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Computer-Aided Design AND APPLICATIONS

Enterprise Supply Chain Optimization Algorithm Based on Big Data

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Abstract. This article uses big data technology to analyze the current situation and problems of enterprise Supply chain management (SCM), puts forward targeted optimization schemes, and designs effective computer-aided algorithms to support supply chain optimization decisions. Firstly, this article combs the related theoretical and practical achievements of SCM and big data technology through literature research, which provides theoretical support and methodological guidance for this study. Secondly, the supply chain optimization model based on big data is constructed by using a mathematical modelling method, and the optimization objectives and constraints are defined. Then, the model is solved and optimized by a computer-aided algorithm design method. In conclusion, the effectiveness and feasibility of the introduced model and algorithm have been confirmed through case studies, leading to relevant research findings and recommendations. The findings reveal that the implementation of the optimization algorithm has notably enhanced the performance of enterprise SCM, with an average score of 9 points. This significant increase surpasses both the pre-implementation level and the industry benchmark. This shows that the algorithm introduced in this article is not only effective but also has strong optimization ability in practical applications. Service attitude, response speed, and problem-solving efficiency have all been highly praised by users.

Keywords: Big Data; Enterprise; Supply Chain Optimization; Computer-Aided Algorithm; Simulated Annealing Algorithm
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1 INTRODUCTION

In the era of globalization and informatization, enterprise SCM is confronting escalating intricacies and unparalleled challenges. Seafood supply chain management, as an important component of the food industry, also faces challenges of technological upgrading and transformation. Aryal et al. [1] explored the application and impact of big data analysis and the Internet of Things in seafood supply chain management. Data technology can monitor real-time environmental parameters such as temperature and humidity of seafood products, ensuring the quality of products during transportation and storage. By analyzing data, identifying quality issues on time, and taking corresponding solutions to improve customer satisfaction. The Internet of Things technology can achieve remote monitoring and control of seafood storage and transportation equipment. By installing sensors and actuators, real-time equipment operation data is collected, and environmental parameters are automatically adjusted to ensure stable equipment operation. The Internet of Things technology can achieve real-time tracking of the entire process of seafood products, from fishing, processing, and transportation to sales, by installing IoT devices at various stages, collecting product-related information, providing customers with transparent supply chain information, and enhancing consumer confidence. By collecting real-time data during the production process, Deng [2] utilizes big data analysis technology to monitor and warn the production process in real time, improving its stability and reliability. It utilizes big data analysis technology to integrate and analyze product quality information, identify the root causes of quality problems, and improve product quality and customer satisfaction. Through big data analysis technology, optimize various links in the supply chain to improve its efficiency and response speed. Using big data analysis technology to integrate and analyze equipment operation data, predict equipment maintenance needs and potential failures, and reduce maintenance costs and downtime. By establishing a comprehensive evaluation index system, I can comprehensively understand the intelligent manufacturing capabilities and supply chain layout advantages of enterprises, providing strong support for enterprises to formulate more scientific and reasonable intelligent manufacturing and supply chain management strategies. The vision of independent Industry 4.0 warehouses is to achieve highly intelligent and automated inventory management and traceability. Emerging technologies such as big data, drones, and blockchain have made it possible to achieve this vision. Fernández et al. [3] explored how to utilize these technologies to build a self-owned Industry 4.0 warehouse and optimize inventory and traceability applications. Drone technology has brought new opportunities for warehouse management. Drones can quickly and accurately complete the transportation, inventory, and tracking of goods, greatly improving the efficiency and accuracy of inventory management. In addition, drones can also monitor the warehouse in real time detect and solve inventory problems on time. The inventory management system based on drones will greatly enhance the intelligence and autonomy level of warehouse management. Blockchain technology provides strong support for traceability in the supply chain. Through blockchain technology, enterprises can achieve transparency and immutability of information throughout the entire supply chain, ensuring product traceability. Traditional SCM methodologies often struggle to adapt to fluctuating market demands, transparency, and traceability expectations, along with cost control and efficiency pressures. Meanwhile, the swift advancement of big data technology has ushered in novel solutions and optimization avenues for SCM. By harnessing vast datasets from various supply chain stages, enterprises can now more precisely forecast market trends, streamline inventory controls, and boost logistics efficacy, thereby augmenting their supply chain's resilience and competitive edge.

With the intensification of market competition, the demand for supply chain optimization by enterprises is becoming increasingly urgent. As a key element in supply chain management, delivery quality directly affects the customer satisfaction and brand image of enterprises. Based on big data, enterprise supply chain optimization can help enterprises achieve more accurate demand forecasting, more efficient inventory management, and more optimized logistics distribution. Gaura et al. [4] focused on exploring how to optimize and evaluate delivery quality objectives in big data-based enterprise supply chain optimization. The application of big data technology enables enterprises to collect and process massive amounts of data, thereby better understanding market demand, supplier capabilities, inventory status, and other information. Through big data analysis, enterprises can predict future market demand, adjust production and procurement plans in advance, and reduce inventory backlog and waste. At the same time, big data can also help enterprises monitor the logistics and distribution process in real-time, identify and solve potential problems on time, and ensure timely, high-quality, and quantity delivery of goods. It utilizes data analysis tools to process and analyze the collected data. Evaluate the completion status of the current delivery quality objectives by comparing the actual completion status with target values. At the same time, delve deeper into the reasons and influencing factors behind the data. The maturity of logistics management capabilities not only affects the operational efficiency of enterprises but also directly relates to their market competitiveness and customer satisfaction. The application of big data technology provides new opportunities for improving logistics management capabilities. Ge et al. [5] explored how to use big data technology to evaluate the maturity of commodity logistics management capabilities in intelligent manufacturing enterprises and analyzed it with practical cases. Real-time monitoring of product quality parameters during production, warehousing, and transportation through big data technology to ensure product quality. Mining and analyzing massive amounts of data provides enterprises with in-depth insights into logistics management and helps them develop more scientific and reasonable logistics strategies. Taking a certain intelligent manufacturing enterprise as an example, analyze the maturity of its commodity logistics management capabilities. Firstly, a comprehensive evaluation is conducted on its organizational structure, process management, technology application, and talent cultivation through an evaluation index system. Then, use big data technology to analyze various indicators and determine their maturity level. Finally, based on the evaluation results, provide targeted improvement suggestions and enhancement plans for the enterprise. The core objective of this research is to delve into big data-driven optimization strategies for enterprise supply chains and devise complementary computer-aided algorithms. This endeavour carries profound theoretical and practical importance. On the theoretical front, it aims to enrich the SCM knowledge base and introduce fresh research viewpoints and techniques. Practically, the study outcomes are poised for direct application in real-world enterprise supply chain settings, aiding in the elevation of management standards, cost reduction, efficiency gains, and, ultimately, bolstering market competitiveness.

