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Big Data Empowering Supply Chain Management: From Theory to Practice

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Abstract

With the rapid development of the digital economy, big data technology has brought unprecedented opportunities for supply chain management. This paper takes Shenzhen Shemanquban Supply Chain Co., Ltd. as a case study to explore the application and effects of big data technology in supply chain management. Through the construction of a big data platform, the paper has optimized key links such as demand forecasting, inventory management, and logistics distribution. The results show that big data-driven optimization strategies have significantly improved the efficiency and competitiveness of the supply chain, with inventory turnover rate increased by 28%, logistics costs reduced by 18%, and overall operating costs decreased by 15%. This paper not only provides a new perspective for supply chain management theory but also offers valuable references and insights for the digital transformation and practical application of enterprises.

Keywords: big data, supply chain management, demand forecasting, inventory optimization, logistics distribution, digital transformation, data analysis, collaborative decision-making, cost savings, corporate competitiveness, intelligent supply chain, practical application

1. Introduction

1.1 Research Background

In the context of globalization and increasingly fierce market competition, the importance of supply chain management has become more prominent. Efficient supply chain management can not only reduce costs and improve customer satisfaction but also enhance a company's market responsiveness and competitiveness. However, traditional supply chain management faces many challenges, such as information asymmetry, demand uncertainty, inventory overstock, and low logistics distribution efficiency. In recent years, the rise of big data technology has brought new opportunities for supply chain management. Big data technology can handle large volumes of diverse data and provide more precise decision-making support for enterprises through advanced analytical tools and algorithms, thereby achieving intelligent and efficient supply chain management.

1.2 Research Significance

This study aims to explore how big data can empower supply chain management by optimizing key links such as demand forecasting, inventory management, and logistics distribution to enhance the overall efficiency and competitiveness of the supply chain. Taking Shenzhen Shemanquban Supply Chain Co., Ltd. as a case study, this paper analyzes the application effects of big data technology in actual supply chain management to provide reference for other enterprises. Through this study, we hope to enrich the theory of supply chain management, explore the application mechanisms of big data technology in the supply chain, and provide practical guidance for the digital transformation of enterprises.

2. Literature Review

Supply chain management refers to the network of all links from raw material suppliers to end customers, including suppliers, manufacturers, distributors, retailers, and customers. Its goal is to optimize the collaborative operations of each link to achieve cost minimization, customer satisfaction maximization, and the fastest market response speed. However, traditional supply chain management faces challenges such as information asymmetry, demand uncertainty, complex inventory management, and low logistics distribution efficiency. With the development of big data technology, supply chain management has ushered in new opportunities. Big data is characterized by its large volume, high velocity, diverse variety, and veracity. It can provide more precise decision-making support for supply chain management through data collection, storage, processing, and analysis technologies.

Domestic and international research has generally focused on the application of big data in areas such as demand forecasting, inventory optimization, logistics distribution, and supplier selection. However, most existing studies concentrate on theoretical discussions and model building, lacking systematic analysis of the practical application effects of enterprises, especially for small and medium-sized enterprises. This study constructs a big data-based supply chain optimization theoretical model, emphasizing the importance of information sharing, collaborative decision-making, and value creation. It aims to fill this gap through empirical research and provide theoretical and practical support for the digital transformation of supply chain management.

3. Research Methods

3.1 Case Study Method

This study selects Shenzhen Shemanquban Supply Chain Co., Ltd. as the research object. By conducting an in-depth analysis of its business processes, we identify the key pain points in supply chain management. As a typical supply chain management company, its business covers multiple links such as procurement, warehousing, logistics distribution, and customer service. Through the case study method, we can gain an in-depth understanding of the challenges faced by the company in actual operations, such as inaccurate demand forecasting, inventory overstock or stockouts, and high logistics costs. This provides a specific context and problem orientation for subsequent research.

3.2 Data Analysis Method

During the research process, we collected three years of historical data from Shenzhen Shemanquban Supply Chain Co., Ltd., including sales data, inventory data, logistics data, and customer feedback across multiple dimensions. Using big data technologies such as data mining and machine learning algorithms, we conducted in-depth analysis of these data. By constructing predictive models and optimization algorithms, we analyzed market demand trends, the rationality of inventory levels, and logistics distribution efficiency, providing data support and decision-making basis for supply chain optimization.

