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# Impact of Digital Transformation on Supply Chain Collaboration Efficiency

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**Abstract:** With the rapid development of information technology, digital transformation has become a key strategy for enterprises to achieve innovative development and improve operational efficiency. This paper focuses on an in-depth study of the impact of digital transformation on the collaborative efficiency of enterprise supply chains. By sorting out the theoretical foundations related to supply chain collaborative efficiency and digital transformation, it deeply analyzes the mechanisms through which digital transformation affects the collaborative efficiency of enterprise supply chains. This paper proposes strategies to enhance the collaborative efficiency of enterprise supply chains from aspects such as internal digital construction of enterprises, collaboration among supply chain partners, and policy support and industry standard construction.

**Keywords:** Digital Transformation; Supply Chain Collaborative Efficiency; Information Sharing; Process Optimization; Risk Management

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## 1. Introduction

In the biotech industry, the entire supply chain process—from raw material procurement, product research and development (R&D), production to sales and distribution—involves numerous complex procedures and participating entities [1]. Digital transformation provides new ideas and approaches to solve these problems. By introducing advanced information technologies, it can effectively enhance supply chain collaborative efficiency and strengthen enterprises' competitiveness in the market [2].

## 2. Theoretical Foundations of Digital Transformation and Enterprise Supply Chain Collaborative Efficiency

### 2.1. Concept of Supply Chain Collaborative Efficiency

Supply chain collaborative efficiency refers to the degree to which each node enterprise in the supply chain achieves the overall supply chain objectives and the effective utilization of resources through collaborative means such as information sharing, resource integration, and process synchronization [3]. In the biotech industry, supply chain collaborative efficiency is reflected in the collaborative operation effects throughout the entire process, from the supply of biological raw materials to the R&D, production, sales, and after-sales service of biological products. For example, in the pharmaceutical

production supply chain, raw material suppliers need to closely collaborate with pharmaceutical enterprises to ensure stable quality and on-time supply of raw materials [4]. The R&D and production departments within pharmaceutical enterprises must efficiently collaborate to accelerate the R&D and production process of new drugs, while the sales and logistics departments need to coordinate with each other to ensure the timely delivery of drugs to medical institutions and patients. Efficient supply chain collaboration can reduce inventory backlogs, lower costs, shorten product delivery cycles, improve product quality and customer satisfaction, thereby enhancing the competitiveness of the entire supply chain [5]. Its measurement indicators include supply chain cost reduction rate, inventory turnover rate, order delivery on-time rate, product quality qualification rate, etc., which comprehensively reflect the efficiency and effect of supply chain collaborative operations.

### 2.2. Basic Concept of Digital Transformation

Digital transformation is a process in which enterprises use digital technologies (such as big data, cloud computing, the Internet of Things, artificial intelligence, etc.) to comprehensively reshape and innovate business models, organizational structures, operational processes, etc. In the biotech industry, digital transformation covers multiple levels. In the R&D link, big data is used to analyze massive biological data to accelerate the discovery and screening of drug targets, and artificial intelligence is used to simulate drug molecular structures and activities to improve R&D efficiency. In the production process, the Internet of Things is used to achieve interconnection and real-time monitoring of production equipment, and automation technologies are used to enhance production precision and efficiency [6]. In supply chain management, digital platforms are used to achieve information sharing and collaborative decision-making, optimizing procurement, inventory, and logistics management. Digital transformation is not just the application of technology, but also a change in thinking mode and management concept. It requires enterprises to break down traditional departmental barriers, realize data-driven decision-making and operations, and adapt to the rapidly changing market environment.

### 2.3. Relationship between Digital Transformation and Supply Chain Collaborative Efficiency

Digital transformation provides powerful technical support and innovative momentum for improving supply chain collaborative efficiency. On the one hand, digital technologies can break down information silos, achieve real-time sharing and transparency of information among supply chain node enterprises, enable enterprises to promptly understand the needs, inventory, production progress, etc., of upstream and downstream enterprises, so as to make more accurate decisions, optimize resource allocation, and improve collaborative efficiency [7]. For example, by establishing a digital supply chain platform, biotech enterprises and suppliers can share real-time raw material inventory and demand information, allowing suppliers to adjust supply plans in a timely manner according to the enterprises' production plans, reducing the risks of stockouts and inventory backlogs. On the other hand, digital transformation promotes the automation and intelligence of supply chain processes, simplifies cumbersome business processes, reduces manual intervention, and improves process execution efficiency and accuracy [8]. For instance, artificial intelligence algorithms are used to optimize logistics distribution routes, improving distribution efficiency and reducing logistics costs. In addition, digital transformation helps enterprises better manage risks, predict supply chain risks through data analysis, formulate response strategies in advance, ensure the stable operation of the supply chain, and thus improve collaborative efficiency.