With the rapid development of Internet of Things technology, fresh food enterprises are gradually combining their supply chain operations with big data analysis to improve efficiency, reduce costs, and enhance competitiveness. However, although big data and the Internet of Things have brought many advantages to fresh food enterprises, there are still some problems and challenges in practical applications. Hasan et al. [6] conducted a critical analysis of the impact of big data on the operation of the IoT supply chain of fresh food enterprises. It utilizes IoT technology to track environmental parameters such as the temperature and humidity of fresh products in real time, ensuring product quality. Meanwhile, through the GPS positioning system, real-time monitoring of transportation vehicles is carried out to improve logistics efficiency. Big data analysis can provide fresh food enterprises with in-depth customer behaviour analysis, helping them develop more accurate marketing strategies and personalized services. The characteristics of fresh products pose many challenges to data collection, such as fluctuations in temperature and humidity, as well as the freshness of the products. These factors may lead to inaccurate or inconsistent data, thereby affecting the results of data analysis. Introducing big data and IoT technologies requires a significant initial investment. For many fresh food companies, this is a significant expense. In addition, the maintenance and updating of technology also require continuous cost investment. The role of key technologies such as intelligent process planning, robot wireless sensor networks, and geospatial big data management algorithms is increasingly prominent. Lăzăroiu et al. [7] explored how to utilize deep learning techniques to assist and optimize these fields. Intelligent process planning is an important link in the manufacturing process, which involves the design, scheduling, and optimization of production processes. Deep learning technology can be applied in this field, automatically identifying and predicting various patterns and trends in the production process by learning historical production data. This helps enterprises allocate resource schedules and develop production plans more effectively, thereby improving production efficiency and reducing costs. Robot wireless sensor network is one of the key technologies for achieving automated production. By installing wireless sensors on robots, various data can be collected and processed in real-time during the production process, providing valuable information for decision-makers. Deep learning technology can be used to optimize the collection and processing of sensor data, improve the accuracy and real-time performance of data, and thus enhance the work efficiency and accuracy of robots. The core purpose of this study is to analyze the current situation and problems of enterprise SCM by using big data technology, putting forward targeted optimization schemes, and designing effective computer-aided algorithms to support supply chain optimization decisions. Specifically, this study has the following innovations:

㊀ Traditional SCM models are often based on limited data and assumptions, and this article innovatively constructs a supply chain optimization model driven by big data. The model can process and analyze the massive, diverse and rapidly changing supply chain data, thus more accurately reflecting the actual operation of the supply chain and providing more refined optimization strategies.

㊁ When constructing the supply chain optimization model, this article not only pays attention to the traditional goal of cost minimization but also comprehensively considers many dimensions such as efficiency, service quality and environmental impact. This multi-dimensional analysis method makes the optimization scheme more comprehensive and balanced and can better meet the actual needs of modern enterprises.

㊂ Aiming at the complexity of supply chain optimization, this article designs an efficient computer-aided algorithm. The algorithm combines heuristic search, domain knowledge and intelligent optimization technology and can find the approximate optimal solution in an acceptable time, which significantly improves the efficiency and practicability of supply chain optimization.

In the structure of the article, this study will be discussed according to the logical framework of "introduction-theoretical basis and literature review-big data-driven supply chain optimization model construction-computer-aided algorithm design and implementation-case analysis and application research-conclusion and prospect". The contents of each section are closely linked and step by step, forming a complete research system.

2 RELATED WORK

With the development of technology and the advancement of globalization, supply chain management has become increasingly complex. Digital supply chain and intelligent logistics, as important means of modern supply chain management, can improve the transparency, predictability, and response speed of the supply chain. Inventory optimization is one of the core issues in supply chain management, which can reduce inventory costs, improve customer satisfaction, and enhance the competitiveness of enterprises. Lin et al. [8] explored the application of intelligent logistics inventory optimization algorithms based on digital supply chains. Linear programming algorithm is a commonly used inventory optimization algorithm that transforms inventory optimization problems into linear programming problems by establishing mathematical models. This algorithm can comprehensively consider multiple factors such as inventory cost, transportation cost, and order processing cost, providing enterprises with the optimal inventory strategy. Digital supply chain refers to the process of utilizing digital technology to manage and optimize the supply chain. Through digital technology, enterprises can achieve transparency, visualization, and intelligence in their supply chains. Intelligent logistics refers to the process of utilizing technologies such as the Internet of Things, big data, and artificial intelligence to intelligently manage and optimize the logistics process. Through intelligent logistics, enterprises can achieve automation, precision, and efficiency in the logistics process. In today's highly interconnected global manufacturing environment, integrated manufacturing requires advanced technology that can handle complex data and optimize supply chain processes. Therefore, Liu et al. [9] proposed a blockchain supply-integrated manufacturing framework based on big data analysis, reinforcement learning, and optimal route planning methods. By combining these advanced technologies, it can better address the challenges in the manufacturing process, improve efficiency, reduce costs, and enhance traceability and transparency in the supply chain. Reinforcement learning is a machine learning technique that can find the optimal strategy through trial and error learning. In integrated manufacturing, reinforcement learning can help enterprises optimize production and logistics decisions based on environmental changes and learned experiences. The optimal route planning method is another important technique in integrated manufacturing. It can help businesses determine the best logistics and transportation routes to reduce transportation costs, shorten delivery times, and improve transportation efficiency. By combining big data analysis and reinforcement learning, the optimal route planning method can more accurately predict changes in demand and supply and automatically adjust transportation routes to adapt to these changes.

