



INDIAN INSTITUTE OF
TECHNOLOGY ROPAR

भारतीय प्रौद्योगिकी
संस्थान रोपड़



AI-POWERED DEMAND FORECASTING FOR PRODUCTS

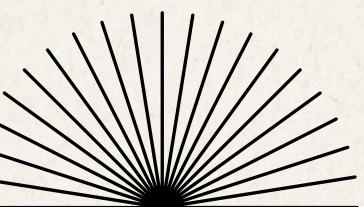
"PREDICTING TOMORROW'S DEMAND, TODAY WITH AI PRECISION"

NAME OF PROJECT:

Minor in AI - Capstone Project

PRESENTED BY:

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Background & Motivation

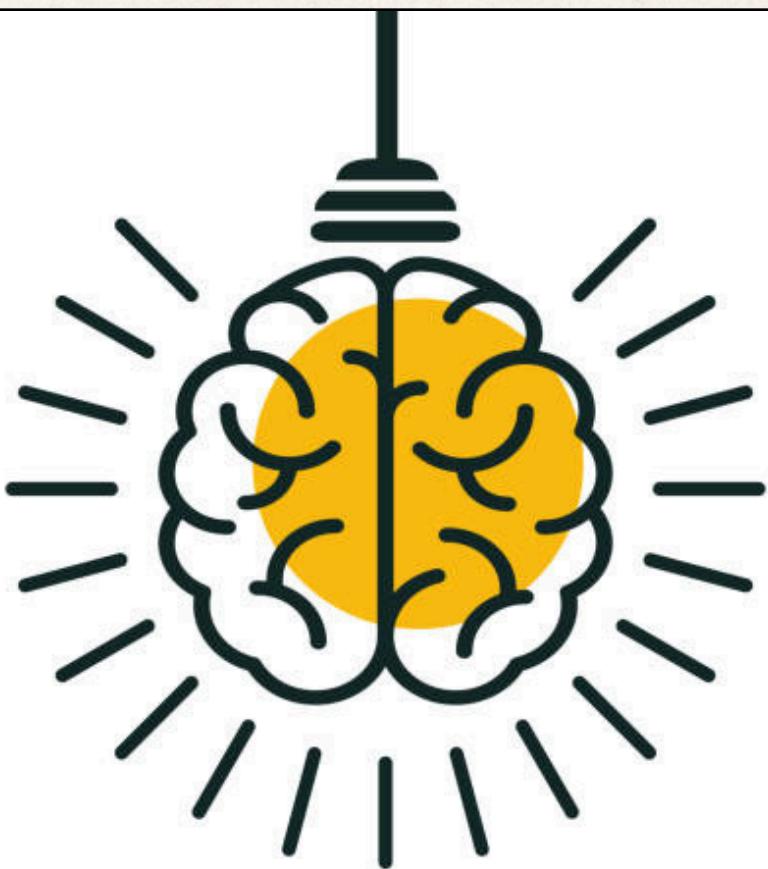
