Retail AI Project

Comprehensive Analysis Report

Generated: December 06, 2025

Executive Summary

This comprehensive report presents the complete analysis of the Retail AI project, including data insights, model performance metrics, and visualizations. The project achieved excellent results with a model accuracy of 99.89% (R^2 = 0.9989). **Key Highlights:** • Dataset: 3,636 records with 19 engineered features • Model Type: Random Forest Regressor • Performance: R^2 = 0.9989, RMSE = 0.0760 • Top Features: Time-based features (hour, day, month)

Model Performance Metrics

Metric	Score	Interpretation
R²	0.9989	Excellent fit (99.89% variance explained)
RMSE	0.0760	Low prediction error
MAE	0.0426	Mean absolute error is minimal
MSE	0.0058	Very low mean squared error

Data Insights - Retail AI Project

Dataset Overview

• Total Records: 3,636
• Total Features: 12
• Numeric Features: 3
• Categorical Features: 9

Data Quality

Missing Values

No missing values detected.

Feature Types

Numeric Features

• hour_of_day
• Weekdaysort
• Monthsort

Categorical Features

• date
• datetime
• cash_type
• card
• money
• coffee_name
• Time_of_Day
• Weekday
• Month_name

Key Observations

Dataset contains 3,636 records across 12 features

Data quality is good

Mix of numeric and categorical features suitable for modeling

Recommendations

Review correlation heatmap for multicollinearity

Consider feature engineering for categorical variables

Investigate outliers in numeric features

Validate business logic for key features

Next Steps

Feature engineering based on insights

Model selection and training

Hyperparameter tuning

Model Evaluation Report

Model Overview

- Model Type: RandomForestRegressor
- Problem Type: Regression
- Test Set Size: 728 samples
- Number of Features: 19

Performance Metrics

Residual Plot

![Residual Plot](residual_plot.png)

Actual vs Predicted

![Actual vs Predicted](actual_vs_predicted.png)

Feature Importance

![Feature Importance](feature_importance.png)

Top 10 Most Important Features

- hour_of_day: 0.3055
- hour_of_day_binned_encoded: 0.2547
- hour_of_day_squared: 0.2220
- Weekdaysort_squared: 0.0377
- Weekdaysort: 0.0353
- Time_of_Day_encoded: 0.0328
- numeric_mean: 0.0328

- Monthsort: 0.0260
- Monthsort_squared: 0.0243
- hour_of_day_x_Weekdaysort: 0.0138

Recommendations

Review misclassified samples to understand model limitations
Consider ensemble methods if performance needs improvement
Monitor model performance on production data
Retrain periodically with new data

