Original Research Article

Research on Supply Chain Management Optimization of Small and Medium-Sized Enterprises Based on Big Data

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Abstract: Under the background of globalization and the rapid development of information technology, the supply chain management of SEMs is facing many challenges, and the application of big data technology provides a new optimization path for SEMs. By discussing the application background of big data technology in supply chain management, analyzing the problems faced by small and medium-sized enterprises in supply chain management, we puts forward targeted optimization countermeasures. The research found that the establishment of efficient data collection and integration mechanism, improvement of data analysis ability and optimization of technology investment and cost management are the key ways for small and medium-sized enterprises to achieve supply chain optimization, providing theoretical support and practical guidance for small and medium-sized enterprises, and helping them improve their supply chain management level and market competitiveness.

Keywords: big data; small and medium enterprises; supply chain management; data collection

1. Introduction

In today's business environment, small and medium-sized enterprises play a vital role in the economic development. With the advancement of globalization and the rapid development of information technology, the application of big data technology has brought new opportunities and challenges for the supply chain management of small and medium-sized enterprises. The traditional supply chain management mode has been difficult to cope with the rapidly changing market demand and the complex and changeable supply chain environment. How to optimize the supply chain through big data technology and improve the competitiveness and operational efficiency of small and medium-sized enterprises has become a hot spot and difficulty in the current research. In discussing the application of big data technology in the supply chain management of small and medium-sized enterprises, so as to provide effective optimization countermeasures.

2. Importance of Optimizing Supply Chain Management for Sems Based on Big Data

2.1. Background of Big Data Technology Application in Supply Chain Management

The rapid development of big data technology has injected new vitality into supply chain management. Big data technology primarily includes data collection, storage, processing, and analysis. These technologies help enterprises achieve precise control and optimization at various stages of the supply chain. The application of big data technology in supply chain management encompasses the following aspects: First, through data collection technology, enterprises gather a large amount of data from various stages of the supply chain. This data includes raw material procurement data, production data, inventory data, logistics data, and sales data. With this data, enterprises can comprehensively monitor the operation status of the supply chain, thereby identifying and resolving problems promptly. Second, through data storage and processing technology, enterprises can efficiently store and process the vast amounts of data collected. Traditional supply chain management methods

often rely on experience and intuition, whereas big data technology uses scientific methods to process and analyze data, providing more accurate and objective decision-making support. Third, through data analysis technology, enterprises conduct in-depth analysis and mining of supply chain data to identify potential issues and optimization opportunities. For example, by analyzing sales data, enterprises can predict market demand changes and adjust production plans in advance to avoid overstock and stockouts. Finally, through data visualization technology, enterprises can intuitively present complex data in the form of charts and reports, helping managers better understand and utilize the data. The application of these technologies not only improves the efficiency and accuracy of supply chain management but also provides enterprises with a new competitive advantage[1].

2.2. Special needs of SMEs in Supply Chain Management

SMEs face different challenges and needs in supply chain management compared to large enterprises. Due to limitations in scale and resources, SMEs require more flexible and efficient solutions in supply chain management. The application of big data technology helps SMEs meet these special needs, thereby achieving optimal resource allocation and improved management efficiency. First, SMEs need to respond quickly to rapidly changing market environments. Changes in market demand, supplier fluctuations, and the complexity of logistics require SMEs to respond and adjust quickly. Big data technology, through real-time data collection and analysis, helps SMEs obtain market information and supply chain status promptly, allowing them to react quickly and avoid losses due to information delays. Second, SMEs often lack sufficient resources and technical support in supply chain management. Compared to large enterprises, SMEs face deficiencies in funding, talent, and technology. The application of big data technology helps SMEs reduce the cost of technology application and improve resource utilization efficiency through shared platforms and partnerships. For example, through cloud computing technology, SMEs can rent big data platforms and tools without the need to build and maintain expensive technical infrastructure. Lastly, SMEs need to focus more on customer satisfaction and market competitiveness in supply chain management. Big data technology helps SMEs better understand customer needs and provide personalized products and services through the analysis of customer demands and behaviors, thereby improving customer satisfaction and loyalty. Additionally, by analyzing competitors, SMEs can timely adjust their market strategies and enhance their market competitiveness.

