Digitalization and Management Innovation III
A.J. Tallón-Ballesteros (Ed.)

doi:10.3233/FAIA250019

Exploring Digital Transformation in the Grain Supply Chain: A Case Study of the Lu Liang Group

Kaili Zhang[1] and Xicai Zhang
[a] *Beijing Wuzi University, China*
ORCiD ID: Kaili Zhang https://orcid.org/0009-0005-9930-362X

Abstract. Amid the trend of global economic integration and digitalization, the stability and sustainability of the food supply chain have become a focal point of concern for many. Governments worldwide are promoting the digital transformation of the food supply chain to enhance operational efficiency, strengthen system resilience, and ensure food safety. The use of digital tools has significantly improved the supply chain's response time, providing the flexibility needed to adapt quickly to market fluctuations and potential shocks. However, the digitalization of the food supply chain also faces a series of challenges. This article delves into the patterns of digital transformation, using the Lu Liang Group as a case study to analyze its rationality and feasibility. Through the analysis of the Lu Liang Group, the article aims to provide valuable experience and reference for other companies in the same industry to optimize their supply chain management and play a greater role in the global food security system.

Keywords. Digital transformation; food supply chain; Lu Liang Group

1. Introduction

China, as a traditional agricultural powerhouse, plays a significant role in the country's overall modernization process. Currently, Chinese agriculture is at a critical juncture of transitioning from a smallholder-based system to a modernized agriculture, which is essential for ensuring national food security, enhancing agricultural competitiveness, and achieving sustainable development. Digitalization has become the cornerstone of modernization and innovation, supporting the transformation of industries and economies worldwide[1][2]. As a new engine for economic development, digital transformation provides novel solutions for the modernization of the grain supply chain[3]. However, due to the relatively low value of grain and the significant upfront investment required for digital transformation[4], there are numerous challenges faced during the digital transformation of the grain supply chain [5]. Amid growing concerns over global food security[6], how to enhance efficiency, transparency, sustainability, and ability to tackle various challenges of the grain supply chain through digital means has become a field that urgently needs in-depth research[7]. This study aims to construct a model for the digital transformation of the grain supply chain, taking the practice of Shandong Lu Liang Group as an example to explore its specific applications and

[1] Corresponding Author: Kaili Zhang, Beijing Wuzi University, China; Email: 2634839620@qq.com

effectiveness in the digital transformation process, providing a reference for other grain companies and supply chain management.

2. Theoretical Foundation and Literature Review

2.1. Theoretical Foundation

Chen Guoquan (1999) suggests that the concept of the supply chain has evolved from the traditional, expanded production concept. The process, which includes the procurement of raw materials and components, transportation, processing and manufacturing, and distribution, culminating in the final delivery to customers, is regarded as an interlocking chain[8]. This chain is what we define as the supply chain. Supply chain management encompasses the planning, coordination, operation, control, and optimization of the entire supply chain system. The goal is to deliver the right products to the right customers, at the right time and place, in the correct quantity and quality, while minimizing the total cost. Shen Houcai et al. (2000) consider the supply chain to be a business process model. This model encompasses the value chain, starting from the end customer and including raw material and component suppliers, product manufacturers, distributors, and retailers, to fulfill customer demand and provide the necessary products and services[9].

Ma Junkai and others (2023) define the resilience of the grain supply chain as "the capacity of the grain supply chain to withstand and effectively respond to a variety of internal and external shocks and pressures." This includes maintaining stability, preventing disruptions, and adjusting to return to pre-impact operational states[10]. Ideally, the chain should also be capable of leveraging crises as opportunities to innovate and improve its structure in the face of market and environmental challenges, both domestically and internationally. Tao Yaping (2023) further classifies the current grain supply chains in China into four distinct types: processing, wholesale, logistics and distribution, and retail[11].

2.2. Literature Review

Currently, Chinese enterprises generally lack a spirit of cooperation and act independently, which artificially disrupts the connection between supply chain stages, leading to issues such as delayed supply chain response, poor communication, and high supply chain costs.

Li Tianxiang and Zhu Jing (2024), after reviewing the experiences and practices of the United States, Canada, and Japan in developing post-harvest grain services, propose to target the entire chain and actively promote transformation, upgrading, and service extension[12]. The grain supply chain system faces numerous challenges in ensuring an efficient, sustainable, and resilient operation. The digital economy of grain enterprises has experienced two significant leaps: first, from tool-based to intelligent systems, and second, from intelligent to more integrated and systematic approaches. These advancements have bolstered the resilience of the grain supply chain, optimizing the production process, enhancing management capabilities, and upgrading the sales segment. Abduwali Aibai and colleagues (2024) believe that rural digitization directly enhances the resilience of the grain supply chain by bolstering its resistance, recovery, and transformation capabilities[13]. This enhancement is predicated on the endowment

and development level of agricultural resources, which are crucial for the digital economy to empower the supply chain's resilience.

