Proceedings of the 4th International Conference on Business and Policy Studies
DOI: 10.54254/2754-1169/164/2025.20828

Application and Strategy Research of Data Analysis and Statistical Methods in Supply Chain Process and Supply Demand Optimization

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Abstract: This study digs into the importance and usefulness of data analysis and statistical methods in making supply chain processes better and balancing supply and demand. It looks at its usefulness in many real-life situations, like figuring out the best way to use resources, making the supply chain more open, managing suppliers better, making logistics more efficient, and lowering business risks. By stressing how important it is to combine data analysis and statistical methods with supply chain process optimization, real-life business examples make the usefulness and practicality of data analysis and statistical methods stand out. At the same time, the study deeply explores the challenges and opportunities encountered in the practical application of data analysis and statistical methods. Finally, we provide an in-depth summary of the research findings and offer suggestions for future research. The goal is to provide forward-looking insights and a solid theoretical foundation for the ongoing improvement and innovation of supply chain management, as well as help businesses better adapt to the tough international market competition environment.

Keywords: Supply chain, Data analysis, Statistical methods, Process optimization, Demand prediction.

1. Introduction

In the current digital business environment, the complexity of supply chain management is increasing exponentially [1]. To gain a competitive edge and maintain a dominant position, enterprises urgently need to utilize data analysis and statistical methods for in-depth supply chain optimization to achieve cost reduction and efficiency improvement [2]. Although various data analysis and statistical methods have been widely applied in the current supply chain process, practical operations still have numerous challenges and limitations in practical operations. Because of this, it is very important to do in-depth research on how to use these methods, what their limitations are, and how to optimize and improve them [3]. This will help lower costs and make the supply chain process more efficient. This not only helps enterprises gain a more profound understanding of the digital development trend of supply chain management but also provides them with practical guidance and inspiration in actual operations, enabling them to achieve sustainable development in the complex and ever-changing market environment [4].

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2. Overview of Supply Chain Process Optimization

2.1. Key Links in the Supply Chain Process

The supply chain process mainly consists of four links: procurement, production, logistics, and sales and distribution.

- Procurement Link: The primary task of an enterprise is to find reliable suppliers and negotiate procurement contracts to ensure that the required materials can be supplied on time, with the right quality and quantity.
- Production Link: This link encompasses a series of activities such as production planning formulation, production scheduling arrangement, production operation execution, and quality control, aiming to efficiently transform raw materials into finished products that meet market demands.
- Logistics Link: It includes key functions such as warehouse management, inventory control, transportation mode selection, and distribution route planning, with the core role of ensuring the smooth flow of products from the production site to the sales site.
- Sales and Distribution Process: Enterprises need to build efficient sales channels, accurately process orders, and ensure timely delivery of products to customers.

2.2. Goals

- Cost Reduction: Through refined optimization of each link in the supply chain, cut costs in procurement, production, logistics, and inventory.
- Quality Improvement: Strictly control the quality in each link of the supply chain to ensure that the product quality always meets or exceeds market standards.
- Delivery Cycle Shortening: Reasonably plan the production plan and logistics distribution scheme to quickly respond to customer needs and shorten the product delivery cycle.

2.3. Significance of Data Analysis and Statistical Methods in Process Optimization

2.3.1. Optimize Resource Allocation

Data analysis is like the sharp eyes of a business, capable of identifying supply chain bottlenecks and inefficiencies. By analyzing production, inventory, and logistics data, companies can identify production slowdowns and resource waste. This enables them to develop targeted improvement plans, increase production efficiency, reduce inventory backlog and costs, and shorten delivery cycles. Therefore, the operational efficiency of the supply chain is higher, like a well-adjusted machine [5].

2.3.2. Improve Supply Chain Transparency

With advanced data analysis and statistical models, it is possible to effectively connect the data sources of every link in the supply chain. This includes data from suppliers, logistics, transportation, warehouse inventory, and more. This allows for the sharing of all information and updates in real time. This enables enterprises to accurately grasp the overall operation status of the supply chain, discover and solve supply chain problems in a timely manner, and ensure that each link is closely connected and coordinated smoothly [6].

