Frontiers in Business, Economics and Management
ISSN: 2766-824X | Vol. 24, No. 2, 2026

Optimization Methods for Fresh-Cut Flower Retail Inventory Management

Liuyue Xie

School of Economics and Management, Southwest Petroleum University, Chengdu, China

Abstract: As a special category of fresh produce, fresh-cut flowers are characterized by high perishability, short shelf life, pronounced seasonality, and volatile market demand, making traditional inventory management methods inadequate for addressing the stochastic nature of floral sales. This study examines the current practices of inventory management in the cut-flower retail sector and identifies critical challenges, including excessive product deterioration, high holding costs, and inaccurate demand forecasting. Adopting the newsvendor model as the core analytical framework and incorporating realistic operational scenarios, this paper develops a demand modeling approach aimed at reducing inventory loss and operating costs while enhancing management efficiency and market competitiveness. The findings offer actionable managerial insights for fresh-cut flower retailers.

Keywords: Cut-flower retail; Inventory management; Inventory cost control; Demand forecasting; Optimization method.

1. Introduction

Flowers, as commodities carrying aesthetic, emotional, and cultural value, have witnessed sustained growth in market demand driven by consumption upgrading and increasing emphasis on spiritual well-being. Whether used for home decoration, festive gifting, corporate events, or wedding arrangements, flowers have become indispensable. Floral retail is shifting from a purely ceremonial purchase to a daily consumption behavior, serving as a medium for emotional expression and lifestyle enhancement. Growing consumer attention to the therapeutic and symbolic value of flowers continues to stimulate demand and propel rapid development in the floral retail sector. However, the biological properties of flowers and their highly dynamic market environment make inventory management a key bottleneck. From a product perspective, flowers are typical short-life-cycle products. Post-harvest shelf life is limited, and storage conditions—temperature, humidity, light—are strictly constrained. Once the freshness window elapses, commodity value decays sharply and may drop to zero, resulting in substantial obsolescence costs. From a demand perspective, floral consumption is influenced by seasonality, holidays, weather, and fashion trends, leading to significant uncertainty. Demand surges during peak periods such as Valentine's Day and Mother's Day, while remaining relatively stable in ordinary periods. Emerging flower varieties can also rapidly replace traditional ones, causing abrupt shifts in demand structure. In this context, floral retailers face acute inventory decision dilemmas. Traditional management relies heavily on empirical judgment and single-dimensional cost control, lacking scientific quantitative tools capable of balancing perishability and demand volatility. Ineffective inventory decisions not only compromise product quality but also damage customer experience and satisfaction, ultimately eroding profitability and competitive advantage. Therefore, introducing rigorous inventory optimization models to address the conflict between demand uncertainty and product perishability holds considerable practical significance.

2. Major Inventory Management Challenges in Fresh-Cut Flower Retail

2.1. Excessive Product Deterioration

Floral products are inherently perishable, and their physical characteristics make them extremely sensitive to environmental fluctuations during storage and transportation. Unlike manufactured or durable goods, inventory loss in floriculture does not merely represent quantity reduction; rather, it reflects continuous value depreciation over time. Freshness directly determines commercial value, which declines progressively from the moment of harvest. Minor deviations in temperature or humidity can accelerate wilting and decay. Under improper storage conditions, the ornamental and market value of roses, for example, may drop by more than 50% within just a few days, manifesting as petal drooping and leaf yellowing.

2.2. High Inventory Holding Costs

To slow down the deterioration of fresh-cut flowers, retailers must commit substantial resources to preservation-related expenditures. These include cold-chain logistics, climate-controlled storage facilities, continuous application of preservative treatments, and intensive daily maintenance labor. Such measures directly elevate the unit holding cost. Due to their intrinsic perishability and time-sensitive value, inventory management in floral retail must prioritize rapid stock turnover, strictly limiting the duration of inventory on hand to avoid accumulation-induced spoilage. However, this creates a structural dilemma. On the one hand, cutting preservation investment to contain costs triggers a sharp rise in deterioration rates, leading to significant value erosion. On the other hand, maintaining stringent freshness-preserving protocols inevitably drives up operating expenses, further squeezing already narrow profit margins. Therefore, the optimization objective is not to maximize freshness at any cost, nor to minimize expenditure by compromising quality. Instead, an optimal economic balance must be struck between preservation effort and inventory risk—determining the precise level of care that justifies the residual value of the product.