Literature review reveals that current research has to some extent focused on exploring how digital transformation enhances the resilience of the grain supply chain by improving its efficiency and transparency, as well as by applying digital technology to make grain production, distribution, and consumption more intelligent and precise. However, there is still a lack of in-depth analysis on the challenges faced by grain enterprises during digital transformation.

3. Internal and External Factors Driving Transformation

Internal factors in corporate digital transformation often include data-driven integration, innovation, operational efficiency, and upgrades in supply chain collaboration. These elements directly affect the feasibility and efficiency of the transformation process. External factors include policy support, shifts in market demand, and technological advancements. Although not directly controlled by organizations, these factors have a profound impact on the direction and strategic decisions of the organization. This article will explore how these factors propel supply chain digital transformation and innovation.

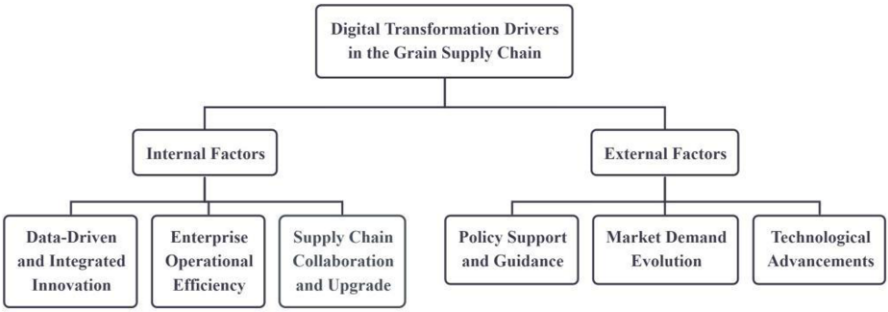

Figure 1. Internal and External Factors Driving Transformation.

3.1. Internal Factors

- Data-Driven and Integrated Innovation

In the digital transformation of the grain supply chain, data-driven and integrated innovation are one of the core internal factors. By leveraging technologies like big data, cloud computing, the Internet of Things, and artificial intelligence, grain companies can achieve real-time monitoring and data analysis of all supply chain stages. This optimizes decision-making, enhances operational efficiency, and improves the ability to respond to market changes. This data-centric culture of innovation is key to propelling the grain supply chain towards intelligence and automation.

- Enterprise Operational Efficiency

Digital transformation significantly impacts business operational efficiency. By adopting advanced information technology, grain companies can automate and optimize

production processes, reducing human errors and boosting productivity. With digital supply chain management, businesses can track inventory and logistics in real-time, fine-tune inventory levels, and minimize the risks of overstock or shortage. These efficiency gains not only cut costs but also strengthen a company's competitive edge in the market.

- Supply Chain Collaboration and Upgrade

Supply chain collaboration and upgrading is another crucial internal factor in the digital transformation of the grain supply chain. The application of digital technology facilitates information sharing and process collaboration between upstream and downstream enterprises in the supply chain, enhancing its transparency and coordination. By establishing a unified data platform, all supply chain parties can share inventory, demand, and logistics information in real-time, leading to more accurate supply-demand matching and more effective resource allocation.

3.2. External Factors

- Policy Support and Guidance

The government plays an indispensable role in fostering the digital transformation of the grain supply chain. By enacting and implementing policies, it offers directional guidance and substantial support to businesses, including funding, tax incentives, and research and development grants. The policies and measures collectively constitute a significant external driving force for the digital transformation of the grain supply chain.

- Market Demand Evolution

As consumer demands for food safety and quality increase, market demand evolution becomes another significant external factor driving the digital transformation of the grain supply chain. Consumers increasingly prefer food brands that offer transparent and traceable information, prompting companies within the grain supply chain to meet these needs through digital means. This shift in market demand undoubtedly provides a strong impetus for the digital transformation of the grain supply chain.

- Technological Advancements

Technological advancements provide a solid foundation for the digital transformation of the grain supply chain. New-generation information technologies, such as big data, cloud computing, the Internet of Things, and artificial intelligence, are profoundly changing the way the grain supply chain operates. The application of these technologies not only improves the efficiency and transparency of the grain supply chain but also brings new growth opportunities for businesses.

