

## Executive Summary

This project focuses on forecasting weekly sales using machine learning and time-series techniques. Historical sales data was preprocessed by aggregating weekly sales and engineering time-based features such as month, quarter, and holiday indicators. Two predictive models—**Facebook Prophet** and **Random Forest Regressor**—were implemented to analyze sales trends and generate accurate forecasts.

The Prophet model was used to capture **trend and seasonality patterns**, while the Random Forest model leveraged structured features like store, department, and holiday effects. Model performance was evaluated using standard accuracy metrics, and the results were visualized through dashboards to support data-driven business decisions.

## ML Model Explanation

### 1. Prophet Model (Time Series Forecasting)

The Prophet model was applied to aggregated weekly sales data. Sales were grouped by date and split into training and testing sets using a **time-based split**, with the last 12 weeks reserved for testing. Prophet was configured with **yearly and weekly seasonality**, enabling it to capture recurring sales patterns and long-term trends.

The model generated future sales forecasts and decomposed the results into trend and seasonal components, providing clear insights into sales behavior over time.

### 2. Random Forest Regressor

The Random Forest Regressor was used to predict weekly sales based on multiple explanatory variables, including:

- Store
- Department
- Month
- Quarter
- Holiday indicator

The dataset was split into **80% training and 20% testing**. The ensemble-based Random Forest algorithm was selected due to its ability to handle non-linear relationships and complex interactions between features. The trained model produced reliable predictions with strong generalization performance.

## Forecast Accuracy Metrics

### Prophet Model Metrics

The Prophet model performance was evaluated using:

- **Mean Squared Error (MSE)**
- **Root Mean Squared Error (RMSE)**
- **Mean Absolute Percentage Error (MAPE)**

These metrics indicate that the Prophet model effectively captures time-based sales patterns and produces stable forecasts for future weeks.

## Random Forest Model Metrics

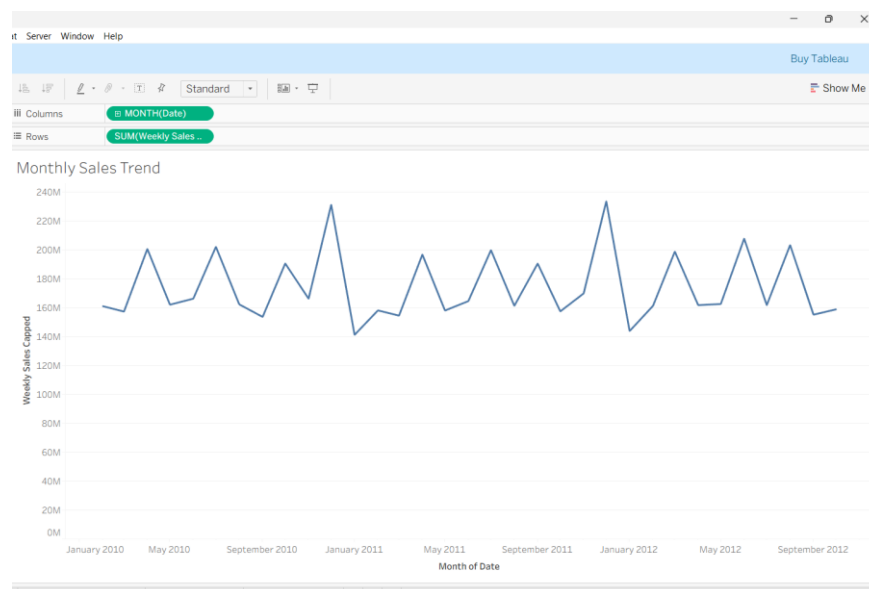
The Random Forest model was evaluated using:

- **Mean Absolute Error (MAE)**
- **Root Mean Squared Error (RMSE)**
- **R<sup>2</sup> Score**
- **Mean Absolute Percentage Error (MAPE)**