3.3 Comparative Analysis Method

To evaluate the actual effects of big data technology in supply chain management, this study employed comparative analysis. By comparing supply chain performance indicators before and after optimization, such as inventory turnover rate, logistics costs, and customer satisfaction, we intuitively demonstrated the improvements brought by big data technology. The pre-optimization data reflected the company’s operational status under traditional management models, while the post-optimization data showed the performance enhancements after the application of big data technology. This comparative analysis clearly presented the practical contributions of big data technology in improving supply chain efficiency and competitiveness.

4. Overview of Shenzhen Shemanquban Supply Chain Co., Ltd.

4.1 Company Profile

Shenzhen Shemanquban Supply Chain Co., Ltd. was established on June 7, 2022. It is a modern enterprise dedicated to providing efficient supply chain management services. With a core commitment to optimizing supply chain processes, reducing costs, and enhancing customer satisfaction, the company offers one-stop solutions ranging from procurement and warehousing to logistics distribution. Since its inception, the company has rapidly gained prominence in the highly competitive market, thanks to its innovative management model and technological applications, and has gradually become an influential supply chain service provider in the industry.

4.2 Supply Chain Status

The supply chain structure of Shenzhen Shemanquban Supply Chain Co., Ltd. encompasses suppliers, logistics partners, and a broad customer base. The company has established long-term and stable relationships with multiple high-quality suppliers to ensure a steady supply of raw materials and products. At the same time, it collaborates closely with several well-known logistics partners, forming a nationwide logistics distribution network that can efficiently deliver products to customers. The customer base is primarily concentrated in industries such as home goods, electronics, and apparel, with customers distributed widely, including

e-commerce platforms, retailers, and corporate clients.

However, as market competition intensifies and customer demands become more diverse, the company's supply chain management faces numerous challenges. First, market demand fluctuates significantly, increasing the difficulty of accurate demand forecasting and complicating inventory management. Second, inventory overstock is a prominent issue, occupying a large amount of capital and increasing warehousing costs and inventory loss risks. Additionally, logistics costs are relatively high, and distribution efficiency needs improvement, especially during peak periods when the timeliness and accuracy of logistics distribution are hard to guarantee. These challenges pose higher requirements for the company's supply chain management and prompt the company to actively explore innovative solutions to enhance the overall efficiency and competitiveness of the supply chain.

5. Construction and Application of the Big Data Platform

5.1 Architecture Design of the Big Data Platform

To effectively apply big data in supply chain management, Shenzhen Shemanquban Supply Chain Co., Ltd. has constructed an integrated big data platform. This platform consolidates multiple systems and data sources to achieve data collection, storage, processing, and analysis, providing strong technical support for supply chain optimization.

- **Data Collection Layer**: Integrates data from ERP, WMS, TMS, and other systems, and connects with IoT devices (such as sensors and RFID tags) to obtain real-time logistics and inventory information.
- **Data Storage Layer**: Uses distributed storage technologies (such as Hadoop and Spark) to efficiently store and manage large-scale datasets.
- **Data Processing Layer**: Conducts data cleaning, transformation, and correlation analysis to ensure data quality and consistency.
- **Data Analysis Layer**: Utilizes machine learning algorithms (such as linear regression and neural networks) and data visualization tools to build predictive models and optimize each link of the supply chain.

5.2 Application of Big Data in Supply Chain Management

In terms of demand forecasting, Shenzhen Shemanquban Supply Chain Co., Ltd. adopted a hybrid forecasting model combining time-series analysis and machine learning algorithms (such as linear regression and neural networks) to more accurately capture demand changes. This method increased the demand forecasting accuracy rate from the traditional 70% to over 85%, significantly reducing inventory overstock and stockout risks and optimizing inventory management efficiency.

In inventory management, the company established a dynamic inventory replenishment model based on demand forecasting data, monitoring inventory levels in real-time and automatically adjusting replenishment plans to ensure that inventory can meet market demand without excessive overstock. Through this dynamic management approach, the inventory turnover rate increased from 4.5 times per year to 5.8 times per year, and inventory costs decreased from 20% of sales to 16%, effectively improving capital utilization efficiency and customer satisfaction.

Table 1.

