Proceedings of Business and Economic Studies, 2025, Volume 8, Issue 7
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Inventory Research on Dual-Channel Supply Chains under Consumer Channel Preferences

Furui Deng[1]*, **Weizhe Shu**[2]

[1]The Party Work Department (Human Resources) of Sichuan Shudao Smart Transportation Group Co., LTD., Chengdu 610000, Sichuan, China
[2]School of Management, Xihua University, Chengdu 610000, Sichuan, China

Author to whom correspondence should be addressed.

Abstract: To meet the diverse consumption needs of modern consumers, many e-commerce companies choose to establish a dual-channel operation system, combining online and offline methods to achieve multi-dimensional market coverage and integration of channel resources. Consumers' channel preferences when shopping will directly affect the company's investment cost in channels, and further influence the final retail price and wholesale price. This article interviews relevant practitioners and consumers in the form of questionnaires to collect relevant data such as the acceptance of offline channels, channel prices, delivery times, and channel service levels. Taking Product A of Company L as an example, a combination of mathematical models and Matlab simulation is adopted, with the goal of maximizing dual-channel revenue. Under actual constraints such as fluctuations in market demand and channel conflicts, To obtain the linear relationship between influencing factors such as travel costs and delivery timeliness and the company's ordering decisions and financial performance when consumers' channel preferences change, thereby providing a quantitative decision-making basis for the company to solve the current inventory overstock problem by transforming the ordering strategy and adjusting the order quantity.

Keywords: Dual-channel operation system; Order quantity; Consumers' preference; Consumer utility

Online publication: December 15, 2025

1. Introduction

With the development and application of the Internet and information technology, the traditional retail model has also changed. According to the latest industry white paper of the China Chain Store & Franchise Association, as of the third quarter of 2023, 85% of large-scale retail companies have completed the integrated layout of online and offline. Many retail companies, while maintaining traditional physical retail, have organically integrated e-commerce platforms with physical networks by establishing dynamic inventory sharing mechanisms, member data intercommunication systems, and intelligent replenishment algorithms, thus building an O2O distribution system that combines online and offline operations [1]. This composite logistics structure, on the one hand, has expanded the company's market reach and improved the overall sales efficiency; on the other hand, it has also brought about some new business problems. The first difficulty lies in how to establish a linkage relationship between the dual-channel inventory systems, that is, fluctuations in online inventory will affect the sales volume of physical stores, and the inventory status of physical channels will in turn affect online sales.

In terms of operational structure, the dual-channel supply chain presents a complex sales network system, with the main feature being the dual attributes of the channel entities. From the perspective of channel integration, there are two typical models: One is the decentralized dual-channel supply chain mainly based on retail, that is, the retail company operates both the offline physical nodes and the online digital platforms, thereby establishing an independent channel system [2]. Another type is the centralized dual-channel supply chain controlled by manufacturers, that is, manufacturers, on the basis of dominating the original retail channels, further expand the market by building their own digital sales channels [3]. In recent years, channel alienation has sparked continuous academic discussions in operation management, especially in the resolution of channel conflicts and collaborative optimization, which has become a research hotspot [4].

Although Company L expanded its dual-channel platform sales network in the early stage, it was found in the actual operation that the independent operation of the inventory systems of the two major channels led to a significant inventory overstock problem. The company is currently in a stage of scale expansion. It is optimizing the current inventory management model, adjusting the existing ordering strategy, and addressing the inventory backlog issue in the dual-channel supply chain to keep the overall warehousing cost within a reasonable range for revenue growth. Therefore, how to implement effective inventory management for the two channels, meet the demands of different channels, solve the inventory backlog problem, and maintain a reasonable inventory level It is an urgent problem that Company L needs to solve. Therefore, this study focuses on the operational practice of Company L, based on the company's goals of sustainable development and efficiency improvement. It constructs an inventory optimization model that integrates consumers' channel preferences for its dual-channel supply chain system, analyzes its optimal order quantity and expected profit, and proposes corresponding ordering strategies.

