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SUPPLY CHAIN TRANSFORMATION IN THE DIGITAL WAVE: A THEORETICAL PERSPECTIVE ON AGRICULTURE AND MANUFACTURING

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Abstract: This paper systematically explores the internal mechanism and practical path of China's supply chain digital transformation in enhancing the efficiency of agriculture and manufacturing. The study first dissects the core mechanism of digital technology empowering supply chains. Through comparative analysis of typical application cases, it reveals the differentiated characteristics and commonalities of digital transformation in different industries. The research further identifies practical challenges and proposes industry-specific policy recommendations. Finally, it points out future research directions, including the construction of a digital transformation maturity assessment framework and differentiated policy research, providing theoretical support and practical guidance for deepening supply chain digital transformation.
Keywords: Agriculture; Manufacturing; Supply chain digitalization; Blockchain; Digital twin

1 INTRODUCTION

With the rapid development of the digital economy, the supply chain management model and innovation have undergone a historic transformation. The necessity of building a digital supply chain stems from the driving forces at three levels: technological innovation, environmental pressure, and demand change. From the perspective of technological change, the application of the Internet of Things has made data visible, turning the information black box of traditional supply chain management transparent and visual, and solving the problem of information discontinuity between enterprises; blockchain is dedicated to the immutability of data, and by recording and analyzing real operational data, it has solved the problems of information asymmetry and data silos in the supply chain [1]; the wide application of artificial intelligence technology has optimized supply chain management decisions, achieving the optimal allocation of resources and risk prevention and control. Based on environmental demands, the traditional supply chain, from raw material acquisition to product disposal, inevitably leads to excessive exploitation and waste of resources, causing significant environmental pressure. Digitalization, through digital twin simulation of risk scenarios and blockchain tracking of carbon footprints, has become a driving force for the construction of sustainable supply chains. Based on consumer demand, due to the rise of consumerism and the growth of personalized consumption trends, traditional batch production can no longer meet the diverse consumer demands, and it is urgent to build models through digital technology to interpret consumer demands and achieve a flexible combination of personalized and large-scale supply chain production.

The core value of a digital supply chain lies in reconfiguring the analysis process based on data integration and analysis, thereby optimizing decision-making and enhancing supply chain resilience. The digital supply chain not only alleviates the predicament of low efficiency, information asymmetry and risk contagion in the traditional supply chain, but also emempowerment enterprises on the chain to strengthen win-win cooperation, thereby achieving the goal of sustainable development [2]. Due to the differences in business attributes, product features and market demands, various industries present diverse innovation paths and challenges in digital transformation. For instance, the manufacturing industry focuses on the coordinated optimization of production and logistics, while agriculture emphasizes product traceability, supply and demand matching, and risk prevention. Therefore, studying the digital innovation of supply chains in different industries helps to distill common patterns, identify industry characteristics, and provide theoretical support and practical references for cross-domain collaboration.

This study selects the digital innovation of supply chains in agriculture and manufacturing as the research object. The main reason for this choice is that agriculture and manufacturing form the foundation of the real economy, covering the entire process from raw materials to finished products, with numerous supply chain links and a wide range of coverage. First, agriculture and manufacturing hold strategic positions. Agriculture and manufacturing belong to the bottom pillars of the supply of human survival materials and production materials, and the efficiency of their supply chains is directly related to the stability of national economy and people's livelihood. Second, there is an urgent need for the transformation and upgrading of agricultural modernization supply chains. Due to the perishable nature and natural dependence of agricultural products, data integration is urgently needed to optimize logistics and inventory management, and real-time data visualization can reduce information asymmetry [3]. The effectiveness comparison formed during the application process of supply chain digital innovation in different industries can better explain the key role of

digitalization in improving supply chain efficiency and risk resistance capabilities. Third, the digitalization process of supply chains in agriculture and manufacturing is actually a typical representative of the upgrade of two different supply chain paradigms. The goal of digitalizing the agricultural supply chain is to achieve traceability throughout the entire process and risk prevention and control, as well as other supply chain optimizations oriented towards trust [4], while manufacturing uses digital supply chains to solve efficiency-oriented problems such as low efficiency, high costs, and resource optimization allocation [5]. The complementarity of the two forms constitutes the reference paradigm for the upgrade path of supply chain digitalization, respectively verifying the repair mechanism of technology for the two core weaknesses of supply chain traceability and trust crisis; Fourth, the challenges faced during the digital transformation of agricultural and manufacturing supply chains represent the issues encountered in building sustainable supply chains. The manufacturing sector grapples with incomplete technical standards and the struggle for data control rights, while agriculture faces a digital divide among small farmers, inadequate infrastructure, and insufficient learning capabilities. These challenges highlight the fundamental contradictions of technological deficiencies and a lack of human resources in digital transformation [6]. Fifth, there is a differentiation in policy formulation and promotion mechanisms. Digitalization in manufacturing is driven by industrial policies, whereas digitalization in agriculture relies on inclusive institutional designs. Together, they form typical cases of how governments and markets jointly promote digital construction in the era of the digital economy.

