Supply Chain Analysis

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Our Team

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Supply Chain Analysis

Make informed strategic decisions for inventory management, order fulfillment, and customer service.

Demand Prediction

Optimize Inventory Management

Improve Production Planning

Reduce Lead Times

Impact on Sustainability

Fraud Detection

Prevent Financial Loss

Preserve Brand Reputation

Improve Operational Efficiency

Enhance Customer Confidence

Fraud Order Clustering

Mitigate Potential Risk

Adapt Fraud Prevention Strategies

Stramline investigation Process

Dataset Overview

We obtained this dataset from Kaggle, and it's originally sourced from the company DataCo Global.

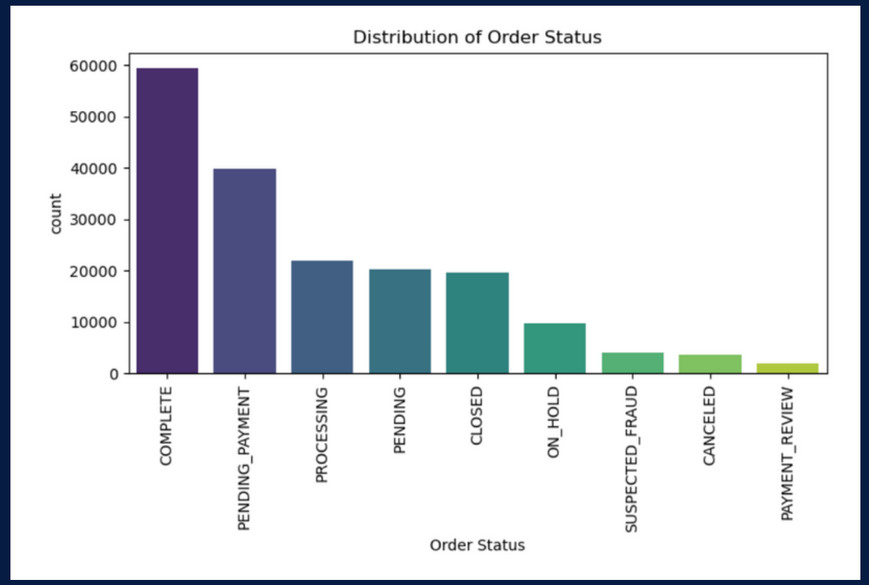
SupplyChainDataset

(180,519 rows, 53 columns)

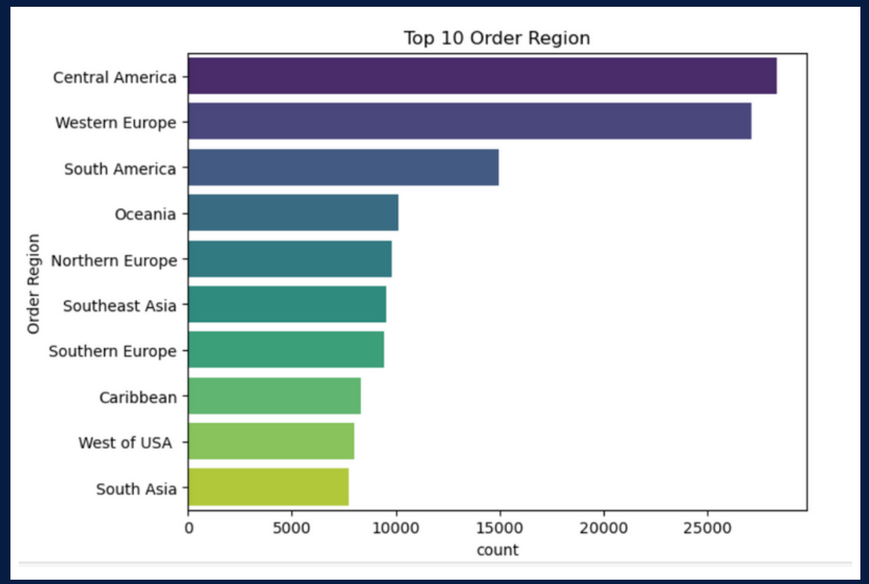
Contains order transaction records, customer data, product information, and logistics.

Key variables: order IDs, product categories, quantities ordered, customer locations, payment methods, and much more.

20,652	65,752	118
Customers	Orders	Products



Order status distribution- healthy completion rate

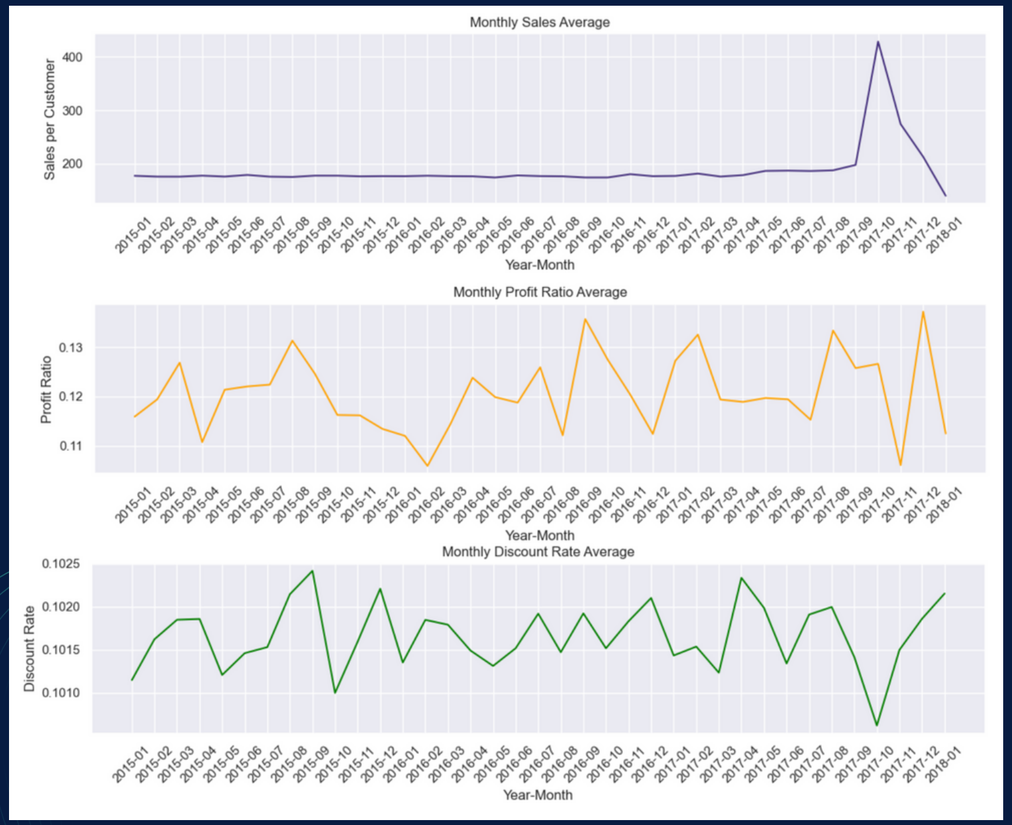


Regional sales volume- Central America a strong market

For:
Strategic planning
Targeting areas for market penetration
Managing fraud prevention measures