In addition, due to the uncertainty of consumer demand, the inventory control mechanism of the dual-channel supply system has also been greatly restricted. When consumers go shopping, they are subject to the interaction of various factors such as the price system, service level and out-of-stock status. When there is a supply gap in a certain channel, it may trigger cross-channel flow of consumers. Moreover, the chain response of demand transmission not only intensifies the complexity of sales forecasting but also makes it difficult for companies to respond promptly due to the distortion of consumer demand information, thereby greatly increasing the difficulty of dynamic supply chain regulation and causing inventory overstock. For this reason, this paper takes the dual-channel supply chain as the background, introduces consumers' channel preferences, studies the dual-channel inventory management methods, and expects to reduce inventory overstock and increase sales profits.

2. The construction of channel preference functions and inventory management models

This paper starts from the traditional newsboy model and establishes a dual-channel inventory management model under consumer channel preferences. Considering that in actual situations, companies usually place orders only after the wholesale and retail prices have been determined, this project focuses on studying how to solve the ordering decision-making problem [5]. Based on the classic newsboy model, the expected return function is constructed, and on the basis of this model, a comparative study of the decentralized inventory management model channel and the centralized inventory management model is conducted. By using the method of numerical experiments, the influence of consumer preferences on the ordering decisions and expected returns of the two types of channels is studied.

2.1. Construction of the consumer utility and channel preference functions

In the process of constructing the consumer utility function, the main focus is on the influence of price factors on consumers' channel preferences. The basic utility function expression was established as shown in Equation (1), incorporate the three new considerations of service level, consumers' travel cost, and consumers' acceptance of the channel into the expression, and expand the above basic consumer utility function expression. At this point, for consumers in online channels, the utility function is as shown in Equation (2).

$$\alpha_m = \theta^* + (1-\theta^*)(1-\theta) = 1 - \frac{(\lambda S - P - Y)\theta}{V} \quad (1)$$

$$\alpha_r = (1-\theta^*)\theta = \frac{(\lambda S - P - Y)\theta}{V} \quad (2)$$

The acceptance of offline channels by consumers, which can be directly measured through surveys or behavioral data, is transformed into a consumer preference function used to quantify the two channels. Next, based on consumers' preferences for channels, study the revenue change patterns of the two types of supply chain inventory management models under the influence of various factors, thereby finding ways to optimize inventory management.

2.2. Development of the decentralized dual-channel inventory management model

Under the framework of decentralized inventory management, Company L and its various levels of distributors each maintain an inventory system with autonomous decision-making units to meet the differentiated service demands of consumers through different channels. These two channels are relatively independent in operation, pursuing the maximization of their own interests, and respectively bear the losses caused by stockout due to insufficient inventory. Based on the analysis of revenue and cost, the profit expressions of Company L and its distributors were respectively constructed to further analyze their profit maximization strategies. Based on Equation (3) and (4), it is concluded that under this inventory management model, product prices, delivery times, service levels, and consumer channel preferences will affect the optimal order quantities of Company L and its distributors.

$$Q^*_m = \alpha_m \left[F^{-1} \left(\frac{p_m - \frac{j_m}{2t^2} + b_m - c - f_m}{p_m - \frac{j_m}{2t^2} - s} \right) \right] - \omega t \quad (3)$$

$$Q^*_r = \alpha_r \left[F^{-1} \left(\frac{p_r + b_r - w - f_r}{p_r + b_r - s} \right) \right] + \beta t \quad (4)$$

2.3. Sensitivity analysis of optimal order quantities under channel preference parameters

Therefore, it can be known from Equation (5) that the optimal order quantity of the distributor is directly proportional to the preference of consumers for offline channels. According to Equation (4), is positively correlated with the acceptance degree θ of offline channels and the difference S of service levels. Therefore, it can be concluded that when the acceptance degree θ of offline channels and the difference S of service levels increase, The optimal order quantity will also increase accordingly. Similarly, is negatively correlated with the travel cost Y. Thus, it can be concluded that the optimal order quantity decreases as the travel cost Y increases.

$$\frac{\partial Q_m^*}{\partial \alpha_m} = \left[H^{-1} \left(\frac{\left(p_m - \left(\frac{j_m}{2t^2}\right) + b_m - c - f_m\right)}{\left(p_m - \left(\frac{j_m}{2t^2}\right) + b_m - s\right)} \right) \right] > 0 \quad (5)$$

3. Examples and analysis of results

Before conducting a sensitivity analysis, it is necessary to obtain parameters such as consumers' acceptance of offline channels, travel costs, and service levels. This article adopts the method of questionnaire survey to depict the consumer image and assigns values to the relevant product data in combination with the sales information of Company L. Based on the actual operation of Company L, a questionnaire was designed according to five dimensions: product features, social environment, personal characteristics of consumers, merchant services and sales channels.