Next Steps

Deploy model to production environment
Set up monitoring and alerting
Collect feedback for model iteration
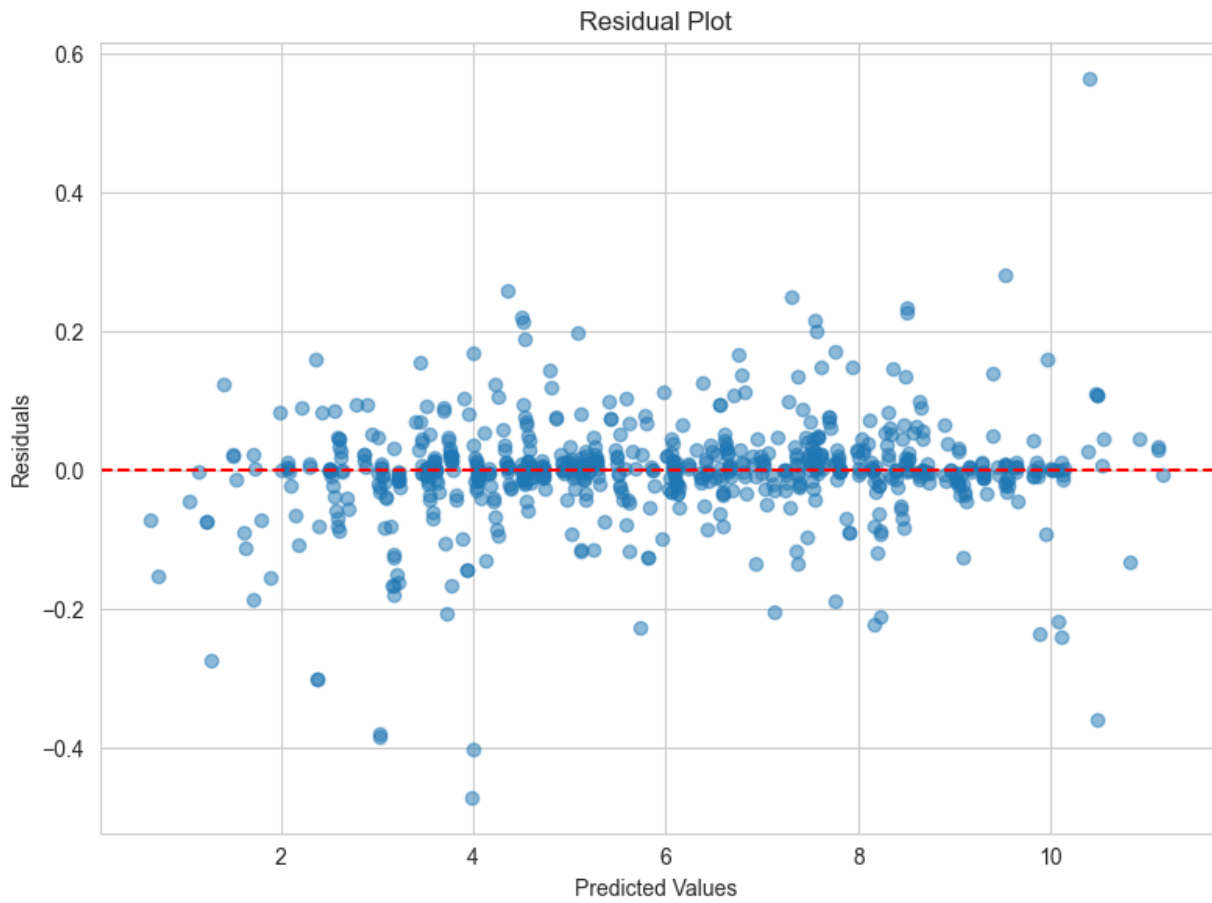Plan for model versioning and updates