2.3. Impact of Supply Chain Management Optimization on Sems Development

Effective supply chain management has a significant impact on the development of SMEs. Through the application of big data technology, SMEs can achieve optimization in the following areas of supply chain management, thereby improving overall operational efficiency and market competitiveness. First, with the application of big data technology, SMEs can achieve visual management of the supply chain. Traditional supply chain management methods often rely on human experience and intuition, whereas big data technology comprehensively collects and analyzes data, visually presenting various stages of the supply chain. This helps managers fully understand the operational status of the supply chain, enabling timely identification and resolution of problems. For example, by analyzing inventory data, enterprises can understand inventory dynamics in real-time, avoiding overstocking or stockouts. Second, with the application of big data technology, SMEs can enhance their forecasting capabilities in supply chain management. Predicting market demand and supply chain risks are crucial stages in supply chain management. Big data technology enables SMEs to make accurate forecasts regarding market demand, supplier performance, and logistics, allowing them to take preemptive measures and

reduce risks brought about by uncertainties. For instance, by analyzing historical sales data and market trends, enterprises can predict future market demand, arrange production plans and inventory management in advance, and avoid losses due to market changes. Lastly, through the application of big data technology, SMEs can achieve collaborative optimization of the supply chain. Supply chain management is not just about internal management but also about the collaborative management of the entire supply chain ecosystem. Big data technology allows SMEs to share information and collaborate with suppliers, logistics service providers, customers, and other supply chain participants, improving overall supply chain efficiency. For example, by sharing supply chain data, enterprises can collaboratively formulate procurement plans with suppliers, reducing procurement costs and the risk of supply chain disruptions[2].

3. Issues in Optimizing Supply Chain Management for Sems Based on Big Data

3.1. Difficulties in Data Acquisition and Integration

In the supply chain management of SMEs, data acquisition and integration is a common and complex problem. SMEs typically face challenges such as dispersed data sources, inconsistent data formats, and low data quality. These issues directly affect the efficiency and effectiveness of supply chain management. First, dispersed data sources are one of the main challenges SMEs face in the data acquisition process. The supply chain of SMEs involves multiple stages, including raw material procurement, production processing, logistics transportation, and sales, each of which involves different data sources. These data sources are often dispersed across different systems and platforms, lacking unified standards and interfaces, making data acquisition and integration very difficult. For example, the procurement department may use different systems to record procurement data, while the production and sales departments use other systems to record production and sales data, necessitating a lot of manual operations and coordination during data integration. Second, inconsistent data formats are another important issue in the data integration process. Due to the different formats and structures of data from different sources, enterprises need to perform extensive data cleaning and conversion during data integration. This not only increases the complexity and workload of data integration but also leads to errors and inconsistencies in data during conversion, affecting the accuracy and reliability of the data. For instance, different suppliers may provide data in different formats, some using Excel spreadsheets, some using CSV files, and some providing paper documents directly, requiring enterprises to convert and standardize formats during data integration. Lastly, low data quality is another significant problem SMEs face during data acquisition and integration. Due to limited resources and capabilities in data management, data collection, entry, and maintenance often lack standardization and strict control, resulting in varying data quality. For example, data may contain duplicates, omissions, errors, and inconsistencies, which not only affect the accuracy and completeness of the data but also lead to incorrect conclusions during data analysis and decision-making.

3.2. Insufficient Data Analysis Capabilities

Despite the powerful tools and methods big data technology provides for supply chain management, SMEs often face the dilemma of insufficient data analysis capabilities in actual applications. Insufficient data analysis capabilities not only limit the depth of data mining and utilization but also directly impact the optimization and decision-making quality of supply chain management. First, SMEs significantly lack data analysis talent. The application of big data technology requires professional data analysts and engineers, but SMEs, due to limited resources, often find it challenging to attract and retain such high-quality talent. This not only leads to a lack of

