The Digital Transformation of Chinese Enterprises in Sustainable Supply Chain Management

Lingfeng Wang[a], Hsing-Hua Hsu[*]

School of Economics and Management, Quanzhou University of Information Engineering, Quanzhou, China

[a]441027704@qq.com, *helenhua@qzuie.edu.cn

Abstract. The paper aims at examining the digital transformation roadmap for sustainable supply chain management in Chinese enterprises, encompassing strategic positioning, goal setting, path planning, risk assessment and response. It further examines the significance of reinforcing data science applications by introducing measures such as data cleaning and standardization, big data, cloud computing, and AI applications. The paper also highlights the importance of facing technical and data risk and the countermeasures in digital transformation, as well as nurturing professional talents, to ensure successful digital transformation through strategic management. In the future, we can expect the trends such as technology integration and innovation, collaborative construction and sharing of supply chain ecosystems, and risk management and compliance, to be implemented in sustainable supply chain.

Keywords: Digital Transformation, Sustainability, Supply Chain Management, Chinese enterprise.

1   Introduction

The digital transformation of sustainable supply chain management, as a key path to enhance enterprise competitiveness, is gradually penetrating and reshaping traditional management models [1]. This transformation is not only a positive response to the intensification of global competition, but also a profound response to the diversification of consumer demands and the promotion of technological innovation. Therefore, digital transformation has become the way to break through the impasse. With the increasingly blurred market boundaries and fierce competition between domestic and foreign enterprises, the improvement of sustainable supply chain management efficiency and flexibility has become a key factor determining the success or failure of enterprises.

As a fundamental strategy for enterprises, technological innovation plays a pivotal role in facilitating the digital transformation of sustainable supply chain management. The rapid advancements in technologies such as cloud computing, big data, and artificial intelligence have laid a robust technological foundation for the intelligent enhancement of sustainable supply chain management practices. The application of these cut-

ting-edge technologies has empowered data-driven decision-making and fostered intelligence across various facets of sustainable supply chain management, resulting in significant reductions in operational costs and improvements in managerial efficiency. Furthermore, they facilitate information sharing and collaboration among all stakeholders within the supply chain ecosystem, driving transparency and visualization throughout the entire value network while ushering unprecedented transformations to sustainable supply chain management.

2   The Impact of Digital Transformation on Sustainable Supply Chain Management

Digital transformation refers to the comprehensive optimization and upgrading of business processes, management models, and organizational structures by enterprises with modern information technologies such as big data [2], cloud computing [3], and Artificial Intelligence (AI) [4], to achieve more efficient and intelligent operations.

The integration of technology is another major characteristic of the digital transformation. The combination of various modern information technologies provides powerful technical support for enterprises. The performance of the manufacturing industry in China is outstanding in this regard, with the number of enterprises using information management increasing from 351,093 in 2020 to 407,690 in 2022, indicating that the manufacturing industry in China is integrating new technologies to improve production efficiency and management level. Intelligent decision-making is one of the important goals of enterprise digital transformation. Through the application of technologies such as artificial intelligence, enterprises can achieve intelligent decision-making processes, thereby im-proving decision-making efficiency and accuracy. In recent years, the number of enterprises using information management in China is increasing. The number of enterprises in the national transportation, warehousing and postal industries that use the Internet for publicity and promotion has increased year by year (see Figure 1). This indicates that all industries are actively embracing digital transformation to enhance their competitiveness and market adaptability.
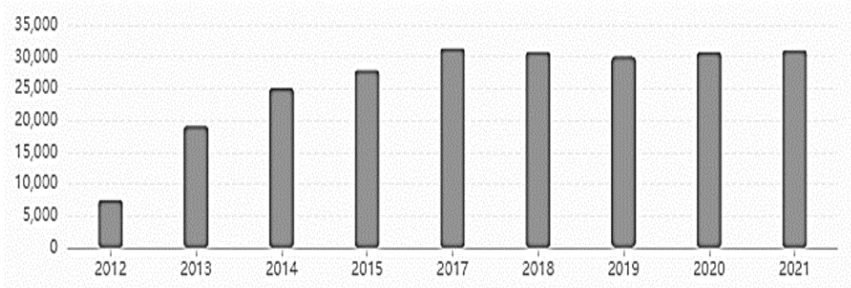
Fig. 1. Number of enterprises in the national transportation, warehousing and postal industries that use the Internet for publicity and promotion, via CEIdata
(https://ceidata.cei.cn/html/operation.htm?tid=2)