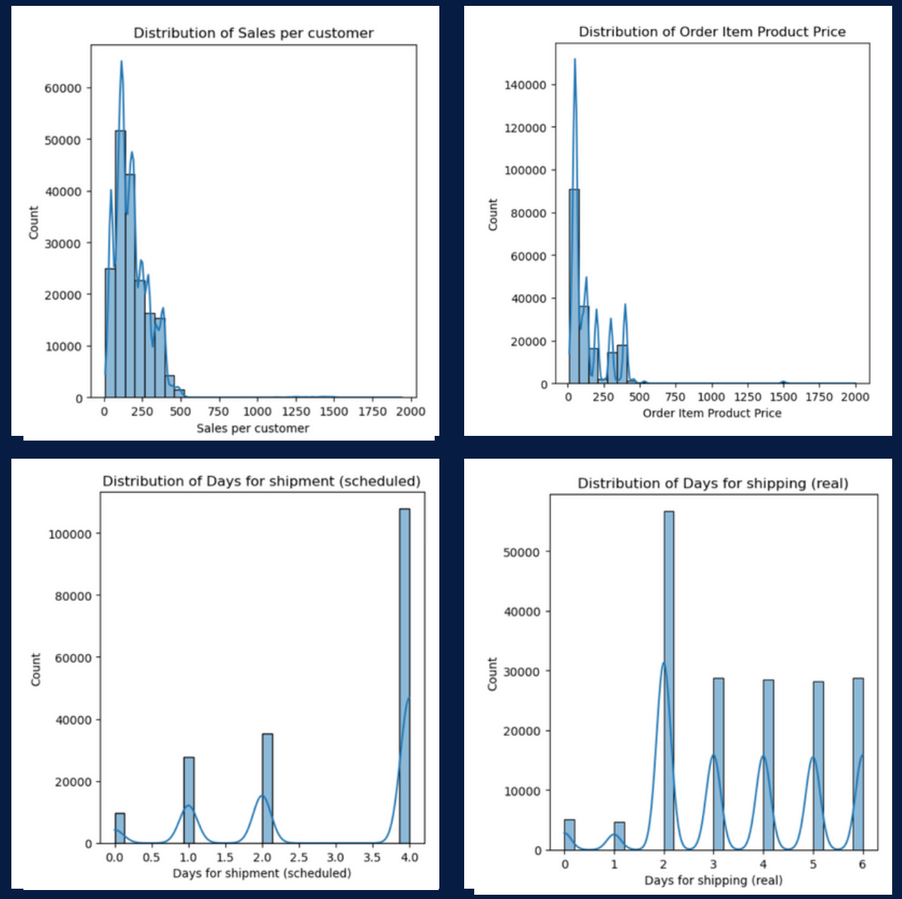
Exploratory Data Analysis

Monthly Business Performance Metrics



- Sales per customer are stable, with an exceptional increase in Oct 2017
- The profit ratio follows a seasonal trends, could be the result of business activities like promotions, changes in cost structure.
- Discount rates vary significantly, suggesting active promotional or pricing adjustments.

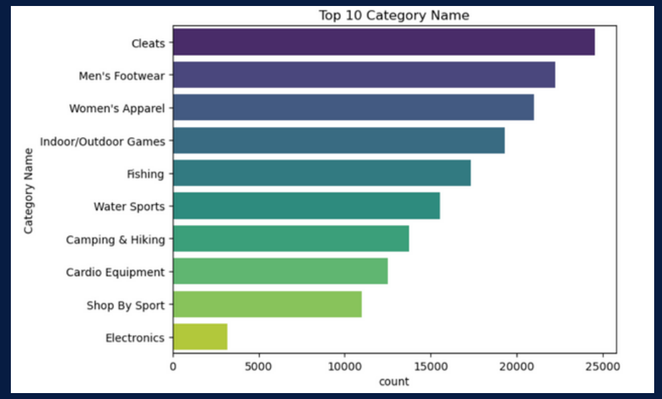
Overview of Customer Sales and Shipping Dynamics



- Sales per customer and order item prices are skewed towards lower values, business model may focus on high volume sales of lower-priced items.
- The discrepancy between the scheduled and actual shipping times might suggest inefficiencies or unexpected delays in the shipping process.

Exploratory Data Analysis

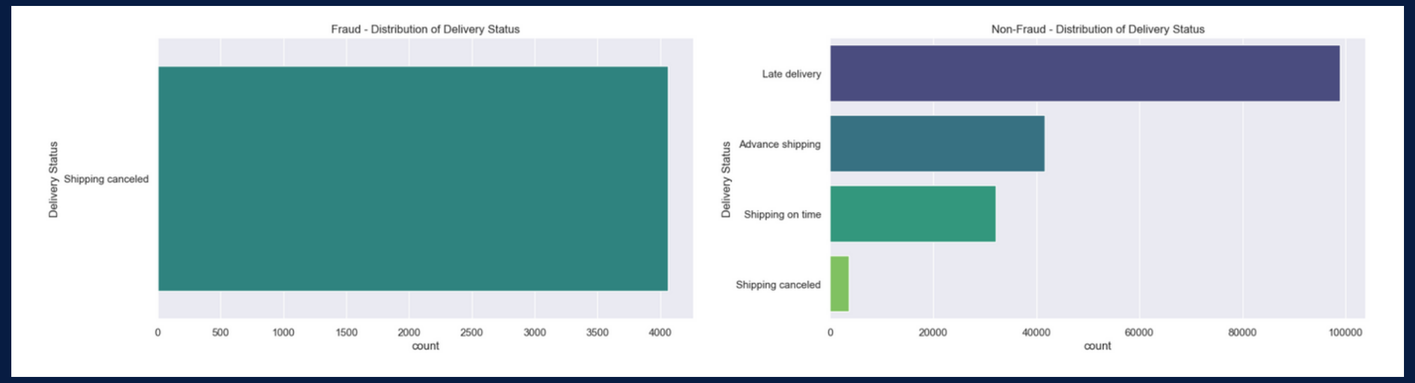
Product Category & Customer Segment



- Popular categories: sports apparel and equipment, less popular: electronics
- The 'Consumer' segment is predominant, which may influence marketing strategies, product offerings, and sales efforts.