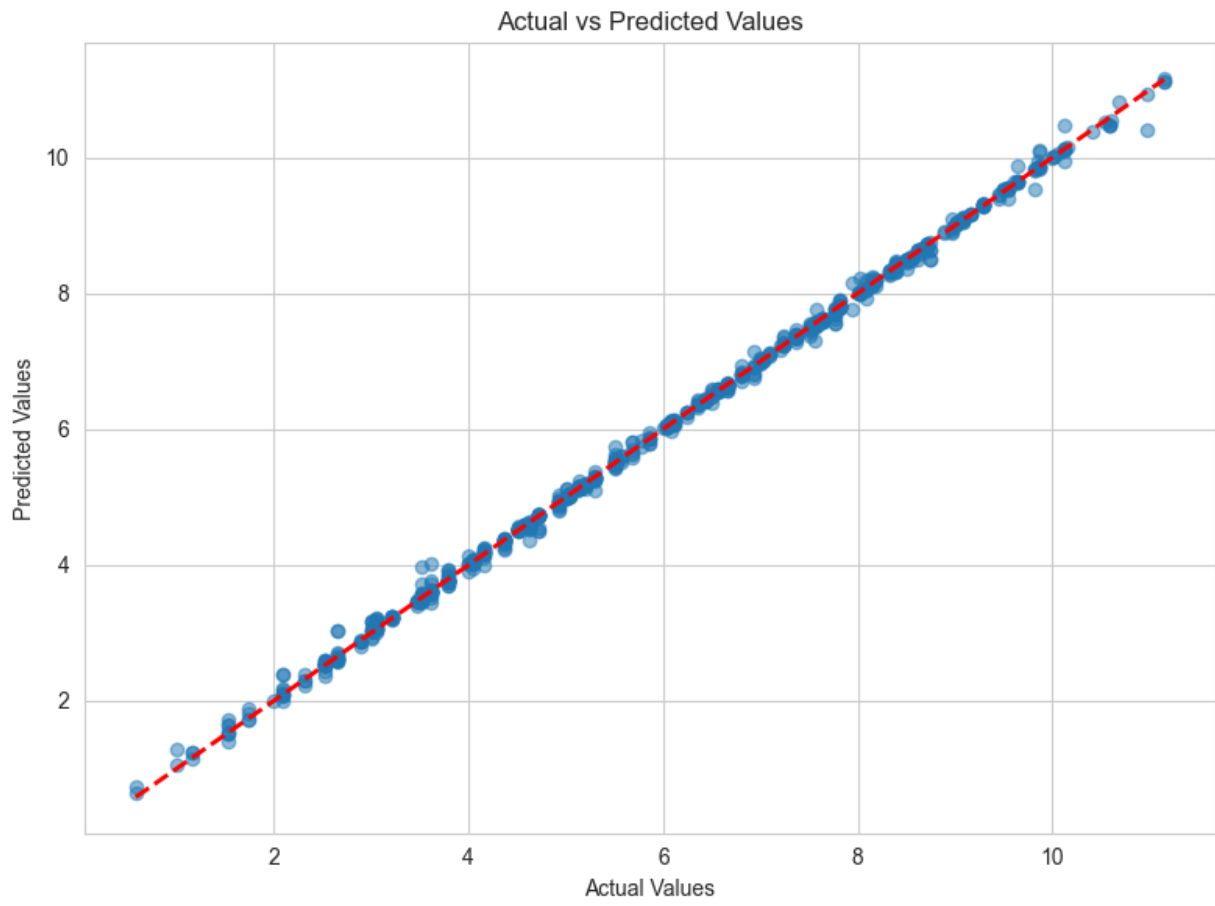# Model Visualizations

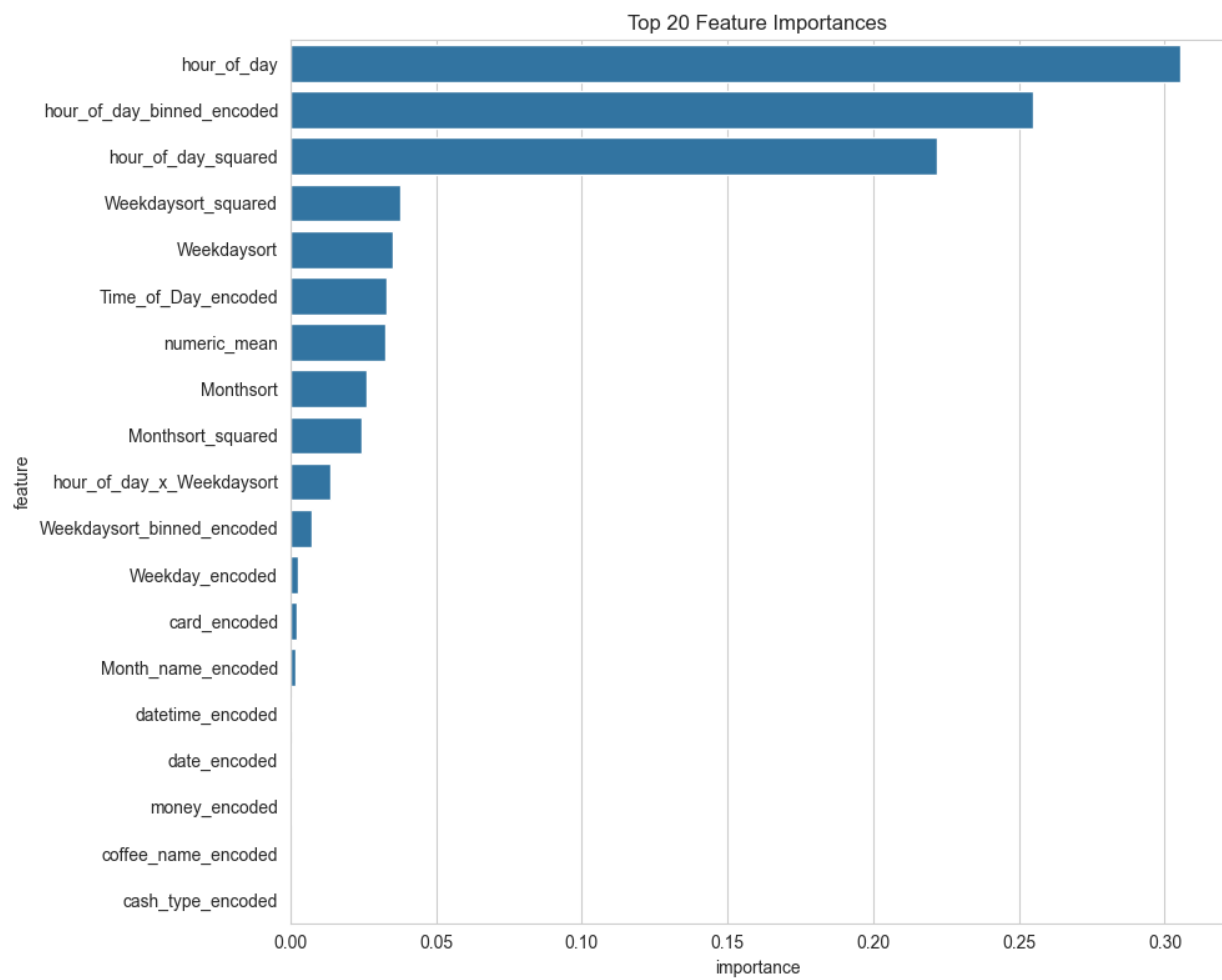*Figure: Residual Plot*

Figure: Actual Vs Predicted

