Journal of Economics and Public Finance
ISSN 2377-1038 (Print) ISSN 2377-1046 (Online)
Vol. 11, No. 3, 2025
www.scholink.org/ojs/index.php/jepf

Original Paper

Research on the Application of Blockchain Technology in Green Supply Chain Operations

Sha Jiang[1*]

[1*] Digital Business School, Sichuan University of Science and Technology, Chengdu, Sichuan 610000, China

E-nail: 455515567@qq.com

Received: May 5, 2025 Accepted: June 26, 2025 Online Published: June 30, 2025

doi:10.22158/jepf.v11n3p38 URL: http://dx.doi.org/10.22158/jepf.v11n3p38

Abstract

In the context of achieving the goals of carbon peak and carbon neutrality, green supply chain management has evolved into an inevitable direction for industry development. However, in practical operations, the problem of information asymmetry continues to restrict the overall efficiency of the green supply chain, hinders the collaborative operations among upstream and downstream enterprises, and weakens consumers' confidence in the reliability of the source of green products. This has led to multiple dilemmas. Blockchain technology, with its decentralized architecture, tamper-proof data security, and efficient traceability capabilities, is opening up new paths to solve the key obstacles in green supply chain management and holds great development potential. Although the combination of the two has broad prospects, the current collaborative mechanism between blockchain and green supply chain still requires systematic research. The core challenge lies in how to significantly optimize the operational efficiency of the green supply chain through blockchain and build a policy environment that positively encourages enterprises to implement green production. This issue has entered the vision of government decision-makers; at the same time, enterprises need to deeply analyze how to promote green innovation through market competition pressure to consolidate market competitiveness; moreover, the introduction of blockchain will increase the cost pressure on the green supply chain, which may become a constraint for enterprises with limited capital strength. The exploration in this field will directly affect the effectiveness of green supply chain management practices. This paper systematically studies the collaborative mechanism between blockchain technology and green supply chain, as well as the dual-chain integration path, in combination with policy support, market competition, and core enterprise capabilities, aiming to promote their deep integration and innovation.

Keywords

Blockchain, Green Supply Chain, Supply Chain Operations

1. Introduction

From the perspective of competitive dynamics, enterprises currently face external competition challenges in a complex and volatile environment. These challenges have a global impact on strategic planning and directly affect the decision-making balance of enterprises in high-priority matters such as technological innovation. In the context of accelerating technological iteration, enterprises' proactive adoption and optimization of new technologies have become a necessary condition for maintaining market position. External competition and enterprise technological innovation form a positive feedback loop: competitive pressure forces enterprises to accelerate the innovation process, while technological progress can be transformed into the competitive moat of enterprises. Specifically, green supply chains bear significant pressure from horizontal competition in the process of resource integration, requiring enterprises to fully adopt environmental responsibility practices in supply chain management. Although the external competitive environment poses severe challenges, it also provides new opportunities and development momentum for enterprises to transform into an environmentally friendly operation model. In increasingly fierce industry competition, technology capitalists have gradually become important participants in enterprise governance, effectively promoting a significant leap in the company's innovation capabilities through direct or indirect means. Changes in the external market environment have a significant impact on enterprises' investment decisions in blockchain technology, and the evolution of technological innovation strategies will deeply change their relationships with upstream and downstream partners and competitors (Zhang Chong et al., 2022). Multiple competitive-related factors have a direct and significant impact on enterprises' investment choices in blockchain technology, and the deployment and application of blockchain technology will dynamically adjust the pricing logic and profit potential of competitive green supply chains. Therefore, when implementing management strategies such as blockchain technology, enterprises should comprehensively consider the macro industry background and deeply analyze the complex interaction between the external competitive situation and blockchain technology investment of the enterprise.

Blockchain technology is expected to play a leading role in supply chain management and become a key force driving the green upgrade of industries, and will play a core role in building green supply chains. The deep integration of blockchain technology in green supply chains is not smooth sailing but is constrained by multiple complex factors. Specifically, the policy support and guidance role of the government at the macro level, the pressure and opportunities of the external competitive environment at the micro level, and the comprehensive capabilities and innovation levels of the enterprise are all decisive factors that enterprises need to consider when adopting blockchain technology. Given this, this study conducts a systematic exploration based on the core advantage of blockchain technology in solving the trust deficit in green supply chains from three dimensions: government subsidy mechanisms, external

competitive landscapes, and green supply chain systems, aiming to explore feasible paths for optimizing the management model of green supply chains and having important theoretical significance and practical guiding value.