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2.3.3. Optimize Supplier Management and Procurement Strategies

Data analysis provides a powerful support tool for supplier performance evaluation, helping companies make wise and scientific judgments in the supplier selection decision-making process. Businesses can accurately find key performance indicators and potential risks by looking at multidimensional statistical data like supplier delivery time, quality indicators, cost structure, and reliability. This helps supply chain managers make beneficial decisions. This helps optimize cooperative relationships in the supply chain, reduce procurement costs, enhance its stability and reliability, and ensure a stable, high-quality, and efficient supply of raw materials.

2.3.4. Improve the Efficiency of Logistics Distribution Network

By using data analysis technology to monitor and analyze various data on transportation routes in real-time, including traffic flow conditions, road condition information, and real-time status of goods, enterprises can optimize logistics routes and transportation modes, reduce logistics costs, improve logistics efficiency, and shorten delivery cycles.

2.3.5. Reduce Potential Risk

Data analysis is crucial in reducing risks. It serves as a sensitive detector to help businesses identify and assess potential supply chain risks, such as supplier disruptions, changes in market demand, and transportation delays or losses. Based on the analysis results, the enterprise has established a risk warning system similar to an alert. Once there are signs of risk, they can promptly detect and resolve them, minimizing negative impacts and ensuring the stable operation of the supply chain [7].

3. The Role of Data Analysis in Supply Chain Process Optimization

3.1. Main Data Analysis Methods in the Supply Chain

3.1.1. Descriptive Analysis

Descriptive analysis is like a historical recorder of the supply chain. It faithfully presents past situations, such as the sales and delivery status of the previous day or the inventory level of the last month. After being sorted and presented, it clearly outlines the past performance of the supply chain, providing indispensable basic materials for subsequent in-depth analysis and optimization, enabling enterprises to review their operation tracks and gain insights into their development context.

3.1.2. Diagnostic Analysis

Diagnostic analysis is like a precise business probe, deeply exploring the root causes of supply chain problems. Diagnostic analysis thoroughly examines the data to pinpoint bottlenecks, inefficient links, and potential hidden dangers, enabling enterprises to gain a clear understanding of the internal causes of the problems. Based on this insight, enterprises can formulate targeted improvement strategies, just like prescribing medicine according to the illness, pointing out the direction for the efficient operation and optimization upgrade of the supply chain [8].

3.1.3. Linear Programming

Linear programming is an exquisite operational research tool in supply chain management. It focuses on dealing with problems where both the objective function and the constraint conditions are linear. In the large stage of the supply chain, within the constraint framework of inventory level, production

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capacity, transportation capacity, etc., it skillfully weighs and seeks the balance between cost minimization and profit maximization. It helps businesses make better decisions about things like allocating resources, planning production, and the layout of their warehouses by using complex mathematical models and scientific calculations to find the best way to move forward.

3.2. Case Analysis: The Practical Application of Data Analysis in Process Optimization

A food processing enterprise is facing problems such as short product shelf life, serious inventory backlog, and low production efficiency.

3.2.1. Data Collection

Collect the whole process data from raw material procurement to the sales terminal, including raw material procurement time, quality, price, production equipment operation parameters, processing time, quality inspection results, product storage environment, inventory quantity, storage time, as well as sales speed and customer feedback [9].

3.2.2. Analysis and Optimization

- In Inventory Management: Analyze the sales data of different products in different regions and seasons. For example, the sales volume of a certain refrigerated cake in southern coastal cities in the summer is three times that of other seasons. Based on this, adjust the inventory strategy, increase the inventory before summer, and reduce it in winter in these areas; the inventory turnover rate is increased by 45%.
- In Production Process: Analyze the production data and find that the defective rate of a certain production line is high in the first two hours after startup on Monday morning because the equipment needs time to reach the optimal operating state after shutdown on weekends. By optimizing the equipment startup program and preheating and debugging key equipment in advance, the defective rate on Monday morning is reduced from 5% to 1%, and the overall production efficiency is increased by 10%.