This questionnaire aims to gain a comprehensive and in-depth understanding of the various factors that consumers consider when making purchase preferences. For the specific content of the questionnaire, please refer to the appendix section. The main subjects of the questionnaire survey are over two hundred people, including ordinary consumers, store staff, warehouse workers, and managers, covering ages ranging from 20 to 50 and having degrees from junior college to postgraduate. Data was collected through offline paper questionnaires and online. A total of 378 questionnaires were distributed. After eliminating invalid questionnaires and organizing the data, 354 valid questionnaires were obtained, with an effective rate of 93.7%, providing a solid foundation for subsequent statistical analysis. Enter the data into SPSS27 to proceed with the next step of research.

3.1. Data collection and consumer parameter estimation

Prior to conducting principal component analysis, it is necessary to strictly verify whether the statistical characteristics of the data structure conform to the normative assumptions of the methodology to ensure that the prerequisite conditions for principal component analysis can be met. The reliability and validity of the questionnaire data were analyzed using SPSS27, and the KMO test value and Bartlett sphericity test value were obtained, which were 0.818 respectively. Both Bartlett sphericity test values were less than 0.01, and the Cronbach coefficient was 0.838, indicating good validity and reliability, and the factor analysis could be conducted.

Through the statistics of the questionnaire survey, the consumer image covered by Company L is depicted. 45.9% of consumers tend to make purchases through online channels, while 54.1% prefer to do so through offline channels, covering all age groups. The expected travel cost is 14 Chinese Yuan. The expected price difference of the product is 40 Chinese Yuan. The expected delivery time is 4. Further analysis determined that the delivery time assignment range was from 0 to 10 days, the travel cost assignment range accepted by consumers was from 0 to 50 Chinese Yuan, and the service level parameters and delivery timeliness sensitivity coefficient were assigned values $\lambda = 12$, $\omega = 13$, and $\beta = 10$ respectively.

3.2. Product selection and market characterization

The footwear and apparel industry, as a highly market-oriented consumer goods sector, features comprehensive clothing brands covering all age groups, and its market structure shows significant age group segmentation characteristics. The stratified sampling method was adopted to fit the consumption distribution of all product categories. It was found that the demands of all age groups presented a normal distribution characteristic.

Based on the model's demand classification criteria, the "urban commuting" themed sports shoe was selected as the representative sample for analysis. This product accounts for 12.7% of Company L's annual sales, and its sales data span both online channels, including the official website and major e-commerce platforms, and offline department store counters, thereby capturing the operational characteristics of the dual-channel system. As a highly popular item, Product A demonstrates broad consumer appeal across age groups. Inventory-related parameters were assigned using internal company documents, contractual information, and averaged settlement records. The distribution time-cost parameter was derived by jointly considering per-unit distribution expenses and delivery duration. A visualization of key statistical indicators is provided in **Figure 1**.

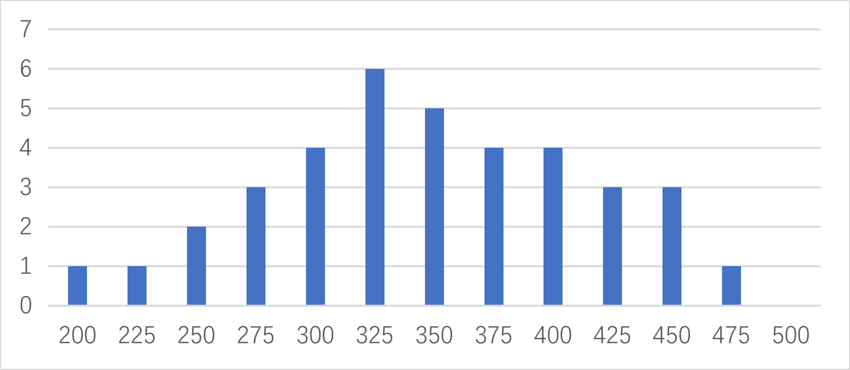

Figure 1. Histogram of sales data.