professional guidance and support during data analysis but also affects the depth and breadth of data analysis. For example, some complex data analysis methods and techniques, such as machine learning and deep learning, often require professional talent for modeling and tuning, and SMEs usually lack this professional capability. Second, SMEs also lack data analysis tools and technologies. Big data analysis requires advanced technical tools and platform support, such as data warehouses, data mining tools, and visualization tools. However, due to financial and technical limitations, SMEs often find it difficult to afford these costly technological investments. This not only limits the technical means available for data analysis but also affects the efficiency and effectiveness of data analysis. For instance, some big data analysis tools and platforms, like Hadoop and Spark, are powerful but require corresponding technical capabilities and resources for deployment and maintenance, which SMEs often find hard to meet. Lastly, SMEs also lack a data analysis culture and awareness. Data analysis requires enterprises to have a certain data-driven culture and decision-making awareness, but SMEs are often still in the early stages in this regard. Many SMEs' management and staff do not fully recognize the value and significance of data analysis, limiting the promotion and application of data analysis within the enterprise. For example, some enterprises focus only on short-term business needs and goals during data analysis, neglecting the long-term value and strategic significance of data analysis, thereby significantly reducing the effectiveness and impact of data analysis[3].

3.3. Technological Investment And Cost Constraints

Technological investment and cost constraints are another major challenge SMEs face in implementing big data technology. The application of big data technology requires substantial investments in hardware, software, and human resources, which SMEs, due to financial and resource limitations, often find difficult to bear. First, the application of big data technology requires substantial hardware investments. Big data analysis typically needs high-performance computing and storage equipment, such as servers, storage devices, and network equipment, and the procurement and maintenance costs of these devices are often very high. SMEs, with limited funds and resources in this area, find it difficult to bear these high hardware costs. For example, some big data analysis tasks require massive data storage and processing, necessitating high-performance data centers and computing clusters, which SMEs often find hard to afford. Second, the application of big data technology also requires substantial software investments. Big data analysis needs various professional software tools and platforms, such as data warehouses, data mining tools, and visualization tools, and the procurement and maintenance costs of these software are also very high. SMEs, with limited funds and technical capabilities, often find it difficult to bear these high software costs. For instance, some advanced data analysis software, such as SAS and Tableau, though powerful, have high licensing fees and maintenance costs, which SMEs often find hard to afford. Lastly, the application of big data technology also requires substantial human resources investments. Big data analysis requires professional data analysts and engineers for data processing, modeling, and analysis, and the recruitment and training costs of these high-quality talents are also very high. SMEs, with limited resources and capabilities in this area, often find it difficult to attract and retain these high-quality talents. For example, some complex big data analysis tasks require professional data scientists for modeling and algorithm optimization, and the recruitment and salary costs of these talents are often very high, which SMEs often find hard to meet.

4. Strategies for Optimizing Supply Chain Management for Sems Based on Big Data

4.1. Establish Efficient Data Collection and Integration Mechanisms

To effectively address the difficulties in data acquisition and integration, small and medium-sized enterprises (SMEs) need to establish efficient data collection and integration mechanisms. Firstly, SMEs should adopt diversified data collection methods, leveraging Internet of Things (IoT) devices and sensors to capture real-time data from various supply chain segments. For instance, in warehousing and logistics, RFID tags and GPS technology can be utilized to track cargo dynamics in real-time, enhancing data accuracy and timeliness. These technologies enable enterprises to monitor critical parameters such as cargo location, temperature, and humidity in real-time, enabling prompt responses to issues and minimizing losses. Additionally, customer data is gathered through Customer Relationship Management (CRM) systems to understand customer needs and market trends, facilitating the formulation of more precise market strategies. Secondly, enterprises should introduce a unified data management platform to centralize and process data dispersed across different systems and departments. This platform should possess robust data integration capabilities, capable of cleansing, transforming, and integrating data from various sources and formats into standardized datasets. For instance, SMEs can use ETL (Extract, Transform, Load) tools to consolidate data from procurement, production, and sales onto a unified platform, facilitating subsequent data analysis and utilization. This approach not only improves data utilization efficiency but also ensures data consistency and reliability, preventing information silos caused by data fragmentation. Furthermore, enterprises should strengthen data quality management, as data quality directly impacts data analysis outcomes and decision-making accuracy. To achieve this, SMEs should establish comprehensive data quality control mechanisms, including standardized data entry, data validation and cleansing, data updating, and maintenance measures. For example, by setting up data quality monitoring indicators, enterprises can regularly inspect and evaluate data quality, ensuring data integrity, consistency, and accuracy. Automated data validation tools should be introduced to reduce human errors, and periodic data cleansing should be conducted to eliminate duplicate, erroneous, and outdated data, guaranteeing high-quality data. Moreover, enterprises should train data users to enhance their awareness and capabilities in data management and maintenance. Lastly, SMEs should prioritize data security and privacy protection. During data collection, integration, and analysis, enterprises must implement corresponding security measures to prevent data breaches and unauthorized access. For example, data encryption technology should be employed to ensure data security during transmission and storage. Simultaneously, enterprises should establish strict data access control mechanisms, allowing only authorized personnel to access relevant data, thereby preventing sensitive information misuse[4].