4. Digital Operation Modes

Han Ji (2024) defines the supply chain as the complex network composed of all individuals, organizations, and companies involved from product production to sales. This article provides a detailed analysis of the digital operation models across various stages of the grain supply chain, including procurement, processing, storage, distribution, and delivery[14].

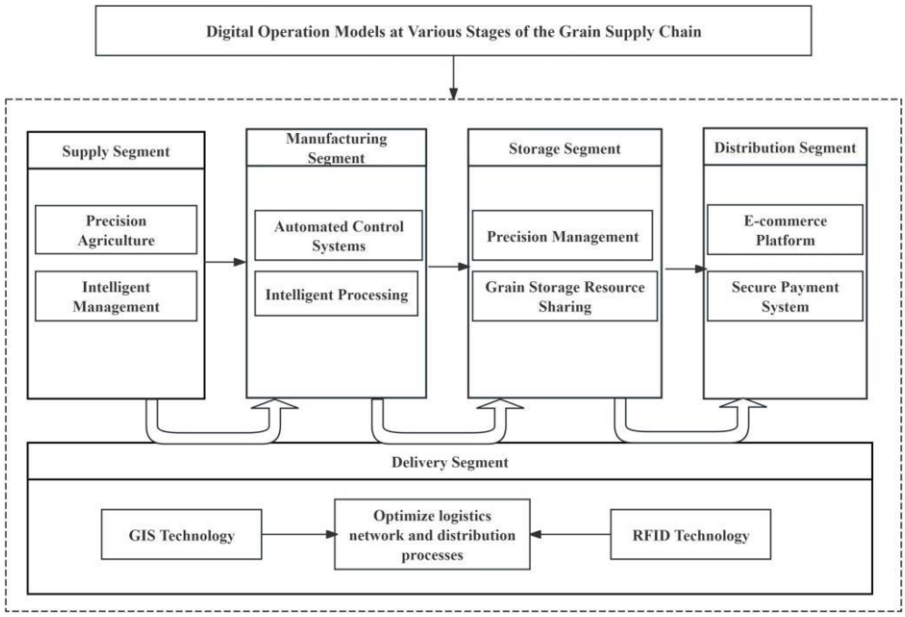

Figure 2. Digital Operation Models at Various Stages of the Grain Supply Chain

4.1. Digital Operation Modes in the Supply Segment

Digital transformation in the supply segment of the grain supply chain is primarily evident in precision agriculture and smart management practices. Using IoT devices and sensors, farmers can monitor crop growth conditions in real time, including soil moisture, temperature, and nutrient levels, leading to more informed planting decisions. Big data analysis predicts crop diseases and market demand, which can optimize planting structures and yields. Blockchain technology ensures traceability of grain sources, enhancing food safety and quality assurance. The application of these technologies not only enhances the efficiency and quality of agricultural production but also solidifies the stability and reliability of the grain supply chain.

4.2. Digital Operation Modes in the Manufacturing Segment

In the grain processing and manufacturing segment, digital technology is primarily applied in the form of automated production lines and intelligent processing equipment[15]. Implementing advanced automation control systems allows grain processing companies to monitor and optimize the production process in real time, thereby enhancing production efficiency and product quality. Furthermore, artificial intelligence and machine learning algorithms enable businesses to analyze production data deeply, predict equipment maintenance requirements, minimize downtime, and maximize operational efficiency. Digitalization also fosters energy conservation and emission reduction in grain processing, supporting the achievement of sustainable development goals.

4.3. Digital Operation Modes in the Storage Segment

Digital technology enhances the intelligence and precision of grain storage management by installing IoT devices, such as sensors for temperature, humidity, and gas, which allow for real-time monitoring of storage conditions. This ensures optimal grain preservation and reduces the risk of loss and spoilage. Big data analysis and forecasting optimize inventory management by predicting storage needs and turnover rates. Digital platforms facilitate the sharing and efficient allocation of grain storage resources, enhancing the utilization and responsiveness of storage facilities. Digital transformation not only ensures the safety and efficiency of grain storage but also solidifies the stability of the grain supply chain[16][17].

4.4. Digital Operation Modes in the Distribution Segment

In the distribution segment of the supply chain, digital transformation primarily involves the construction of e-commerce platforms and the security of payment systems. E-commerce platforms provide online shopping channels, enabling consumers to browse and purchase products anytime, anywhere, which not only enhances the user experience but also expands sales channels for businesses. At the same time, to ensure the security of transactions, payment systems employ encryption technology, security protocols, and fraud detection systems to protect consumers' financial information, ensuring the security and integrity of the data. Through these measures, the distribution segment of the supply chain can operate more efficiently and safely, meeting the needs of modern consumers.