3   Strategies for Implementing Digital and Sustainable Supply Chain Management

3.1   Developing Clear Digital Transformation Strategies

In the wave of digital transformation, China's industries have ushered in unprecedented development opportunities. To adapt to this trend, companies in the industry urgently need to clarify their strategic positioning for digital transformation and regard it as the core driving force for enhancing competitiveness. It is particularly important to set practical and feasible short-term and long-term digital transformation goals through in-depth analysis of the current situation of the enterprise. These goals should focus on key areas such as improving sustainable supply chain transparency, reducing costs, and increasing response speed to ensure that the trans-formation results can effectively help companies stand out in fierce market competition.

It is crucial to develop a detailed transformation roadmap in the process of achieving these goals. Enterprises should plan a digital transformation path that is both in line with industry's trend of sustainable development and tailored to their own characteristics from multiple dimensions such as technology selection, system upgrades, and process reengineering, based on their actual situation. This not only ensures the orderly progress of the transformation process, but also minimizes trans-formation risks to the greatest extent possible.

The digital and sustainable transformation has not been smooth sailing. Enterprises need to remain vigilant and closely monitor potential risk points during the transformation process [5]. Technical risks, data risks, organizational risks, etc., are potential threats that cannot be ignored. In response to these risks, enterprises should develop corresponding measures to ensure quick response and minimize losses.

3.2   Strengthening Advanced Technology Applications

In the modernization process of sustainable supply chain management, digital transformation has become a key path to improve overall efficiency and enhance market competitiveness. This process covers multiple dimensions such as data cleaning and standardization [6], big data, cloud computing, and AI applications.

The process of data cleaning involves a series of procedures to ensure the accuracy and reliability of collected raw data, including the identification and treatment of outliers. Outliers can arise from errors in data entry, equipment malfunctions, or abnormal conditions, which can distort the results of data analysis if not promptly addressed. Appropriate handling of missing values is crucial, such as imputation using measures like mean, median, mode or inference based on contextual information. The purpose of data standardization is to eliminate dimensional discrepancies among different datasets, enabling data comparison and analysis on a consistent scale. During the process of data analysis, disparate dimensions and units across various sources or categories pose challenges in comparing the data. The standardized processing methods, such as minimum-maximum standardization, Z score, etc., should be chosen based on the distribution characteristics and analysis requirements of the data. In practice, the data cleaning and

standardization applied in supply chain management involve multiple steps, which are summarized in Table 1.

Table 1. Basic steps of data cleaning and standardization in supply chain management.

Data cleaning	Steps	Details
1	Data analysis	Identifying quality problems in raw data through manual inspection or computer analysis procedures.
2	Defining rules	Developing cleaning strategies and rules based on the type of data quality problem.
3	Identifying error instances	Using automated detection algorithms or manual detection to identify the wrong instances in dataset.
4	Error correcting	Correcting erroneous, incomplete, inconsistent data in the dataset according to cleaning strategies and rules.
5	Data backflow cleaning	Streaming the cleaned data back into the original data source, and replacing the original dirty data.

Data standardization	Steps	Details
1	Uniformization of data format	Data from different sources and formats are integrated into a unified format, such as JSON, XML, etc., which is convenient for subsequent data processing and analysis.
2	Data coding specification	To ensure the accuracy and consistency of data, a unified data coding standard was developed to code all kinds of entities in logistics, such as goods, vehicles, warehouses, etc.
3	Data interface standardization	A standardized data interface is established to realize the data exchange and sharing between different logistics systems, and improve the efficiency and effectiveness of data integration.

Big data technology enables in-depth analysis and mining of massive data within supply chain. By comprehensively analyzing historical, real-time, and external data, big data technology can unveil patterns and potential issues in supply chain. The utilization of big data technology enables accurate prediction and optimization, as evidenced by the results of comprehensive data analysis. In addition, big data technology facilitates the optimization of supply chain management processes to enhance efficiency and accuracy in operations. Through real-time monitoring and analysis of diverse supply chain data sets, companies can promptly identify and resolve issues to ensure seamless operations. In addition, big data technology aids in the identification and mitigation of risks within the supply chain. By means of real-time monitoring and early warning mechanisms, big data technology enables timely detection of potential risks in supply chain, thereby providing enterprises with prompt risk notifications. This facilitates proactive measures to minimize potential losses and mitigate the impact of risks.