In the big data environment, enterprises can collect, process, and analyze massive amounts of data to better understand customer needs, optimize business processes, and improve operational efficiency. Blockchain technology provides enterprises with a decentralized, secure, and transparent data exchange platform, which can effectively reduce transaction costs, improve transaction speed, and enhance data security. However, how to combine these two technologies to achieve intelligent optimization and control of enterprise costs is an important issue currently faced by enterprises. Enterprises need to utilize big data technology to collect massive amounts of data from various sources, including internal business data, external market data, competitor data, etc. After cleaning and integrating these data, in-depth mining is carried out through data analysis tools to discover the patterns and trends behind the data. After obtaining valuable information, enterprises need to integrate it into the blockchain environment. Through technologies such as smart contracts, enterprises can automate cost control strategies, such as automatically adjusting procurement volumes based on market price fluctuations and production plans based on production demand [10]. Supply chain management has become an important component of the core competitiveness of manufacturing enterprises. In the era of big data, how to use big data technology to virtualize the supply chain and improve its transparency, predictability, and response speed is an important issue facing manufacturing enterprises. Matsuda et al. [11] explored how to use big data and electronic catalogues to virtualize the supply chain from the perspective of manufacturing enterprises. Big data technology provides strong support for supply chain virtualization. Electronic catalogues, as an important data management tool, play a crucial role in supply chain virtualization. Through electronic catalogues, enterprises can centrally manage supplier information, product information, quality standards, and other data, achieving real-time updates and sharing of data. This not only improves the transparency of the supply chain but also facilitates communication and collaboration between enterprises and suppliers. During the implementation process, manufacturing enterprises need to continuously monitor the operation of the supply chain and adjust and optimize strategies based on actual situations. At the same time, it is necessary to regularly evaluate the performance of electronic catalogues to ensure that they can meet the needs of enterprises.

With the development of globalization and informatization, enterprises are facing increasingly complex supply chain environments. To address this challenge, many enterprises are exploring the use of multi-agent systems to manage and optimize their supply chains. Nishi et al. [12] proposed a solution that utilizes enterprise electronic catalogues to construct a virtual supply chain automatically as a multi-agent system, aiming to improve the flexibility and response speed of the supply chain. A multi-agent system is a system composed of multiple autonomous agents that can collaborate with each other to complete complex tasks. In supply chain management, multi-agent systems can help enterprises achieve more flexible, fast, and intelligent decision-making. A virtual supply chain is a form of supply chain based on information technology, which can dynamically organize and adjust supply chain resources to adapt to market changes. Based on historical data and market trends, analyze the changes in demand in the supply chain and provide a basis for the construction of virtual supply chains. It utilizes the intelligent agents of a multi-agent system to automatically match the best supplier and product combination based on the results of requirement analysis and data collection. Dynamically adjust the resource allocation of virtual supply chains based on market changes and demand fluctuations to ensure efficient operation of the supply chain. In supply chain management, demand forecasting is a crucial aspect that directly affects the production and resource allocation of enterprises. Seyedan and Mafakheri [13] explored predictive big data analysis for supply chain demand forecasting based on big data, including methods, applications, and research opportunities. It uses time series data, through trend analysis and seasonal adjustments, to predict changes in demand for some time in the future. This method considers the continuity and periodicity of historical data and can accurately predict short-term demand changes. By forecasting demand changes in the future, enterprises can adjust production plans in advance, optimize resource allocation, and improve production efficiency and response speed. Demand forecasting can help enterprises arrange inventory reasonably, avoid inventory backlog and waste, and reduce inventory costs and risks. Based on demand forecasting, enterprises can develop more accurate procurement strategies, arrange procurement time and quantity reasonably, and reduce procurement costs and uncertainty.

The metal processing industry occupies an important position in industrial manufacturing, and the optimization and management of its value chain are of great significance for enhancing enterprise competitiveness and the overall development of the industry. With the widespread application of big data technology, metal processing enterprises are facing opportunities and challenges in digital transformation. Sorger et al. [14] explored how to use big data technology to standardize and digitize the value chain of metal processing while considering the special needs and challenges of small and medium-sized enterprises. The standardization of the value chain in metal processing is the key to improving industry efficiency and product quality. By developing and implementing a unified process flow, technical specifications, and data standards, the cost of information exchange between enterprises can be reduced, and the collaboration efficiency of the entire industry can be improved. Big data technology provides strong support for the standardization of the value chain. Through data collection, analysis, and mining, potential problems and improvement areas can be identified, providing a scientific basis for standardization work. A large metal processing enterprise has achieved digital management and optimization of the production process by introducing big data technology and intelligent equipment, greatly improving production efficiency and product quality. With the intensification of market competition, the optimization decision-making of the supply chain has become increasingly important. The negative spillover effect and service competition in the supply chain are two key factors that have a significant impact on the efficiency and profits of the supply chain. Based on big data analysis, Wu et al. [15] explore how to consider negative spillover effects and service competition to formulate effective supply chain optimization decisions. The negative spillover effect refers to the negative impact of a change in one link in the supply chain on other links. Service competition is a means for enterprises to gain competitive advantages by improving service quality. In the supply chain, negative spillover effects and service competition are interrelated, jointly affecting the performance and profits of the supply chain. Formulating effective supply chain optimization decisions based on the results of big data analysis. This may include measures such as adjusting inventory levels, optimizing transportation strategies, and improving supplier management. It puts optimization decisions into practice and utilizes big data technology for real-time monitoring. Adjust and optimize according to the implementation effect to ensure the effectiveness of decision-making.