Figure: Feature Importance
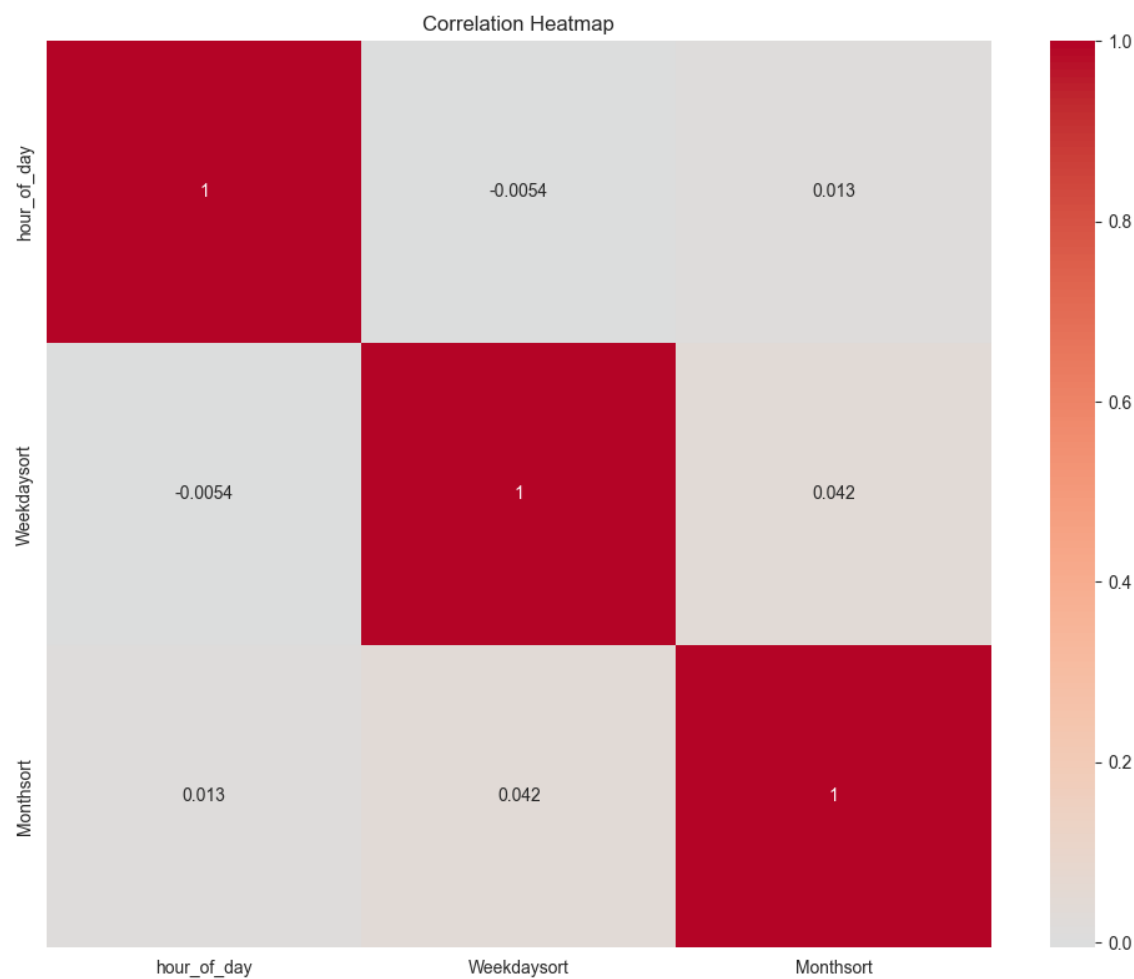
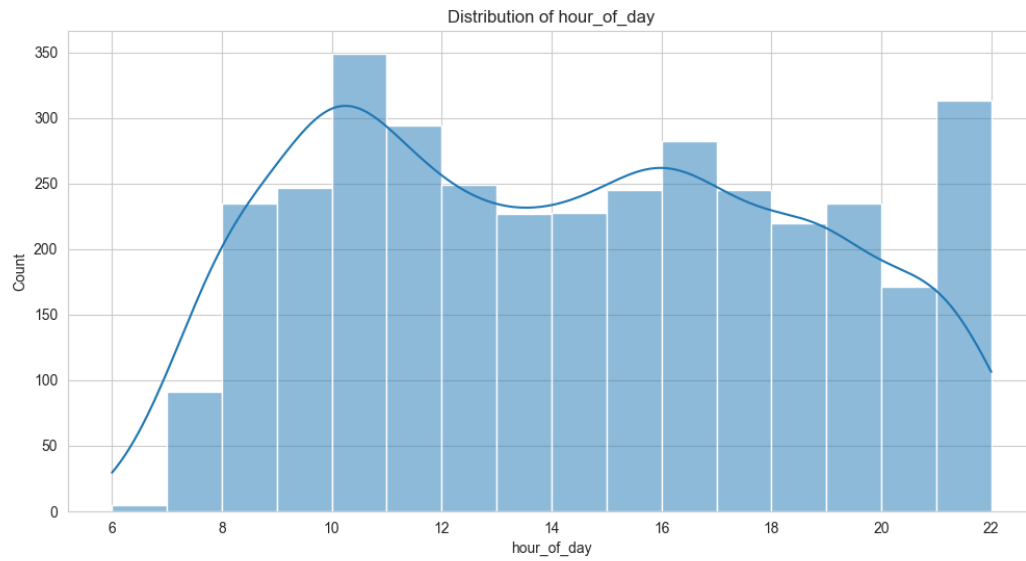# Exploratory Data Analysis