In 2021, the national cloud computing market witnessed a growth rate of 48.4% (see Figure 2), underscoring the robust demand for this technology in the market while also validating its role in reducing operational expenses and enhancing economic benefits for businesses. Cloud computing facilitates collaborative supply chain management and information sharing. The cloud platform enables seamless data exchange among upstream and downstream enterprises in the supply chain, optimizing inventory management and minimizing resource waste to enhance overall competitiveness. The high

availability and stability of cloud computing provide robust technical support for supply chain management. The cloud computing platform automatically performs load balancing, effectively handles sudden traffic surges, and ensures the stable operation of the supply chain management system.
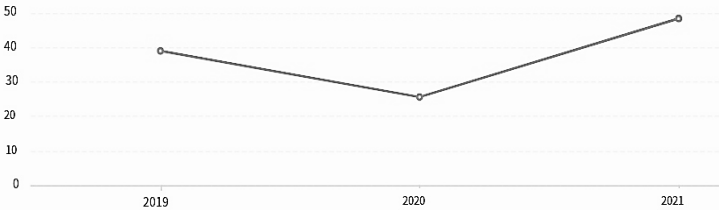
Fig. 2. Growth rate of national cloud computing market size in China, via CEIdata
(https://ceidata.cei.cn/html/operation.htm?tid=2)

Driven by the emerging technologies of Artificial Intelligence (AI), supply chain management is undergoing a profound transformation. By leveraging data analysis and predictive capabilities of AI, enterprises can more accurately assess suppliers' sustainability performance, thereby establishing higher entry barriers [7]. AI can also assist companies in mobilizing social resources and capital for investment in innovation and identifying revolutionary transformation opportunities. In addition, AI plays a crucial role in optimizing cash flow management, enhancing consumer education, and facilitating industry consensus. It enables companies to devise long-term procurement strategies through data analysis, enhances consumers' awareness of sustainability, and resolves profit distribution conflicts within the supply chain.

The introduction of other advanced technologies such as the Internet of Things (IoT) has also enabled sustainable supply chain management systems to have a higher level of automation and intelligence [8]. By building intelligent warehousing, logistics, production and other systems, enterprises can achieve automated management and intelligent decision-making of their supply chain. The application of these intelligent systems not only improves the operational efficiency and accuracy of sustainable supply chain, but also significantly enhances the resilience and security of the operation.

3.3   Technical Risk, Data Risk, and Countermeasures

In the process of digital transformation of sustainable supply chain management, technology selection and integration pose as primary technical risks that logistics enterprises must confront. To mitigate the risks, enterprises need to gain a comprehensive understanding of the advantages, disadvantages, and applicability of various technologies while formulating sound strategies for technology selection. During system integration, emphasis should also be placed on data sharing and exchange to ensure seamless flow between different systems.

Ensuring data security and confidentiality is also of paramount importance. Given that logistics enterprises possess a vast amount of sensitive information, including cargo transportation details and customer data, they have become prime targets for potential data breaches. Such breaches not only result in substantial economic losses and

reputational damage to these enterprises but also pose irreparable harm to their customers. Therefore, it is imperative to implement effective preventive measures aimed at mitigating the risk of data breaches. Consequently, logistics enterprises should fortify network security protection by regularly identifying and promptly addressing any detected vulnerabilities. Additionally, employing technologies such as firewalls and intrusion detection systems can effectively thwart hacker intrusions. Internal leaks refer to instances where enterprise employees inadvertently or maliciously disclose sensitive information due to negligence or system loopholes.

The risk of data tampering and fraud may arise from both internal personnel and external attackers. Insiders have the potential to manipulate or falsify data for personal gain or malicious purposes, while external attackers can unlawfully access and manipulate data through tactics such as hacker attacks and viruses. To promptly identify instances of data tampering, enterprises must implement effective monitoring measures. Simultaneously, they should conduct thorough investigations and analyses of incidents to determine their root causes and responsible parties, subsequently implementing appropriate disciplinary actions.