Therefore, by focusing on agriculture and manufacturing as the main subjects and conducting research on the digitalization of supply chains, it is possible not only to summarize the intrinsic differences in the internal laws of industrial development empowered by digital technology through comparative analysis, but also to extract a universal transformation framework based on its driving effect, providing a theoretical fulcrum for exploring mechanisms that integrate digital productivity and promote the development of the real economy.

This paper takes the digital transformation of agricultural and manufacturing supply chains as the research object. By deconstructing the internal mechanisms of data-driven decision optimization and full-chain visualized collaboration, and through the comparison of typical cases in manufacturing and agriculture, it reveals the logic of differentiated industrial transformation. The research aims to systematically identify common challenges and industry bottlenecks, propose a sector-specific policy framework and future breakthrough directions, and provide theoretical support and practical routes for building an efficient and secure digital supply chain system.

2 RESEARCH REVIEW

2.1 Review of Supply Chain Digitalization Research

Regarding academic research on the digitalization of supply chains, scholars have focused more on examining issues such as supply chain data visualization, supply chain resilience, supply chain toughness, risk control, and the construction of digital supply chains from a network perspective during the digital transformation process. Based on the conceptual level of supply chain digitalization, Buyukozkan et al. pointed out that the digital transformation of supply chains is centered around customer needs [7], utilizing a series of digital technologies to achieve supply chain data visualization and intelligent supply chain management. Supply chain digitalization transformation is based on data and uses information technology to promote the overall structure and mode transformation of the supply chain [8]. From the perspectives of research fields and contents, scholars have conducted studies based on theories and empirical models, focusing on aspects such as the development process, influencing factors, and economic effect assessment of supply chain digitalization transformation. Supply chain digitalization transformation is not merely the application of digital technologies; it also emphasizes using digital technologies and other means for internal coordination within the supply chain, external resource management, and data element generation to promote the shaping of a digital supply chain [9]. Supply chain digitalization is the process of data collection and processing, thereby orderly integrating suppliers and customers, with digital technologies and digital human resources being key elements [10]. Zhao et al. empirically analyzed the impact of supply chain digitalization on supply chain resilience and supply chain performance [2], and found that supply chain digitalization can enhance the response and recovery capabilities of the supply chain, thereby improving supply chain performance.

2.2 Review of Research on Digitalization of Agricultural Supply Chain

Regarding the research on the digitalization of agricultural supply chains, some scholars believe that the application of Internet of Things (IoT) technology plays a role in the process of promoting the digitalization of agricultural supply chains by optimizing processes and achieving collaborative integration, precisely matching supply and demand, reducing operational risks in the supply chain, and thereby enhancing supply chain performance [6]. Digitalization of agricultural supply chains, such as blockchain and smart contracts, can solve problems of information asymmetry, quality fraud, and trust loss in the agricultural product circulation process [11]. Subsequently, the researchers selected three Thai food manufacturers as case samples to explore the challenges and opportunities faced during the digital transformation of the food supply chain, proposed a framework for the digital transformation of the food supply chain, and identified key factors that need to be focused on in the digital transformation of the food supply chain, including supply chain operational efficiency, information transparency, product traceability, environmental and social impact, and legal responsibilities [12].

2.3 Review of Research on Digitalization of Manufacturing Supply Chain

Regarding the research on the digitalization of manufacturing supply chains, scholars mainly focus on the application of digital twin technology in manufacturing supply chains. The application value of digital twin in industrial processes is manifested as predictive analysis, agility, and stronger adaptability [13]. Subsequently, scholars have endeavored to explore the broader application value of manufacturing digital twins. Digital twin integrates physical product data, virtual product data, and associated data to provide more efficient support for product design, manufacturing, and services, and enhance sustainability. Digital twin technology simulates the manufacturing environment, processes data handling and analysis, and assists in optimizing and upgrading the supply chain and achieving the purpose of risk warning and control [5].

