Time Series Forecasting of Product Demand

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Abstract

This project focuses on forecasting consumer demand for three beverage categories (Craft Beer, Whisky, and White Wine) using statistical time series methods such as Moving Averages, Exponential Smoothing, and ARIMA. The primary objective is to compare these models, evaluate their accuracy, and identify the most suitable approach for reliable demand forecasting. Analysis reveals that Holt-Winters exponential smoothing and ARIMA perform strongly, with Holt-Winters showing particular strength in handling trend and seasonality for multiple product categories.

1. Introduction

Forecasting product demand is critical for marketing, supply chain, and resource planning. The Skyrose Marketing Agency case study aims to use Google Trends data to anticipate consumer demand patterns for beverages. Classical time series models are employed to analyze and predict weekly demand, providing insights for capacity planning, campaign timing, and client advisory. By analyzing demand patterns, the study helps smooth workload peaks and improve planning for 2026.

2. Dataset Description

• Source: Google Trends data
• Products: Craft Beer, Whisky, White Wine
• Variable: Weekly search volume index
• Frequency: Weekly observations
• Period: Multi-year historical data till 2025

The dataset was cleaned by removing irrelevant columns for each analysis, converting the date column to datetime, and checking for missing values. Initial exploratory plots were generated to visualize trends, seasonality, and autocorrelations.

3. Methodology

The following forecasting models were implemented and compared:
• Naive Forecast – baseline using last observed value.
• Moving Average (SMA/WMA) – smoothing short-term fluctuations.
• Simple Exponential Smoothing (SES) – exponential weighting.
• Double Exponential Smoothing (DES/Holt's method) – trend handling.
• Triple Exponential Smoothing (TES/Holt-Winters) – trend and seasonality modeling.
• ARIMA/Auto-ARIMA – autoregressive integrated moving average for capturing autocorrelation.

Evaluation metrics used:
• Mean Squared Error (MSE)
• Root Mean Squared Error (RMSE)
• Mean Absolute Percentage Error (MAPE)
Residual diagnostics were performed to validate model assumptions.

4. Results & Evaluation

• Naive Forecast & Moving Averages: Provided simple benchmarks but limited accuracy.
• SES & DES: Improved forecasts but struggled with seasonality.
• TES (Holt-Winters): Best overall performance for Craft Beer and White Wine; captured both trend and seasonality.
• ARIMA/Auto-ARIMA: Competitive accuracy, particularly for Whisky; required stationarity adjustments.

Best Models:
• Craft Beer – Holt-Winters Exponential Smoothing
• Whisky – ARIMA/Auto-ARIMA
• White Wine – Holt-Winters Exponential Smoothing

Overall, Holt-Winters and ARIMA consistently outperformed simpler methods, achieving lower RMSE and MAPE values.

5. Conclusion & Insights

This project demonstrated that classical time series forecasting models can effectively predict product demand when demand patterns exhibit clear trends and seasonality. Holt-Winters proved effective for seasonal products, while ARIMA captured autocorrelation well for non-seasonal demand. Forecasts for 2026 provide actionable insights for Skyrose Marketing Agency to optimize marketing campaign timing, manage resources, and advise clients on demand peaks.

Future Work:
• Test SARIMA for enhanced seasonal modeling.
• Explore Prophet or machine learning approaches (LSTM, Random Forest) for nonlinear patterns.
• Integrate external regressors such as promotions or holidays for improved accuracy.