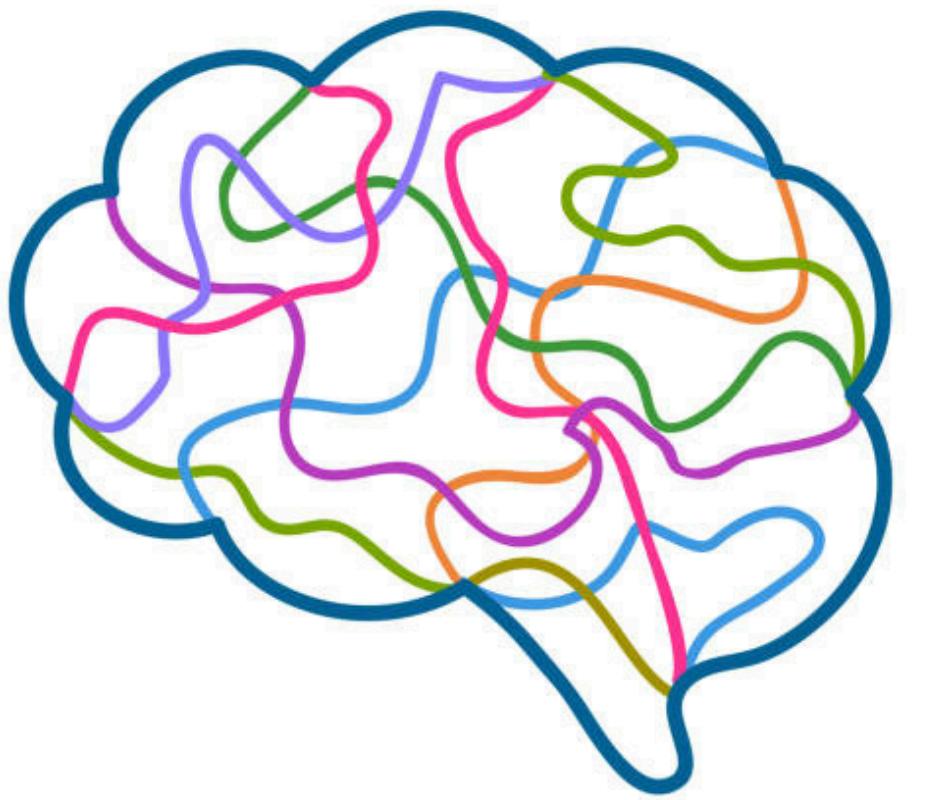
- 01** Demand forecasting helps businesses optimize inventory, improve supply chain efficiency, and increase profitability.
 - 02** Accurate forecasts prevent overstocking and stockouts, reducing costs and enhancing customer satisfaction.
 - 03** Traditional forecasting methods rely on simple historical trends and often overlook complex influencing factors.