In today's data-driven era, enterprises are placing increasing importance on data collection and analysis. The collection device for enterprise status information, as a key device for obtaining enterprise operation data, has performance and efficiency that directly affect the decision-making and operational effectiveness of the enterprise. Yu and Neely [16] discussed how to use big data technology to assist in optimizing the collection device of enterprise status information. The application of big data technology can help enterprises obtain and analyze status information more comprehensively and accurately. By processing and analyzing a large amount of data, enterprises can better understand the operation status of equipment, identify potential problems, and optimize space. At the same time, big data technology can also provide real-time data monitoring and analysis, helping enterprises discover and solve equipment failures on time improving equipment stability and reliability. The supply chain in the petrochemical industry is a complex and dynamic network that involves multiple links and participants. In order to better manage and optimize this supply chain, it is necessary to establish an accurate model to simulate its operation. Zang et al. [17] proposed a new digital generation method for supply chain scenarios in the middle and downstream of the petrochemical industry, combined with stochastic optimization techniques, to provide decision support for supply chain management. In the supply chain of the petrochemical industry, there are many uncertain factors, such as market demand fluctuations, supply interruptions, transportation delays, etc. These uncertain factors make it difficult for traditional deterministic optimization methods to find the optimal solution. Therefore, this article adopts a stochastic optimization model to consider various uncertainty factors and provide more accurate decision support for supply chain management. The stochastic optimization based on a new method for generating numerical scenarios in the petrochemical midstream and downstream supply chain is an effective supply chain management method. By combining scenario number generation and stochastic optimization techniques, enterprises can better cope with uncertain factors in the supply chain and improve the accuracy and effectiveness of decision-making. With the rapid development of technology and intensified market competition, the mobile phone industry is facing ever-changing and complex market demands. Meanwhile, the characteristics of mobile phone products determine the existence of various uncertainties and variability in their supply chain, such as the incompleteness of product quality and the uncertainty of market demand. To address these challenges, procurement and coordination strategies based on big data are particularly important in supply chain management. Zeng and Hou [18] discussed the procurement and coordination issues in the mobile supply chain under incomplete quality and uncertain demand in the big data environment. The application of big data technology provides strong data support and analysis capabilities for supply chain management. Through big data, enterprises can monitor market trends in real time, analyze consumer behaviour, predict future demand, and more. At the same time, big data can also help enterprises identify problems in the supply chain, optimize procurement and coordination strategies, and improve the efficiency and flexibility of the supply chain. In terms of procurement and coordination, enterprises can develop more accurate procurement plans and coordination strategies based on the results of big data analysis. In addition, through big data analysis, enterprises can also discover potential suppliers and partners, expand procurement channels, and improve the diversity and stability of the supply chain.

3 THEORETICAL BASIS AND LITERATURE REVIEW

3.1 Theoretical Basis of SCM

SCM encompasses a wide range of activities and procedures involved in strategizing, aligning, implementing, overseeing, and refining the entirety of the supply chain framework. This spans from suppliers to the final consumers, encompassing procurement of raw materials, production, logistics, sales, and post-sales services. The ultimate objective of SCM is to enhance the overall supply chain performance by minimizing costs, maximizing efficiency, and elevating customer satisfaction. The fundamental stages of SCM comprise planning, procurement, production, dispatch, returns, and recycling, as delineated in Table 1.

Process link	*Describe*	*Main content*
Plan	It involves planning and forecasting the overall operation of the supply chain.	Demand forecasting Production plan Logistics plan
Purchase	Establish contact with suppliers to manage purchase orders and purchase process.	Supplier selection Purchase order management Incoming goods inspection and quality control
Manufacture	Covers the production process of products, including production scheduling, quality control, etc.	Production schedule Production line management Quality control and inspection
Delivery	Responsible for product logistics distribution and inventory management.	Logistics and distribution Stock control Order fulfillment and delivery

Return	Handle the return process and after-sales problems of unqualified products.	Rejection treatment of unqualified products After-sales service and support
Retrieve Process link	Responsible for the recycling and reuse of waste products	Recycling of waste products Resource reuse and environmental protection treatment

Table 1: Process links of SCM.

The basic principles of SCM include systematic principle, coordination principle, dynamic principle and benefit principle. The systematic principle requires that the supply chain should be regarded as a whole system. The principle of coordination emphasizes the coordination among all links in the supply chain to achieve overall optimization. The dynamic principle points out that SCM should adapt to the changes in the market environment and adjust strategies and measures in time. The benefit principle pursues the maximization of the overall benefit of the supply chain.

The integration of big data technology into SCM has emerged as a prevalent trend. Big data technology excels in managing vast, varied, and rapidly evolving datasets, offering robust data support and analytical capabilities to SCM. Leveraging big data analytics, businesses can refine their predictions of market demand, streamline inventory control, and enhance logistics effectiveness. Currently, the utilization of big data in SCM is evident in several key areas: demand forecasting, inventory optimization, logistics route planning, and risk management, among others. Demand forecasting utilizes historical sales figures and market trends to anticipate future product demand, thereby informing production plans and market strategies. Inventory optimization determines optimal stock levels and replenishment tactics by scrutinizing inventory data alongside market demand, aiming to minimize inventory costs and mitigate the risk of stockouts. Logistics route planning taps into big data analytics to refine distribution routes and elevate both logistics efficiency and service standards. Risk management promptly identifies potential hazards by surveillance of the entire supply chain's data and facilitates timely interventions. As big data technology continues to evolve and find broader applications, its integration into SCM is poised to become even more comprehensive and profound. Future trends include the use of big data technology for collaborative supply chain management, intelligent decision support, and customer relationship enhancement.

Computer-aided algorithm design plays an important role in supply chain optimization. By designing efficient algorithms, we can solve complex supply chain optimization problems and improve the accuracy of decision-making. At present, many algorithms have been applied in the field of supply chain optimization, such as linear programming, integer programming, dynamic programming, heuristic algorithms and so on. Linear programming and integer programming are two commonly used mathematical programming methods that can solve supply chain optimization problems with linear objective functions and constraints. Dynamic programming is suitable for supply chain optimization with multi-stage decision-making characteristics. A heuristic algorithm is an algorithm design method based on experience, which can solve large-scale and complex supply chain optimization problems in an acceptable time.

In recent years, some new algorithms have been applied in the field of supply chain optimization, such as genetic algorithm, SAA (Simulated Annealing Algorithm), ant colony algorithm, and so on. These algorithms have global search ability and adaptive characteristics and show good performance in dealing with complex supply chain optimization problems.

By summarizing and analyzing the existing literature, we can find that the shortcomings of the current research are mainly concentrated in the following aspects: First, the application of big data in SCM is still in the exploratory stage, lacking in-depth theoretical analysis and empirical research; Second, the existing algorithms have some limitations and deficiencies in solving complex supply chain optimization problems, which need to be further improved and perfected; Third, there is a lack of research on the combination of big data technology and computer-aided algorithm design to achieve more efficient supply chain optimization decision support.

In view of the above shortcomings, this study comprehensively uses big data technology and computer-aided algorithm design methods to build an enterprise supply chain optimization model based on big data and design an efficient solution algorithm. The practicability of the proposed model and algorithm is verified by empirical research, which provides decision support and method guidance for enterprises. Therefore, this study has certain innovation and practical value.