Fraud Order v.s. Non-Fraud Order

Please visit our github for more detailed analysis!



- 'TRANSFER' is a common transaction type in fraudulent activities, whereas 'DEBIT' is the most common type for non-fraudulent transactions.
- Fraudulent transactions predominantly result in 'Shipping canceled', which is a logical step to mitigate loss due to fraud; Non-fraudulent transactions are mostly 'Late delivery'

Scenario Overview

Demand Prediction

Aggregation to get predictors and target
X: sales, shipping days, product price...
y: monthly order quantity

Data Preprocessing
Missing values, Feature Engineering, One hot encoding, Standardization

Feauture Selection
By Random Forest

Model and Hyperparameter Tuning
LSTM, RF, GB, LR

Fraud Detection

Data Preprocessing
Feature Engineering, Label encoding, Standardization

Handle Imbalanced Dataset
Oversampling fraudulent orders

Feature Selection
By Recursive Feature Elimination (RFE)
Selected features: type, order hour, latitude..

Model and Hyperparameter Tuning
Ensemble methods-voting (LR, RF, SVM)
XGBoost, LightGBM

Fraud Order Clustering

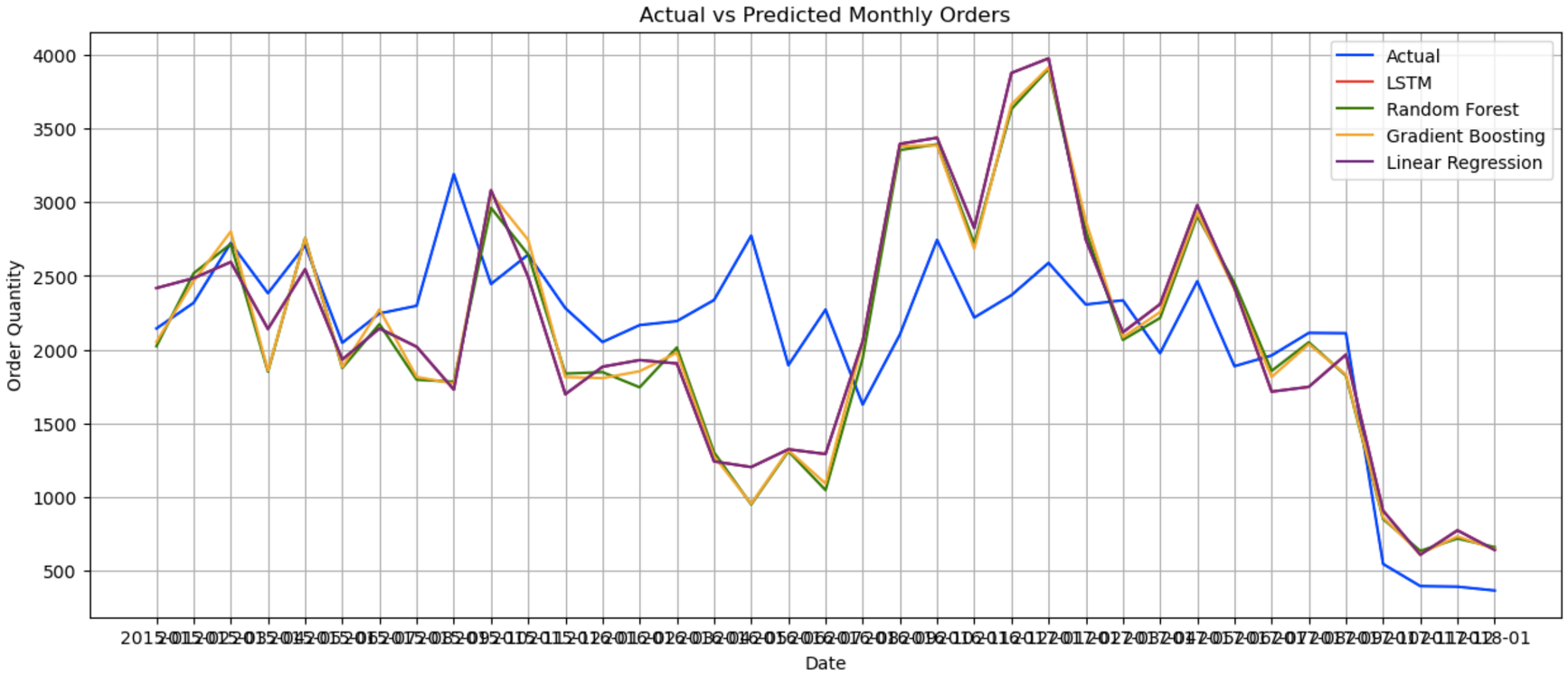
Data Preprocessing
Filter fraud, Drop unary variables and correlated features, one hot, Standardization

Decide the number of clusters
Calculate inertia

KMeans Clustering
Inverse transform the cluster centroids and visualize features of each cluster

