Dynamic Pricing and Stochastic Demand Forecasting for Efficient Inventory Management in the Fashion Industry

Sohan Bandary (2020IMG-016)

Supervisor: Prof. Gyan Prakash

ABV-Indian Institute of Information Technology and Management Gwalior

Outline

Introduction

- **Dynamic Pricing for Inventory Management** 🔄
  - Businesses face unpredictable demand, especially during seasonal or promotional periods. Dynamic pricing helps adjust prices in real-time based on demand variations.
  - The main goal of dynamic pricing is to maximize profits and optimize inventory levels by responding to market changes in real-time.

- **Stochastic Demand Forecasting** 📈
  - Forecasting future demand under uncertain and fluctuating market conditions is challenging.
  - A stochastic approach takes randomness and volatility into account, helping to develop better models for future demand predictions.

- **Exponential Smoothing Method**
  - Exponential smoothing assigns exponentially decreasing weights to past demand data to generate a forecast, balancing recent demand trends with historical patterns.
  - It allows businesses to adjust inventory strategies and pricing quickly as new data becomes available.

Research Questions

- How can **dynamic pricing strategies** be integrated with stochastic demand forecasting to optimize inventory management for seasonal sales environments?
- What is the **impact of using exponential smoothing** in demand forecasting on profit margins and inventory replenishment strategies in a dynamic pricing framework?
- How can businesses **effectively manage safety stock and buffer inventories** while responding to **real-time** demand fluctuations using stochastic demand models?

Problem Statement

- **Challenge of Demand Uncertainty** ⚠
  - Businesses struggle to predict demand accurately, leading to either overstocking or stockouts. These inefficiencies increase operational costs and reduce profitability.
- **Static Pricing Limitations** ⏱
  - Traditional pricing models are static and fail to respond to real-time demand changes, which leaves businesses unable to capitalize on peak demand periods or reduce losses in low-demand times.
- **Need for Integrated Demand and Pricing Strategy** 🧩
  - There is a need for a unified framework that combines accurate demand forecasting with flexible pricing strategies, allowing businesses to make data-driven decisions.

Research Gaps

- **Lack of Integrated Approaches**
  - Existing studies often examine components like dynamic pricing or demand forecasting individually. Few explore an integrated model combining stochastic demand modeling, exponential smoothing, and dynamic pricing for profit maximization.
- **Limited Focus on Sustainability**
  - The intersection of inventory management, dynamic pricing, and sustainability is underexplored. More research is needed on integrating eco-friendly practices with pricing strategies.
- **Opportunities in Data-Driven Decision Making**
  - There is potential to leverage machine learning for more accurate demand forecasts and dynamic pricing strategies that respond to real-time data.

Literature Review & Research Gaps

Author(s)	**Stochastic demand**	**Dynamic pricing**	**Demand forecasting**
Alawneh and Zhang	✓	×	×
Boukas et al.	✓	×	×
Boer and Zwart	×	✓	×
Chen et al.	×	×	✓
Gallego and Van Ryzin	✓	✓	×
Garai and Paul	✓	×	×
Hsieh and Dye	×	✓	✓
Jauhari et al.	✓	×	×
Khedlekar et al. (2023)	✓	×	×
Khedlekar et al. (2024)	×	✓	✓
Willemain et al.	×	×	✓
Xu et al.	✓	×	✓
You	×	✓	×
Zhao et al.	✓	×	×
Objective(tentative)	✓	✓	✓

Literature Review - Part 1

- Jauhari et al. (2023) develops a sustainable vendor-buyer inventory model that integrates green technology investment, carbon emission reduction incentives, and energy usage optimization under stochastic demand, providing a framework for minimizing costs and emissions in supply chains while complying with government carbon regulations.

- Palanivel et al. (2024) presents a comprehensive inventory management model incorporating Weibull distribution deterioration, ramp-type demand, carbon emission reduction, and various shortage scenarios, aiming to optimize inventory systems while addressing environmental sustainability.

- Tadayonrad and Ndiaye (2023) introduces a key performance indicator (KPI) model for demand forecasting in inventory management, focusing on incorporating supply chain reliability and seasonality factors to optimize safety stock levels and improve forecast accuracy, thus reducing both stockouts and excess inventory.

Literature Review - Part 2

- Poloni and Sbrana (2015) proposes a novel estimation method for multivariate exponential smoothing, which simplifies the forecasting of demand by breaking down complex high-dimensional models into more manageable univariate ones, improving computational efficiency and maintaining accuracy.

- Shukla and Khedlekar (2013) proposes an adjustment factor to correct the underestimation of the standard deviation in lead time demand when using simple exponential smoothing, offering a more accurate formula that accounts for both the smoothing constant and lead time length, which is essential for effective inventory control.

- Ahmadi et al. (2008) presents a modified Winter's exponential smoothing model to forecast the number of patrons visiting a university library and seeking assistance at the reference desk, helping to optimize staffing decisions despite the inherent variability in daily data.

Literature Review - Part 3

- Sbrana and Silvestrini (2013) provides an analytical comparison of top-down and bottom-up approaches to forecasting aggregate demand within a multivariate exponential smoothing framework. It extends previous research by allowing for interdependencies between variables and shows that the relative accuracy of these approaches depends on the parametric structure of the data, with simulation results supporting the theoretical findings.

- Chen et al. (2000) examines the impact of exponential smoothing forecasts on the bullwhip effect in supply chains, demonstrating that this forecasting method can amplify demand variability as it moves up the supply chain, compared to moving average forecasts.

- Taylor (2003) introduces a double seasonal Holt-Winters exponential smoothing method to improve short-term electricity demand forecasting by capturing both within-day and within-week seasonal patterns, outperforming traditional Holt-Winters and ARIMA models in terms of forecast accuracy.

Objectives (tentative)

- **Optimize Inventory Management**
  - Develop a comprehensive model that integrates demand forecasting and dynamic pricing strategies to ensure efficient inventory replenishment.
- **Improve Demand Forecasting Accuracy**
  - Use stochastic demand models and exponential smoothing to enhance the accuracy of demand predictions, which will allow for better decision-making.
- **Maximize Profitability with Dynamic Pricing $**
  - Introduce pricing mechanisms that adjust according to real-time demand, helping businesses capitalize on high-demand periods and mitigate losses during low-demand periods.
- **Adaptation to Market Changes**
  - Ensure that the model can continuously adapt to fluctuating demand trends by leveraging real-time data analytics.

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Thank you!