Importance & Challenges

1. Market demand is influenced by multiple factors: marketing campaigns, seasonal trends, price fluctuations, competitor pricing, stock availability, and holidays.
2. Capturing these factors in traditional models is challenging due to their complexity and non-linearity.
3. Real-world sales data is often noisy, incomplete, and affected by many external variables.
4. AI-powered forecasting aims to overcome these challenges through advanced modeling techniques and feature engineering.





Problem Statement

"Stockpiling appropriate quantities is extremely important to the smooth running of a business. Demand forecasting was generally considered an art form, and any imprecise estimation could result in stockouts, loss of business opportunity, and diminished prestige in the eyes of its consumers. Unlike a single factor demand forecast that typically considers past sales figures, multi-factor demand meetings will be held to address issues such as marketing campaigns, seasonal trends, pricing actions taken by competitors, and stock levels. This project will develop an AI-driven demand forecasting system that incorporates these factors through machine learning models to provide demand predictions for retail products that are both accurate and actionable."

Goal: *Develop, compare, and evaluate machine learning models to predict weekly demand for retail products.*

Focus: *Utilize historical sales data enriched with marketing, seasonal, and pricing information.*

Dataset Overview

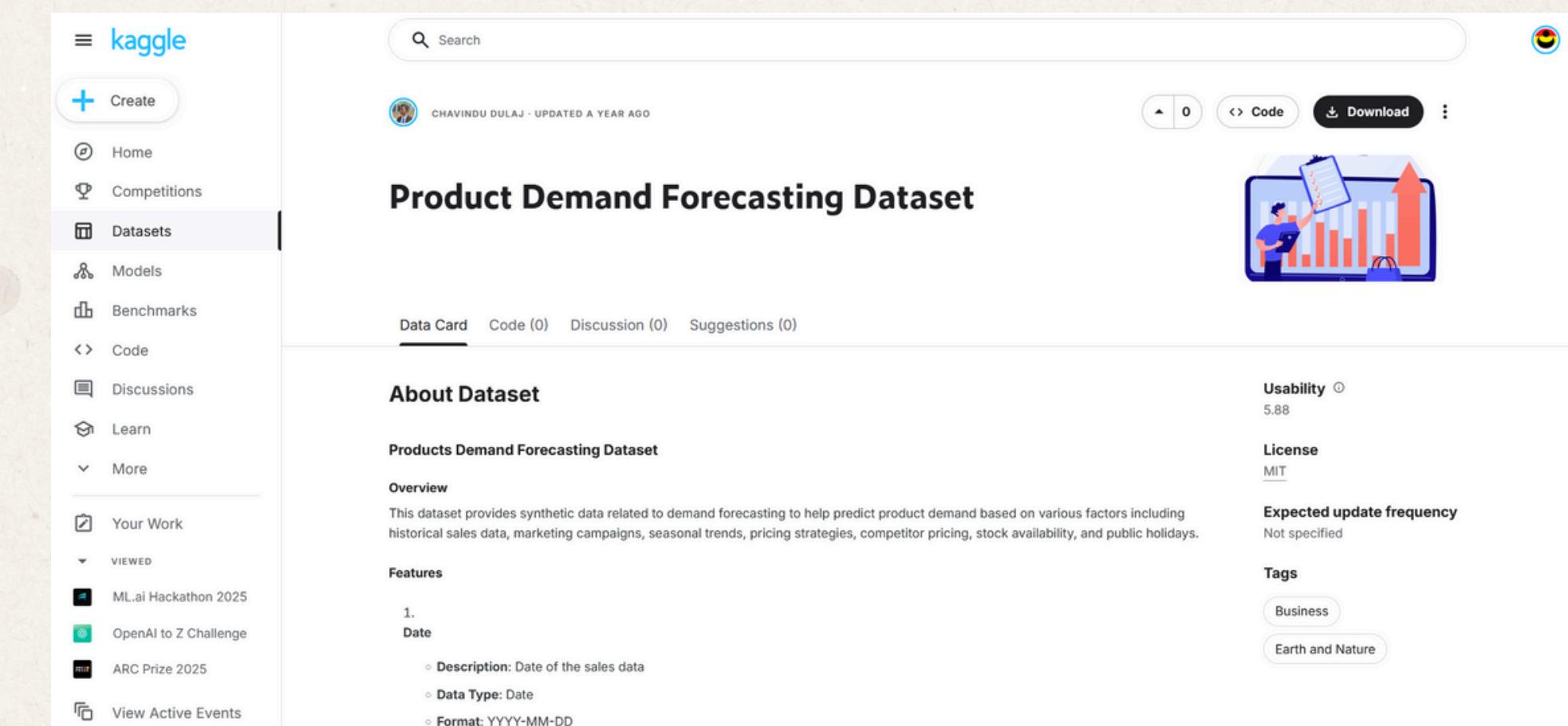
Dataset : Product Demand Forecasting Dataset (Kaggle)

- Historical sales data across multiple years (weekly).

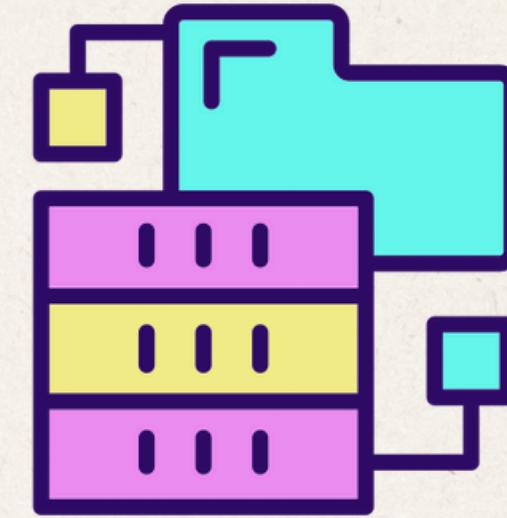
Key features:

- Date, Product ID, Base Sales
- Marketing Campaign & Effect
- Seasonal Trend & Effect
- Price, Discount, Competitor Price
- Stock Availability, Public Holiday
- Target variable: Actual Product Demand.