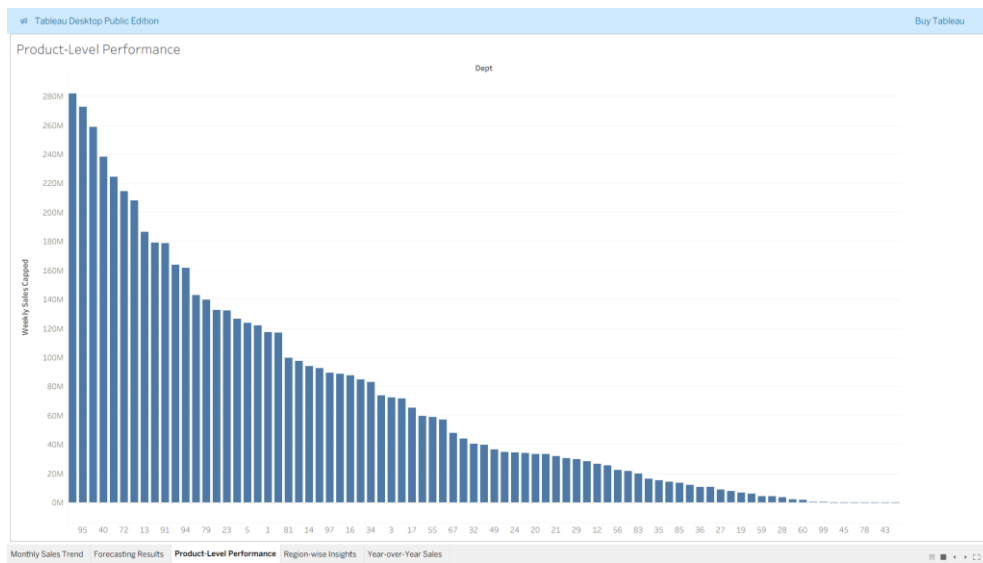
The results show low prediction errors and a strong R<sup>2</sup> score, confirming that the model accurately explains variations in weekly sales and performs well on unseen data