3.3. Sensitivity analysis of consumer channel preferences

After taking into account the influences of price, service and other aspects, the value V that consumers are willing to pay for this purchase will be set as 280. Among them, the service level of the product is an important part of the consumer experience. According to the relevant analysis, the online service level S_m is taken as 20 and the offline service level Sr as 40. On this basis, a mathematical model was established with the consumer's travel cost Y being 10 Chinese Yuan. The service level parameters and the sensitivity coefficient of delivery timeliness were λ = 12, ω = 13 and β = 10, respectively. The ratio of offline channel preference relationship $\alpha_m = 23\theta/60$, and the ratio of online channel preference $\alpha_r = 1\text{-}23\theta/60$. Set θ at 0.01 and take the variation from 0 to 1 to investigate its impact on the optimal order quantity and the total revenue of the dual-channel supply chain.

When comparing the two different inventory management models, decentralized and centralized, it can be found that when the value of θ is between 0 and 0.4, the profit of the decentralized management model is higher than that of the centralized one. When the value of θ exceeds 0.4 and approaches 1, the profit of the centralized management model begins to surpass that of the decentralized one. The results show that when consumers are increasingly inclined to use traditional offline sales methods, adopting a centralized control approach can better enhance overall profits.

By comparing the sales data of 2022 and 2023, it can be concluded that after applying the centralized inventory management model, the remaining inventory quantity of each SKU of product A has significantly decreased, and the inventory backlog has dropped by 22.18% to 58.25%. The company's profit indicators achieved a gradient growth ranging from 6.64% to 32.25%. The sales data fully demonstrate that under the centralized dual-channel supply chain inventory management model, the overall profit of L Company's dual-channel supply chain has improved compared to the previous management model. As consumers' acceptance of offline channels gradually increases, adopting a centralized and coordinated inventory management approach can not only optimize the turnover efficiency of SKUs, shorten the processing cycle of slow-moving items, and reduce inventory overstock, but also fully tap the commercial value of the physical retail network and enhance the profit margin of the entire business.

4. Conclusion

Based on the operational realities of Company L and the inventory overstock challenges it currently faces, this study undertakes a comprehensive examination of its decentralized dual-channel inventory management model. Using historical operational data, the research analyzes the firm's supply chain inventory system from three key perspectives: demand uncertainty driven by consumer channel preferences, inaccuracies in sales forecasting, and the limitations inherent in decentralized decision-making. Furthermore, the study evaluates how consumer channel preferences influence optimal order quantities and expected profits while explicitly incorporating delivery time into the decision model. A comparative analysis of the expected returns of decentralized and centralized models allows for the identification of a more effective inventory management strategy for Company L. Ultimately, the company implemented a centralized inventory management model and, informed by the sensitivity analysis results, selected Product A for pilot deployment, achieving demonstrable improvements in inventory performance.

Disclosure statement

The author declares no conflict of interest.

References

[1] Wang J, Zheng Y, Xu Q, et al., 2020, Controllability Analysis and Optimal Control of Mixed Traffic Flow with Human-driven and Autonomous Vehicles. IEEE Transactions on Intelligent Transportation Systems, 22(12): 7445–7459.

[2] Zhou P, Zhang Y, Akyol S, 2023, A Novel Consumer Preference Model Based on Blockchain and Topic Similarity Clustering in Cross-Border E-Commerce. Journal of Organizational and End User Computing, 35(1): 1–14.

[3] Ma Y, Han H, Zhang M, 2025, Research on Supply Chain Emission Reduction with Blockchain Technology under Production Uncertainty. Procedia Computer Science, 266: 423–430.

[4] Liu A, Yang Y, Miao J, et al., 2023, Pricing Research for Automotive Supply Chains Considering Low-Carbon Consumer Preferences under a Dual Policy. Kybernetes: The International Journal of Systems & Cybernetics, 2023(6): 52.

[5] Zhang H, Lou Z, Yan Y, et al., 2024, Supplier Encroachment and Quality Disclosure Strategy in an E-supply Chain with Blockchain Technology. Journal of Systems Science and Systems Engineering, 33(6): 682–715.