URL: [Dataset Link](#)



The screenshot shows the Kaggle interface. On the left is a sidebar with options like Create, Home, Competitions, Datasets (which is selected), Models, Benchmarks, Code, Discussions, Learn, and More. Below that are sections for Your Work and VIEWED challenges. The main content area displays the 'Product Demand Forecasting Dataset' by CHAVINDU DULAJ, updated a year ago. It includes a Data Card, Code (0), Discussion (0), and Suggestions (0). The dataset is described as providing synthetic data for demand forecasting based on various factors. It has a Usability rating of 5.88, MIT license, and is not specified for update frequency. Tags include Business and Earth and Nature. A sidebar on the right shows a person analyzing a chart with an upward arrow.



Data Preprocessing & Feature Engineering

- Date conversion and cleaning missing/invalid entries.
- Aggregated demand by year, week, product, and base sales.
- Encoded categorical variables (Product ID, Base Sales) into numeric codes.



- Created lag features (previous weeks' sales) for temporal patterns.
- Added quarter feature to capture seasonality.

Model Performance Comparison

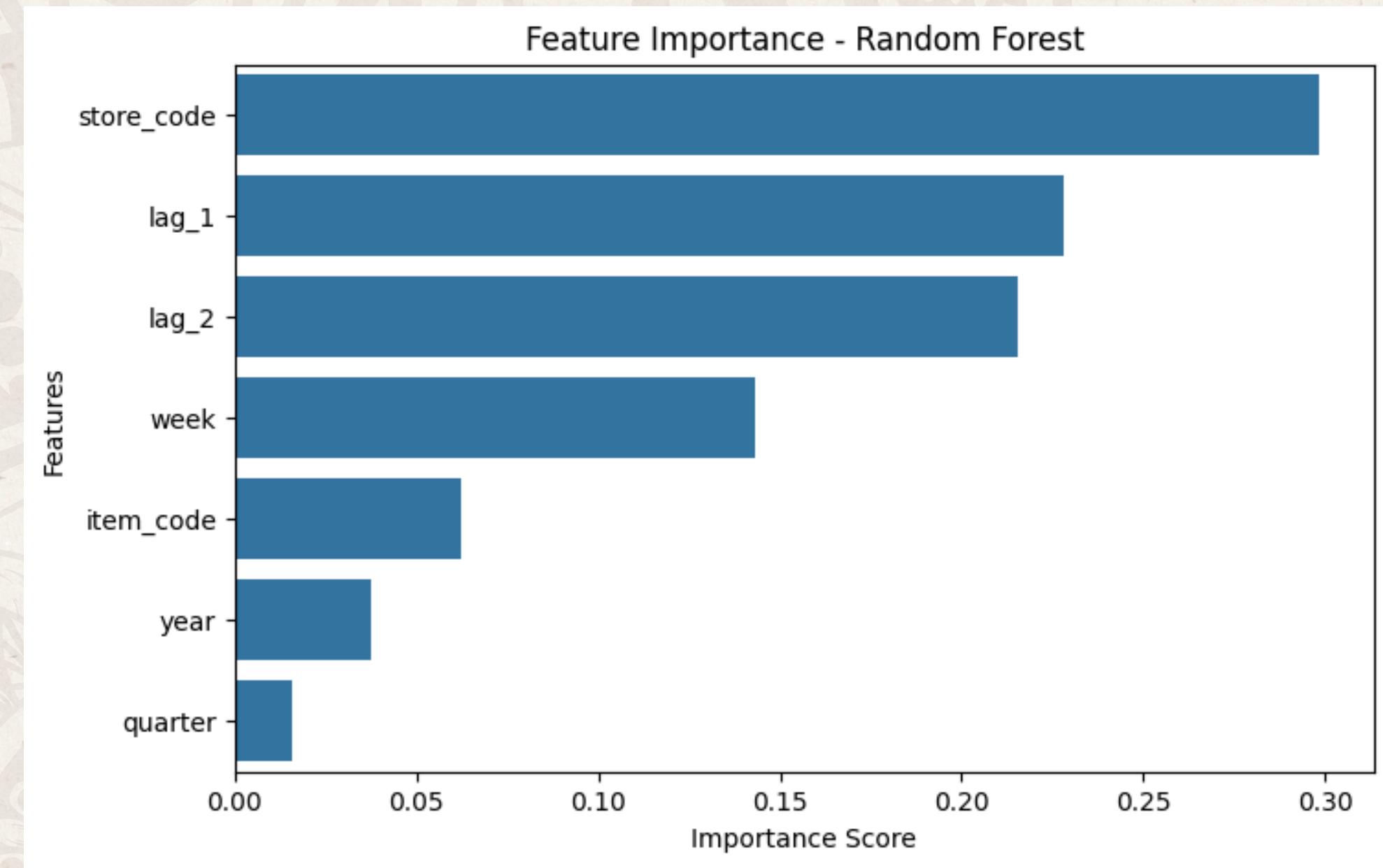
Model	RMSE	MAE
Random Forest	44,290.27	32,506.80
Gradient Boosting	43,185.97	31,442.08
XGBoost	43,570.65	31,748.87

