cronbach's alpha coefficient is used to assess the reliability of the measurement model, with values above 0.7 indicating acceptable reliability. To check the validity of the measurement model, convergent validity and divergent validity indicators have been used. Convergent validity was assessed using factor loadings, composite reliability (CR), and mean-variance extracted, as shown in Table 4. The coefficients of the factor loadings determine how much of the variance of the latent variables are explained by the latent variable. Composite reliability reflects the correlation of the items of each construct, with an acceptable threshold of 0.6. The acceptable value for the mean-variance extracted for each of the main variables of the model is 0.5. Divergent validity has been evaluated based on the correlation of latent variables with each other. If the correlation between latent variables is not excessively high (above 0.7), it can be concluded that the constructs are measuring different aspects. The results indicated that the main variables had correlations lower than 0.7 with each other, confirming appropriate divergent validity of the measurement model. The structural model was evaluated using the coefficient of determination (R^2) and its comparison with the thresholds of 0.19, 0.33, and 0.67, representing weak, moderate, and strong R^2 values, respectively. With the R^2 value for the pharmaceutical value chain variable at 0.269 (as seen in Figure 3), the structural fit of the model was deemed acceptable.

Table 9. Validity, Reliability and Normality of Model Variables (** P < 0.05)

Variable	Concept	Load Factor	T	Cronbach α	CR	AVE	Test K-S	
							Z	Sig
Implications	-			0.744	0.576	0.592	0.294	0.000
	IMP1	0.779						
	IMP2	0.804						
	IMP3	0.720						
	IMP4	0.901						
Strategies	-	0.570	5.262	0.762	0.589	0.518	0.338	0.000
	STR1	0.779						
	STR 2	0.817						
	STR 3	0.815						
Intervening factors	-	0.819	7.370	0.824	0.618	0.603	0.165	0.000
	INT1	0.920						
	INT2	0.809						
	INT3	0.874						
Contextual conditions	-	0.625	6.096	0.745	0.712	0.567	0.312	0.000
	CON1	0.802						
	CON2	0.861						
	CON3	0.904						
Core phenomenon	-	0.484	4.113	0.757	0.664	0.524	0.452	0.000
	COR1	0.780						
	COR2	0.921						
Causal conditions	-	0.262	3.281	0.781	0.592	0.543	0.345	0.000
	CAU1	0.808						
	CAU2	0.762						
	CAU3	0.794						
	CAU4	0.824						

Finally, the goodness of fit (GOF) index was used to assess the overall fit of the model (measurement and structural). To calculate the GOF index, root square of the multiplication of $\overline{com}$ (0.558) and $\bar{R}$ (0.385) was used. The amount of this index for the research model is equal to 463. According to the three values of 0.1, 0.25 and 0.36 which are introduced as weak, medium and strong values for GOF, 0.463 indicates a strong fit of the model.