Although existing studies have conducted multi-level and multi-angle investigations and analyses on the ways and economic consequences of digital transformation in agricultural and manufacturing supply chains, there are still limitations such as insufficient theoretical depth and insufficient cross-domain integration. Further exploration and improvement are needed in research on the feasibility of supply chain digitalization. Firstly, existing studies mostly focus on the application effects of a single technology, while there is relatively less systematic research on the synergy effects among technologies. Additionally, existing studies have discussed the digitalization paths of large enterprises more, but the research on small and medium-sized enterprises is somewhat lacking. Small and medium-sized enterprises face core challenges such as technical application compatibility bottlenecks, shortage of digital talents, and data security risks. However, the existing results mostly remain at the general strategy level and lack precise solutions tailored to specific industries and regions.

3 INNOVATIVE PRACTICES IN THE DIGITAL TRANSFORMATION OF SUPPLY CHAINS

With the increasing individualization and diversification of consumer demands, the core contradiction faced by traditional agriculture has shifted from "insufficient total output" to "misalignment between supply and demand". The decision-making based on experience in the production process has led to the frequent occurrence of the phenomenon where agricultural product prices plummet. Moreover, due to the lack of bargaining power among scattered farmers and the existence of information asymmetry, farmers suffer severely from the exploitation of profits by middlemen. Under this background, it is urgent to deepen the digital reform of the agricultural supply chain. To achieve the full-chain digital reform of agriculture, on one hand, digital technology can reshape the production decision-making model by collecting real-time data on farmland conditions, crop growth, and meteorological environment, combined with historical patterns and intelligent algorithm models, to optimize resource allocation, reduce production costs and risks, and thereby achieve precise prediction of agricultural product output; downstream, through blockchain and big data analysis technologies, integrate the diversified and personalized demand information of end consumers, and feed it back to the production end through the data platform, truly allowing demand to guide supply. This digital supply chain process, by integrating data information from production, processing, circulation, and sales links, forms a "data-driven decision-making" smart governance paradigm, enabling enterprises at each node of the supply chain to dynamically adjust resource allocation based on real-time market signals. Therefore, the digital reform of the agricultural supply chain has restructured the sustainable development paradigm of the agricultural value chain [14].

Similarly, with the intensification of global competition, the gradual personalization of market demands, and the uncertainty of the global economic environment, the digitalization of manufacturing supply chains is also an inevitable requirement for modern industrial development. The inevitability of the digital transformation of manufacturing supply chain stems from the structural flaws of the traditional manufacturing supply chain model. Firstly, the traditional manufacturing supply chain has information black boxes such as distorted demand information transmission and inventory mismatch, as well as the whip effect of risk contagion. The production progress and raw material inventory status data of upstream suppliers cannot be shared in real time with manufacturers. Once raw materials are cut off, it will trigger a chain-like transmission of risks [15]. Moreover, the downstream distribution data and customer demands can only be transmitted to the production end through hierarchical aggregation, resulting in production plans lagging behind the actual market demand. Traditional supply chain management decisions rely on manual decisions and hierarchical approvals, leading to a delayed response to market changes. However, through big data analysis to achieve real-time demand prediction and automatically generating production plans through intelligent algorithms, the agility and efficiency of the supply chain in response to the market are significantly improved. Digitalization builds real-time data monitoring and intelligent emergency mechanisms, which can predict risks in advance and enhance supply chain resilience [15]. Thirdly, the product quality screening in traditional supply chains relies on sampling inspections, resulting in low efficiency in quality product traceability, lagging problem identification, and through the construction of digital supply chains, it is possible to achieve full traceability of data information and preventive intervention through the immutable recording of data information. In conclusion, digitalization is a systematic solution to break through information islands, resource rigidity, and risk vulnerability [5].