- Gradient Boosting was the best performer and showed a lower value of RMSE and MAE, indicating a more accurate forecast. Comparing actual and forecasted sales of top products shows a close match, thus validating the model.



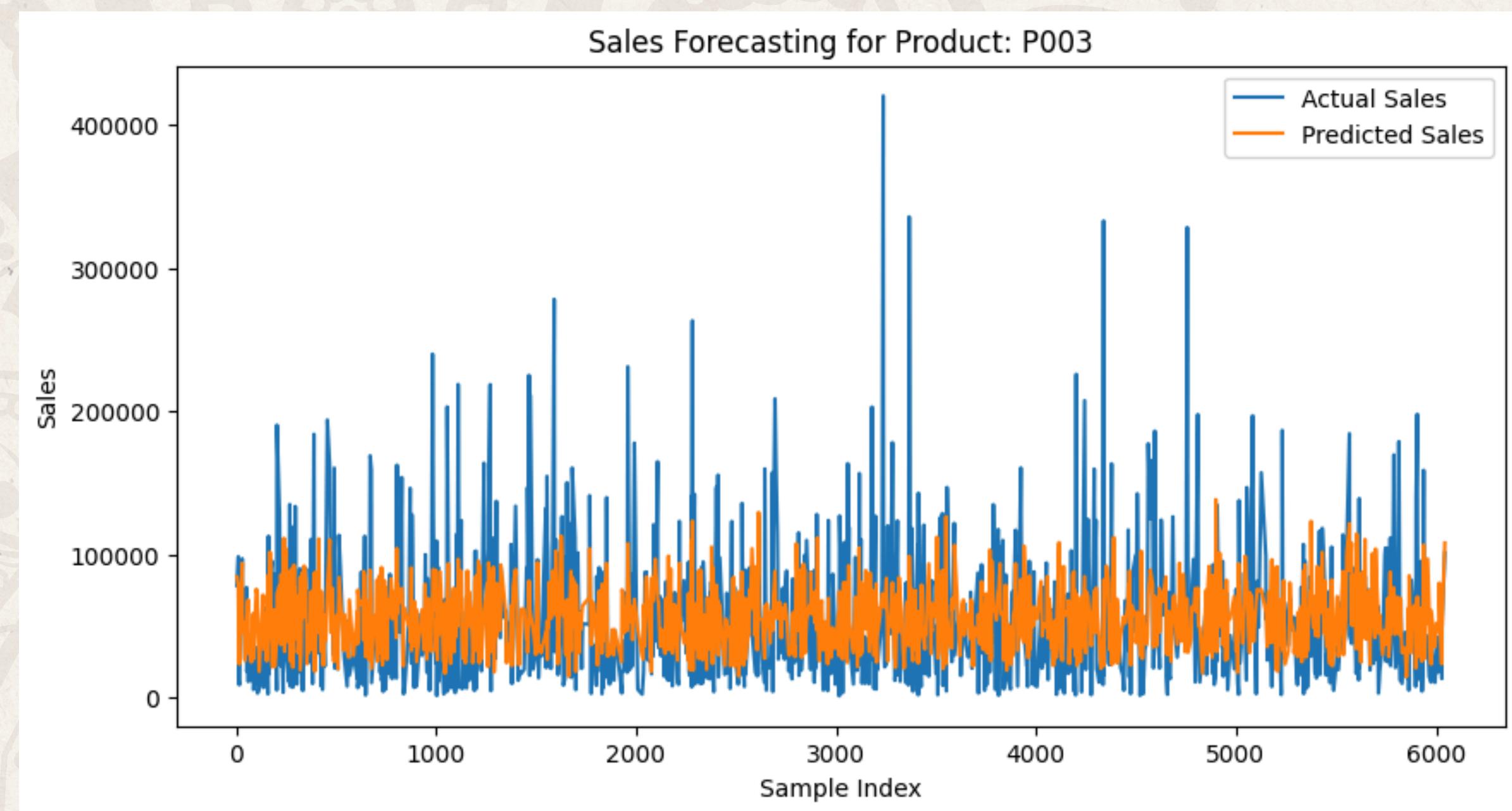
Feature Importance

- Lag features (previous weeks' sales) are the most influential in predicting demand.
- Seasonal indicators (quarter) significantly impact forecast accuracy.
- Marketing effects and pricing strategies also strongly affect product demand.
- Feature importance helps businesses understand key demand drivers.
- Enables data-driven decisions to optimize marketing and inventory management.