4 CONSTRUCTION OF SUPPLY CHAIN OPTIMIZATION MODEL DRIVEN BY BIG DATA

4.1 Supply Chain Optimization Requirements

In the increasingly fierce market environment of global competition, it is increasingly urgent for enterprises to optimize the supply chain. Supply chain optimization can not only reduce operating costs and improve operating efficiency but also enhance enterprises' market competitiveness and customer satisfaction. In view of these needs, this study makes an in-depth analysis from multiple dimensions such as cost, efficiency, and service quality.

Firstly, a pivotal goal of SCM is cost optimization, whereby enterprises strive to minimize expenses related to raw material acquisition, manufacturing, logistics, and distribution. This streamlining aims to bolster overall profitability. Secondly, enhancing efficiency is paramount to swiftly adapting to market fluctuations and fulfilling customer demands. By refining the supply chain's operational procedures and information flow, enterprises can mitigate unnecessary delays and resource wastage, thereby achieving optimal performance. Lastly, service quality serves as a pivotal metric for evaluating supply chain performance. Enterprises must guarantee timely and high-quality product delivery to customers while providing exemplary after-sales support to foster positive customer relationships and uphold a favourable corporate reputation.

4.2 Big Data Collection and Processing

To fulfill the need for supply chain optimization, this investigation leverages big data technology extensively for data gathering and manipulation. Initially, for data acquisition, the research incorporates information from a wide array of sources. This includes internal records like sales, inventory, and production figures; external market insights such as industry overviews and market surveys; and data shared by supply chain collaborators, including supplier details and logistics updates. This diverse dataset offers a holistic and detailed understanding of supply chain operations.

During data manipulation, several preprocessing techniques and quality assurance measures are implemented. Firstly, the data is cleansed and organized, eliminating any duplicates, inaccuracies, or incomplete entries to ensure its reliability and uniformity. Secondly, advanced techniques like data mining and machine learning are employed to extract meaningful insights and patterns hidden within the dataset. Finally, using data visualization tools, the refined data is presented in graphical and tabular formats, facilitating easy comprehension and trend identification for decision-makers.

4.3 Construction of Supply Chain Optimization Model

The supply chain optimization model is constructed based on the results of big data analysis. The model takes cost minimization, efficiency maximization, and service quality optimization as objective functions and considers various constraints, such as supply capacity limitation, demand satisfaction rate, and inventory capacity limitation. Specifically, this article transforms the supply chain optimization problem into a mathematical programming problem and describes the optimization goal by constructing an objective function. The objective function comprehensively considers many cost factors, such as purchasing cost, production cost, logistics cost, and inventory cost, and seeks to minimize the total cost. Moreover, this article also considers the service quality indicators such as time efficiency, order satisfaction rate and service level and introduces them into the model as constraints. The algorithm design is shown in Figure 1.

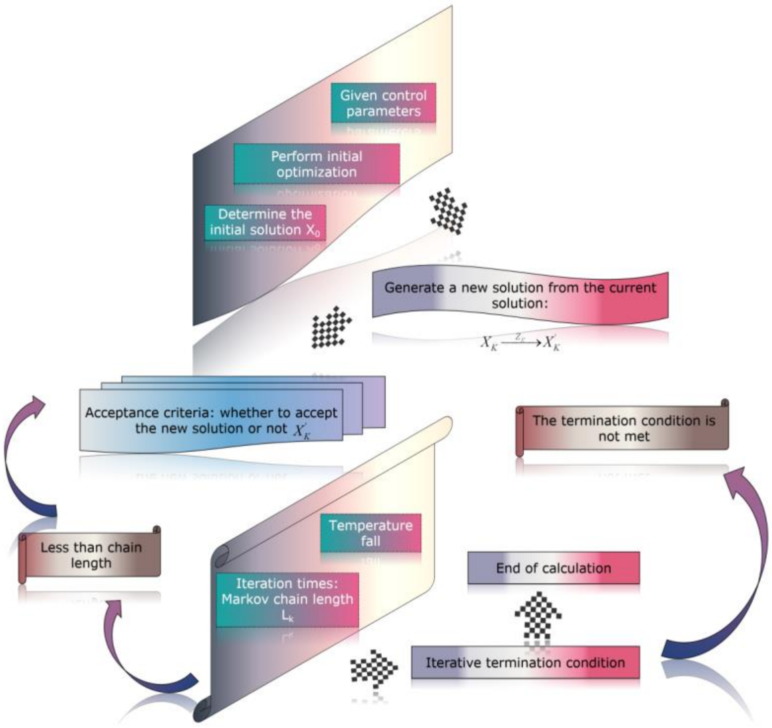

Figure 1: Algorithm design drawing.

When building the model, make full use of the results of big data analysis. The market demand is accurately predicted by the demand forecasting model, and the prediction result is taken as one of the input parameters of the model. Optimize the logistics distribution route through the logistics path planning model to improve logistics efficiency. These big data-driven model construction methods make the supply chain optimization model more in line with the actual situation and have strong operability and practicality.

5 DESIGN AND IMPLEMENTATION OF COMPUTER-AIDED ALGORITHM

5.1 Algorithm Design

A computer-aided algorithm based on big data analysis aimed at the problem of supply chain optimization is designed in this study. Firstly, according to the objective function and constraints of the supply chain optimization model, the optimization problem is transformed into a computable mathematical form. Through mathematical modelling, the essence and solving requirements of supply chain optimization problems can be clearly described. Secondly, an appropriate algorithm framework is adopted to solve the SCM optimization problem. Considering that SCM optimization problems are usually large-scale, complex, and multi-constrained, SAA is chosen as the solution framework in this study. SAA, which stands for stochastic optimization algorithm, utilizes a Monte Carlo iterative solution strategy and is rooted in the principles of solid annealing. This approach has the potential to surpass local optimal solutions, ultimately converging on the global optimum. The term "probability" within this context refers to the likelihood of achieving such a result:

$$p = \exp\left(\frac{-\Delta E}{kT}\right) \tag{1}$$

Where ΔE is the energy difference, k is Boltzmann constant; T is to control the temperature of the annealing process.