2. The Relevant Concepts

2.1 The Green Supply Chain

The academic community generally believes that the green supply chain, as a new management concept, sets resource conservation and environmental protection as its core goals, marking a new trend in the development of the supply chain field. Currently, this model is experiencing rapid growth, not only enriching its theoretical framework but also expanding its application scope, thereby promoting the emergence of innovative concepts such as green production and reverse logistics, and standardizing related terms. In the context of the new era, green supply chain management faces higher standards: enterprises need to optimize production processes systematically, significantly reduce environmental loads, and focus on maximizing resource efficiency to achieve the goal of sustainable development. This management model has transcended the limitations of single enterprise collaboration and formed a complete network covering raw material suppliers to end-users, integrating the participation of multiple stakeholders. Domestic scholars have deeply analyzed the green supply chain system, and its system composition includes four subsystems: production, consumption, society, and environment.

2.2 The Overview of Blockchain Technology

Blockchain technology, as a typical representative of distributed ledger technology, has core characteristics such as decentralization, immutability, transparency and traceability, as well as key technical features like smart contracts. From the architectural perspective, the blockchain network is composed of the data layer, network layer, consensus layer, incentive layer, contract layer and application layer. The collaboration of these layers ensures the security and reliability of the system.

In the green supply chain scenario, the technical characteristics of blockchain demonstrate significant advantages. Firstly, its distributed ledger feature enables all participants in the supply chain to obtain the same transaction data in real time, fundamentally solving the problem of information isolation. For example, by using the hash algorithm to package transaction data into blocks and ensuring data immutability through timestamps and chain structure, it provides technical support for the full life cycle traceability of green products. Secondly, the smart contract technology can automatically execute pre-set business logic, such as automatically triggering the payment process for procurement when a batch of raw materials meets the set environmental protection standards, improving efficiency and reducing the risk of human intervention.

From the perspective of technical implementation, blockchain is mainly adopted in supply chain management in an alliance chain architecture, which retains the transparency of public chains while ensuring commercial privacy through access control mechanisms. Specifically, based on consensus algorithms such as PBFT or RAFT, it can achieve high transaction throughput while ensuring data

consistency, meeting the high concurrency requirements of supply chain business. In addition, by combining the environmental data collected by IoT devices (such as carbon emissions) with blockchain verification, it can provide immutable data support for green certification.

3. The Green Supply Chain Operation Strategies under the Influence of Government Subsidies for Blockchain Technology

3.1 The Sensitivity Analysis of the Operating Cost Optimization Coefficient

This paper, through rigorous numerical methods, explores the mechanism by which the operational cost optimization coefficient affects the optimal social welfare and profits of different participants in the green supply chain (such as manufacturers, retailers, and governments), and systematically elaborates on the design of the optimal subsidy scheme for the members of the green supply chain system. The research results show that as the operational cost optimization coefficient continues to increase, the marginal benefit of blockchain technology in reducing operational costs exhibits a decreasing characteristic, which in turn leads to a significant compression of the marginal profits of manufacturers and retailers. In this context, there is an inherent demand for the expansion of the fiscal subsidy scale by the government to enhance the incentive effect. It is worth noting that the level of social welfare, under the interaction of multiple factors such as the decline in manufacturer and retailer profits, the increase in subsidy investment, and the reduction in economic operation efficiency, shows a gradually decaying trend as the operational cost optimization coefficient increases. The study reaches the following core conclusions: (1) Regardless of the level of the operational cost optimization coefficient, the investment application of blockchain technology has a positive economic incentive effect on manufacturers, retailers, and relevant government departments; (2) If the government adopts a subsidy policy based on production scale, this strategy has a superior comprehensive performance in improving the optimal social welfare value, the economic benefits of manufacturers, and the profits of retailers compared to the other three possible subsidy models. Especially when the initial investment cost coefficient of blockchain technology for manufacturers is small, regardless of how the specific operational cost optimization coefficient changes, the government's measure of applying the number of blockchain technology products through subsidies has the optimal strategic value.