DBSCAN
Obtain 6 clusters and identify the noise

Demand Prediction - Results



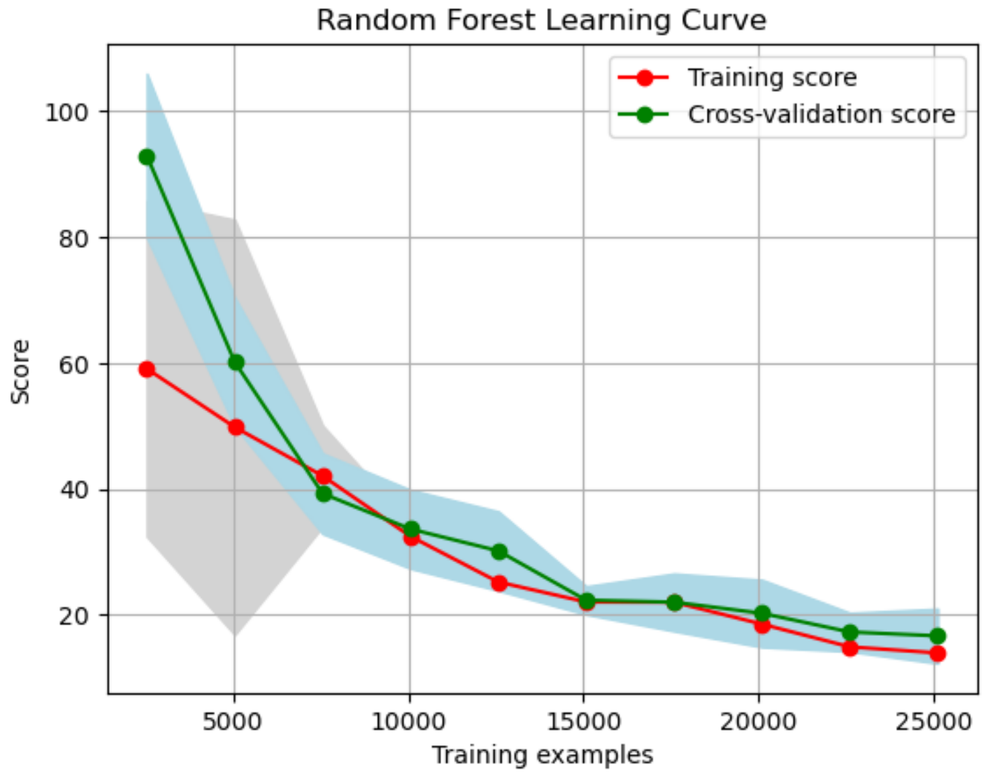
Model	MSE	MAE
LSTM	128.06	4.7
RF	19.42	**0.48**
GB	**9.05**	1.08
LR	132.55	4.7

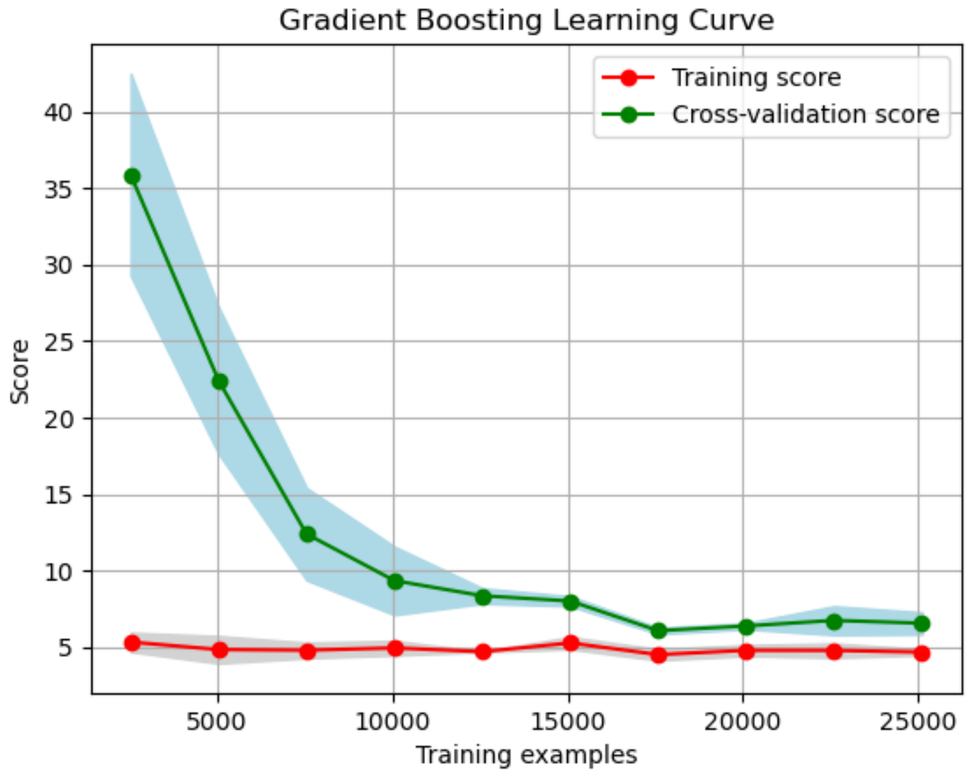
Random Forest and Gradient Boosting Hyperparameters

- the number of trees: 30, 50, 70, **90**
- maximum number of features when splitting a node: 5, 10, 15, **20**, square root, log2
- mininum number of samples to split: 1, **50**, 100, 150, 200

- **Random Forest** has the smallest **MAE**
- **Gradient Boosting** has the smallest **MSE**

Demand Prediction - Results





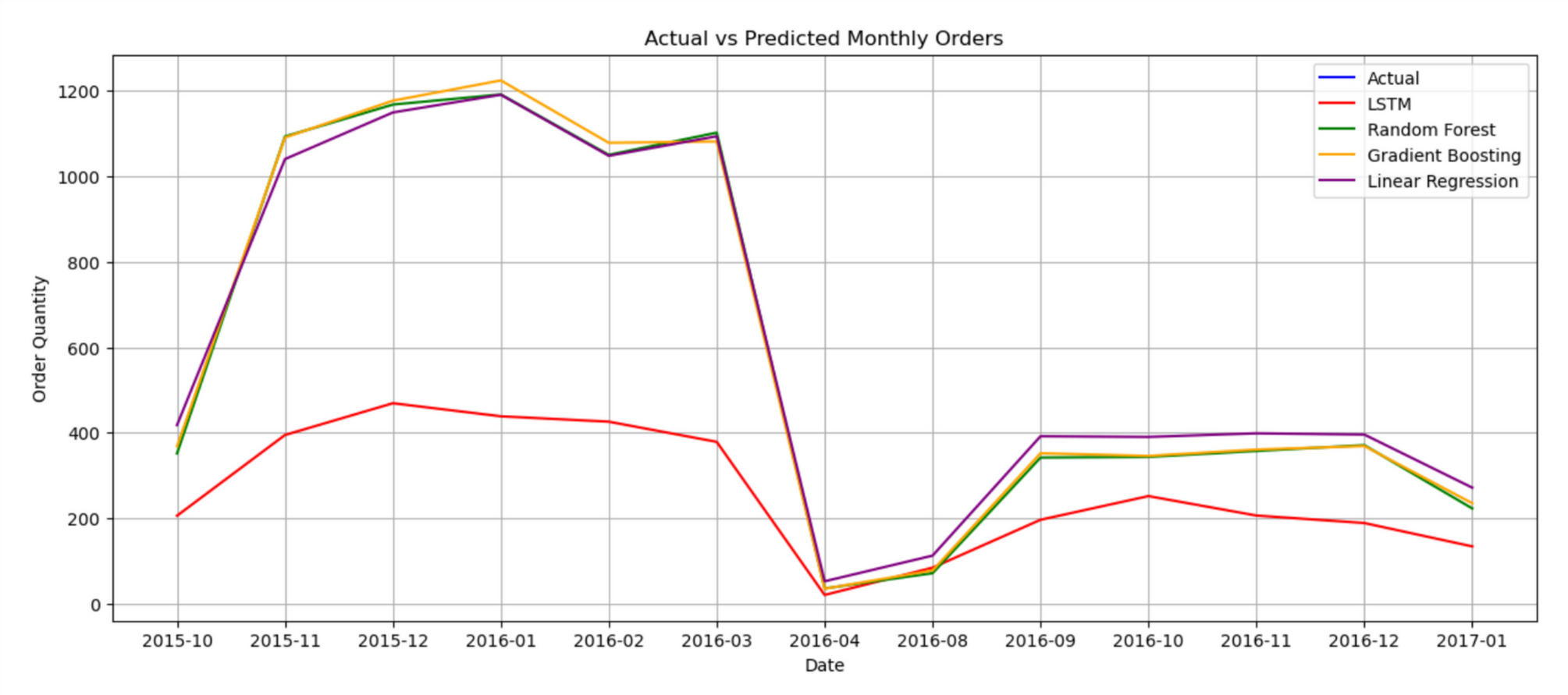
Random Forest and Gradient Boosting Learning Curves