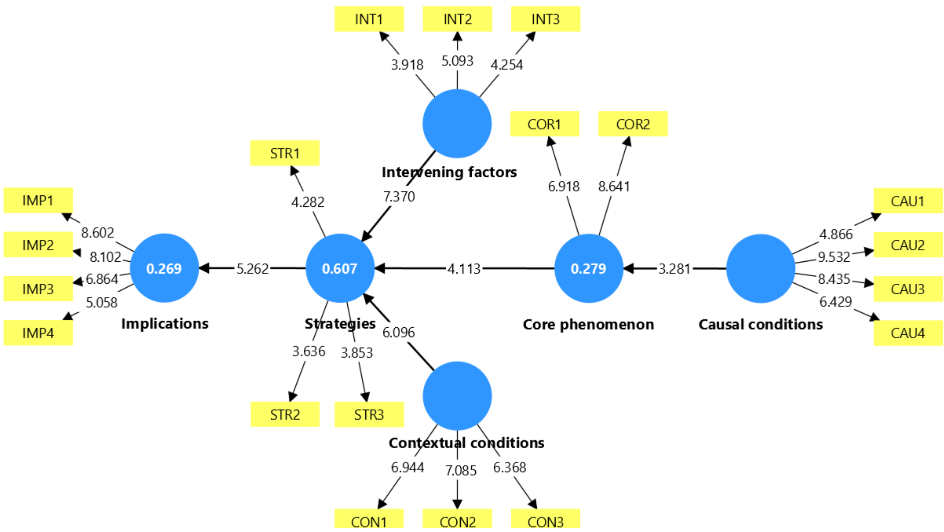

Figure 2. Research model in case of significant values

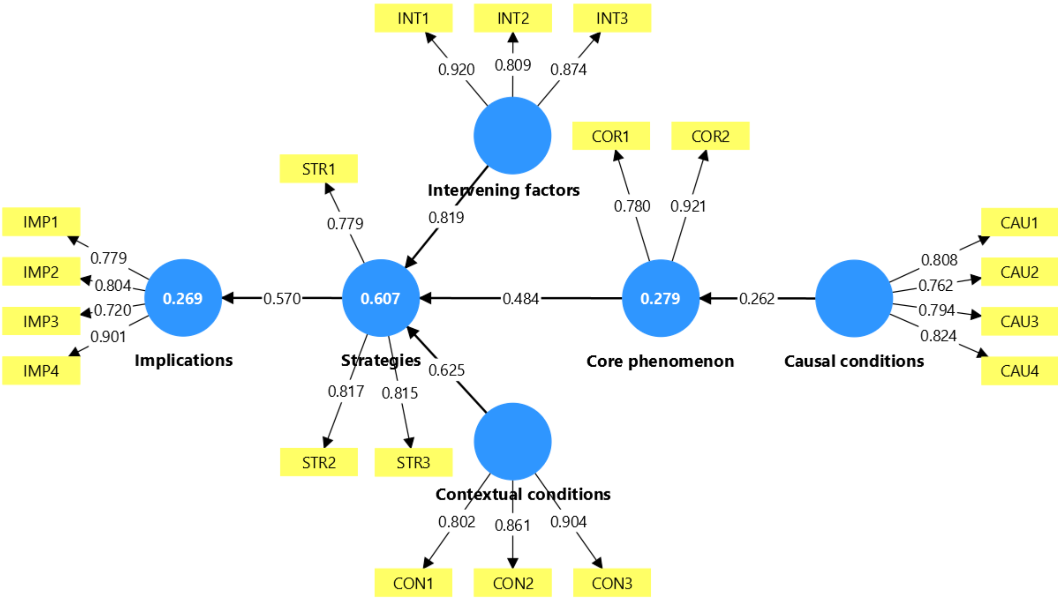

Figure 3. Research model in case of standard coefficient

4.5. Model Relations Evaluation

After assessing the model fit, the significance of the model relationships has been examined. According to the t-statistic values, any value outside the range of [-1.96 1.96] indicates a significant relationship at a 95% confidence level. According to the significant values in figure (2), all t-values don't lie within the significance range, indicating their significance in the proposed model. In this study, the significance of model's relationships, investigated using path coefficients (factor loading). The results indicates that "intervening factors" has the highest path coefficient in relation to "strategies" (0.819), followed by the path coefficient of "contextual condition" and "strategies" (0.625). The impact of "strategies" on "implications" is also relatively high (0.570). While, the coefficient between "core phenomenon" and "strategies" and "casual conditions" and "core phenomenon" are equal to 0.484 and 0.262, respectively.

5. Discussion and conclusion

In recent years, the integration of blockchain technology in supply chain management has become an essential topic of research and practice. This study aimed to develop a comprehensive framework for implementing blockchain technology within the Golrang Industrial Group's supply chain, utilizing a qualitative research approach based on Strauss and Corbin's paradigm model. Data was collected through in-depth interviews with ten food industry experts, university professors, and specialists, followed by a rigorous grounded theory analysis. The coding process resulted in the extraction of 54 secondary codes, which were subsequently classified into 19 distinct concepts. The findings identified several critical factors influencing the successful adoption of blockchain technology within supply chain operations. Among the most significant causal conditions were blockchain strategy and structural design, inter-company collaboration, and robust financial infrastructure. Additionally, core factors such as industrial transformation, the integration of IoT and AI, and workforce skill development emerged as pivotal in driving blockchain adoption. Furthermore, the study highlighted contextual elements, including transformational leadership, legal frameworks, and organizational scaling strategies, as essential prerequisites for a seamless blockchain integration process. Moreover, effective identity and access management, encryption protocols, and cybersecurity measures were recognized as critical strategic enablers for blockchain implementation. The research findings underscore the tangible benefits of blockchain adoption in supply chain operations, particularly in enhancing production security, improving corporate transparency, optimizing product traceability, and minimizing transportation and maintenance costs. These results offer a deeper understanding of both the opportunities and challenges associated with blockchain deployment in the food supply chain industry. Furthermore, the outcomes of this study align with previous research conducted by Jayashri et al. (2023), Susheelamma et al. (2023), and Ranjbar Malekshah et al. (2022), further validating the significance of blockchain technology in modern supply chain management. The insights gained from this research can serve as a foundation for future studies and practical implementations of blockchain-driven supply chain optimization, not only within Golrang Industrial Group but also across other analogous industries. This study contributes to the expanding body of knowledge on blockchain applications in supply chain management, offering a well-defined model for integration and an in-depth analysis of its benefits and potential obstacles. Future research should focus on comparative studies examining blockchain integration in various food industry supply chains, evaluating sector-specific challenges, advantages, and operational outcomes. Additionally, the study recommends exploring the synergies between blockchain and other emerging technologies, such as IoT, artificial intelligence (AI), and big data analytics, to optimize food supply chain efficiency and sustainability.

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