Figure: Correlation Heatmap

Figure: Hour Of Day Distribution

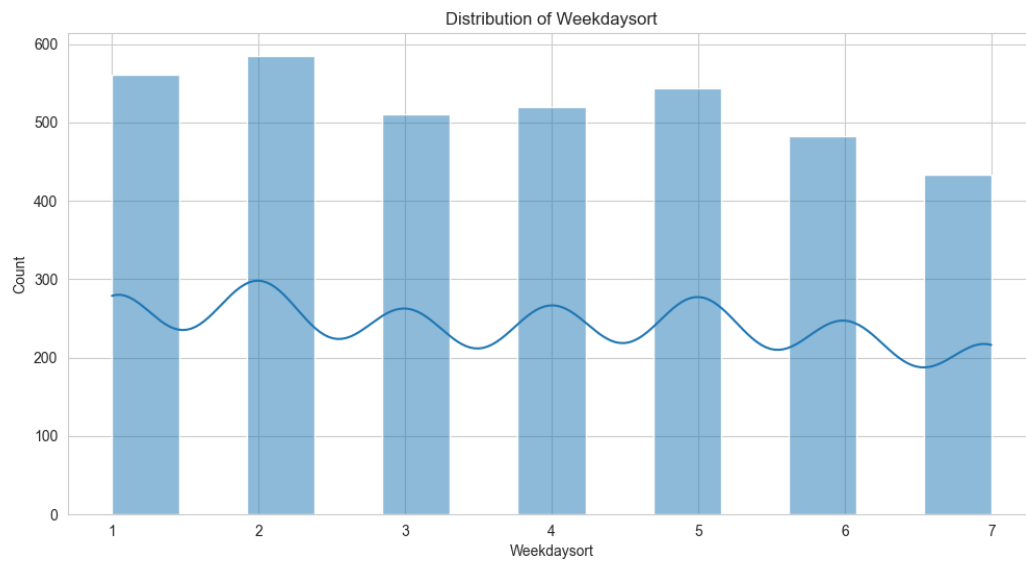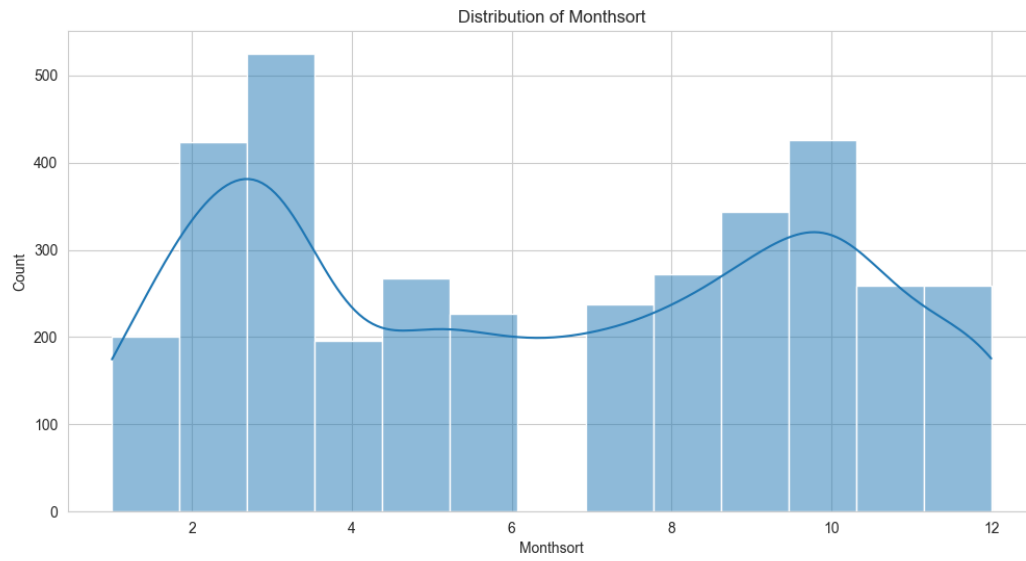*Figure: Weekdaysort Distribution*