- The training and validation curves in both models converge at a low error rate (neg_mean_squared_error). Error rates are lower for Gradient Boosting, proving better performance.
- Both models approaches performance limits after 15000 training examples, but the Gradient Boosting model reaches a better performance plateau.

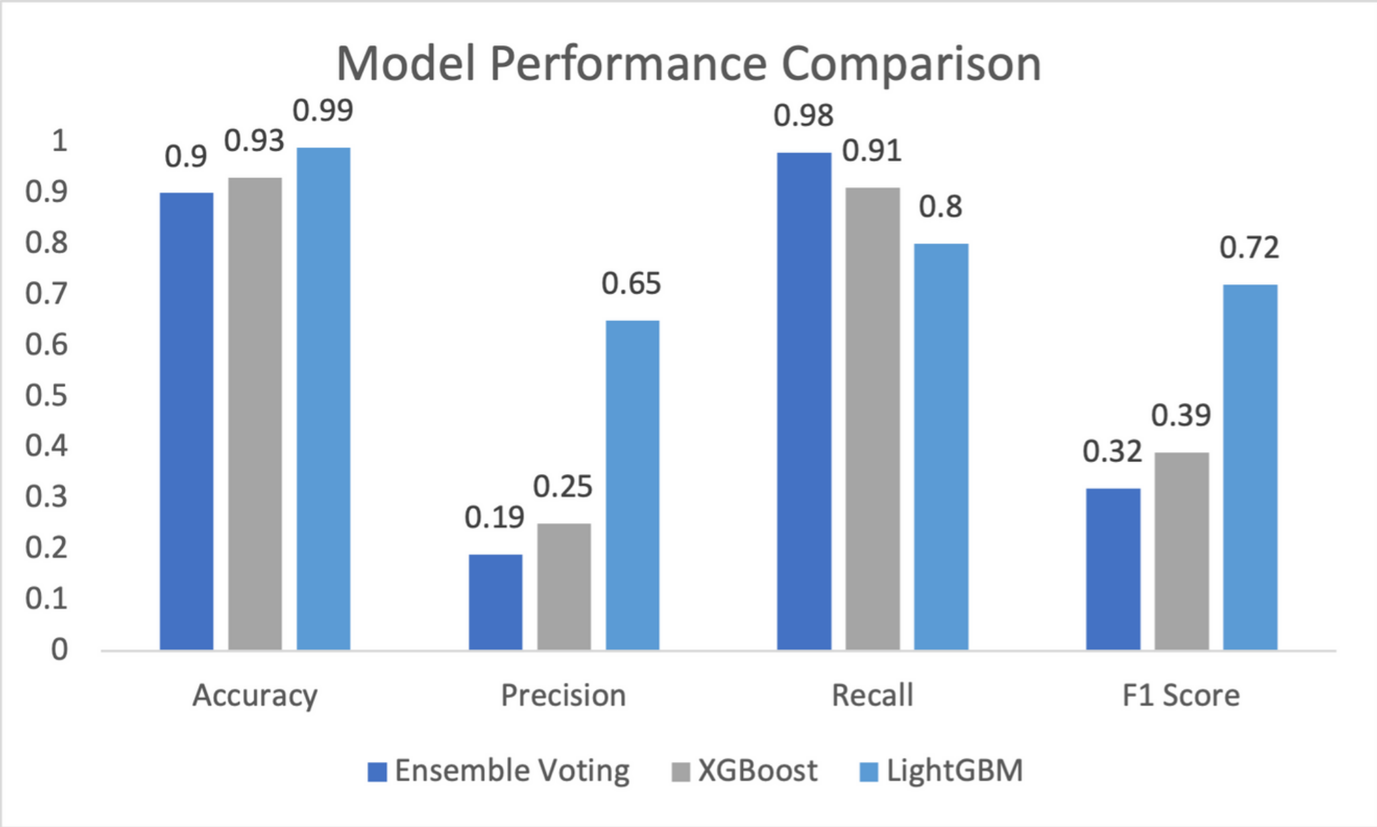
Demand Prediction Application

The models can be used to predict demand for specific product category and region

