Analysis of the Effect of Big Data on Supply Chain Optimization: A Case Study of JD Logistics' Freight and Warehousing Operations

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Abstract. In the context of the deep integration of the digital economy, supply chain management is confronted with challenges such as demand fluctuations and information asymmetry. Big data technology is emerging as the core driving force for the precise transformation of supply chains. This paper takes JD Logistics as the research object and systematically analyzes the application paths and optimization effects of big data in the e-commerce supply chain. The research starts from the characteristics of supply chain big data, summarizes the development process and technical architecture of JD Logistics, and focuses on the specific practices of big data in inventory management, intelligent warehousing operations, and delivery optimization. Through a combination of case analysis and literature research, it demonstrates the significant role of big data technology in reducing JD's warehousing costs and improving delivery efficiency, with a single delivery cost decreasing by 8.5%, unit warehousing cost decreasing by 12%, and order fulfillment rate increasing to 97%. The study shows that the supply chain management driven by big data achieves the unity of cost reduction, efficiency improvement, and service quality enhancement, providing a feasible practical path for the digital transformation of e-commerce logistics enterprises.

Keywords: Big data; Supply chain optimization; JD Logistics; Warehouse management; Inventory optimization.

1. Introduction

In the era of deep integration of the digital economy in 2026, the global supply chain is undergoing unprecedented complexity and dynamic changes. Affected by factors such as geopolitical fluctuations, frequent emergencies, and individualized consumer demands, the uncertainty of the supply chain has significantly increased. The traditional supply chain management model relies on historical experience and static rules, often having the problem of information asymmetry, resulting in demand forecasting errors, excessive inventory accumulation and shortage risks coexisting, and being unable to adapt to the rapidly changing market environment. Against this backdrop, new-generation information technologies represented by big data and artificial intelligence are reconfiguring the operational logic of the supply chain from the bottom layer.

The comprehensive application of big data technology is fundamentally addressing these pain points. By collecting, integrating and analyzing massive multi-dimensional data, enterprises can make data-driven, precise decisions in areas such as demand forecasting, inventory management, route optimization and risk assessment, promoting the evolution of supply chain management towards more precise, refined and shared directions [1]. For e-commerce logistics enterprises that prioritize speed and efficiency as their core competitiveness, relying on big data technology to systematically restructure traditional processes is not only a technological upgrade but also a strategic choice for enterprises to enhance response speed, reduce operating costs and strengthen supply chain resilience [2]. The e-commerce logistics industry has entered a new competitive stage of "warehouse and distribution integration and technology-driven", and data elements are becoming the core assets of enterprises.

The academic community has made certain progress in the interdisciplinary research on big data and supply chain management. Jiang Qiping systematically reviewed the logic and transformation path of the modernization of JD's supply chain and pointed out the crucial driving role of data

elements in the reconfiguration of the supply chain [3]. Jiang Pengcheng analyzed the optimization path of supply chain management under the big data environment from the perspective of smart logistics, emphasizing the application value of deep learning models such as LSTM in demand forecasting [4]. Wu using JD as an example, explored the specific practices of big data in procurement, warehousing, and distribution from the perspective of cost control [5]. However, most of the existing studies have conducted analyses from a single dimension and lack a systematic demonstration of the causal relationship between the application of big data at the enterprise level and the optimization effect of the supply chain. In particular, the optimization mechanism of the core node of the supply chain, namely the warehousing process, has been insufficiently explored. While big data improves efficiency and thereby increases enterprise profits, it is necessary to ask: After actually applying big data to the enterprise supply chain, what are the specific optimization mechanisms and paths?

This paper takes JD Logistics as the case study object, aiming to systematically analyze the application status and optimization effect of big data technology in supply chain management, with a focus on three dimensions: inventory management in the warehousing link, intelligent operations, and key technologies. The research integrates JD's publicly available operational data and existing academic achievements, striving to reveal the internal mechanism of how big data drives supply chain optimization, and providing theoretical references and practical lessons for the digital transformation of e-commerce logistics enterprises.