3.2 The Sensitivity Analysis of Consumer Preference Coefficient for Blockchain Technology

This study adopts rigorous quantitative research methods to systematically examine the significant impact of consumers' preference for blockchain technology on the social welfare and profit distribution mechanism of each node enterprise in the green supply chain network. Through in-depth analysis of the optimization model of green supply chain members, this research reveals the design path of the optimal incentive strategy under different subsidy policies. The research results show that when the cost input coefficient of manufacturing enterprises in blockchain technology development is relatively small, regardless of the pure market environment or the government providing special fiscal subsidies, the comprehensive income of manufacturers and retailers will show a regular growth pattern as the

acceptance degree of consumers for blockchain technology increases. Particularly, when the government adopts a fiscal subsidy policy based on the quantity of blockchain products, the model exhibits a clear nonlinear characteristic. Specifically, when the preference level of consumers for blockchain technology is in the lower range, the total social welfare and the profitability of manufacturing enterprises show a significant positive correlation, increasing continuously as the preference coefficient increases. However, once the preference coefficient exceeds a specific threshold, the social welfare indicators and the profits of manufacturing enterprises may instead show a marginal utility decline phenomenon. In sharp contrast, the profits of retailers always maintain a high positive correlation with the preference coefficient of consumers and show a continuous upward trend, unaffected by the critical point. This finding provides key insights for policy makers in the green supply chain regarding the design of subsidy mechanisms.

As the cost input of manufacturers for blockchain technology continues to rise, the optimal social welfare indicators and the income levels of manufacturers and retailers show a significant trend of positive correlation with the preference coefficient of consumers for blockchain technology. It is notable that when the government adopts a subsidy mechanism based on the quantity of blockchain technology adoption, the optimal social welfare, the profits of manufacturers and retailers show the highest order sensitivity coefficient to the degree of consumers' preference for blockchain technology. This phenomenon clearly verifies that the government, through the form of product output subsidies, can significantly stimulate the enthusiasm of manufacturers and retailers to adopt blockchain technology and help enhance the overall welfare contribution of the entire society. Through horizontal analysis of different models, it can be found that regardless of the changes in the acceptance degree of consumers for blockchain technology, the overall social welfare level and the profitability of each link in the supply chain always remain at the optimal state. This conclusion fully proves that implementing a product quantity subsidy strategy by the government to promote the application of blockchain technology not only has significant advantages for all participants in the supply chain, but is also the optimal policy path to maximize the overall social interests.

3.3 The Sensitivity Analysis of the Investment Cost Coefficient of Manufacturer Blockchain Technology

This paper systematically analyzes how the investment cost coefficient of manufacturing enterprises in blockchain technology significantly affects the optimal social welfare and economic benefits of all participants in the green supply chain, and verifies the relevant hypotheses through detailed quantitative research. Empirical studies show that, under the condition that the market efficiency and consumer acceptance that blockchain technology can enhance remain constant, the social welfare level and the optimal profits of manufacturers and retailers in the supply chain exhibit a regular characteristic of gradually weakening as the investment cost coefficient of blockchain technology by manufacturers increases. Particularly crucially, when government subsidies are linked to the quantity of products adopting blockchain technology, the sensitivity of social welfare, manufacturer profit margins, and retailer profits to the change in the cost coefficient reaches its peak. This phenomenon reflects that as the investment cost coefficient of blockchain technology by manufacturers rises, the actual application

benefits of this technology decrease accordingly, and the rapid growth of costs directly weakens the profitability of manufacturers. In this context, the government needs to simultaneously increase the subsidy standards to ensure that manufacturers maintain continuous investment and market promotion of blockchain technology. Although retailers may have limited direct economic benefits from adopting blockchain technology, they still need to bear fixed implementation costs, resulting in a downward trend in their profits as the investment cost coefficient of blockchain technology by manufacturers increases. Under the multiple influences of the overall weakening of supply chain profitability, continuous increase in government subsidy expenditures, and decline in technical optimization effects, social welfare levels are constrained, and ultimately form a fluctuating pattern of decreasing with the increase of the investment cost coefficient of blockchain technology by manufacturers. This research conclusion provides an important theoretical basis for the government to formulate green supply chain technology support policies. By comparing the optimal social welfare and the benefits of all parties in various models, it can be seen that regardless of how the intensity or iteration range of the investment in blockchain technology by producers changes, if the government implements a special compensation for products adopting blockchain technology, this policy has obvious and outstanding comprehensive benefits for manufacturers, suppliers, and user groups, and demonstrates efficient decision-making advantages.