4.5. Digital Operation Modes in the Delivery Segment

Digital transformation in the delivery phase of the grain supply chain enhances efficiency and accuracy by optimizing logistics networks and delivery processes. GIS technology and optimization algorithms plan the most efficient delivery routes, cutting transportation costs and time. RFID technology and real-time tracking systems ensure transparent and traceable grain delivery, guaranteeing timely and quality arrivals. Digital platforms facilitate real-time communication and feedback with customers, thereby improving service quality and satisfaction. Moreover, digital delivery systems can swiftly adapt to market fluctuations and urgent demands, bolstering the supply chain's flexibility and resilience.

5. Case Analysis of the Lu Liang Group

5.1. Basic Overview of the Shandong Grain Group

Lu Liang Group Co., Ltd. is a provincial state-owned key grain enterprise, established in August 2017 by the Shandong Provincial Party Committee and the provincial government to implement the national grain security strategy and enhance Shandong Province's responsibility in grain security. Lu Liang Group focuses on the management of reserved grain as its main responsibility and business, innovatively proposing the work positioning of "reserved grain has to choose me" and the management guidance system of "responsible grain storage, scientific grain storage, and clean grain storage". The group

is committed to building a scientific, informatized, and intelligent “Qi Lu Granary”, which is in a leading position nationwide.

5.2. Lu Liang Group's Digital Transformation Initiatives

In response to the national grain security strategy, Lu Liang Group has actively embraced digital transformation and technological innovation to ensure grain safety and promote the innovative development of the grain supply chain. The group has implemented a 'one network' centralized control system and a data mid-end project, focusing on supporting the full industry chain development plan that encompasses “planting, producing, purchasing, storing, processing, and selling”. It utilizes internet technology and information tools to bolster grain security.

Table 1. Lu Liang Group's Digital Transformation Initiatives

Measures	Time	Description
Data Mid-end Construction	2023	Built a unified and controllable data governance system at the group level, relying on Huawei Cloud's data governance center to build a data mid-end.
Green Storage Upgrade and Transformation	July 2023	Invested over 88 million yuan for the quasi-low temperature transformation and functional enhancement of nearly 500,000 tons of provincial grain storage warehouses, reducing the grain storage cycle loss rate.
Automated Production	August 2021 - June 2023	Lu Liang Grain Industry established a modern sightseeing experience type rice processing factory, achieving automated production and increasing daily output to 300 tons.
Intelligent Transformation	2023	Promoted the exploration and practice of information technologies such as big data, artificial intelligence, 5G, and industrial internet in the grain industry, empowering the transformation and upgrading of traditional industries.
Grain Warehouse Phosphine Aluminum Fumigation Robot "Liang Huibao"	May 2024	Independently developed the third-generation product of the grain warehouse phosphine aluminum fumigation robot "Liang Huibao", which has intelligent functions such as unmanned fumigation, unmanned inspection, and real-time monitoring.
Electronic and Intelligent Management System for Grain Warehouses "Hui Guan Liang"	May 2024	Jointly developed with Inspur Digital Grain Storage, it is an intelligent management platform that integrates grain storage, grain purchase and sale, safe grain storage, and safe production.

Lu Liang Group has entered into a strategic cooperation agreement with Inspur Group to jointly advance the construction of smart grain systems, integrating new-generation information technology with the traditional industrial economy to safeguard national grain security. Additionally, the group's self-developed phosphine fumigation robot for grain warehouses, 'Liang Huibao,' and the electronic and intelligent grain warehouse management system 'Hui Guan Liang,' co-developed with Inspur Digital Grain Storage, have garnered attention at the 2024 National Grain and Materials Reserve Science and Technology Activity Week.

Lu Liang Group's digital practices serve as a benchmark for other grain enterprises and supply chain management, particularly in enhancing the digitalization and

intelligence of the grain supply chain. As a leader in the industry, Lu Liang Group is at the forefront of these advancements.

6. Conclusions and Recommendations

Through the analysis of the digital transformation of Lu Liang Group's supply chain, it is evident that the digital transformation of the grain supply chain faces numerous challenges, such as uneven technology application, inadequate data sharing, incomplete infrastructure, and governance structures that are not well-suited, all of which hinder its in-depth development. To address these issues, this article proposes the following strategies:

1. Strengthen the integration of technology and business: To mitigate the risk of misalignment between technology and business operations, it is imperative for enterprises to engage in a profound comprehension of their operational requirements. Such an approach facilitates the seamless integration of technology within the business framework, thereby preventing the occurrence of technological and operational misalignment. Furthermore, the implementation of ongoing assessments and modifications is essential to guarantee the efficacious utilization of technological solutions and to foster the enhancement of business procedures.