## 3. Impact Mechanisms of Digital Transformation on Enterprise Supply Chain Collaborative Efficiency

### 3.1. Enhancement of Information Sharing and Collaborative Efficiency

Timely and accurate information transmission is crucial in the supply chain of the biotech industry. Digital transformation realizes centralized management and sharing of information across all supply chain links by constructing unified information platforms, such as Enterprise Resource Planning (ERP) systems and Supply Chain Management (SCM)

systems. Take biopharmaceutical enterprises as an example: R&D departments can use such platforms to transmit information on new drug R&D progress, raw material demands, etc., to procurement and production departments in real time [9]. The procurement department promptly purchases suitable raw materials based on this information, while the production department reasonably arranges production plans according to R&D progress and raw material supply. Meanwhile, the sales department can obtain product inventory and delivery time information from the production department through the platform to accurately commit delivery dates to customers. This information sharing avoids decision-making errors and process delays caused by information asymmetry, improving collaborative efficiency among all links. The application of big data technology enables enterprises to analyze and mine massive supply chain data to obtain valuable information, such as market demand trends and supplier performance, providing data support for enterprise decision-making and further optimizing supply chain collaboration [10]. For instance, by analyzing historical sales data and market trends, enterprises can more accurately predict product demand, adjust production and procurement plans in advance, and achieve more precise collaboration with suppliers and sales channels.

### 3.2. Enhancement of Process Optimization and Collaborative Efficiency

Digital transformation assists enterprises in comprehensively sorting out and optimizing supply chain processes. Using the concept of Business Process Reengineering (BPR) combined with digital technologies, it simplifies and automates traditional cumbersome and inefficient processes. In the production process of biological products, introducing automated production lines and intelligent manufacturing technologies realizes digital control of the production process, reduces manual operation links, and improves production efficiency and product quality stability. Meanwhile, digital technologies make the process connections among all supply chain links closer and smoother [11]. For example, in the logistics distribution link, the Internet of Things (IoT) technology is used to achieve real-time monitoring and tracking of goods transportation, allowing logistics enterprises to adjust distribution routes in a timely manner according to actual transportation conditions and ensure on-time delivery. Departments within enterprises can also achieve collaborative office through digital processes—for example, procurement applications and approval processes are automated through electronic systems, significantly shortening process cycles. In addition, digital transformation promotes the flexible development of supply chains, enabling enterprises to quickly adjust production and distribution plans according to market demand changes, improve market response speed, and further enhance collaborative efficiency [12]. For instance, when market demand for a certain biological product suddenly increases, enterprises can quickly adjust production equipment parameters through digital systems to increase output and collaborate with logistics enterprises to accelerate distribution speed and meet market demand.

### 3.3. Enhancement of Risk Management and Collaborative Efficiency

The supply chain of the biotech industry faces numerous risks, such as raw material supply disruptions, market demand fluctuations, and policy/regulatory changes. Digital transformation provides enterprises with more effective risk management means. Through big data analysis and artificial intelligence (AI) technologies, enterprises can conduct real-time monitoring and early warning of supply chain risks [13]. For example, big data is used to analyze information such as the production capacity and financial status of raw material suppliers to predict potential supply disruption risks, and alternative suppliers are sought in advance or procurement strategies are adjusted. In terms of market demand risk management, analyzing market data and consumer behavior enables enterprises to more accurately predict market demand changes, timely adjust production and inventory strategies, and avoid inventory backlogs or stockout risks caused by demand fluctuations [14]. When facing policy or regulatory changes, enterprises can quickly obtain relevant information through digital platforms and coordinate adjustments across all supply chain links to ensure compliant operations. For instance, when drug regulatory policies change, pharmaceutical enterprises can promptly convey policy requirements to suppliers and production departments, jointly adjust production processes and quality control standards, and ensure products comply with regulatory requirements [15]. Effective risk management ensures the stable operation of the supply

chain, reduces the negative impact of risk events on collaborative efficiency, and thus improves supply chain collaborative efficiency.

# 4. Strategies for Improving Enterprise Supply Chain Collaborative Efficiency under Digital Transformation

## 4.1. Strategies for Internal Digital Construction of Enterprises

Enterprises should increase investment in digital technology R&D and applications. For biotech enterprises, key focuses can include the application of big data analysis in biological data processing and drug R&D, as well as using AI technologies to optimize production processes and quality control. Establish a sound data management system to ensure data accuracy, completeness, and security. Set up a specialized data management department responsible for data collection, organization, storage, analysis, and application; formulate data standards and specifications to improve data quality. Strengthen the integration of internal information systems to break down information silos between departments. Deeply integrate systems such as ERP, SCM, and Customer Relationship Management (CRM) to achieve real-time data sharing and seamless docking of business processes. For example, the production department's plans are transmitted in real-time to the procurement and sales departments, while the procurement department's progress is promptly feedback to the production department, enhancing internal collaborative efficiency. Strengthen the cultivation and introduction of digital talent to improve employees' digital literacy. Cultivate compound talents who understand both biotech professional knowledge and digital skills through internal training, cooperation with universities and research institutions, etc. Meanwhile, actively introduce external digital talent to enrich the enterprise's digital construction team and provide talent support for digital transformation.