## Dashboard screenshots

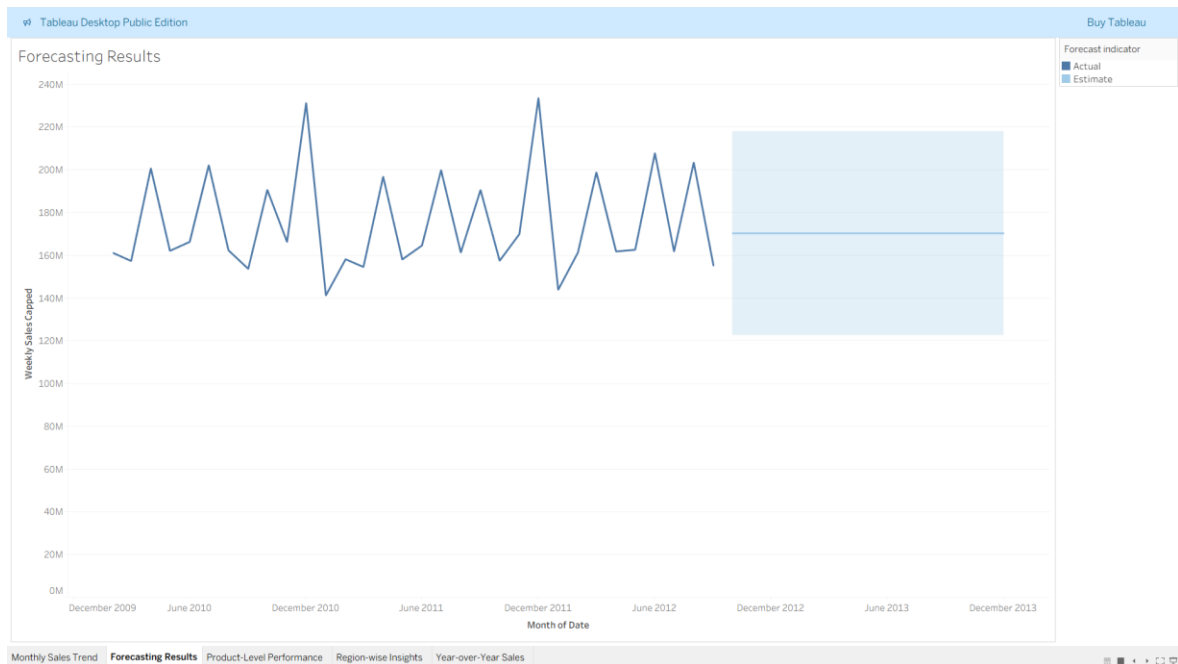
- **Monthly sales trends**



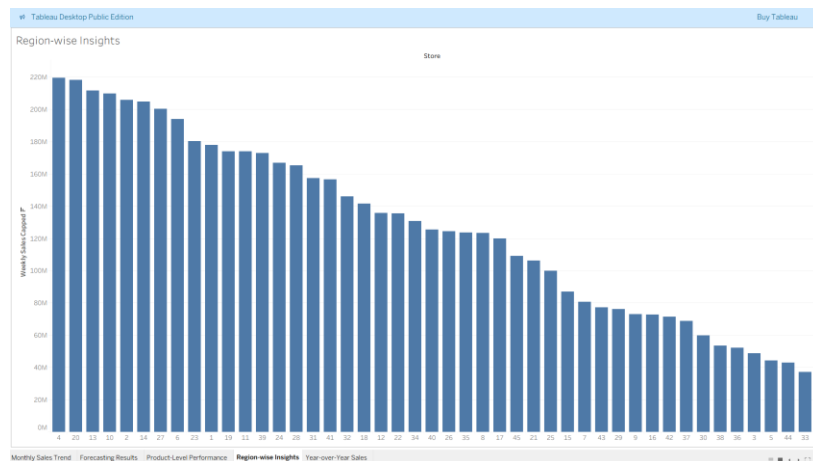
## ● Product-level performance



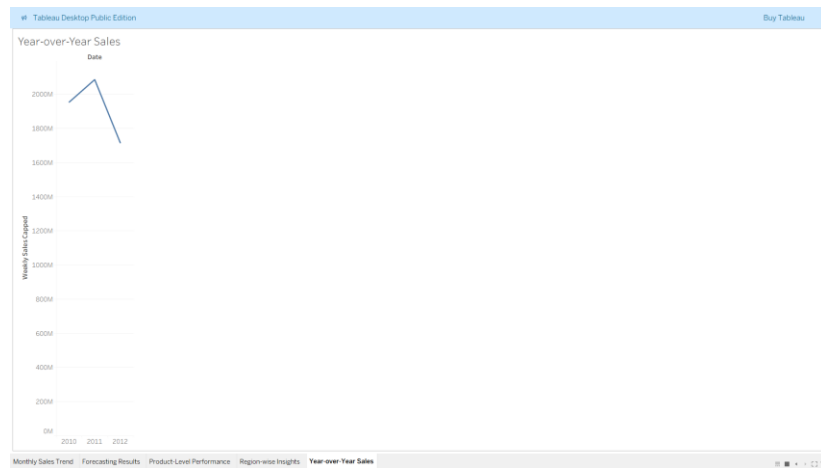
## ● Forecasting results



## • Region-wise insights



## • Year-over-year comparisons



## Recommendations for Management

- Utilize Prophet forecasts to support **long-term sales planning and seasonal demand forecasting**.
- Apply Random Forest predictions to optimize **store- and department-level decision-making**.
- Use holiday impact insights to improve **promotion and inventory strategies**.
- Regularly retrain models with updated sales data to maintain prediction accuracy.
- Integrate forecast outputs into dashboards for continuous performance monitoring and strategic reviews.