Product: Cardio Equipment **Region: Pacific Asia**



Fraud Detection – Results



XGBoost Hyperparameters

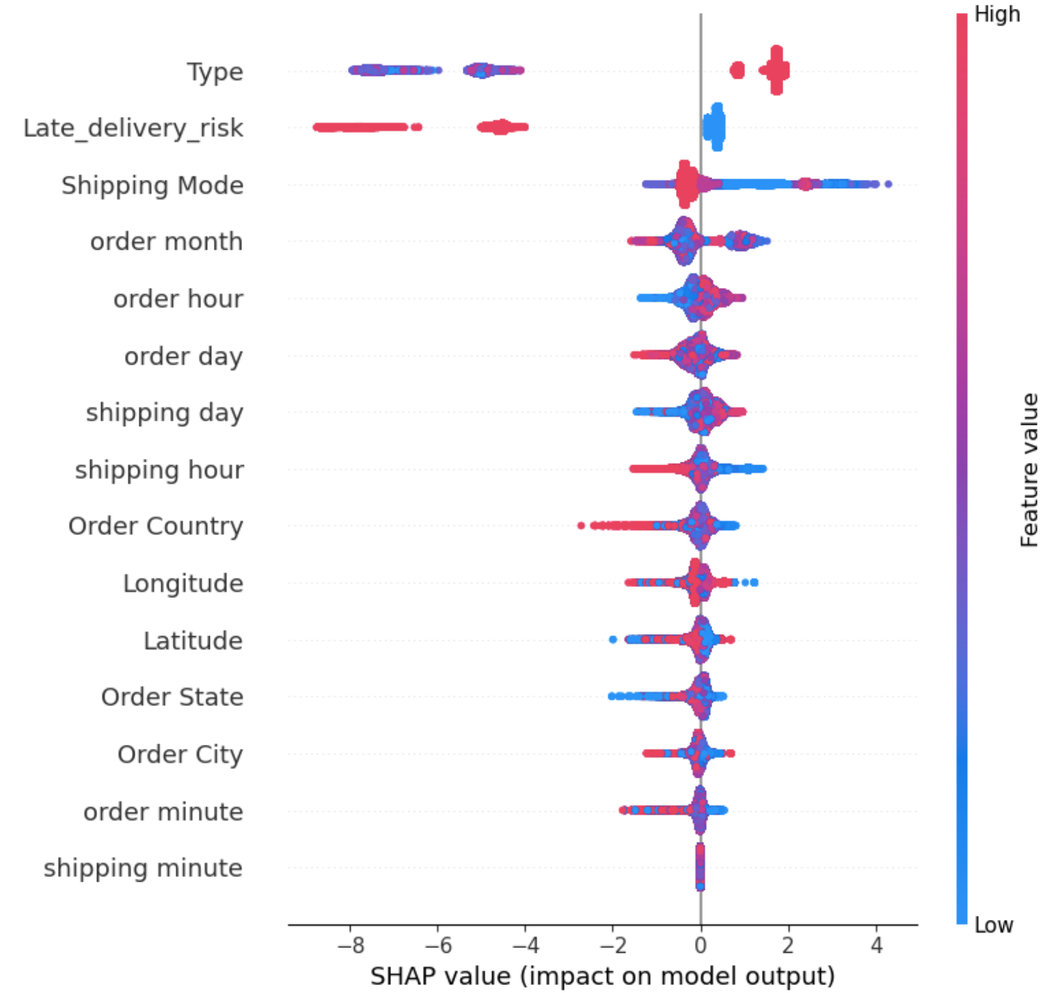
- maximum depth of a tree: 3, 4, **5**
- learning rate: **0.1**, 0.01
- the number of trees: 100, **200**

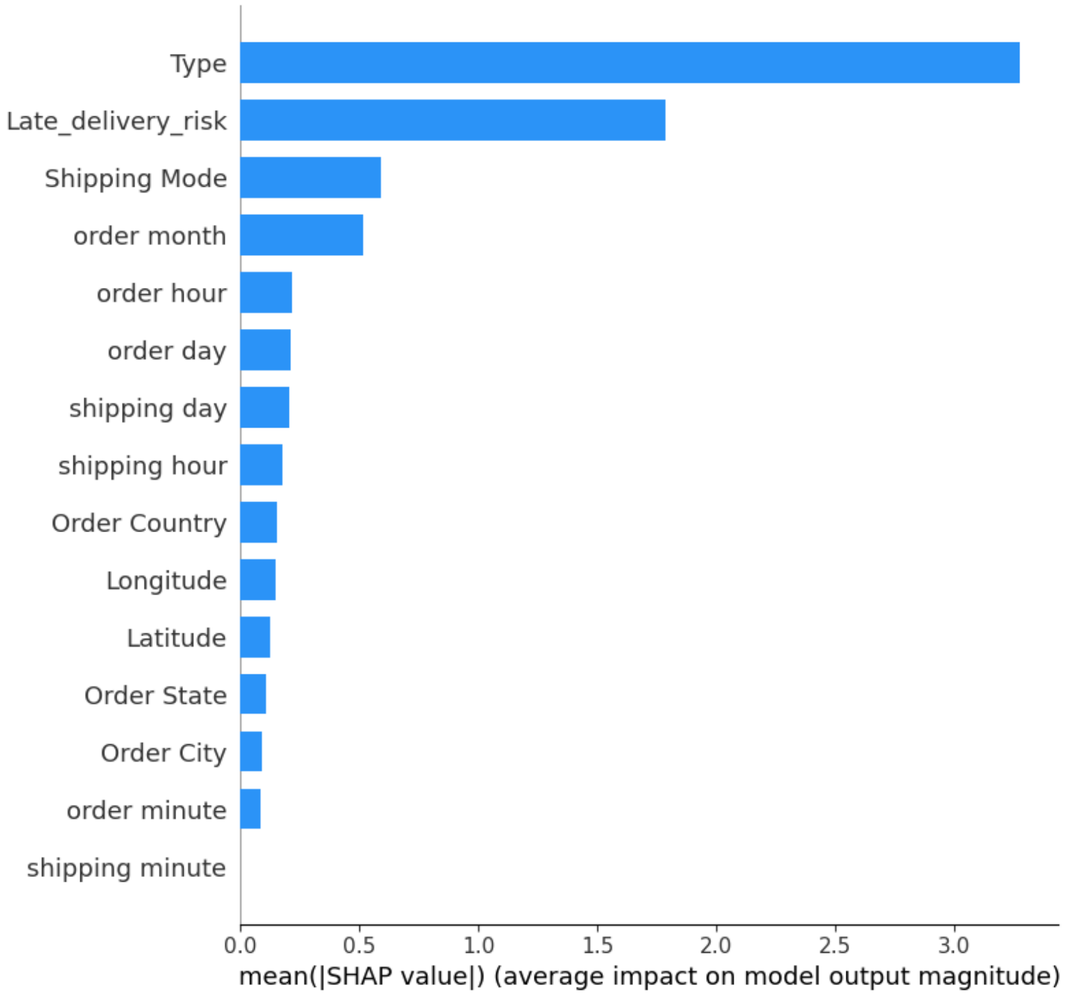
LightGBM Hyperparameters

- maximum number of leaves: 31, **50**
- learning rate: **0.1**, 0.01
- the number of trees: 100, **200**

- **LightGBM has the highest accuracy (0.99), precision (0.65)** and **f1 score (0.72)**
- Ensemble voting (from LR, RF, SVM) has the highest recall (0.98)
- Flagging real customer orders as fraudulent orders (false positive) damages the customer-business relationship, **prioritize precision**!