4. The Green Supply Chain Operation Strategies under the Influence of External Competition from Blockchain Technology

To conduct a systematic study on the intrinsic influence of external competition on enterprises' decision-making regarding green supply chain implementation in the blockchain technology environment, this research selects two major categories of green manufacturing enterprises as the analysis objects. It examines the various combinations of competitive states that may arise when these enterprises choose between persisting in the traditional green production model or investing in the application of blockchain technology. The aim is to clarify how the competitive environment specifically affects the adoption paths of enterprises towards blockchain technology and its effect on the overall optimal interests of the enterprise's supply chain.

Experimental data reveals that in a competitive market, if two manufacturers make differentiated decisions regarding the application of blockchain technology, the enterprise that solely adopts this technology may not consistently generate better benefits than the one relying on the traditional environmentally friendly production method. The reason for this is that although blockchain can provide significant technical advantages, its high research and development and operational expenses cannot be ignored. Especially when introducing immature technology, a longer evaluation stage is required to weigh the investment return against the cost, and to balance the investment and consumption. Moreover, manufacturers must comprehensively consider the intensity of the competitive environment and formulate dynamic and scientific technology deployment plans. In a market with relatively low competitive pressure, companies that adopt blockchain technology can significantly enhance internal

demand and achieve a surge in sales, while at the same time enjoying the technological advantages of enterprises that are comparable. At this time, technology investors can obtain far superior and substantial profits compared to competitors.

In the current intense competition among enterprises, the adoption rate of blockchain technology has significantly increased. Consumers' willingness to pay additional fees for products that provide transparent environmental information and are highly credible has also significantly strengthened. Although the integration of technology may bring certain cost increases, its impact is still within a reasonable range. Therefore, even if the price of products using blockchain technology is slightly higher than traditional green products, the market still maintains stable growth. This positive phenomenon greatly promotes enterprises' investment in technological innovation and helps achieve new breakthroughs in green development. Especially in competitive supply chain environments, once the competitive intensity exceeds a certain threshold, enterprises tend to adopt similar research strategies to ensure that their product technological leadership matches that of their competitors, in order to maintain their market competitiveness. As the competition intensifies, the resource allocation among enterprises gradually shows a homogenized trend, leading to a continuous increase in the substitutability of products.

5. The Green Supply Chain Operation Strategies under the Influence of Blockchain Technology Financing

The application and implementation of blockchain technology usually require enterprises to invest a large amount of capital, which poses a significant financial burden for most companies. In this context, supply chain financing has developed into the core financial means currently supporting enterprises in their comprehensive expansion. From the perspective of enterprises, This paper conducts an in-depth study on the financing strategies of applying blockchain technology to the green supply chain, and thoroughly explores how different interest rate structures and methods can promote the smooth operation of the green supply chain. It aims to provide a solid theoretical basis for enterprises to determine the optimal solution among various financing options.

This research establishes a two-level green supply chain system consisting of manufacturers with limited funds and retailers with abundant funds. In this system structure, manufacturers use four differentiated financing methods to solve the funding gap problem caused by the introduction of blockchain technology. Specifically, the no-funding (NF) strategy allows manufacturers to complete the investment deployment and production operation of blockchain technology solely relying on internal resources; the trade financing (TCF) strategy supports manufacturers in obtaining trade credit from upstream retailers and using this fund specifically for the introduction and application of blockchain technology; the bank financing (BCF) strategy provides manufacturers with the means to apply for and obtain loans from financial institutions; and the hybrid financing (HF) strategy innovatively combines some bank loans and some equity financing, aiming to effectively meet the financial needs of introducing blockchain technology through diversified capital combinations. Through a rigorous theoretical framework and

detailed quantitative analysis, the study systematically investigates the determination of optimal decisions, market demand fluctuations, and the realization of profit maximization under the four financing models. This financing initiative promotes the research plan of blockchain technology in the green supply chain, and its core purpose is to overcome two key challenges: (1) Under what conditions do enterprises investing in blockchain technology choose financing? How does blockchain technology significantly influence the capital choices and profits of green supply chain participants through decisive factors? (2) What are the optimal operational decisions for green supply chain members under each financing strategy? What financing strategy should manufacturers adopt when investing and applying blockchain technology?