3.1 The Internal Mechanism of How Digitalization of Supply Chain Can Enhance the Efficiency of Agriculture and Manufacturing

The digitalization of supply chains has a significant enabling effect on the manufacturing industry, mainly by significantly improving the efficiency of resource allocation and the collaborative capabilities of the value chain. For

the agricultural supply chain digitalization, the core objective is mainly to cope with natural uncertainties and improve timeliness. Emerging digital technologies, by reconfiguring the temporal and spatial logic of agricultural product circulation and the decision-making model of agricultural production, promote the traditional supply chain to achieve the prediction of future risks and the exploration of hidden demands, transforming "post-event remediation" into "pre-event insight". First, relying on satellite remote sensing to monitor the areas of drought, flood, and pests and diseases in farmland, it solves the information blind spots at the production end; using the field sensor network can detect soil temperature, humidity, and light intensity in real time, and issue early warnings of risks. Second, blockchain builds a direct connection channel between "consumers" and "farmers", eliminating quality concerns. The essence of agricultural supply chain digitalization is to break through the constraints of natural economy and institutional deficiencies, reorganize the agricultural value chain through data flow, penetrate the constraints of natural economy with technology, and achieve optimal resource allocation, minimal risk, and fair value distribution revolution [3].

The digitalization of the manufacturing supply chain enables real-time sharing of product status information through the Internet of Things. These data are stored and shared through blockchain to ensure the authenticity and non-modifiability of the data, thereby enhancing the authenticity of supply chain information transmission and alleviating the phenomenon of data silos, achieving resource optimization allocation. Moreover, through the integration of multiple data on the cloud computing platform, enterprises can dynamically adjust production plans based on actual demands, avoiding overcapacity [10]. Secondly, the manufacturing industry utilizes the construction of digital supply chains such as digital twins to achieve simulation and simulation of the entire supply chain from suppliers, factories, distributors, to customers. Through digital algorithms, it can achieve real-time insight into supply chain status and risk prediction, thereby enhancing supply chain resilience [5]. Thirdly, in the field of market demand analysis, with the assistance of artificial intelligence in engineering analysis of consumers' preferences, purchasing behaviors, and demand trends, enterprises can precisely target the market and develop products that better meet market demands; in the aspect of after-sales service, data analysis helps enterprises establish a complete customer feedback mechanism, responding promptly to customer needs and enhancing customer satisfaction [15]. Table 1 compares and analyzes the similarities and differences in the application of supply chain digitalization in agriculture and manufacturing.

Table 1 Comparative Analysis of Digital Transformation Characteristics between Agricultural and Manufacturing Supply Chains

Comparison Dimensions	Digitalization of Agricultural Supply Chains	Digitalization of Manufacturing Supply Chains	Common Characteristics
Motive Factors	Coping with natural risks, improving the ability to trace the quality of agricultural products, and enabling small farmers to adjust planting decisions according to market demand signals	Enhancing production efficiency and improving supply chain resilience	Affected by technological innovation, changes in market demand and policy promotion
Application of Key Technologies	Internet of Things (soil/climate sensors)Blockchain (traceability)Artificial intelligence technology	Industrial Internet platformDigital twinArtificial intelligence technology	Dependent on the improvement of digital infrastructure
Difficulties in Transformation	Weak digital capabilities of small farmersBackward digital infrastructure in rural areas	Non - uniform cross - enterprise standardsLong payback period for technical investment	All face problems such as high technical costs, talent shortage and inherent path dependence
Core Transformation Goals	Improving resource utilization efficiency and ensuring food safety and sustainability	Achieving cost reduction and efficiency improvement, and quickly responding to market demand	Pursuing the visualization and collaborative optimization of the entire supply chain

3.2 Digital Application of Supply Chains in Agriculture and Manufacturing

The theoretical framework and core driving forces of the digital transformation of the supply chain have been systematically elaborated in the previous text. To deeply explore the innovative practice paths and differentiated effects of this transformation in different industrial fields, this study specifically selects the apple industry in Yanchuan County of China and Haier Group as typical cases for analysis. The former represents how the agricultural sector can leverage digitalization to reshape the agricultural product value chain under the small-scale farming economy, achieving precision, branding, and value enhancement; the latter, as a manufacturing benchmark, its in-depth digital transformation of the supply chain provides an outstanding model for large-scale customization in industrial scenarios and the ecological transformation from user demands to product delivery. Together, these two cases have constructed a new paradigm of precise demand response and industrial ecosystem collaboration in the digital transformation of the supply chain.