2. Characteristics of Supply Chain Big Data

Firstly, taking JD as an example, JD not only possesses a large amount of customer transaction data, but also acquires information such as the total warehouse capacity, delivery locations, user information, and even credit information related to JD Finance.

At the same time, this series of data information was aggregated and formed a diverse and comprehensive large database. Then, the customers' locations and the merchants' inventories were also included in this information and applied to the actual supply chain of JD. This can help JD save time and costs in the process of planning freight and delivery and other distribution operations, and in terms of inventory, it can also help JD make timely responses in inventory management. In summary, in the process of optimizing and adjusting the supply chain of JD, big data provides a large amount of information and efficiently saves costs.

Secondly, this big data is updated in real time. On the JD deliveryman APP and the real-time monitoring system of the warehouse, JD integrates the obtained freight route data and warehouse monitoring data in real time. Therefore, the latest data is beneficial for planning delivery routes and adjusting inventory capacity. The method by which JD obtains the optimal routes and inventory plans is to categorize the data and reanalyze these data. In addition, JD will adjust the big data model in response to real-time dynamic changes in the data. For example, the demand for various products will significantly increase during e-commerce activities. To meet the demands of different market situations, JD will analyze the data situation in real time and optimize it and then adjust the resource allocation mode.

Overall, this data can provide a strong guarantee for the supply chain operation of JD. Besides being applied in logistics transportation routes and warehouse monitoring, JD can also use big data to profile and predict customers, simulate the direction of users' demands, and thus pre-position the goods needed by target users in the nearest warehouse. This approach not only saves time and costs on logistics but also helps optimize the management of warehouse inventory. For example, JD has established "Asia One" intelligent warehouses and regional distribution centers in various regions as its storage facilities.

3. Current Situation of JD Logistics System and Big Data Application

3.1. The Development History and Scale of JD Logistics

JD Logistics was established in 2007. Initially, it was the internal logistics department of JD Mall, responsible for the warehousing and delivery services of its own products.

After years of development, JD Logistics has become the leading comprehensive logistics service provider in the country. In 2021, JD Logistics was listed on the Hong Kong Stock Exchange. By the end of 2024, JD Logistics had over 3,600 warehouses, with a total storage area of over 32 million square meters, and more than 190,000 delivery personnel. Its services are available in all regions across the country. In 2024, JD Logistics' annual revenue reached 1.1588 trillion yuan, and in the first quarter of 2025, its revenue was 301.1 billion yuan, with a year-on-year growth of 15.8%. The reason why JD Logistics can develop rapidly and sustainably over the long term is that it has continuously invested in big data and intelligent technologies and has successfully transformed from "enterprise logistics" to "logistics enterprise".

3.2. JD Logistics Technology Framework

JD Logistics takes the big data platform as its core and has established a complete technical chain from data collection to data storage, data analysis, and finally to intelligent decision-making [6]. In terms of data collection, JD collects order information, warehouse status, delivery trajectories, and user behavior data in real time through terminal devices such as delivery personnel apps, warehouse sensors, RFID tags, and GIS geographic positioning systems. The daily processed data volume reaches the petabyte level. In terms of data storage and computing, JD relies on its independently developed distributed storage system and cloud computing platform to achieve efficient management and rapid retrieval of massive heterogeneous data. In terms of intelligent decision-making, JD applies various core algorithms, including LSTM demand prediction models, dynamic path optimization algorithms, AGV intelligent scheduling systems, and C2M consumer-to-manufacturing direct connection platforms, to provide real-time decision support for all links of the supply chain [7]. This complete data technology model supports the efficient operation of JD Logistics.

3.3. JD's Warehousing Model

JD's warehousing system adopts a three-level network architecture of "Regional Distribution Center (RDC) - Front-End Distribution Center (FDC) - End-Point Distribution Station". Among them, super-large intelligent warehousing centers represented by "Asia One" are equipped with automated sorting systems, AGV (Automated Guided Vehicle) handling robots and intelligent stackers.