2. Enhance data governance capabilities: Establish an effective data governance system to ensure the accuracy, completeness, and security of data. Strengthen data security and privacy protection, promote standardized data management, and address challenges related to data security and compliance.

3. Reinforce cybersecurity protection: In the face of increased cybersecurity risks, companies need to establish a robust cybersecurity system to protect critical information infrastructure from attacks and ensure the security of data transmission and processing. Adopt advanced technologies to optimize network management models and improve the efficiency of cybersecurity management.

4. Promote the upgrading of traditional industries: Overcome internal and external resistance by promoting the digital transformation of traditional grain businesses through technological innovation and improvements in management models. Strengthen staff training to increase acceptance of new technologies and ensure that business processes can adapt to the application of new technologies.

5. Increase policy support and financial investment: The government should provide policy support and financial investment, especially in areas and segments where technology is lagging, to promote the balanced application and development of technology. At the same time, strengthen infrastructure construction to improve network coverage and the efficiency of logistics and distribution systems.

References

[1] Barbara B, Serena F, Alberto P, et al. The digitalization of supply chain: a review. Procedia Computer Science, 2022, 200: 1806-1815, doi: 10.1016/J.PROCS.2022.01.381

[2] Büyüközkan G, Göçer F. Digital Supply Chain: Literature review and a proposed framework for future research. Computers in Industry,2018,97:157-177, doi: 10.1080/16258312.2020.1816361

[3] Blandine A, Omar B, Angappa G. Digital supply chain: challenges and future directions. Supply Chain Forum: An International Journal,2020,21(3): 133-138, doi: 10.1080/16258312.2020.1816361

[4] Xiwen C. Food safety is the foundation of a modernized strong country. China Development Observation, 2024, (05):115-120.
[5] Jingling H. The Application of Digital Technology in Building New Momentum for Food Security. Food Science and Technology and Economy,2021,46(06):20-23, doi: 10.16465/j.gste.cn431252ts.20210604.
[6] Lan H, Ke S. Research on Issues in China's Food Supply Chain. China Business and Market, 2005, (02):13-16.
[7] Zhuo C. Research on the Analysis and Prevention of Food Supply Chain Risks. Rural Economy, 2011, (12):24-28.
[8] Guoquan C. Supply Chain Managemen. China Soft Science, 1999, (10):101-104.
[9] Houcai S, Qing T, Yibo C. Theories and Methods of Supply Chain Management. Chinese Journal of Ma nagement Science,2000, (01):1-9, doi: 10.16381/j.cnki.issn1003-207x.2000.01.001
[10] Junkai M, Guangsi L, Dong H. Digital Economy Empowering the Resilience of the Food Supply Chain: Pathways and Policy Orientations. Social Sciences in Xinjiang, 2023, (01):46-54, doi: 10.20003/j.cnki.xjshkx.2023.01.006.
[11] Yaping T. Innovative Paths to Strengthen the Resilience of China's Food Supply Chain in the New Era. Ningxia Social Sciences, 2023, (01):118-124.
[12] Tianxian L, Jing Z. International Experience and Enlightenment in the Construction of Post-harvest Grain Service Systems. World Agriculture,2024, (04):50-60. doi:10.13856/j.cn11-1097/s.2024.04.005
[13] Abduwali A, Milkamili D, Zhennan Z. Rural Digitalization and the Resilience of the Food Supply Chain: Theoretical Mechanisms, Empirical Evidence, and Policy Options. Journal of Northwest A&F University (Social Science Edition),2024,24(04):83-90. doi: 10.13968/j.cnki.1009-9107.2024.04.09.
[14] Ji H. Reshaping the Food Supply Chain in the Digital Age and Ensuring China's Food Security. Journal of Southwest University of Science and Technology (Philosophy and Social Science Edition),2024,41(04):43-52.
[15] Chouyong C, Jinghan X. Evaluation System for Digital Transformation Capability of Manufacturing Enterprises and Its Application. Science and Technology Management Research,2020,40(11):46-51.
[16] Chunhua C, Li Z, Hao Z. Innovative Research on the Digital Survival Management Practices of Chinese Enterprises. Journal of Management Sciences in China,2019,22(10):1-8.
[17] Lihua H, Hailin Z, Weihua L. Corporate Digital Transformation and Management: Research Framework and Prospects. Journal of Management Sciences in China,2021,24(08):26-35. doi: 10.19920/j.cnki.jmsc.2021.08.004.