2.3. Forecast Errors Induced by Demand Volatility

Floral demand is inherently unstable, shaped by the sentimental and occasion-driven character of consumption. It exhibits simultaneous seasonal cycles, holiday peaks, and stochastic noise. Accurate demand sensing is therefore central to inventory control, yet current practice among Chinese florists remains largely informal. Ordering decisions are typically guided by rough extrapolations of past sales and subjective judgment, which fail to systematically incorporate drivers such as temperature shifts, festival calendars, and changing tastes. The limitations are evident. Spring weddings and home-decorating impulses lift sales well above winter baselines; Valentine's Day alone can trigger a multi-fold surge in rose demand within a single day. Such discontinuities expose the inadequacy of static rules. Because both predictable seasonality and unpredictable shocks coexist, traditional rule-of-thumb forecasting cannot prevent either costly overstocking or revenue-losing shortages. This inability to translate uncertain demand into reliable order quantities represents a fundamental bottleneck to sustainable margins.

To cope with these compounded uncertainties, this paper adopts the newsvendor formulation, wherein demand is treated as a random variable with a known distribution, and the optimal order quantity trades off overstocking and understocking penalties.

3. Optimization Model and Solution Approach for Floral Retail Inventory

3.1. Theoretical Foundation of the Newsvendor Model

Inventory theory has remained a central research stream in operations research and management science since its inception. Far from being obsolete, the field continues to evolve, absorbing stochastic optimization, behavioral factors, and data-driven extensions, and has developed into a theoretical system with rich connotation and broad applicability. Within this corpus, the newsvendor model stands out as a canonical framework for single-period inventory control under demand uncertainty. Fresh-cut flowers are intrinsically short-life products—effectively single-cycle commodities—whose demand is randomly shaped by weather, promotions, and emotional consumption occasions. These features align closely with the newsvendor assumptions. For retailers without cold-chain capacity, the model offers a transparent mechanism to compute the order quantity that balances the risk of over-ordering (spoilage) against under-ordering (lost sales). In perishable categories, this trade-off is especially valuable. For instance, roses with a narrow vase life can be ordered near their critical-fractile optimum, directly reducing deadstock loss while preserving service level.

The core assumptions of the newsvendor model are as follows:

(1) The product is a short-life-cycle good. Sales occur within a single selling period, and any inventory left unsold at the end of the period has zero or negligible salvage value.

(2) Demand is a random variable with a known probability distribution.

(3) The order quantity Qis the decision variable, placed once before the selling period begins, and no replenishment is allowed during the cycle.

(4) The cost structure consists of procurement cost, holding (preservation) cost, and shortage cost. The retailer aims to determine the optimal order quantity that either minimizes the expected total cost or, equivalently, maximizes the expected total profit.

3.2. Model Formulation

The notations used in this model and their definitions are listed in Table 1.

Table 1. Description of model parameters

Symbol	Description
D	Daily stochastic demand for the product (e.g., roses: average 50 stems/day, fluctuating between 30 and 70 stems)
Q	Planned order quantity of the retailer (decision variable), determined before the start of each selling period
c_o	Unit overstocking cost, c: procurement cost, s: salvage value (discount sale, donation, or discard)
c_u	Unit understocking cost, p: selling price, c: procurement cost, k: goodwill loss / customer attrition cost due to stockout.
$f(x)$	Probability density function of demand
F(Q*)	Optimal service level, i.e., Pr(D≤Q∗); the critical fractile that balances understocking and overstocking costs.
Q*	Optimal order quantity, where μand σare the mean and standard deviation of daily demand, and Z is the standard normal quantile corresponding to the optimal service level F(Q∗).