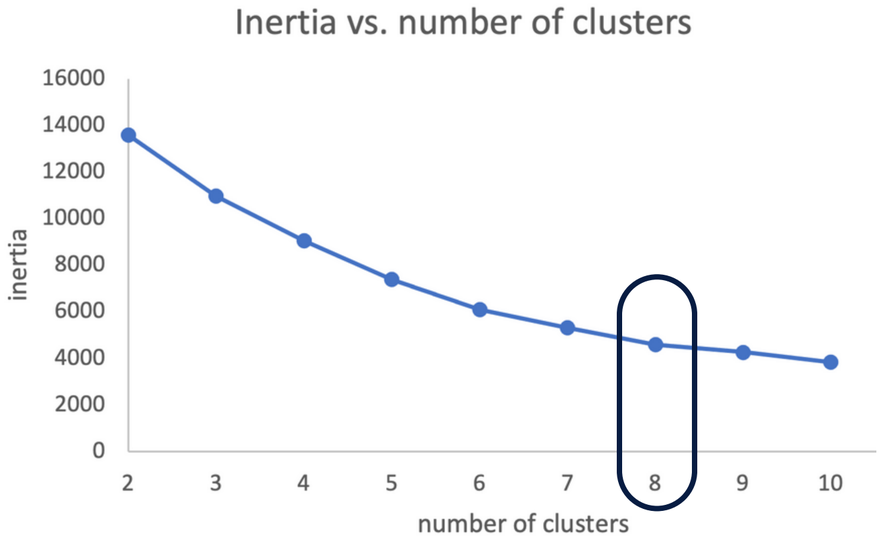
Fraud Detection – Feature Importance





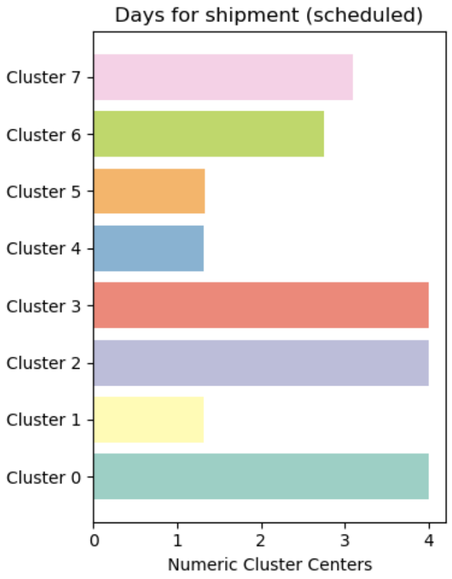
Type of transaction (debit, transfer, payment, cash), **late delivery risk, shipping mode** (standard, second, first, same day), **order month** are important features detecting fraudulent orders

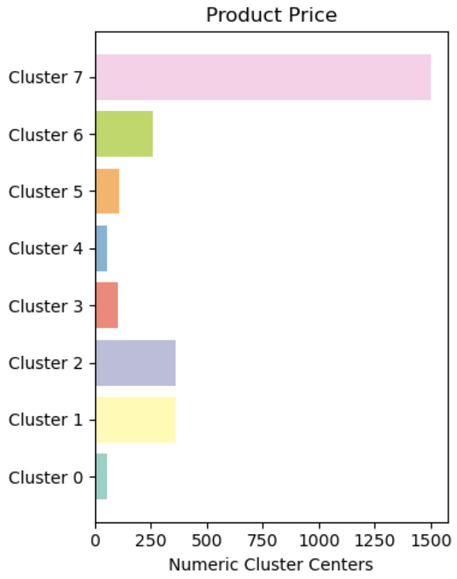
Fraud Order Clustering

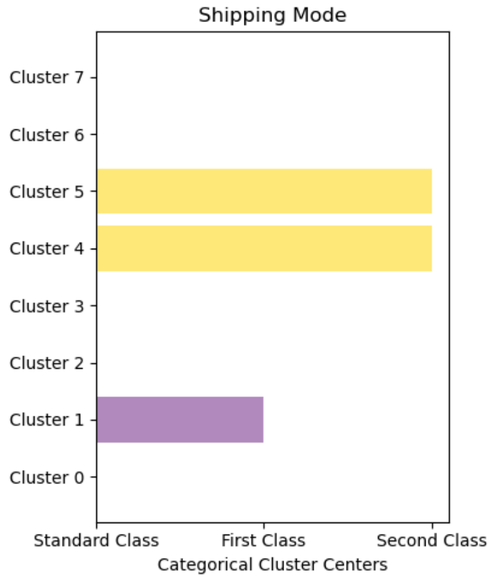


Two Representative Clusters

- quick delivery, low quantity, low profit, second class shipment
- moderate quantity, negative profit, moderate price, standard shipment







Summary

Exploratory Data Analysis

- Discrepancy in scheduled vs. actual shipping times suggests process inefficiencies
- Type of transaction - transfer is common in fraud, debit is common in non-fraud
- Fraudulent transactions often result in shipping canceled while non-fraud transactions frequently face late delivery, indicating logistics or inventory issues.

