

DEMAND FORECASTING FOR HOME APPLIANCES DURING FESTIVE CAMPAIGNS

1. Background and Problem Statement:

A national home appliance retailer observed erratic spikes in demand during festive seasons such as Diwali, Christmas, and New Year. While campaigns boosted visibility and sales, inaccurate forecasting often led to stockouts of high-demand models and excess inventory of slower movers. The management needed a robust **promotion-sensitive demand forecasting** model to guide campaign inventory buildup and warehouse distribution planning.

2. Objectives:

- To forecast SKU-level appliance sales during festive periods using historical sales and campaign data
- To model the impact of advertising spend, campaign duration, and timing on demand
- To provide inventory recommendations for different product categories (ACs, microwaves, washing machines, etc.)
- To reduce campaign-related stockouts and post-campaign overstocking

3. Methodology:

Data Sources:

- 3 years of weekly sales data (SKUs \times stores)
- Marketing campaign details (spend, timing, theme)
- External factors: holiday calendar, Google Trends data (indexed for product keywords)

Tools and Techniques:

- **R:** forecast, lm, ggplot2, tidyverse
- Forecasting models:
 - Multiple Linear Regression
 - ARIMA with external regressors (ARIMAX)
 - Holiday dummy variables and lagged effects for promotion impact

Steps:

1. Data Engineering:

- Created promotional dummy variables for each festive season
- Aggregated Google Trends and campaign budget as exogenous inputs
- Adjusted for weekday effects in weekly data

2. Modeling Approach:

- Model 1: Baseline ARIMA
- Model 2: ARIMAX with holiday + campaign budget + trend index
- Model 3: Multiple regression with lagged effects of spend and duration
- Cross-validation on festive weeks (e.g., Week -2 to Week +1 around event)

3. Forecast Horizon:

- Focused on T-30 to T+15 days around each festival
- Used model outputs to simulate stock requirement under different confidence intervals

4. Results:

Forecast Accuracy:

- Regression + ARIMAX yielded lowest MAPE of **9.8%** for Diwali campaigns
- Naïve model MAPE exceeded 21%, proving campaign context is critical
- Model showed that **spend lag** had a stronger effect than same-week spend → early promotions performed better

Inventory Impact:

- Stockout rates during Diwali reduced by **41%** compared to previous year
- Overstock reduction for underperforming SKUs (e.g., older microwave models) by **18%**
- Enabled warehouse staging with regional demand segmentation based on model outputs

5. Interpretation and Insights:

- Advertising spend and timing are strong predictors of appliance demand during campaigns

- High ticket appliances have longer purchase cycles; therefore, pre-campaign targeting is more effective
- Overreliance on historic sales without campaign context leads to planning errors
- Google Trends improved demand visibility for new products not yet in historical data

6. Recommendations:

- Start inventory build-up at least 30 days before major campaigns
- Use ARIMAX with updated campaign inputs in rolling forecast windows
- Include online pre-orders as leading indicators for campaign forecasting
- Tailor promotion strategies for each category based on elasticity (e.g., discounts work better for microwaves than for washing machines)

7. Future Work:

- Expand model to include competitor pricing and stock visibility (scraped from online marketplaces)
- Develop a dashboard for real-time tracking of forecast vs. actual during campaigns
- Integrate model output with dynamic pricing tools for margin optimization

8. Stakeholder Relevance:

Academic:

- Ideal for courses on promotional analytics, time series modeling with exogenous variables, or retail operations
- Shows integrated use of regression, ARIMA, and calendar effects

Corporate:

- Useful for retail chains and consumer electronics brands managing festive demand surges
- Enables data-driven campaign execution and reduces guesswork in inventory decisions