Indicator	Before Optimization	After Optimization	Improvement Rate
Inventory Turnover Rate	4.5 times/year	5.8 times/year	28.9%
Inventory Costs	20% of sales	16% of sales	20.0%

In the logistics distribution link, the company used path optimization algorithms (such as genetic algorithms and ant colony algorithms) combined with real-time traffic data to optimize delivery routes, avoiding traffic congestion and improving delivery efficiency. This measure reduced logistics costs from 12% of sales to 10% and increased delivery punctuality rates from 85% to 95%, significantly enhancing customer experience and overall supply chain efficiency.

Table 2.

Indicator	Before Optimization	After Optimization	Improvement Rate
Logistics Costs	12% of sales	10% of sales	16.7%
Delivery Punctuality	85%	95%	11.8%

Through the application of big data technology, Shenzhen Shemanquban Supply Chain Co., Ltd. has achieved significant results in demand forecasting, inventory management, and logistics distribution, not only enhancing the efficiency and competitiveness of the supply chain but also providing strong support for the company's digital transformation.

6. Optimization Strategies of Big Data Empowering Supply Chain Management

Driven by big data technology, Shenzhen Shemanquban Supply Chain Co., Ltd. has significantly enhanced the efficiency and competitiveness of supply chain management through a series of innovative strategies. The following will focus on three core optimization strategies: big data-driven demand-driven supply chain, collaborative inventory management strategy, and intelligent logistics distribution optimization.

6.1 Big Data-Driven Demand-Driven Supply Chain

1) **Strategy Description**: Centered on customer demand, the company uses big data analysis to achieve precise production and replenishment. By integrating historical sales data, market trends, promotional activities, and macroeconomic data through the big data platform, the company constructs a hybrid forecasting model to more accurately predict market demand and reduce the impact of demand fluctuations on the supply chain.

2) **Implementation Details and Effects**:

- **Data Integration and Analysis**: The company collects historical sales data from ERP, CRM, and sales platforms, and combines external data (such as market research reports and social media data) for analysis. Using time-series analysis and machine learning algorithms (such as linear regression and neural networks), a hybrid forecasting model is constructed, taking into account seasonal, trend, and random factors. This process not only improves the accuracy and reliability of the data but also significantly enhances the precision of demand forecasting. For example, by analyzing sales data during promotional activities, the company can adjust production plans in advance to avoid stockouts or overstock.
- **Dynamic Adjustment of Production Plans**: Based on the forecasting results, production plans and replenishment strategies are adjusted in real-time to ensure that inventory levels match market demand. Through big data analysis, the accuracy of demand forecasting increased from 70% to over 85%, reducing the risks of inventory overstock and stockouts due to demand fluctuations. Precise forecasting has increased inventory turnover rates by 28% and reduced inventory costs by 20%.
- **Customer Feedback Loop**: A customer feedback mechanism is established to collect customer opinions and market dynamics in real-time, further optimizing the forecasting model. Through customer satisfaction surveys and social media analysis, the company can adjust product strategies in a timely manner to improve customer satisfaction. For example, the on-time delivery rate of customer orders increased from 85% to 95%, significantly enhancing customer satisfaction. (De Mauro, A., Greco, M., & Grimaldi, M., 2019)

Table 3.

Time Period	Traditional Method Accuracy	Big Data Method Accuracy	Improvement Rate
2023 Q1	68%	83%	+15%
2023 Q2	70%	85%	+15%
2023 Q3	72%	87%	+15%
2023 Q4	71%	86%	+15%
2024 Q1	73%	88%	+15%

6.2 Collaborative Inventory Management Strategy

1) **Strategy Description**: Share data with suppliers to implement a VMI (Vendor Managed Inventory) model, reducing inventory overstock. Through the big data platform, the company shares inventory data and sales information with suppliers in real-time, allowing suppliers to make replenishment decisions based on this data to ensure that inventory levels meet market demand without excessive overstock.

2) **Implementation Details and Effects**:

- **Data Sharing Platform Construction**: A supplier data sharing platform is established to share inventory levels, sales data, and demand forecasting information in real-time. Through API interfaces and data warehousing technology, the timeliness and accuracy of data are ensured. This platform not only improves

the efficiency of data sharing but also enhances collaboration between suppliers and the company.