Demand Prediction

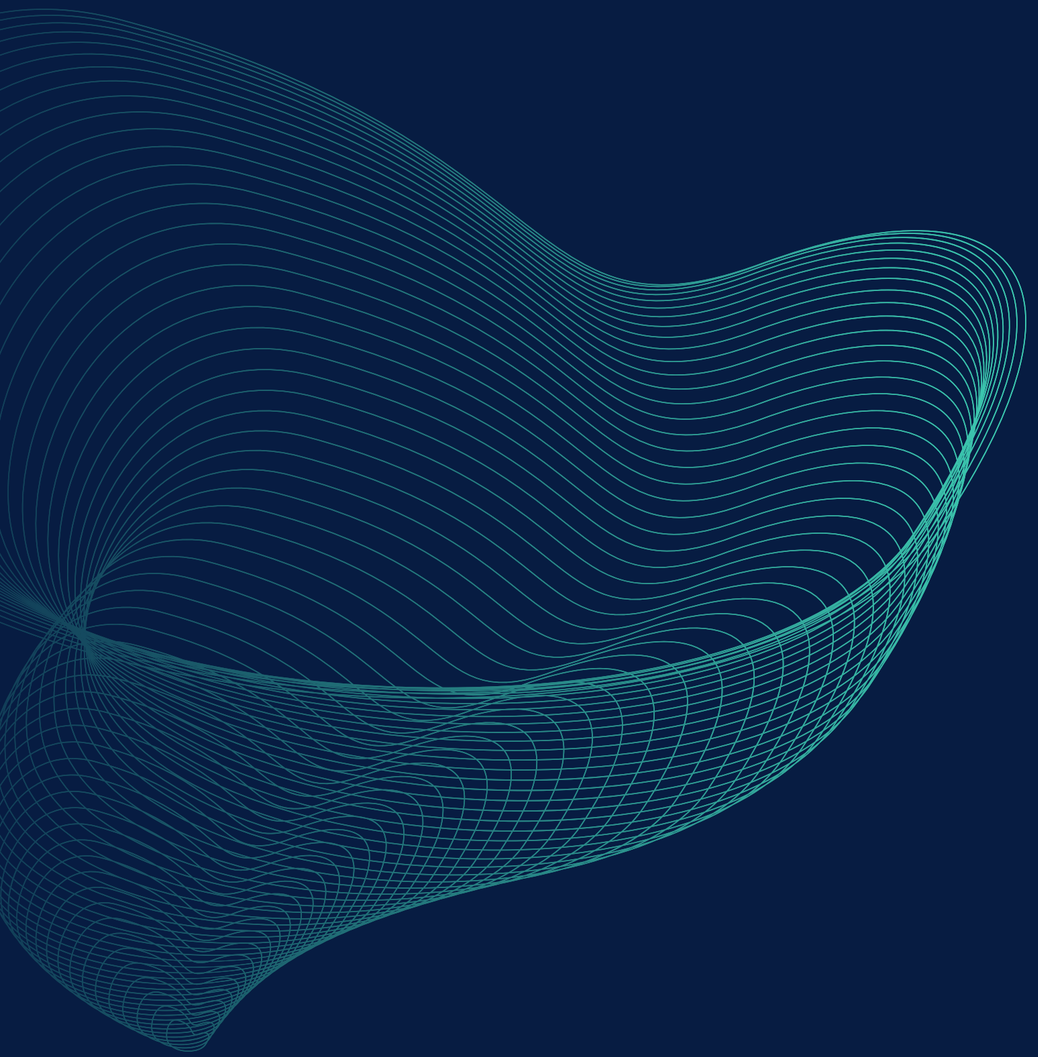
- Gradient Boosting performed the best among 4 models with MSE equal 9.05
- The prediction model can be used to predict demand for specific product category and region
- Accurate prediction can help product planning and improve inventory management

Fraud Detection

- LightGBM had an accuracy of 0.99 and a precision of 0.65, which performed best among 3 models
- Type of transaction, late delivery risk, shipping mode, order month are important features detecting fraud
- Fraud detection prevents financial loss, and further improve the prediction of demand prediction

Fraud Order Clustering

- KMeans clustering divided fraudulent orders to 8 clusters while DBSCAN to 6 clusters
- By clustering, we can analyze the patterns of fraud orders. While fraudsters constantly evolve their strategies to bypass detection mechanisms, the model can adapt to new patterns by updating the model with new data



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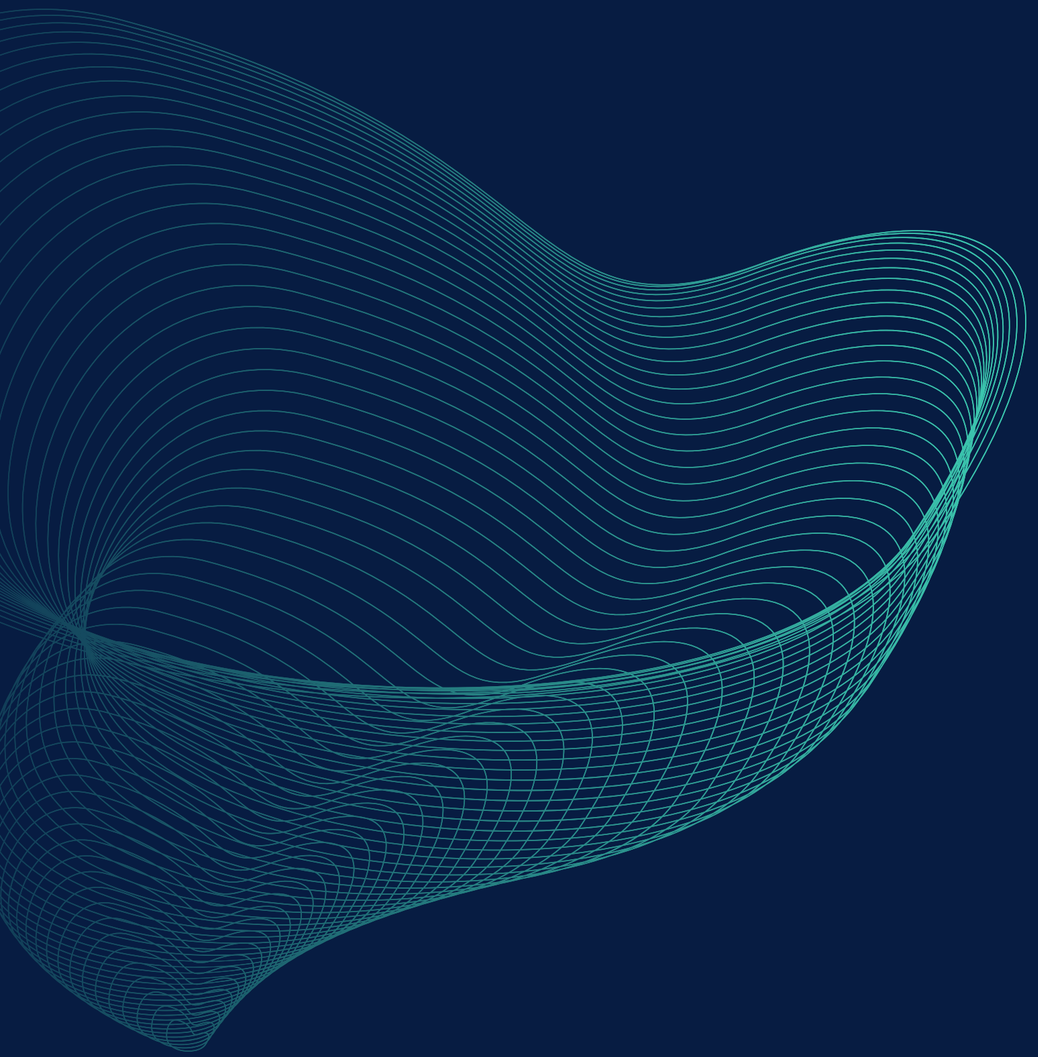

Github

Repository: DataCo_Supply_Chain

https://github.com/McGill-MMA-EnterpriseAnalytics/DataCo_Supply_Chain/tree/main

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