JD can handle millions of orders every day. Using provincial capital cities as regional distribution logistics hub centers, they are responsible for the distribution and adjustment of goods within their respective regions. For the front-end warehouses, they are deeply located in urban communities and county-level markets. Based on big data demand predictions, they prepare goods in advance and allocate them to the storage nodes closest to consumers, thereby significantly shortening the delivery time [8]. This three-level storage network is deeply integrated with the big data demand prediction model, achieving industry-leading levels. The significant achievement is that over 90% of orders are delivered within 24 hours [3], providing a solid hardware guarantee for JD's end delivery timeliness and user experience.

4. Analysis of the Optimization Effect of Big Data on the Warehousing Process of JD

4.1. Inventory Management Optimization

Through big data analysis, JD's inventory management approach has shifted from being "experience-driven" to "data-driven". Traditional inventory management relied on manual

experience to formulate replenishment plans, often resulting in structural contradictions such as overstocking of unsold goods and shortages of popular goods. JD adopted the LSTM neural network model and combined multi-dimensional data such as users' historical purchase behaviors, browsing records, and delivery addresses to accurately predict future commodity demands in different regions, thereby pre-storing goods at the nearest warehouse nodes to users [9]. This "on-demand storage" proactive replenishment model significantly reduced inventory holding costs, reducing JD's inventory turnover days to 14 days, which is much lower than the average 30 to 45 days cycle of traditional retail enterprises [4]. At the same time, JD established a dynamic replenishment mechanism based on real-time sales data, such as when the inventory of a certain SKU in a warehouse falls below the safety threshold, the system will automatically generate replenishment instructions to ensure that high-traffic goods are prioritized for shipment and to supplement the shortage of goods in advance through closed-loop management. Moreover, JD established a supplier evaluation index system during the procurement process, using data to evaluate supplier quality, selecting suppliers with lower prices while maintaining the same quality, and formulating procurement plans based on historical sales data and market trends, thereby reducing inventory costs in the upstream of the supply chain [5].

4.2. Intelligent Warehouse Operation Optimization

JD has significantly enhanced the operational efficiency of warehouse storage through the deep integration of big data and automated equipment. In the case of the "Asia One" intelligent warehouse, JD adjusted the AGV robot scheduling system based on operational research algorithms. By solving large-scale integer programming problems in real time, it optimized the transportation routes and task allocation of the robots, significantly improving the turnover efficiency of goods in the warehouse [8]. Moreover, JD plans out different outbound tasks based on the spatial and temporal distribution characteristics of warehouse orders. After integrating orders with the same or similar destinations, the relevant operators can reduce the distance of their activities and avoid the same and repetitive labor when inspecting the goods. In the logistics distribution process, JD combines over 1 billion merchant address data, geographic information system (GIS) positioning system, and real-time traffic data to calculate the optimal delivery route, thereby reducing the single-item delivery cost [5]. The data shows that in the operation of the Asia One warehouse, the single-item delivery cost decreased by 8.5%, and the unit warehouse cost decreased by 12% [6]. In terms of order fulfillment efficiency, the average fulfillment cycle was shortened from 5.8 days to 3.9 days, the fulfillment efficiency increased by approximately 32.8%, and the order fulfillment rate was raised to 97% [4]. These data demonstrate the significant optimization of operational efficiency in various aspects of warehouse operations through big data technology.

4.3. Key Technologies of Warehouse Big Data Analysis

The key technologies for big data analysis in JD's warehousing mainly include the following three aspects.

Firstly, the demand prediction model based on LSTM (Long Short-Term Memory Network). This model can capture the time series characteristics of user consumption behavior, combine seasonal factors and promotional activity variables, and conduct rolling predictions of regional demand for the next 7 to 30 days.

The prediction accuracy can reach over 90% [9]. By deeply integrating the prediction results with the Warehouse Management System (WMS), JD has achieved an automated closed loop of "prediction to stocking to allocation to replenishment". Secondly, the intelligent path planning system is based on GIS and real-time traffic data. This system integrates massive address data and real-time traffic information and can calculate the optimal delivery path from the warehouse to the user within seconds. It comprehensively considers multiple factors such as distance, traffic congestion, and weather, providing efficient decision support for end delivery. Thirdly, the user profiling system is based on machine learning. By analyzing users' search, browsing, collection, and purchase history, a

multi-dimensional user tag system is constructed, providing a decision-making basis for precise marketing and pre-stocking in the warehouse, thereby improving customer conversion rate while reducing ineffective inventory [10].