## 4.2. Strategies for Supply Chain Partner Collaboration

Establish long-term stable strategic partnerships with suppliers to achieve information sharing and collaborative planning through digital platforms. Jointly formulate raw material procurement plans, production plans, and inventory management strategies to ensure the stability and timeliness of raw material supply. For example, biotech enterprises share production plans and inventory information with raw material suppliers, who arrange production and distribution in advance based on enterprise needs, reducing inventory costs for both parties. Strengthen collaborative cooperation with logistics enterprises, using IoT, big data, and other technologies to achieve visual and intelligent management of logistics distribution. Track goods transportation status in real-time, optimize distribution routes, and improve distribution efficiency. Enterprises can co-develop logistics information sharing platforms with logistics enterprises to realize real-time information interaction and promptly solve problems in the logistics distribution process. Promote digital collaborative innovation among upstream and downstream supply chain enterprises. In the biotech industry, encourage pharmaceutical enterprises to cooperate with scientific research institutions, universities, etc., in new drug R&D, sharing R&D data and resources through digital platforms to accelerate the R&D process. Meanwhile, in product production and sales links, upstream and downstream enterprises jointly explore digital innovation models to enhance the competitiveness of the entire supply chain. For instance, pharmaceutical enterprises and packaging enterprises co-develop digital packaging technologies to achieve product traceability and anti-counterfeiting functions, enhancing product added value.

## 4.3. Policy Support and Industry Standard Construction

In the process of digital transformation in the biotech industry, policy support and industry standard construction serve as important pillars to ensure the improvement of supply chain collaborative efficiency. Governments need to construct a multi-level policy system, providing special support for technical R&D, equipment upgrading, and other links in the digital transformation of biotech enterprises. A digital transformation fund for the biotech industry can be established to subsidize projects where enterprises use technologies such as big data and artificial intelligence to transform supply chains. For

example, biopharmaceutical enterprises introducing intelligent warehouse management systems could receive financial support at a certain proportion of their equipment investment. Meanwhile, tax preferential policies should be introduced to implement pre-tax deductions for expenses such as enterprises' procurement of digital testing equipment and construction of cloud-based supply chain management platforms, reducing transformation costs for enterprises.

Strengthening the construction of digital infrastructure for the biotech industry is a key direction of policy support. It is necessary to accelerate the deep coverage of 5G networks in biotech industrial parks, build a low-latency and high-reliability industrial Internet environment, and meet the real-time data transmission needs of production equipment. For instance, in vaccine production enterprises, 5G networks can enable millisecond-level transmission of operational data from key devices such as fermentation tanks and purification equipment, providing real-time data support for supply chain collaborative decision-making. Additionally, constructing exclusive cloud computing centers for the biotech field to offer professional services like gene sequencing data storage and protein structure simulation calculations can lower the technical threshold for digital transformation of small and medium-sized enterprises.

Strengthening policy implementation supervision and industry self-discipline mechanisms is equally important. Government departments can establish an evaluation platform for digital transformation policy implementation to dynamically monitor the use of enterprise subsidy funds and transformation effects, ensuring effective allocation of policy resources. Industry associations should take the lead in formulating the Biological Supply Chain Data Security Management Specifications, clarifying encryption transmission and storage standards for sensitive information such as genetic data and production process data to prevent data leakage risks. Through the dual role of policy guidance and standard constraints, a standardized and orderly digital ecosystem can be constructed, laying a institutional foundation for improving the supply chain collaborative efficiency of biotech enterprises.

### 4.4. Strategies for Digital Collaborative Innovation of Industry-University-Research

Aiming at the special needs of technology transformation from R&D to production in the biotech industry, constructing a digital collaborative innovation system for industry-university-research is a key path to improve supply chain collaborative efficiency. Biotech enterprises can join hands with universities, research institutions, and industrial parks to build a cloud-based digital collaborative R&D hub, realizing end-to-end data connectivity from laboratory data, pilot process to large-scale production. For example, in the scenario of vaccine R&D, the research team shares strain screening data in real time through the platform, the enterprise's production department simulates large-scale cultivation process parameters synchronously, and the logistics team plans cold chain storage solutions in advance, forming a digital collaborative network of "R&D-production-distribution".

Establishing standardized technical transformation data interfaces is the core of this strategy. It is necessary to formulate biological data collection specifications (such as gene sequences, fermentation parameters, etc.) and develop API interfaces adapted to different R&D tools, so that laboratory equipment, pilot devices and enterprise ERP systems can achieve data interconnection. Through this model, a biopharmaceutical enterprise has shortened the cycle of monoclonal antibody drugs from cell line construction to trial production by 40%, and increased the transmission accuracy of key process parameters to 98%. Meanwhile, digital twin technology is introduced to carry out virtual modeling of the pilot production line. Researchers can verify the feasibility of process scaling in a virtual environment, discover production bottlenecks in advance, and reduce the number of iterations in actual pilot trials.

## 5. Conclusion

In summary, digital transformation is a key path for biotech enterprises to improve supply chain collaborative efficiency. It enhances enterprise competitiveness through information sharing, process optimization, and risk control. It is recommended that practitioners leverage their professional advantages to promote digital practices, seize opportunities in career development, and help achieve common growth of enterprise and personal value.

## Disclosure statement

The author declares no conflict of interest.

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