SAA can give an approximate optimal solution in an acceptable time, which is suitable for solving complex optimization problems. Based on SAA, combined with the specific characteristics of supply chain optimization, a series of targeted operation strategies and improvement measures are designed. Finally, the algorithm is iteratively optimized and debugged, and the performance and stability of the algorithm are continuously improved until it meets the needs of practical application. According to the problem example, set the initial state of SAA:

$$I\begin{bmatrix} a_1 & a_2 & \cdots & a_n \\ b_1 & b_2 & \cdots & b_n \\ c_1 & c_2 & \cdots & c_n \end{bmatrix} \tag{2}$$

The initial temperature is defined as T_1 the end temperature and L represents the number of iterations of the model. Let the feature vector of the sample x_i be expressed as:

$$a_{i1}, a_{i2}, a_{i3}, \ldots, a_{im} \tag{3}$$

Then, the expectation and variance of each attribute in all sample points X are calculated respectively:

$$avg\ X\ a_i \ = \frac{1}{g_i}\sum_{j=1}^{g_i} a_{ji} \quad i = 1,2,\ldots,m \tag{4}$$

$$std\ X\ a_i \ = \sqrt{\frac{1}{g_i - 1}\sum_{j=1}^{g_i} x_i\ a_i \ - avg\ X\ a_i \ ^2} \quad i = 1,2,\ldots,m \tag{5}$$

Where $x_i\ a_i$ is expressed as the value of sample j on the a_i attribute. Randomly generate a neighbourhood solution $j \in N\ i$ and calculate the increment of the target value:

$$\Delta f = f\ j\ - f\ i \tag{6}$$

The core components of SAA are its acceptance criteria and cooling strategy, which work together to determine the algorithm's capacity for global exploration and escaping local optima. The acceptance criterion enables the algorithm to tolerate a certain level of solution degradation during the search, providing an avenue for escaping local optima and pursuing the global optimum. Meanwhile, the cooling strategy regulates the algorithm's search behaviour, favouring global exploration at higher temperatures and shifting towards local refinement as the temperature decreases.

Determine the optimization object x and the objective function E, and then set the relevant parameters. Disturbance to the state $x\ n$ generates a new state $x'\ n$, and the corresponding objective function changes from $E\ x\ n$ to $E\ x'\ n$. The calculation formula is as follows:

$$\Delta E = E\ x'\ n\ - E\ x\ n \tag{7}$$

If $\Delta E < 0$ the next state value is $x'\ n$ If $\Delta E > 0$, then:

$$p = e^{-\frac{\Delta f}{T}} \tag{8}$$

Then, compare it with the generated random number, and the formula is as follows:

$$\xi \quad 0<\xi<1 \tag{9}$$

Suppose $\xi < p$ the next state value is $x' \; n$. Conversely, the next status value is still $x \; n$.

In the process of algorithm implementation, parameter setting and debugging are also needed. By constantly adjusting the parameters of the algorithm, the performance of the algorithm and the solution results can be optimized. Moreover, many experiments and comparative analyses are needed to verify the effectiveness and stability of the algorithm.

5.2 Performance Analysis of the Algorithm

In order to evaluate the performance of the designed algorithm, this study analyzes the time complexity and space complexity, and the results are shown in Figure 2 and Figure 3.

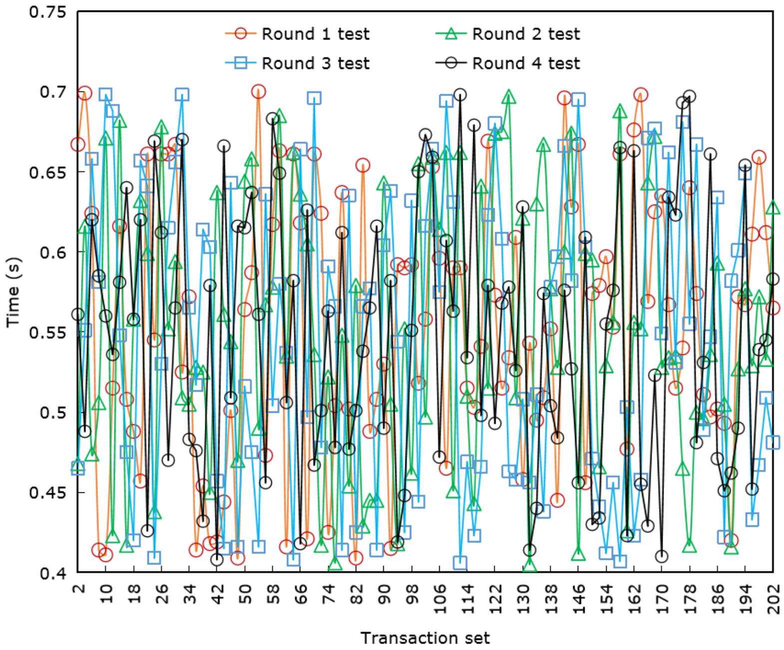

Figure 2: Time complexity test.

In terms of time complexity, supply chain optimization problems usually have large-scale and complex characteristics, so the algorithm needs to give an approximate optimal solution within an acceptable time. By analyzing the time complexity of the algorithm, the efficiency of the algorithm for solving problems of different scales can be evaluated. The results show that the designed algorithm can solve a satisfactory supply chain optimization scheme in a reasonable time.

In terms of space complexity, considering that the supply chain optimization problem involves a large number of data and variables, the algorithm needs to make reasonable use of storage space to save the intermediate results and final solutions. By analyzing the spatial complexity of the algorithm, we can evaluate the occupation of storage resources by the algorithm. The experimental results show that the designed algorithm performs well in space occupation and can meet the needs of practical applications.

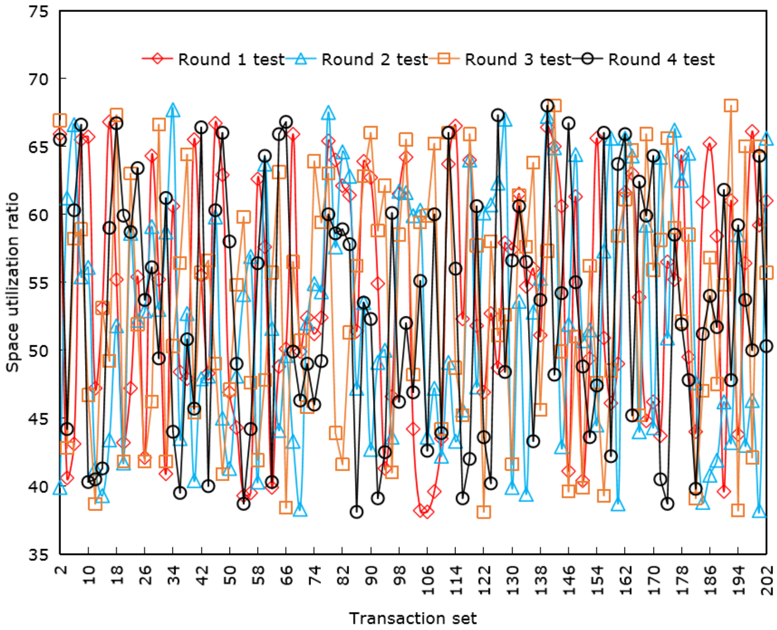

Figure 3: Spatial complexity test.