5. The Comprehensive Effectiveness of Big Data Applications

After applying big data in areas such as transportation, warehousing, and demand estimation for goods, JD has achieved significant optimization in terms of both time and financial investment. The most direct result is the rapid growth of the company's profits. After the deep application of big data technology, JD's annual revenue in 2024 was 1.1588 trillion yuan, and in the first quarter of 2025, it reached 301.1 billion yuan, with a year-on-year growth of 15.8% [3]. In terms of cost control, by monitoring warehouse data in real time, prioritizing the dispatch of goods with high liquidity and making advance replenishments when there is a shortage, the single-item delivery cost in the Asia One warehousing case decreased by 8.5%, and the unit warehousing cost decreased by 12%.

Using the LSTM model to simulate user profiles in advance and prepare goods, combined with geographical data to calculate the optimal path, the inventory turnover days only require 14 days [4].

At the infrastructure level, JD's total warehouse area exceeds 32 million square meters, and the total number of warehouses is over 3,600 [3]. This provides a solid storage guarantee for the supply of goods. The number of JD delivery personnel exceeds 190,000 [5], supporting a vast end-to-end transportation network. In addition, JD holds over 1 billion merchant address data [5], and the delivery timeliness has achieved that more than 90% of orders are delivered within 24 hours [3]. Data and manpower are important manifestations of JD's hardware capabilities. The combination of the two has deeply optimized the entire delivery process, significantly improving the delivery time and accuracy.

From the perspective of the effectiveness of market expansion, with the support of user and merchant address data, JD can find the nearest merchants for county-level users, shorten the transportation time, and better serve the lower-tier market. The orders in county areas of JD have increased by 130% year-on-year.

By analyzing the address data to find better routes and shorten delivery time, JD successfully entered the food delivery market, and the number of food delivery orders exceeded 25 million. Using the LSTM model to simulate user profiles and prepare goods in advance for promotion and serving new users, JD achieved double-digit growth in active user numbers for six consecutive quarters [3]. These achievements further demonstrate that the application of big data in the supply chain not only optimizes JD's investment in supply chain costs, but also continuously improves JD's profits, market share, and supply efficiency [11].

6. Conclusion

This article takes JD Logistics as an example and systematically analyzes the current application status and optimization effect of big data technology in supply chain management. The research shows that JD has achieved data-driven precise decision-making in inventory management, intelligent warehousing operations, and distribution route optimization through building a technical architecture centered on the big data platform. Specifically, demand forecasting based on the LSTM model has shortened the inventory turnover days to 14 days. The Asia One intelligent warehouse has achieved a cost optimization of 8.5% in single-piece delivery costs and 12% in unit storage costs, and over 90% of orders have been delivered within 24 hours. In addition, the user profiling system empowered by big data has supported JD's new business expansion in county-level markets and the food delivery sector. The core of the above optimization effects lies in the data elements breaking down the information barriers among all links of the supply chain, achieving dynamic matching between the demand side and the supply side, and thereby achieving coordinated optimization of cost reduction and efficiency improvement as well as service quality enhancement.

This study also has certain limitations. Firstly, the research is mainly based on a single case of JD, and the generalizability of the conclusions needs to be verified through comparative studies involving multiple enterprises. Secondly, due to the limitation of data availability, some optimization effect indicators are derived from public data of enterprises and secondary literature, lacking the support of first-hand empirical data. Future research can further expand in the following directions: Firstly, extend the research perspective to the ecological sustainability dimension of the supply chain, exploring the application potential of big data in carbon emission monitoring, green packaging optimization, and reverse logistics management; Secondly, pay attention to the integration application of emerging technologies such as generative artificial intelligence and digital twins in supply chain simulation and emergency management; Thirdly, through simulating the real supply chain network in e-commerce promotion activities, real-time simulate the impact of logistics and funds, providing forward-looking decision support for supply chain risk management, and constructing a more resilient and sustainable intelligent supply chain system.

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