Visualizing Predictions

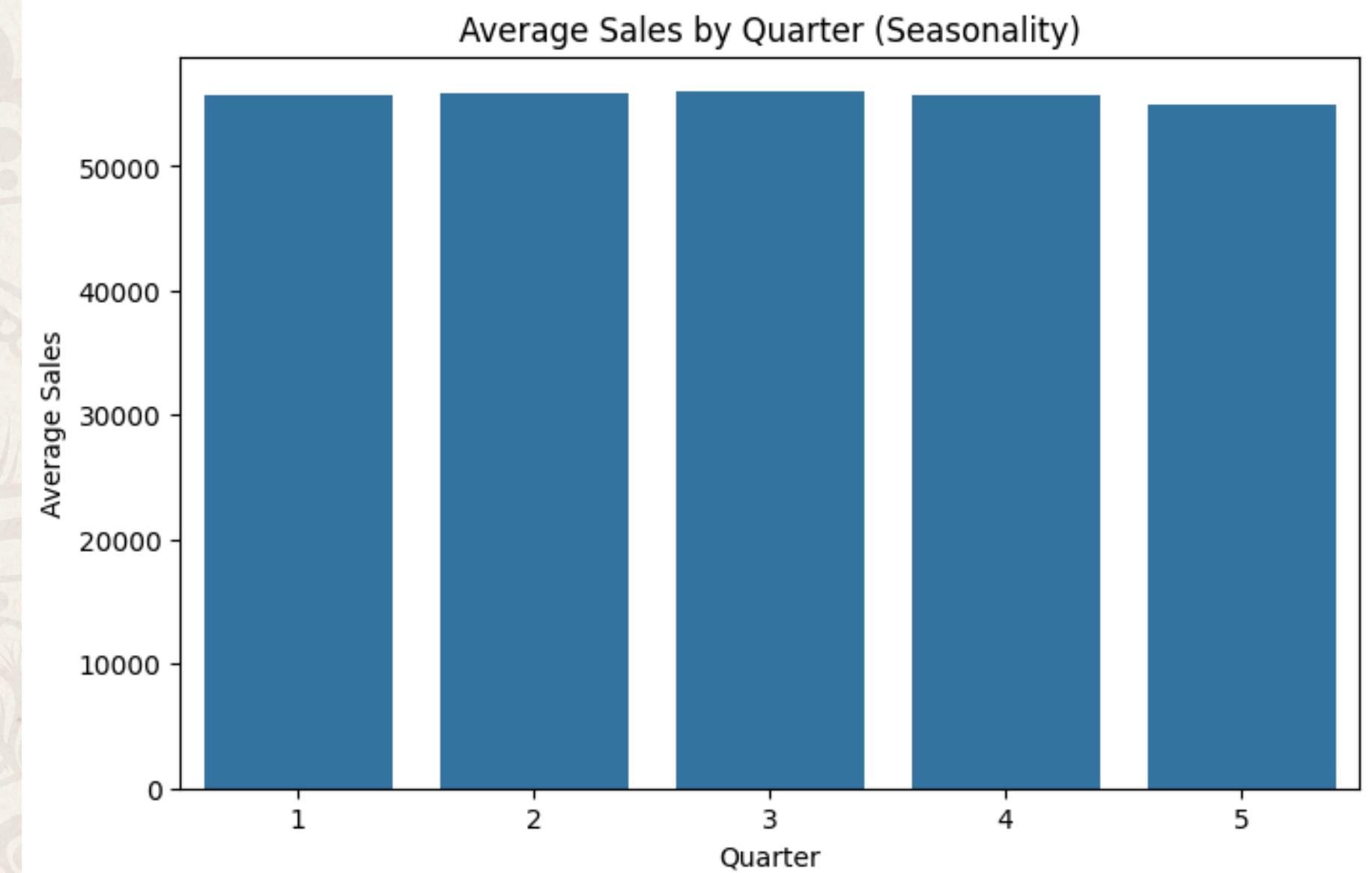
- Actual vs predicted sales trends closely align, validating model effectiveness.
- Visual analysis performed on top-selling products to ensure targeted insights.
- Helps identify patterns like demand spikes or drops on a per-product basis.
- Enables proactive inventory planning based on forecasted demand fluctuations.
- Empowers sales teams to tailor strategies for specific products and seasons.



(One graph has been shown here. Rest in the code snippet).