The digitalization practice of the apple industry chain of a certain brand in Shaanxi Province of China has achieved ideal results. Its success has verified the feasibility of digital technology in economically underdeveloped regions. This model adopts an innovative approach of supply chain services + ICT (Information and Communication Technology) +

financial services to realize the digitalization of the entire supply chain from the planting end, processing end, to agricultural product production, logistics, sales and services. The application practice of digitalization in the apple industry chain demonstrates the enabling effect of supply chain digitalization on agriculture [16]. The application of ICT (Information and Communication Technology) in Yanchuan Four Apples mainly focuses on three aspects: First, the farmer's information, planting management data, planting area, planting years, historical yield, estimated yield, etc. are all agricultural information and are presented intuitively in the intelligent management system, so data mining and calculation can be carried out based on the constantly updated big data. Second, for real-time monitoring of micro-weather data, it is to integrate various sensing nodes on the agricultural production site, including planting environment, soil, images, etc., and wireless communication networks, integrate meteorological, market, and planting data, realize real-time monitoring and early warning of the agricultural production environment, and through data analysis, push irrigation and fertilization suggestions to farmers, providing precise data support for the efficient operation of each link of the apple and other agricultural product industry chain [16]. Thirdly, blockchain traceability ensures that all the information from the planting to the sales process of apples can be recorded as unalterable data, providing consumers with the entire process data. Fourthly, the innovation in supply chain financial services is that farmers can convert their planting process data, such as organic fertilization records, IoT irrigation compliance rates, and other agricultural data, into financial credit. They then establish the "agriculture + finance" and "agriculture + insurance" models, solving the problem of farmers' loan difficulties in traditional industrial and agricultural supply chains. This shows that the agricultural intelligent supply chain, through the application of digital technology, not only can maximize the protection of farmers' interests, but also, through agricultural production technology services, production material services, and financial services, ultimately achieve the goals of revitalizing the county economy, connecting the interests of small farmers, and building the resilience of the supply chain.

In the practical exploration of the digital transformation of the manufacturing industry supply chain, the practical innovations of Haier Group have provided practical and theoretical references for the same industry. The remarkable achievements of its digital transformation not only reflect the improvement of internal operational efficiency, but also lie in its exploration of an innovative path that integrates advanced information technology, reconfigures the corresponding market mechanisms, and promotes value chain collaboration. First, through the digital platform, the scope of procurement is expanded and procurement costs are reduced. In terms of procurement digitalization, Haier Home Appliances utilizes CRM (Customer Relationship Management) and BBP (Electronic Procurement) platforms to build a seamless communication bridge between users and suppliers. Moreover, this platform conducts strict qualification reviews of suppliers, effectively reducing the default risk and costs of suppliers [17]. Second, from "chain control" to "network ecology". Haier launched COSMOPlat, which introduces an industrial internet platform where users participate in the entire process of experience. The traditional supply chain follows the logical structure of enterprises independently developing, enterprises purchasing, and product production, but Haier's "chain group contract" model and COSMOPlat essentially transform enterprises into an open value co-creation network, and the two together support the operation of the networked ecology [18]. This model achieves the synergy between organizational efficiency and user value through user demand-driven approach and chain group's autonomous order-taking. In essence, user demand-driven means shifting from the traditional model where enterprises solely define product performance and usage to users directly participating in the innovation of product design concepts. The essence of chain group's autonomous order-taking is to dismantle the traditional supply chain into numerous autonomous decision-making groups. Through user demand-driven, each node of the chain group independently assesses its capabilities and then takes the order. The core value of Haier COSMOPlat lies in leveraging industrial internet technology to simultaneously achieve a significant increase in production efficiency and the precise satisfaction of users' personalized needs.

Through the brief analysis of the above cases, the digitalization of agricultural supply chains has connected the information flow from the field to the table, enhanced the transparency of agricultural product quality and the matching degree of market demand, and effectively solved the problem of small farmers' connection with the large market. The digitalization of manufacturing supply chains has achieved the transformation from large-scale manufacturing to large-scale customization. Through data-driven methods, it has realized precise demand forecasting, flexible production and efficient collaboration, greatly improving the response speed and resource efficiency.

3.3 Challenges of Supply Chain Digitalization

Although the digitalization of supply chains has demonstrated significant innovative value and transformation potential in the agricultural and manufacturing sectors, its implementation process still faces numerous deep-seated structural challenges. Identifying and clarifying the actual challenges and predicaments is an indispensable step in assessing the sustainability of the transformation and planning the future development path.

