SALES FORECASTING USING ARIMA IN R: A CASE STUDY ON MONTHLY ELECTRONICS RETAIL PERFORMANCE IN THE U.S.

1. Background

A mid-sized U.S. electronics retailer with over 50 stores nationwide sought to improve its inventory and procurement planning. Sales had shown significant seasonal volatility, and past forecasting methods failed to capture demand peaks for product categories like TVs and home automation kits. The retailer engaged us to build a reliable forecasting pipeline using R, with outputs guiding inventory purchasing decisions and promotional calendar alignment.

2. Objective

- To forecast monthly store-wise total sales with category-level breakdowns
- To assess the strength of seasonality and trend in historical sales
- To deliver a forecasting framework that improves planning for inventory restocking and marketing campaigns

3. Data Used

Source: Internal ERP transaction system **Data Type**: Monthly aggregated sales totals per store and category **Time Span**: January 2018 – December 2023 (72 months)

Key Variables:

- Date, Store_ID, Category, Monthly_Sales_Amount
- Categories included: TV, Audio, Smart Devices, Gaming, Accessories
- External inflation adjustment: U.S. CPI merged for real sales tracking

4. Methodology

4.1 Preprocessing and Transformation

- Aggregated raw sales to monthly totals by category
- Adjusted for inflation using CPI (to obtain Real_Sales)
- Performed log transformation for variance stabilization

4.2 Exploratory Analysis

- Used ggplot2 and tsibble to plot trends and detect seasonality
- Decomposed sales series using stl() and seasadj() for deseasonalized analysis

4.3 Forecasting with ARIMA

- Applied auto.arima() from the forecast package on each category
- Checked ACF, PACF plots for residual diagnostics
- Validated with train-test split (last 12 months as test set)

```
model_tv <- auto.arima(tv_ts)

forecast_tv <- forecast(model_tv, h = 12)
```

4.4 Model Evaluation

- Accuracy metrics used: RMSE, MAPE
- Best-performing model: ARIMA(1,1,1)(1,1,1)[12] for TV category
- Compared with ETS and naive forecasts using accuracy() function

5. Results

Category	Best Model Type	MAPE (%)	RMSE
TV	ARIMA seasonal	6.1%	$18,200
Audio	ETS (A,A,N)	8.7%	$13,700
Smart Devices	ARIMA + CPI cov.	5.9%	$9,300
Gaming	Naive w/ season	12.5%	$22,500
Accessories	ETS damped	9.8%	$6,100

6. Interpretation and Recommendations

- **TVs and smart home categories** showed strong seasonality (peak Nov–Dec, dip Feb–Mar)
- Forecasts indicated **5–8% year-on-year growth** in smart devices, outperforming other categories

- Stock planning for accessories should be reviewed monthly due to **shorter demand cycles**
- Campaign budgets can be pre-allocated using projected MAPE confidence intervals
- Suggested creation of **store-level ARIMA models** for top 10 revenue locations

7. Reporting Output

- **R Markdown Report (PDF, 30 pages)**
  - Forecast plots with 80% and 95% intervals
  - Category-wise forecast vs. actual overlay
  - Residual diagnostics and AIC comparison tables
- **Interactive Excel Dashboard**
  - Category-wise forecasts by store
  - Dynamic filters for viewing seasonal peaks
  - Monthly vs. cumulative forecast views
- **R Scripts**
  - Modular scripts to forecast each category
  - Export function: generate_forecast_report(category, output_dir)
  - Built-in model evaluation wrapper for RMSE/MAPE scoring

8. Business Impact

- Helped reduce **stockouts during holiday season by 19%**
- Reduced **excess inventory carry costs** by ~$85,000 in Q4 2023
- Provided input to **marketing team's promotion calendar** based on predicted category peaks
- Enabled regional managers to set **store-specific monthly targets** aligned with forecasts