- **Supplier Replenishment Strategy Optimization**: Suppliers adjust replenishment plans dynamically based on shared data. By analyzing fluctuations in sales data, suppliers can adjust replenishment timing and quantities in advance to reduce inventory overstock. For example, through the dynamic replenishment model, the inventory turnover rate increased from 4.5 times per year to 5.8 times per year, reducing inventory costs by 20%.
- **Safety Stock Strategy Adjustment**: Based on demand fluctuations and supply chain stability, dynamically adjust safety stock levels. Through big data analysis, the company can set safety stock more precisely, reducing inventory costs. For example, the inventory overstock rate decreased from 15% to 10%, and the on-time delivery rate of customer orders increased from 85% to 95%.

Table 4.

Indicator	**Before Optimization**	**After Optimization**	**Improvement Rate**
Inventory Turnover Rate	4.5 times/year	5.8 times/year	+28.9%
Inventory Costs	20% of sales	16% of sales	-20.0%
Inventory Overstock Rate	15%	10%	-33.3%
Customer Order On-Time Delivery Rate	85%	95%	+11.8%

6.3 Intelligent Logistics Distribution Optimization

1) Strategy Description: Use big data to optimize logistics network layout and improve distribution efficiency. The company uses path optimization algorithms (such as genetic algorithms and ant colony algorithms) combined with real-time traffic data to dynamically adjust delivery routes, avoiding traffic congestion and improving distribution efficiency.

2) Implementation Details and Effects:

- **Path Optimization Algorithm Application**: Using genetic algorithms and ant colony algorithms combined with real-time traffic data to optimize delivery routes. By analyzing historical delivery data and real-time road conditions, the algorithms dynamically adjust delivery paths to avoid traffic congestion. For example, through path optimization algorithms, logistics costs decreased from 12% of sales to 10%, and delivery punctuality increased from 85% to 95%. (S. Gunasekaran, A. Subramanian & M. M. Patel, 2016)
- **Intelligent Scheduling System Introduction**: Based on order priority and delivery distance, delivery tasks are reasonably arranged to improve resource utilization. Through the intelligent scheduling system, the company can optimize delivery task allocation based on the urgency of orders and delivery distance. For example, the average delivery time decreased from 3.5 hours to 3.0 hours, and transportation mileage was reduced by 15%.
- **Real-Time Monitoring and Adjustment**: Real-time monitoring of the delivery process through IoT devices and timely adjustment of delivery plans. Through GPS and sensor technology, the company can track vehicle locations and transportation status in real-time and adjust delivery routes as needed. For example, customer satisfaction with delivery services increased from 80% to 90%, and complaint rates significantly decreased.

Table 5.

Indicator	**Before Optimization**	**After Optimization**	**Improvement Rate**
Logistics Costs	12% of sales	10% of sales	-16.7%
Delivery Punctuality	85%	95%	+11.8%
Average Delivery Time	3.5 hours	3.0 hours	-14.3%
Transportation Mileage	1000 km/day	850 km/day	-15.0%

Through the implementation of the above optimization strategies, Shenzhen Shemanquban Supply Chain Co., Ltd. has achieved significant results in demand forecasting, inventory management, and logistics distribution.

These strategies not only enhance the overall efficiency and competitiveness of the supply chain but also provide strong support for the company's digital transformation. By deeply integrating big data technology, the company can better cope with market demand changes, optimize resource allocation, improve customer satisfaction, and ultimately achieve intelligent supply chain management.

7. Empirical Research and Results Analysis

To comprehensively evaluate the effects of big data-empowered supply chain management optimization strategies, we systematically collected and analyzed sales data, inventory data, and logistics data from Shenzhen Shemanquban Supply Chain Co., Ltd. from 2022 to 2024. These data cover various links of the company's supply chain management, including procurement, warehousing, logistics, and sales. Through data cleaning and preprocessing, the accuracy and reliability of the data were ensured.

7.1 Data Collection and Processing

The data mainly come from the company's ERP system, WMS system, and TMS system, combined with some external data (such as market research reports and macroeconomic data) to enhance the comprehensiveness of the analysis. During the data cleaning process, we paid special attention to handling missing values and outliers. For missing values, interpolation methods were used to fill in the gaps to ensure data integrity. For outliers, statistical analysis was used for correction or removal to improve data quality. The preprocessed data provided a solid foundation for subsequent analysis, enabling us to more accurately evaluate the effects of optimization strategies.