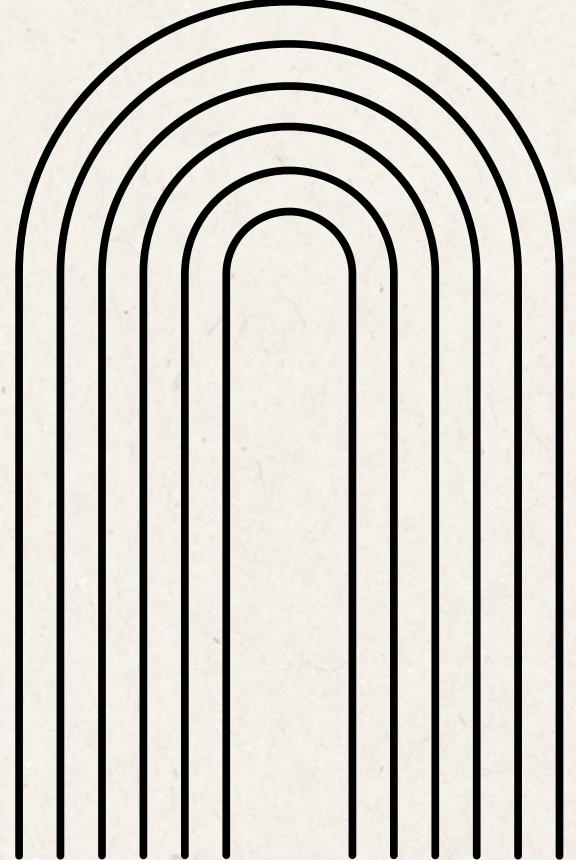
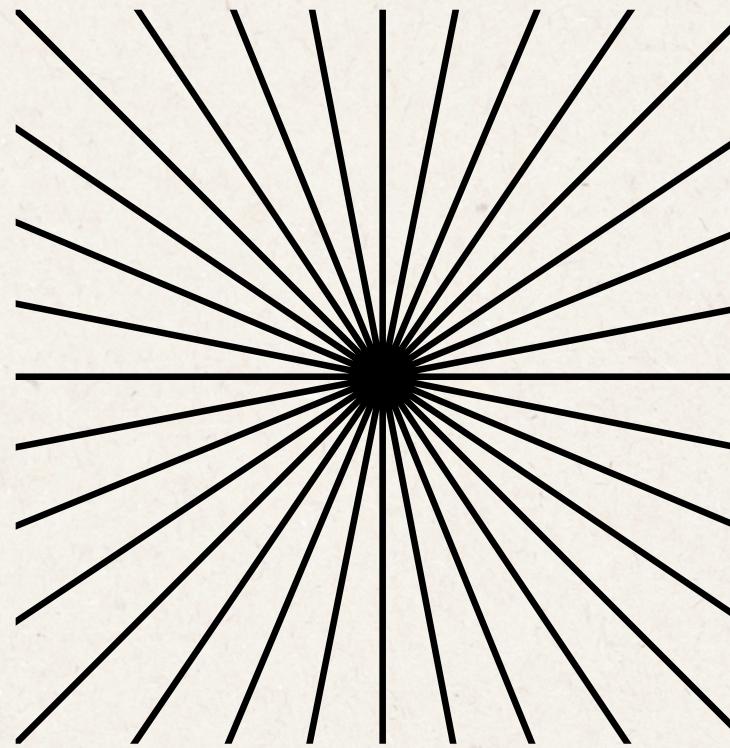
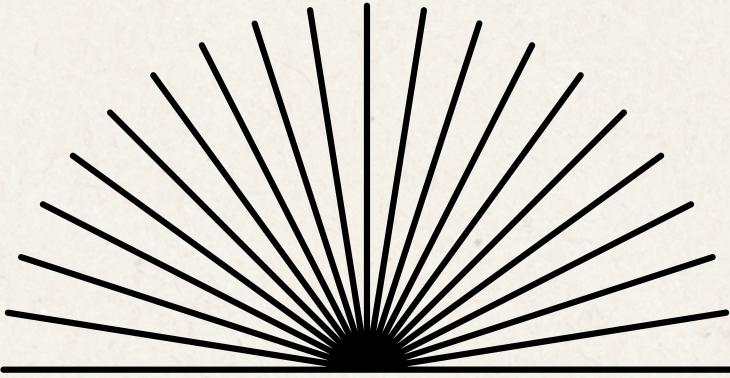
Seasonality Analysis

- Average sales vary significantly across different quarters, highlighting strong seasonality.
- Sales typically peak in specific quarters due to holidays, festivals, or weather changes.
- Understanding seasonality helps in planning marketing campaigns and inventory stocking.
- Seasonal adjustments improve model accuracy by capturing recurring sales patterns.
- Enables businesses to allocate resources efficiently during high-demand periods.



Conclusion & Future Work

- Developed AI models that accurately forecast product demand using enriched data features.
- Gradient Boosting model provided the best performance among tested algorithms.
- Feature and seasonality analysis offer actionable insights for business decisions.
- Future enhancements: integrating real-time data (e.g., social media sentiment), applying deep learning models like LSTM.
- Potential to develop interactive dashboards for dynamic demand monitoring and alerts.



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