3.2.1. Cost Function for Floral Ordering

The newsvendor model begins by constructing a cost function in terms of the random demand Dand the decision variable Q (order quantity), so as to capture the perishability of fresh-cut flower retail. In this formulation, max (Q−D, 0) denotes the unsold quantity at the end of the selling period, while max (D−Q, 0) denotes the unmet demand due to stockout:

$$c_u = (p - c) + k$$

$$c_o = c - s$$

Cost function: When the selling window closes, excess flowers deteriorate while unmet demand forgoes revenue. The combined penalty from these two sources yields the total end-of-period cost:

$$G(Q, D) = c_o \cdot \max(Q - D, 0) + c_u \cdot max(D - Q, 0)$$

3.2.2. Deriving the Expected Cost as a Function of Demand

Demand for fresh-cut flowers is stochastic. One must first fit a probability distribution to historical sales data and then evaluate the expected cost—i.e., the average cost over all possible demand realizations. When realized demand x≤Q, the retailer holds Q−x unsold stems, and each incurs the overstocking cost co; the integration runs over the region x∈[0, Q]. Conversely, when x>Q, the shortfall is x−Q stems, each incurring the understocking cost cu; the integration runs over x∈[Q, ∞). Here f(x)denotes the probability density function of the demand distribution (for instance, the density of a normal distribution):

$$G(Q) = E[G(Q,D)]$$

$$G(Q) = c_o \int_0^{\infty} max(Q - x, 0) f(x) dx + c_u \int_0^{\infty} (x - Q, 0) f(x) dx$$

$$G(Q) = c_o \int_0^{Q} (Q - x) f(x) dx + c_u \int_Q^{\infty} (x - Q) f(x) dx$$

3.2.3. Derivation of the Optimal Order Quantity

The optimal order quantity is obtained by minimizing the expected cost function. Differentiating G(Q) with respect to Q and setting the first derivative to zero yields the optimal solution. Since G(Q) is convex in Q, this stationary point corresponds to a unique global minimum:

$$\frac{dG(Q)}{dQ} = c_o F(Q) - c_u (1 - F(Q)) = 0$$

$$\frac{d^2 G(Q)}{d^2 Q} = (c_o + c_u) f(Q) \geq 0$$

$$\frac{dG(Q)}{dQ} | Q = 0 = c_o F(0) - c_u (1 - F(0)) = -c_u < 0$$

($F(Q) = \int_0^Q f(x) dx$ is the cumulative distribution function of demand, i.e., the probability that demand does not exceed Q.)

Rearranging the first-order condition yields the optimal service level F(Q*), which is the probability that floral demand does not exceed the order quantity. In light of the perishable nature of cut flowers, F(Q*) endogenously trades off the risk of overstocking (spoilage) against the risk of understocking (lost sales), and thus aligns with the single-period ordering logic of short-life-cycle products. By adjusting cost parameters and demand dispersion, the retailer can recalibrate Q* across different operational scenarios.

$$F(Q^*) = \frac{c_u}{c_o + c_u}$$

The optimal order quantity Q* is obtained from the demand distribution. The quantile Z corresponding to the cumulative probability (optimal service level) is taken from the standard normal distribution, and product-specific demand parameters are substituted into the formula to compute the optimal order quantity for each flower variety:

$$Q^* = \mu + Z \cdot \sigma$$

4. Results and Discussion

This study takes the practical inventory challenges of fresh-cut flower retail as its starting point and examines the suitability of the newsvendor model for inventory optimization. The main findings are as follows:

(1) Alignment Between Floral Characteristics and the Newsboy Model

The short life cycle of cut flowers aligns closely with the single-period assumption of the classical newsvendor model. This framework applies to products with a limited selling window and zero end-of-cycle salvage value, where order quantity is set under demand uncertainty. For flowers, the post-harvest freshness period defines the sales cycle, meaning any unsold stock loses its commercial value once the period ends. In addition, orders are placed before the selling window opens; mid-cycle replenishment is infeasible due to long lead times and unavoidable freshness degradation. This structure coincides exactly with the newsvendor assumption of no intra-period replenishment. Therefore, the model's single-period decision logic can be directly applied to floral inventory management.