6 CASE ANALYSIS AND APPLICATION RESEARCH

6.1 Case Selection and Research Methods

Before the case analysis, this article defines the selection criteria of the case. Firstly, the representative enterprises in the supply chain field are selected, which are in the leading position in the industry, and their practical experience and problems in SCM are universal. Secondly, the availability and integrity of case data are considered to ensure that enough information can be collected to support the analysis of this article. Moreover, this article also pays attention to the diversity of cases and selects enterprises of different industries and sizes to verify the applicability of the model and algorithm more comprehensively.

In terms of research methods, quantitative analysis and qualitative analysis are adopted. Firstly, the case data collected is processed and analyzed using the established supply chain optimization model and algorithm. Secondly, combined with field interviews, questionnaires and other means, first-hand information on the current situation and problems of SCM of case enterprises is obtained so as to understand and analyze the case more deeply.

6.2 Case Analysis

In the case analysis stage, the selected cases are analyzed by using the supply chain optimization model and algorithm. Firstly, the supply chain system of the case enterprise is comprehensively combed and analyzed, including its supply chain structure, operation process, cost composition and so on. Then, based on big data analysis technology, the historical sales data, inventory data and logistics data of case enterprises are deeply mined and processed, and useful information and patterns are extracted. Next, the processed data is input into the SCM optimization model, and the optimized supply chain scheme is obtained by running the algorithm. The scheme includes optimization suggestions on purchasing strategy, production plan and logistics distribution. In addition, this article also uses the model to simulate and predict the optimization scheme and evaluates the possible effects of cost saving, efficiency improvement and service quality improvement. The change in procurement cost before and after the optimization of the case enterprise is shown in Figure 4, and the timeliness of logistics distribution is shown in Figure 5.

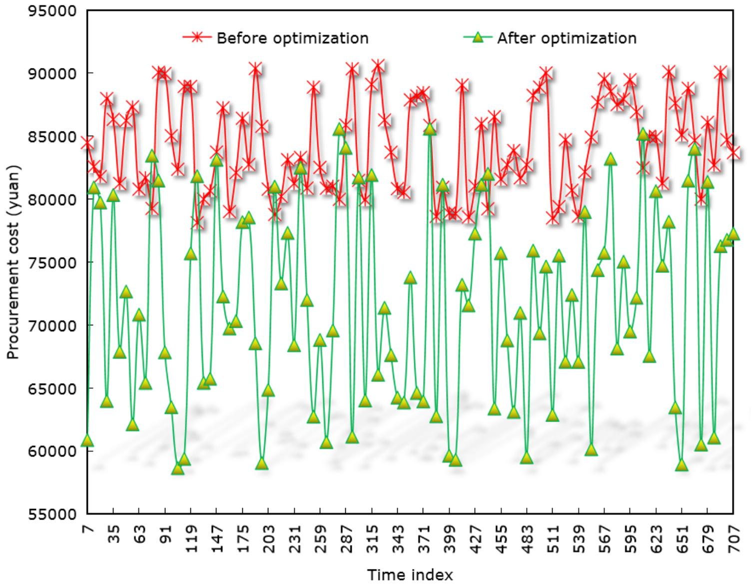

Figure 4: Changes in procurement cost before and after case enterprise optimization.

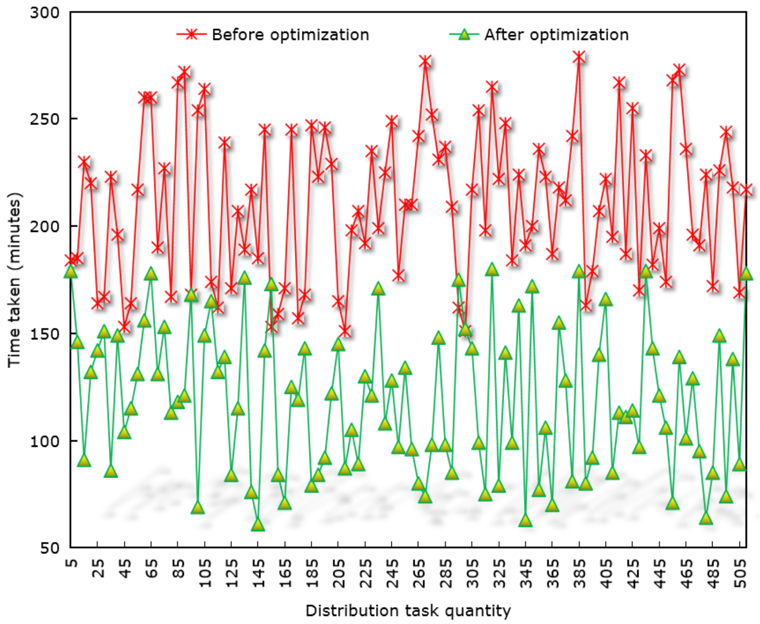

Figure 5: Time limitation of logistics distribution.

In this article, a certain number of users are selected as experimental participants, while the diversity of participants is ensured. The results are shown visually in Figure 6.