4. The Role of Statistical Methods in Supply Demand Prediction

4.1. Main Statistical Analysis Methods in the Supply Chain

4.1.1. Time Series Analysis

This method focuses on analyzing the trends and seasonal patterns presented by historical data over time to achieve accurate predictions of future market demand. It deeply mines the periodic patterns in sales data, such as the sales peaks or troughs in specific seasons every year and the long-term growth or decline trends [10].

4.1.2. Regression Analysis

Regression analysis can guess important factors in the supply chain, like cost and demand, by building a mathematical model of the relationship between independent and dependent variables.

4.1.3. Correlation Analysis

Correlation analysis aims to determine the correlation strength and direction between multiple variables. This is achieved in the supply chain by analyzing the correlations between variables such as sales data, inventory levels, and production costs.

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4.1.4. Inventory Control Models (Taking EOQ and ROP Models as Examples)

The Economic Order Quantity (EOQ) model and the Reorder Point (ROP) model are both based on the idea that inventory costs and ordering costs should be equal. These models help businesses figure out the best level of inventory and ordering strategy by giving them numbers.

4.2. Case Analysis: The Practical Application of Statistical Methods in Process Optimization

A supermarket chain is facing problems such as large differences in demand for different stores and product categories and being greatly affected by holidays and promotional activities, resulting in high difficulty in demand prediction.

For bread in food products, build a demand prediction model based on multiple regression analysis, taking the daily sales volume of bread as the dependent variable and the independent variables including the population of the store area, the average temperature of the day, whether it is a holiday, and whether there is a bread promotion activity by competitors around.

It is found that for every 5°C increase in temperature, the bread sales volume increases by 10%; the sales volume on holidays is 20% higher than that on weekdays. According to the results of the time series prediction model, adjust the bread inventory and procurement plan, reducing the bread out-of-stock rate from 8% to 3% and the inventory cost by 12%.

For air conditioners in household appliances, adopt a hybrid prediction model of Seasonal Autoregressive Integrated Moving Average (SARIMA) and machine learning. First, use the SARIMA model to look at how sales of air conditioners change with the seasons and over time. Next, put the results and other factors that affect them into the Support Vector Machine (SVM) model to make more predictions and study the topic more.

5. Challenges and Opportunities

5.1. Data Privacy and Security Issues

In supply chain data applications, data privacy and security are crucial. Enterprises handle a large amount of sensitive information, and the current centralized storage and processing of statistical analysis methods increase the risk of data leakage. For example, data sharing in multi-enterprise cooperative supply chains may lead to privacy issues.

5.2. The Challenges of Data Integration and Analysis

The supply chain data comes from a wide range of sources with different formats and qualities, and a huge amount of data makes it difficult to integrate and extract valuable information. For example, in the global procurement supply chain, the data formats and languages of suppliers in different countries and regions differ, making integration difficult.

5.3. Opportunities Brought by Technological Progress

The development of technologies such as big data, artificial intelligence, and blockchain brings opportunities for optimizing supply chain processes. Big data technology can efficiently store and process massive amounts of data and explore potential problems and optimization opportunities; artificial intelligence technology can improve the accuracy and efficiency of demand forecasting and risk assessment; blockchain technology can solve data trust and security issues, ensuring data authenticity and immutability.

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6. Conclusion

In conclusion, this study has delved deeply into the application and strategies of data analysis and statistical methods in supply chain processes and supply-demand optimization. Data analysis and statistical methods play a crucial and multifaceted role in supply chain management. They enhance supply chain visibility, optimize various links (such as supplier management and logistics), and support intelligent decision-making. By identifying bottlenecks and inefficiencies, these methods enable enterprises to allocate resources more effectively, reduce risks, and respond promptly to market changes.

Nevertheless, the application of these methods is not without challenges. The rapid development of technology, such as the wide application of IoT, brings both opportunities and difficulties.

Looking ahead, future research could focus on how to better integrate emerging technologies with data analysis and statistical methods to enhance supply chain performance. Moreover, exploring more effective ways to train and develop data analysis professionals for the supply chain industry is of great significance. By addressing these aspects, we can expect supply chain management to achieve greater levels of optimization and innovation, helping enterprises thrive in the highly competitive market environment.

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