4.2. Enhance Data Analysis Capabilities

Enhancing data analysis capabilities is crucial for SMEs to achieve supply chain management optimization. First, enterprises should focus on cultivating and introducing data analysis talent. Through internal training and external recruitment, they can build a professional data analysis team. Training should include the use of data analysis tools and techniques, data modeling, and mining methods. For example, enterprises can organize employees to attend data analysis-related training courses and certification exams to improve their professional skills and knowledge. Second, enterprises should introduce advanced data analysis tools and platforms. Selecting appropriate data analysis tools and platforms can significantly enhance data analysis efficiency and effectiveness. For example, using big data platforms such as Hadoop and Spark to process massive amounts of

data and utilizing machine learning and artificial intelligence algorithms for in-depth data mining and predictive analysis. Additionally, introducing data visualization tools like Tableau and Power BI can present complex data analysis results in intuitive charts, making it easier for management to understand and make decisions. Finally, enterprises should strengthen the integration of data analysis with business applications. The ultimate goal of data analysis is to support business decision-making. Therefore, enterprises should focus on the practical application of data analysis results. For example, by analyzing sales data and market trends, they can optimize inventory management and production planning to improve the supply chain's responsiveness and flexibility. By analyzing customer behavior data, they can develop personalized marketing strategies to enhance customer satisfaction and loyalty.

4.3. Optimize Technological Investment and Cost Management

In the journey of implementing big data technology in small and medium-sized enterprises (SMEs), optimizing technical resource allocation and meticulous cost management constitute two core strategies. Firstly, enterprises must base their decisions on actual needs, carefully planning their technology investment roadmap, and avoiding the temptation to blindly follow trends towards high-end hardware and software. A wise move would be to select cost-effective technical solutions that precisely match the urgent demands of business development and the reality of financial budgets. For instance, actively embracing open-source software and cloud services can not only effectively meet technical functional requirements but also significantly reduce expenses, maximizing resource utilization. Secondly, SMEs should leverage shared platforms and build robust partner networks to lower the thresholds and costs of technology adoption. Specifically, by partnering deeply with big data service giants and technology pioneers, enterprises can easily access the powerful data storage and computing capabilities provided by cloud computing platforms, eliminating the heavy burden of building and maintaining expensive data centers. Collaborating with third-party data analysis experts not only compensates for technical shortcomings but also quickly yields professional and insightful analyses, providing solid data support for decision-making. Moreover, enterprises must take a long-term view and prioritize the long-term benefits of technology investments. This implies evaluating technology investments by weighing not only short-term cost savings and revenue growth but also profoundly understanding and pursuing their long-term positive impacts on enhancing supply chain management efficiency, reducing inventory costs, accelerating production processes, and improving customer satisfaction. These profound transformations will jointly build a solid foundation for the enterprise's core competitiveness, enabling it to stand out in fierce market competition and solidify its market position. Lastly, enterprises should establish a scientific cost-benefit evaluation system to conduct meticulous effect analyses for each technology investment, ensuring that every penny invested translates precisely into quantifiable business value. Through such meticulous management, SMEs can not only navigate the waves of big data steadily but also achieve sustainable development driven by the dual wheels of cost control and technological innovation[5].

5. Conclusions

Big data technology offers brand-new possibilities for the optimization of supply chain management in small and medium-sized enterprises (SMEs). Research has found that SMEs face difficulties in data acquisition and integration, insufficient data analysis capabilities, as well as limitations in technology investment and cost in supply chain management. In response to these issues, strategies are proposed to establish efficient data collection

and integration mechanisms, enhance data analysis capabilities, and optimize technology investment and cost management. These strategies can assist SMEs in overcoming current challenges, achieving comprehensive optimization of their supply chains, and improving overall operational efficiency and market competitiveness. Future research should continue to focus on the application of big data technology in SME supply chain management, exploring more theoretical support and practical pathways to provide robust support for the sustainable development of SMEs.

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