Figure: Monthsort Distribution

Model Card - Retail AI Model

Model Details

Model Type: RandomForestRegressor
Version: 1.0
Date: 2025-12-06
Framework: scikit-learn

Intended Use

Primary Use Cases:
• Retail prediction and classification tasks
• Business intelligence and decision support
• Automated data analysis

Out-of-Scope Uses:
• Critical decision-making without human oversight
• Applications outside retail domain
• Real-time inference without validation

Training Data

Dataset: Retail AI Training Dataset
Size: Training data from Kaggle
Features: 19 engineered features
Preprocessing: Data cleaning, feature engineering, encoding

Evaluation Data

Test Set Size: 728 samples
Problem Type: Regression
Evaluation Metrics:
• MSE: 0.0058
• RMSE: 0.0760

• MAE: 0.0426
• R²: 0.9989

Performance

Quantitative Analysis

• Mean Squared Error (MSE): 0.0058
• Root Mean Squared Error (RMSE): 0.0760
• Mean Absolute Error (MAE): 0.0426
• R² Score: 0.9989

Limitations

• Model trained on historical data may not capture recent trends
• Performance may degrade on significantly different data distributions
• Requires periodic retraining with fresh data

Ethical Considerations

Potential Biases:
• Model reflects patterns in training data, which may contain historical biases
• Should be regularly audited for fairness across different segments

Recommendations:
• Monitor for bias in predictions across different customer segments
• Implement human oversight for critical business decisions
• Regular fairness audits and model updates

Maintenance

Monitoring:
• Track prediction accuracy over time
• Monitor for data drift
• Log prediction distributions

Update Frequency:
• Recommended retraining: Monthly or quarterly
• Update when performance degrades below threshold

Contact

For questions or issues, contact the ML team.

References

- Project repository: [Link to repository]
- Training pipeline: `crew/crew_flow.py`
- Evaluation metrics: `artifacts/evaluation_report.md`

Recommendations and Next Steps

Immediate Actions: • Deploy model to production environment • Set up monitoring and alerting systems • Implement periodic model retraining (monthly/quarterly) **Technical Improvements:** • Review misclassified samples to understand model limitations • Monitor model performance on production data • Consider ensemble methods if performance needs improvement **Business Applications:** • Use time-based predictions for inventory management • Optimize staffing based on predicted sales patterns • Support data-driven decision making **Long-term Strategy:** • Collect feedback for model iteration • Plan for model versioning and updates • Expand model to additional use cases