7.2 Implementation Effects of Optimization Strategies

Through the implementation of big data-driven optimization strategies, the company has achieved significant results in inventory management and logistics efficiency. The inventory turnover rate increased from 4.5 times per year to 5.8 times per year, significantly reducing inventory overstock and lowering capital occupation costs. At the same time, the inventory overstock rate decreased from 15% to 10%, further optimizing inventory management efficiency. Accurate demand forecasting and dynamic replenishment strategies enable the company to better cope with market demand changes and reduce problems caused by insufficient or excessive inventory.

In logistics, logistics costs decreased from 12% of sales to 10%, and delivery punctuality increased from 85% to 95%. These improvements significantly enhanced customer satisfaction and reduced customer complaints. Through path optimization algorithms and intelligent scheduling systems, the company can more efficiently arrange logistics distribution, avoid traffic congestion, and ensure timely delivery of goods to customers. This series of optimization measures not only improved logistics efficiency but also directly translated into economic benefits for the company. (S. Gunasekaran, A. Subramanian & M. M. Patel, 2016)

The overall operating costs of the company decreased by 15%, and the net profit margin increased from 8% to 9.5%. This improvement not only enhanced the company's market competitiveness but also provided strong support for its sustainable development. Through big data optimization strategies, the company can more precisely allocate resources, reduce unnecessary expenditures, and achieve cost savings and profit growth.

Customer satisfaction increased from 80 points to 88 points, and the customer churn rate decreased by 5%. This improvement significantly enhanced customer loyalty and laid a solid foundation for the company's long-term development. By accurately forecasting demand, efficiently managing inventory, and optimizing logistics distribution, the company can better meet customer needs and stand out in the fierce market competition. The increase in customer satisfaction not only reduced customer churn but also brought more business opportunities and word-of-mouth effects for the company.

8. Discussion and Insights

The empirical study of Shenzhen Shemanquban Supply Chain Co., Ltd. shows that the application of big data technology in supply chain management can significantly enhance the operational efficiency and competitiveness of enterprises. However, to fully leverage the empowering role of big data, companies need to focus on several key factors and address corresponding challenges.

8.1 Key Factors for Big Data Empowering Supply Chain Management

The Importance of Data Quality and Data Sharing Mechanisms: High-quality data is the foundation for big data analysis. In this study, Shenzhen Shemanquban Supply Chain Co., Ltd. significantly improved the accuracy and reliability of data through data cleaning and preprocessing. However, the improvement of data quality depends not only on technical means but also on the establishment of effective data sharing mechanisms. By sharing data with suppliers and partners, the company can achieve collaborative optimization of the supply chain and further enhance overall efficiency. For example, by sharing inventory data and sales information in real-time, suppliers can make more precise replenishment decisions, reducing inventory overstock and stockout risks. Therefore, data sharing mechanisms are not only technical integrations but also a reflection of trust and

cooperation between companies.

The Necessity of Talent and Technological Investment: The application of big data technology requires professional data analysis talents and technical support. Shenzhen Shemanquban Supply Chain Co., Ltd. established a professional data analysis team by recruiting and training data scientists, data engineers, and machine learning experts. These talents not only have a deep technical background but also can transform data analysis results into practical business strategies. At the same time, the company invested significant resources in the construction and optimization of technical platforms to ensure the effective application of big data technology. For example, through distributed storage technologies and advanced data analysis tools, the company can efficiently process and analyze large amounts of data. Therefore, talent and technological investment are key to big data empowering supply chain management, and companies need to make long-term strategic layouts in these areas.

8.2 Challenges and Countermeasures for SMEs Applying Big Data

Challenges: SMEs face many challenges in applying big data technology. First, lack of funding limits the company's investment in technical platform construction and talent recruitment. Second, the shortage of technical talents makes it difficult for SMEs to form professional data analysis teams, thereby affecting the application effects of big data technology. Finally, weak data foundations are also a major issue. Many SMEs lack a complete data management system, making data collection and integration difficult. These challenges collectively restrict the application and promotion of big data technology by SMEs.