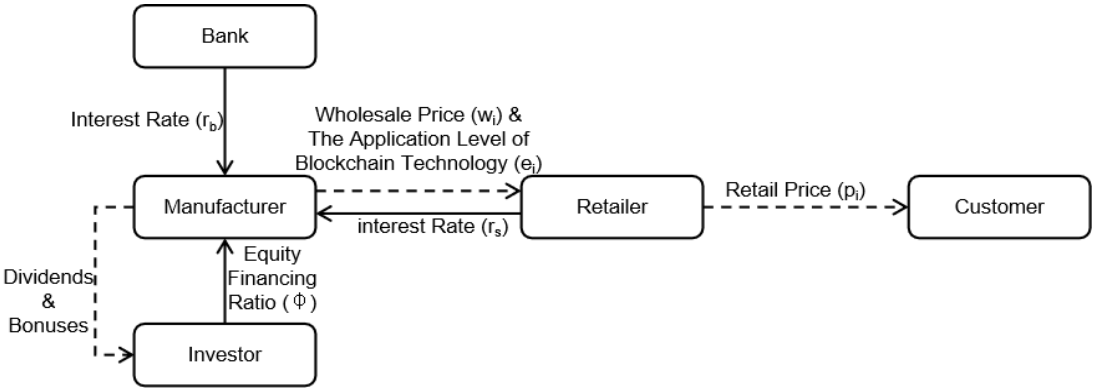

Figure 1. System Diagram of Green Supply Chain Financing Mode

5.1 The Impact of the Preference Coefficient of Blockchain Technology on Supply Chain Operations

Through quantitative research, it has been confirmed that the profits of manufacturers and retailers show a positive trend as consumers' acceptance of blockchain technology gradually increases under the TCF, BCF, and HF strategies; in contrast, the related profits in the NF financing model exhibit a negative correlation. Within the TCF, BCF, and HF strategy systems, as consumers' understanding and adoption of blockchain technology enhance, the optimal decision-making configuration and market capacity show significant growth. However, for the NF strategy, even as the consumer preference coefficient continues to increase, manufacturers still need to deepen the deployment scope and implementation intensity of blockchain technology, but due to their own capital limitations, they are unable to effectively respond to the continuous expansion of market demand for blockchain technology, which ultimately leads to a contraction in market capacity and subsequently has a negative impact on the profitability of retailers under the NF model.

From the perspective of manufacturers, TCF (trader financing) and BCF (bank supply chain finance) have obvious advantages over the HF (supplier holding inventory) strategy because the latter requires additional proportional splitting of profits for shareholder distribution. Among all strategies, TCF performs better, but its disadvantage is that the high cost of third-party financing by banks will erode the overall profit level of the supply chain. Moreover, the NF (no intermediary) financing model is limited

by the manufacturer's original capital shortage, and due to the positive attitude of consumers towards the emerging blockchain technology, manufacturers find it difficult to meet their requirements, resulting in limited profits.

Given the relatively limited public awareness of blockchain technology, the investment return of its application has limitations. For retailers, implementing the no-funding (NF) strategy has significant feasibility. However, as consumers' acceptance of this technology gradually increases, relying solely on the NF strategy is unable to meet the growing market demand, and its advantageous position will gradually weaken. In the horizontal comparison of various financing strategies, retailers choosing high financing (HF financing strategy) are expected to achieve the most optimal profit level. It is worth noting that when the preference of market participants for blockchain technology increases, that is, when the technical investment return rate improves continuously, retailers adopting the total control financing (TCF strategy) will exhibit the most prominent profit growth trend. This growth rate will be significantly faster than the balanced control financing (BCF strategy) and ultimately surpass the HF financing strategy.

5.2 The Impact of the Operational Cost Optimization Coefficient on Supply Chain Operations

No matter how the financing strategies change, the profit level of manufacturers will gradually weaken due to the increase in the coefficient of blockchain technology in optimizing operational costs. Especially in the three financing methods of TCF, BCF and HF, the retailers' profits show a downward trend simultaneously, while only in the NF strategy, the profit performance of both manufacturing and retail sides shows an opposite change feature.

Although the coefficients of different blockchain technologies in optimizing operational costs fluctuate, when adopting the NF strategy, its retail pricing and market demand volume perform better compared to the TCF, BCF and HF strategies. The situation of market supply exceeding demand caused by the NF strategy will lead to long-term pressure on merchants' profits. In contrast, the dispersion degree of retail prices is higher than the change amplitude of market demand, which makes the HF strategy the profit-maximizing solution, followed by the TCF strategy. When the coefficient of optimizing operational costs by blockchain technology continues to increase, the profit gap between merchants in the TCF and HF strategies shows a tendency to gradually narrow.