(2) Capturing Demand Uncertainty

The newsvendor model is fundamentally concerned with demand uncertainty, characterizing random demand through probability distributions. This feature aligns closely with the stochastic nature of floral demand. Flower sales are shaped by multiple drivers, including seasonality, holidays, weather, and shifting consumer preferences, and consequently exhibit persistent volatility that cannot be captured by deterministic models. By assuming demand follows a specified distribution, such as normal or Poisson, the newsvendor framework quantifies this randomness and provides a principled basis for inventory decisions. Moreover, the distributional parameters can be estimated from historical sales data, giving the model sufficient flexibility to adapt to evolving demand patterns in floral retail.

(3) Balancing Overstocking and Stockout Costs

The central challenge in floral inventory management is the trade-off between understocking and overstocking costs, precisely the balance targeted by the newsvendor model. The understocking cost corresponds to foregone sales opportunities and client dissatisfaction when supply falls short, and the overstocking cost corresponds to product spoilage once inventory exceeds the viable freshness period. By quantifying these two costs, the model delivers an optimal order quantity that resolves the core inventory trade-off in floral retail. Its cost architecture also permits practical extensions. For instance, preservation costs can be embedded into the holding cost, and brand or reputation loss into the understocking cost, further improving the model's alignment with actual floral operations.

(4) Practicality for Small and Medium Retailers

Most fresh-cut flower retailers are small and medium-sized enterprises that lack specialized inventory personnel and advanced information systems. As a result, they place a premium on optimization methods that are both easy to apply and practically relevant. The newsvendor model fulfills these criteria. It requires only readily available data—selling price, purchase cost, understocking and overstocking penalties, and historical demand—to compute the optimal order quantity, keeping the implementation threshold low. Its output is a simple, interpretable order rule that can be immediately used to guide daily procurement, aligning well with the operational reality of floral retail businesses.

5. Conclusion

Optimizing floral retail inventory is a systemic task requiring a transition from experience-based practice to data-driven, standardized, and technology-enabled management. By adopting the newsvendor framework, retailers can lower deterioration losses, accelerate cash conversion, and raise service quality, collectively building a stronger market position. Future advances in IoT and predictive analytics will drive floral inventory systems to become smarter and more automated, enabling the sector to respond more agilely to competitive dynamics and changing customer expectations.

References

[1] Yanrong, T. (2025). Optimization strategies for fresh product inventory management. China Economist, (10), 53–54. (In Chinese)

[2] Shubei, L., Li, H., & Ke, F. (2025). Research on the impact of climate risk on the adjustment of enterprise inventory holding level. Financial Theory and Practice, (7), 78–91. (In Chinese)

[3] Fuchang, L., & Jingyi, Y. (2025). Study on joint optimization of pricing and inventory of cross-border e-commerce import supply chain of agricultural products in Yunnan Province. Logistics Science & Technology, 48(17), 109–114. (In Chinese)

[4] Xiaojiao, W. (2024). Research on convenience store inventory optimization strategies: Based on moving average forecasting method and EOQ model. National Circulation Economy, (22), 12–15. (In Chinese)

[5] Ke-Feng, B. (2025). Analysis of inventory management issues and countermeasures in automotive parts enterprises. Internal Combustion Engine & Parts, (19), 125–127. (In Chinese)

[6] Song-Heng, C., & Qin-Hong, Z. (2021). Joint pricing and ordering policy for a fresh food e-commerce advance booking system with consumers' preference for freshness. Logistics Engineering and Management, 43(8), 116–125. (In Chinese)

[7] Sai, W., & Yan, C. (2020). Research on inventory control based on modified EOQ model. Logistics Engineering and Management, 42(1), 92–96. (In Chinese)

[8] Jingxing, X. (2025). Origin and early development of newsvendor model. Mathematical Modelling and Its Applications, 14(1), 106–113. (In Chinese)

[9] Yichen, S., Wenjing, L., & Yuan, Y. (2025). Inventory control strategy for fresh product supply chains: A case study of Hema Fresh. China Logistics & Purchasing, (1), 101–102. (In Chinese)

[10] Meng, W., Chi, Z., & Zhiyong, W. (2024). Problem analysis for automatic pricing and replenishment decisions of vegetable products. Mathematical Modelling and Its Applications, 13(2), 27–36. (In Chinese)