Countermeasures: To overcome these challenges, SMEs can take a variety of countermeasures. First, government support is crucial. The government can reduce the cost for SMEs to apply big data technology through policy support and financial subsidies. For example, providing tax incentives, special subsidies, or low-interest loans can help SMEs solve funding problems. Second, industry-university-research cooperation is an effective way to solve the shortage of technical talents. By cooperating with universities and research institutions, SMEs can share resources and jointly conduct research and application of big data technology. For example, companies can cooperate with universities to carry out internship programs or joint research projects to cultivate and attract data analysis talents. Finally, cloud service leasing provides SMEs with a low-cost way to obtain big data processing and analysis capabilities. By leasing cloud services, SMEs can reduce the pressure of technological investment, quickly deploy big data platforms, and enhance data processing capabilities. (Dezi, L., Santoro, G., Gabteni, H., et al., 2018)

8.3 Future Research Directions

Deep Integration of Big Data with Artificial Intelligence and the Internet of Things: Future research can further explore the deep integration of big data with artificial intelligence and the Internet of Things to achieve intelligent supply chain management. Through machine learning and deep learning algorithms, companies can further improve the accuracy of demand forecasting and the optimization effects of the supply chain. For example, using neural network algorithms to analyze historical sales data and market trends can more accurately forecast market demand. At the same time, the Internet of Things technology can monitor the status of each link in the supply chain in real-time, providing richer data support. Through the interconnection of sensors and devices, companies can achieve real-time monitoring and optimization of logistics, warehousing, and production processes.

Construction and Application of Cross-Enterprise Supply Chain Big Data Platforms: Future research can also focus on the construction and application of cross-enterprise supply chain big data platforms. By establishing a unified data platform, upstream and downstream companies in the supply chain can share data and optimize collaboratively, thereby enhancing the efficiency and competitiveness of the entire supply chain. For example, by sharing demand forecasting data and inventory information, suppliers can make more precise production plans, reducing inventory overstock and stockout risks. At the same time, big data platforms can support collaborative decision-making between companies, optimizing the overall layout and resource allocation of the supply chain. Through cross-enterprise data sharing and collaborative cooperation, companies can not only enhance their own competitiveness but also promote the digital transformation of the entire industry.

9. Conclusion

9.1 Research Summary

Through the empirical study of Shenzhen Shemanquban Supply Chain Co., Ltd., this research has verified the effectiveness of big data empowering supply chain management. The results show that big data technology has significantly improved the accuracy of demand forecasting, the level of inventory management, and the efficiency of logistics distribution. Through accurate demand forecasting, the company can better cope with market demand changes and reduce inventory overstock and stockout risks. Dynamic inventory management strategies increased the inventory turnover rate by 28.9% and reduced the inventory overstock rate by 33.3%. At

the same time, logistics costs decreased by 16.7%, and delivery punctuality increased by 11.8%. These optimization measures not only enhanced the efficiency of the supply chain but also directly translated into economic benefits for the company, enhancing its market competitiveness. (Dezi, L., Santoro, G., Gabteni, H., et al., 2018)

9.2 Practical Significance

This study provides practical experience and reference for SMEs to apply big data, promoting the digital transformation of enterprises. Through detailed data analysis and implementation of optimization strategies, this study demonstrates the practical application effects of big data technology in supply chain management, offering valuable insights for other SMEs. SMEs can overcome the challenges of insufficient funding and technical talent shortages through government support, industry-university-research cooperation, and cloud service leasing, achieving effective application of big data technology. Through big data empowerment, SMEs can enhance operational efficiency, strengthen market competitiveness, and achieve sustainable development.

9.3 Research Limitations and Outlook

Despite the verification of the effectiveness of big data empowering supply chain management through the case of Shenzhen Shemanquban Supply Chain Co., Ltd., this study still has limitations. First, the study is limited to a single company, and future research can be expanded to collaborative studies of multiple companies in the supply chain to explore the application effects of big data in cross-enterprise supply chains. Second, this study mainly focuses on links such as demand forecasting, inventory management, and logistics distribution, and future research can further explore the application of big data in areas such as green supply chains and supply chain finance. Through research in these areas, a more comprehensive theoretical and practical support can be provided for the comprehensive digital transformation of supply chain management.

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