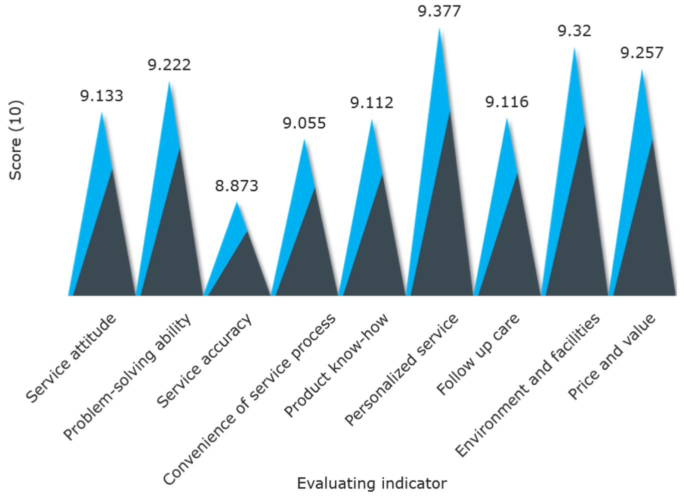

Figure 6: User's evaluation of enterprise service quality.

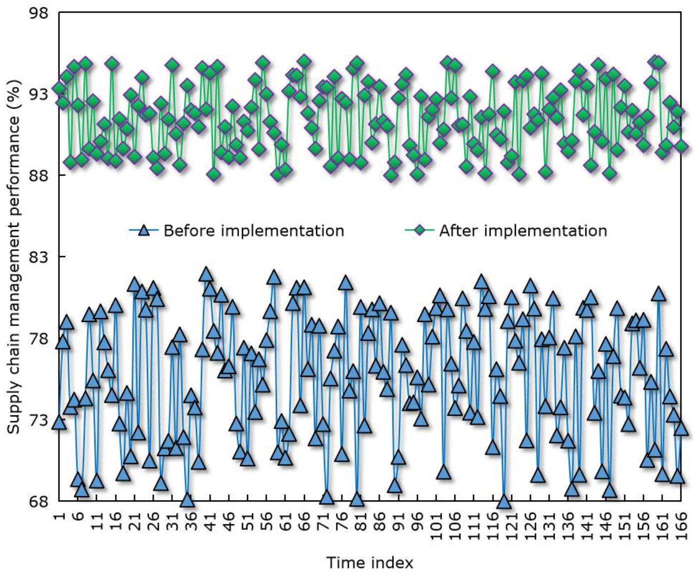

Figure 7: SCM performance of case enterprises.

As shown in Figure 6, the average score of about 9 points reflects that users are highly satisfied with the service as a whole. In most scoring systems, 9 points is usually regarded as excellent or nearly perfect performance. This shows that service providers are excellent at interacting with users, can accurately understand users' needs, and can provide effective solutions in time.

Select a representative enterprise as the case study object to ensure that the enterprise faces typical challenges and opportunities in SCM. Collect the performance data of SCM of case enterprises before the experiment as benchmark data. Moreover, the supply chain optimization model and algorithm developed in this study are introduced into the case enterprise. Cooperate with the enterprise management team to customize and adjust the model and algorithm to meet the specific environment and needs of the enterprise. Within six months, let the case enterprises apply the optimization model and algorithm to SCM. Monitor and record key data in the implementation process, including cost saving, efficiency improvement and customer satisfaction improvement. After the end of the implementation period, collect the performance data of SCM of case enterprises. Using statistical analysis and comparative analysis methods, the data after implementation are compared with the benchmark data before implementation and the industry average data, and the results are shown in Figure 7.

The results show that compared with before implementation, the performance index of SCM of case enterprises has been significantly improved after adopting the optimization scheme. This shows that the model and algorithm of this study can effectively improve the efficiency of SCM and service quality of enterprises in practical application.

6.3 Result Discussion

In this section, the results are deeply discussed and verified. Firstly, the optimization scheme is compared with the existing SCM strategy of the case enterprise, and it is found that the optimization scheme has obvious advantages in many aspects. In terms of cost, the optimization scheme has achieved significant cost reduction through refined procurement strategy and inventory control. In terms of efficiency, the optimization scheme improves the overall operation efficiency by optimizing the production plan and logistics distribution route. In terms of service quality, the optimization scheme improves customer satisfaction by improving the order satisfaction rate and reducing the shortage phenomenon.

In order to further verify the practicability of the model and algorithm, this article also compares the analysis results with the industry average. The results show that the performance of SCM of case enterprises has been significantly improved after adopting the optimization scheme, which exceeds the industry average. This shows that the supply chain optimization model and algorithm have strong practical application value and can provide effective decision support and method guidance for enterprises.

7 CONCLUSION AND PROSPECT

This study focuses on supply chain optimization driven by big data and aims to solve the challenges faced by enterprises in SCM, such as cost, efficiency and service quality, by constructing the supply chain optimization model and designing computer-aided algorithms. After a series of research and analysis, we draw the following main conclusions.

First of all, big data technology has great application potential in SCM. By collecting, processing and analyzing the big data related to the supply chain, we can gain insight into the inherent laws and potential problems of supply chain operation and provide strong support for supply chain optimization. Secondly, the supply chain optimization model we built can effectively solve the practical problems of enterprises in SCM. The model comprehensively considers many dimensions, such as cost, efficiency, and service quality, and obtains the optimization scheme through an algorithm solution, which significantly improves the overall performance of the supply chain. Finally, we verify the practicability of the model and algorithm through case analysis. After the application of the optimization scheme, the case enterprise realized the reduction of cost, the improvement of efficiency, and the improvement of service quality, which further proved the practical value of the research results.

Based on the above research conclusions, this article puts forward the following practical significance and improvement suggestions for enterprise SCM.

First of all, enterprises should give priority to the use of big data technology in SCM. By building a big data platform and integrating internal and external data resources, real-time data sharing and efficient utilization can be realized, and the intelligence level of SCM can be improved. Secondly, enterprises can learn from the supply chain optimization model and algorithm constructed in this study and adjust and apply it according to their own actual situation. By optimizing the supply chain strategy, we can reduce operating costs, improve operating efficiency and improve service quality, thus enhancing the core competitiveness of enterprises. Finally, enterprises should strengthen cooperation with supply chain partners. Through information sharing, resource integration and business process docking, the collaborative optimization of the supply chain can be realized, and the response speed of the whole supply chain can be improved.

With the continuous development of big data technology and the continuous expansion of application fields, we believe that supply chain optimization driven by big data will play an important role in more fields. Future research can further explore the combination of big data and other areas of SCM and innovative applications, such as intelligent warehouse management, logistics path planning, demand forecasting, etc., to provide enterprises with more comprehensive and accurate supply chain optimization solutions.

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