Lastly, to ensure the security and compliance of data, risk assessment serves as the foundation. Logistics enterprises should regularly conduct comprehensive assessments of data risks, encompassing the identification and analysis of various risks such as data leakage, tampering, and compliance. During the assessment process, enterprises should employ scientific methods and techniques while considering business practices and industry characteristics to determine the magnitude and potential impact of risks.

3.4   Cultivating Professional Talents and Enhancing Team Capabilities

To effectively promote digital transformation, building a high-quality and professional digital team is the key. Talent cultivation is an indispensable part, and enterprises need to actively expand recruitment channels [9]. By accurately positioning out-standing graduates in fields such as computer science, data science, and artificial intelligence on campus, as well as searching for professional talents with rich experience in digital intelligence projects in society, they can inject fresh blood into the team and bring cutting-edge technological perspectives and practical experience.

Internal training is an effective way to enhance the digital intelligence ability of the team. Through regular workshops, online courses, expert lectures, and other forms, team members' professional skills and knowledge breadth should be continuously improved. For external training, it is important to establish a reasonable incentive mechanism to stimulate the enthusiasm and innovative spirit of team members [10]. Cross departmental collaboration is another key to ensuring the smooth progress of digital transformation. By regularly holding joint meetings, sharing data resources, and collaborating to solve problems, we can form a joint force to jointly formulate digital transformation strategies, ensure that various transformation measures can be effectively implemented, and continuously optimize and improve them in practice.

4   Conclusion

The inevitability of digital transformation stems from the dual drive of market demand and technological progress. With the increasingly fierce market competition, consumers' demands for product delivery speed, personalized needs, and service quality are constantly increasing, forcing enterprises to accelerate response speed and optimize resource allocation. Meanwhile, the mature application of advanced technologies such as big data, artificial intelligence, and cloud computing provides powerful technical support for enterprises, making digital transformation possible. The significant improvement in competitive advantage is a direct result of the digital transformation. Enterprises that have successfully implemented digital trans-formation have achieved comprehensive improvement in market competitiveness by optimizing resource allocation, improving response speed, and reducing operating costs. The transformation towards digitalization has become an inevitable trend and direction for deep transformation in sustainable supply chain management for Chinese enterprises. Facing the future, enterprises should actively embrace digital technology, accelerate the pace of transformation, to cope with market challenges and achieve sustainable development.

References

1. P. J., Daugherty, H. Chen, and B. G. Ferrin. 2011. Organizational structure and logistics service innovation. The International Journal of Logistics Management 22(1), 26-51.
2. J. L. Hung, W. He, and J. Shen. 2020. Big data analytics for supply chain relationship in banking. Industrial Marketing Management 86, 144–153.
3. K. E. Ali, S. A. Mazen, and E. E. Hassanein 2018. A proposed hybrid model for adopting cloud computing in e-government. Future Computing and Informatics Journal 3(2), 286–295.
4. E. H. M. Payne, J. Peltier, and V. A. Barger. 2021. Enhancing the value co-creation process: artificial intelligence and mobile banking service platforms. Journal of Research in Interactive Marketing 15(1), 68–85.
5. R. Qiao, and L. Zhao. 2023. Reduce supply chain financing risks through supply chain integration: dual approaches of alleviating information asymmetry and mitigating supply chain risks. Journal of Enterprise Information Management 36(6), 1533–1555.
6. T. Fang, D. Nengsheng, Z. Zhong, L. Chunlin, and L. Youlong. 2024. An improved sensing data cleaning scheme for object localization in edge computing environment. The Computer Journal.
7. K. Aditya, S. Chakraborty, A. Dahire, A. Kumari, and M.F. Milanova. 2024. Integrating Blockchain, IoT, and AI in Supply Chain Management. Apress, Berkeley, CA.
8. L. Wang, A. A. Hamad, and V. Sakthivel. 2022. IoT assisted machine learning model for warehouse management. Journal of Interconnection Networks 22(Supp02), 2143005.
9. Y. Shi, and R. Handfield. 2012. Talent management issues for multinational logistics companies in China: observations from the field. International Journal of Logistics Research and Applications 15(3), 163-179.
10. H. Kurokawa. 2023. Human resource education in logistics. Navigation 224, 3-3.