To promote the comprehensive digitalization of the agricultural supply chain, a series of practical challenges rooted in the characteristics of the industry need to be overcome. Firstly, the current coverage of digital technology application in the agricultural supply chain is relatively small. Farmers lack a clear understanding of the digitalization of the supply chain and have poor learning abilities, which results in insufficient application of technologies such as big data, the Internet of Things, and artificial intelligence. Secondly, due to the fact that agricultural production is mainly concentrated in remote areas, the construction of digital infrastructure such as broadband, 5G, and data centers is relatively weak, and there is a shortage of digital technology talents in remote areas, which leads to a lack of application foundation for digital technologies. Thirdly, due to the numerous and long supply chain links in the agricultural

products, the organizational structure of the supply chain cannot well adapt to the needs of digital transformation, and the response speed is relatively slow. The loose relationships among supply chain entities make information sharing difficult, especially core enterprises have a low willingness to share advantageous information resources, and supply chains often experience information islands, resulting in the slow development of transparent supply chain organization structures [14]. Fourthly, due to the relatively low level of specialization among the entities in the agricultural supply chain and insufficient digital integration of business processes, as well as the incomplete establishment of a digital operation system for business processes, a complete digital operation system has not yet been established [14]. Moreover, due to the problems such as poor internal information exchange within the agricultural industry chain, unstable cooperation among entities, and unbalanced distribution of benefits, the integration of blockchain and the agricultural industry chain is difficult. It requires the use of information sharing, risk control, and benefit distribution mechanisms. Finally, the governance of the agricultural product supply chain is limited to the joint governance among the supply chain members, ignoring the governance effect of third-party organizations, especially government-led supply chains. This requires the government departments to establish sound guarantee policies for digital governance and break the mechanism obstacles of digital governance in the supply chain [9].

During the digital transformation of the manufacturing supply chain, many challenges are also encountered. Firstly, the issue of uneven data quality is particularly prominent. Some data have problems such as low accuracy, lack of completeness, and inconsistent data formats, which makes the effective utilization of data difficult. Secondly, as data is widely used in the manufacturing industry, data security faces severe threats. Risks such as data leakage and malicious attacks are constantly increasing, which not only may damage the business interests of enterprises but also may affect the stable operation of the entire supply chain [19].

4 SUGGESTIONS AND FUTURE RESEARCH DIRECTIONS

Supply chain digitization has become a key driving force for the transformation and upgrading of agriculture and manufacturing industries. In agriculture, the focus is on enhancing the data decision-making capabilities and economic feasibility of the participating entities, especially farmers. In manufacturing, the core objective is to achieve deep integration of technical systems and secure governance of data assets. Based on the summary of this research, this paper proposes the following suggestions: First, the government should strengthen the construction of digital platforms and focus on cultivating a number of supply chain platforms that are fully traceable throughout the chain and fully visible across the entire domain. Second, the government should promptly improve the standardization application system of digital technologies related to agriculture, with a particular emphasis on developing key artificial intelligence technological innovations and application standards for information intelligent decision-making and management, blockchain traceability, smart warehousing and logistics, etc. in the supply chain, and promote the digitalization process of the supply chain [14]. Finally, the government should promptly improve the laws and regulations related to supply chain digitization, establish a support mechanism for digital transformation, coordinate the interests of all parties in the supply chain, promote the construction of digital infrastructure, guide farmers to actively improve their own digital literacy, and ensure the sustainable progress of digital transformation [4].

Based on the findings and limitations of this study, it is suggested that future research can conduct in-depth exploration in the following directions. First, based on the role evolution and interaction mechanism of stakeholders in the digitalization process of the supply chain, explore how consumer demands can be reverse-driven to standardize agricultural production through digital platforms; study the deep integration of technology between technology suppliers and traditional enterprises, especially the applicable innovation in the small-scale agricultural economy scenarios in developing countries. Second, based on the research level of institutional adaptability innovation, the adaptability of digital technology application in different regions needs to be focused on, such as quantifying the return on investment of digital infrastructure, establishing a cost-benefit assessment model applicable to developing countries, and conducting more in-depth regional institutional analysis on the impact of regional heterogeneity on the digitalization of agricultural supply chains [10]. Third, research on how to deeply integrate artificial intelligence, digital twins, and blockchain technologies to achieve real-time optimization of the entire supply chain. Explore cross-enterprise data sharing mechanisms to solve the problem of "data islands", and how to balance data openness and protection of business secrets. Fourth, with the development of green supply chains, deeply study how digital technologies can help achieve precise tracking and visualization of the entire life cycle carbon footprint, and empower the circular economy model is also a topic that needs to be focused on.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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