5.3 The Impact of Financing Interest Rates on Supply Chain Operations

Within the framework of the BCF and HF strategies, the manufacturer's profit level shows a negative and decreasing trend as the financing interest rate rises. In sharp contrast, the profit under the TCF strategy exhibits an inverse variation characteristic. It is worth noting that regardless of the TCF, BCF or HF strategies, the net profit of retailers follows a regular pattern of decreasing in tandem with the growth of the financing interest rate. For manufacturers, leveraging the collaborative financing of retailers can significantly enhance their operating profits, and the operation of the trade credit system essentially becomes an important driving force for them to continuously advance the research and development of blockchain technology. Although the TCF strategy requires manufacturers to share part of the capital usage costs, it can increase the retail price reasonably to enhance the overall profitability. In comparison,

the BCF and HF strategies not only force manufacturers to bear additional financing costs but also face the dual constraints of a downward wholesale price and a declining market demand. Eventually, this leads to a severe squeeze on their profit margins. As the financing cost increases, the investment in blockchain funds by producers will gradually decrease, and the shortage of funds will severely limit their research and deployment of new technologies, thereby reducing the actual effectiveness of blockchain technology. Eventually, this triggers a shrinking demand for related innovative products in the market, and delays the industrial iteration process.

6. The Conclusion

The application research of blockchain technology in the operation of green supply chains has demonstrated significant practical value and broad development prospects. In competitive green supply chains, different enterprises have different responses to the behaviors of their competitors and the degree of threat they perceive. Enterprises that are highly sensitive to competition feel greater threats from their rivals. Therefore, when the rival enterprises take actions, they will promptly adjust their related strategies and behaviors. Overall, external competition drives enterprises to invest in blockchain technology. The competition among enterprises has a significant impact on their investment decisions in blockchain technology. At the same time, blockchain technology also enhances the competitiveness of enterprises. When external competition is relatively small, investing in blockchain technology can generate advantages such as high consumer trust in products, stimulating consumption preferences, forming product differences with competitors, obtaining competitive advantages, reducing product substitutability, and enabling enterprises to achieve sustainable development under the pressure of green production.

References

Dong, C., Chen, C., Shi, X., et al. (2021). Operations strategy for supply chain finance with asset-backed securitization: Centralization and blockchain adoption. *International Journal of Production Economics*, *241*, 108261.

Gong Qiang, Ban Mingyuan, & Zhang Yilin. (2021). Blockchain, Enterprise Digitalization and Supply Chain Finance Innovation. *Management World*, *37*(02), 22-34 + 3.

Jian, H. W., & Lin, W. (2022). Research on Decision-Making and Coordination of Green Supply Chain Considering Fair Preference of Retailers. *Journal of Systems Science and Mathematical Sciences*,2022,42(2), 386.

Li Yongjian, & Chen Ting. (2021). Blockchain Empowering Supply Chain: Challenges, Implementation Pathways and Prospects. *Nankai Management Review*, *24*(05), 192-201 + 212 + 202-203.

Liang Xiaobei, Jiang Jiang, Meng Hu, et al. (2020). Decision-making Model for Green Supply Chain Considering Government Subsidies and Risk Avoidance. *Prediction*, *39*(01), 66-73.

Liu Liang, & Li Fushou. (2022). Investment Decision and Coordination of Blockchain Technology in Fresh Food Supply Chain Considering Retailer Risk Aversion. *Journal of Management Engineering*, *36*(01), 159-171.

Stekelorum, R., Laguir, I., Gupta, S., et al. (2021). Green Supply Chain Management Practices and Third-Party Logistics Providers' Performances: A Fuzzy-Set Approach. *International Journal of Production Economics*, *235*, 108093.

Tan Chunqiao, Liu Ruicun, & Zhao Chengwei. (2022). Research on Pricing Strategy of Vaccine Supply Chain Based on Blockchain Technology. *Journal of Management Engineering*, *36*(06), 205-220.

Xia Xiqiang, Zhu Qinghua, & Liu Junjun. (2021). Comparative Analysis of Upstream and Downstream Green R&D Models and Coordination Mechanism Research. *Systems Engineering Theory and Practice*, *41*(12), 3336-3348.

Zhang Chong, Wang Yaxian, & Liu Tianliang. (2022). Financing Decision Analysis of Green Supply Chain under Chain-And-Chain Competition. *Journal of Management Engineering*, *36*(02), 159-172.