

# Retail AI Project

## Comprehensive Analysis Report

Generated: December 08, 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
R <sup>2</sup>	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

# 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 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

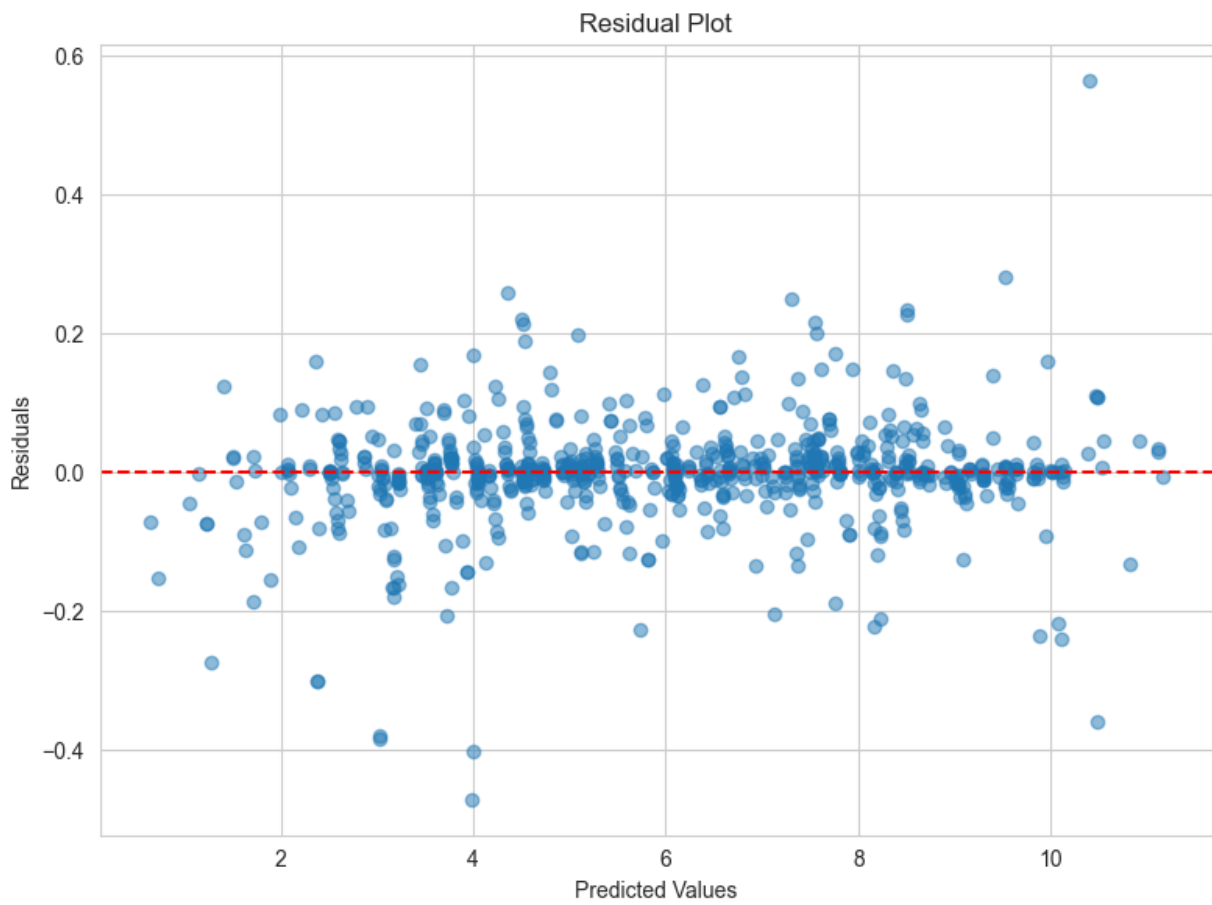


Figure: Residual Plot



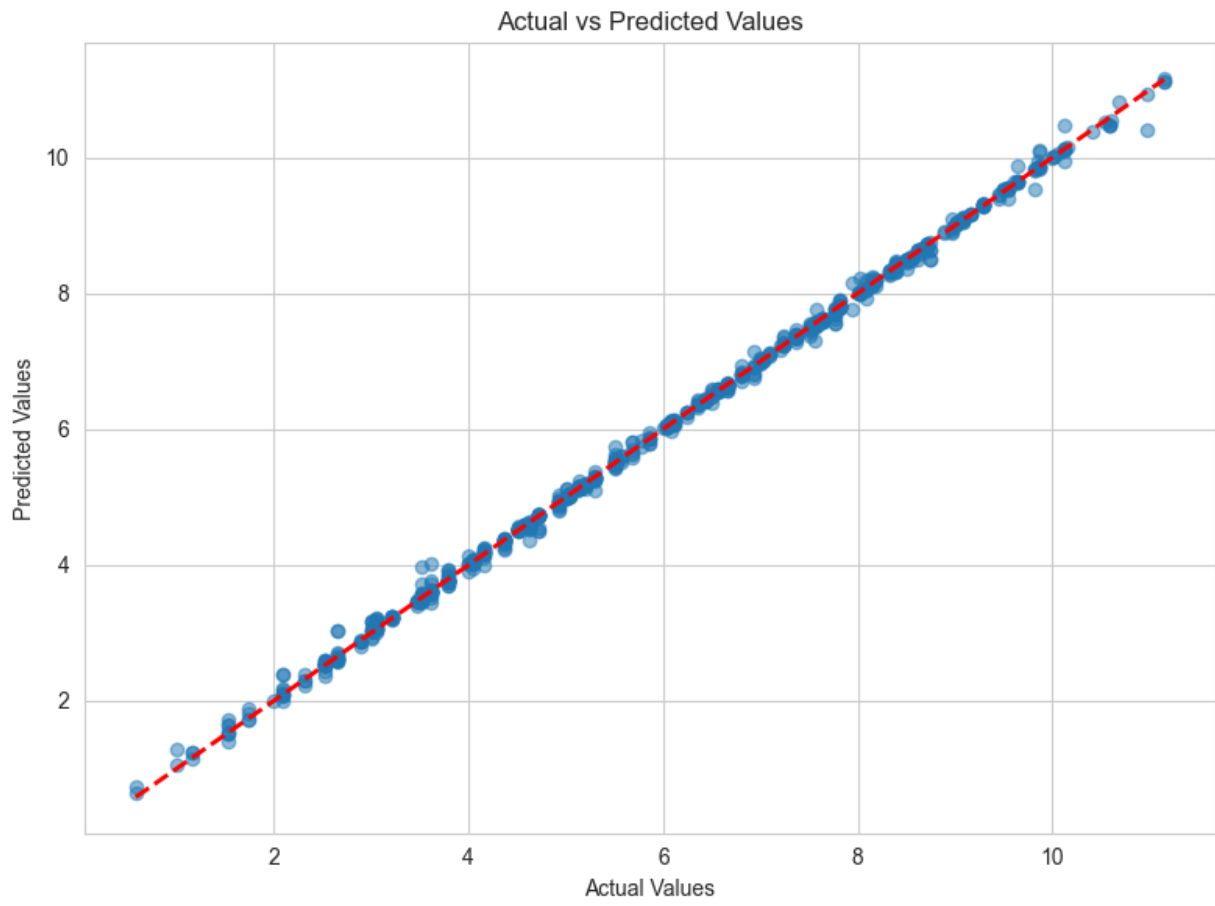
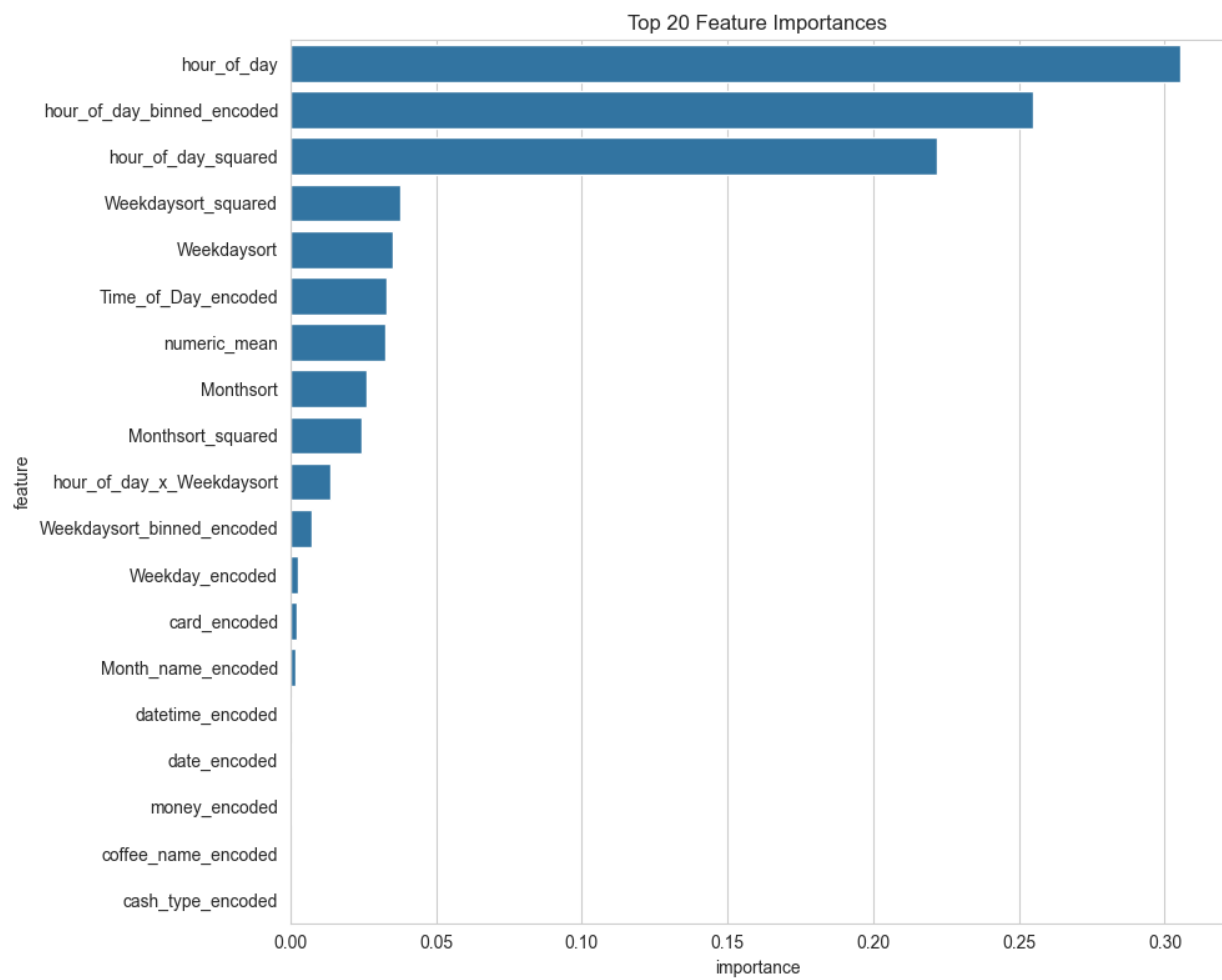


Figure: Actual Vs Predicted



*Figure: Feature Importance*

# Exploratory Data Analysis

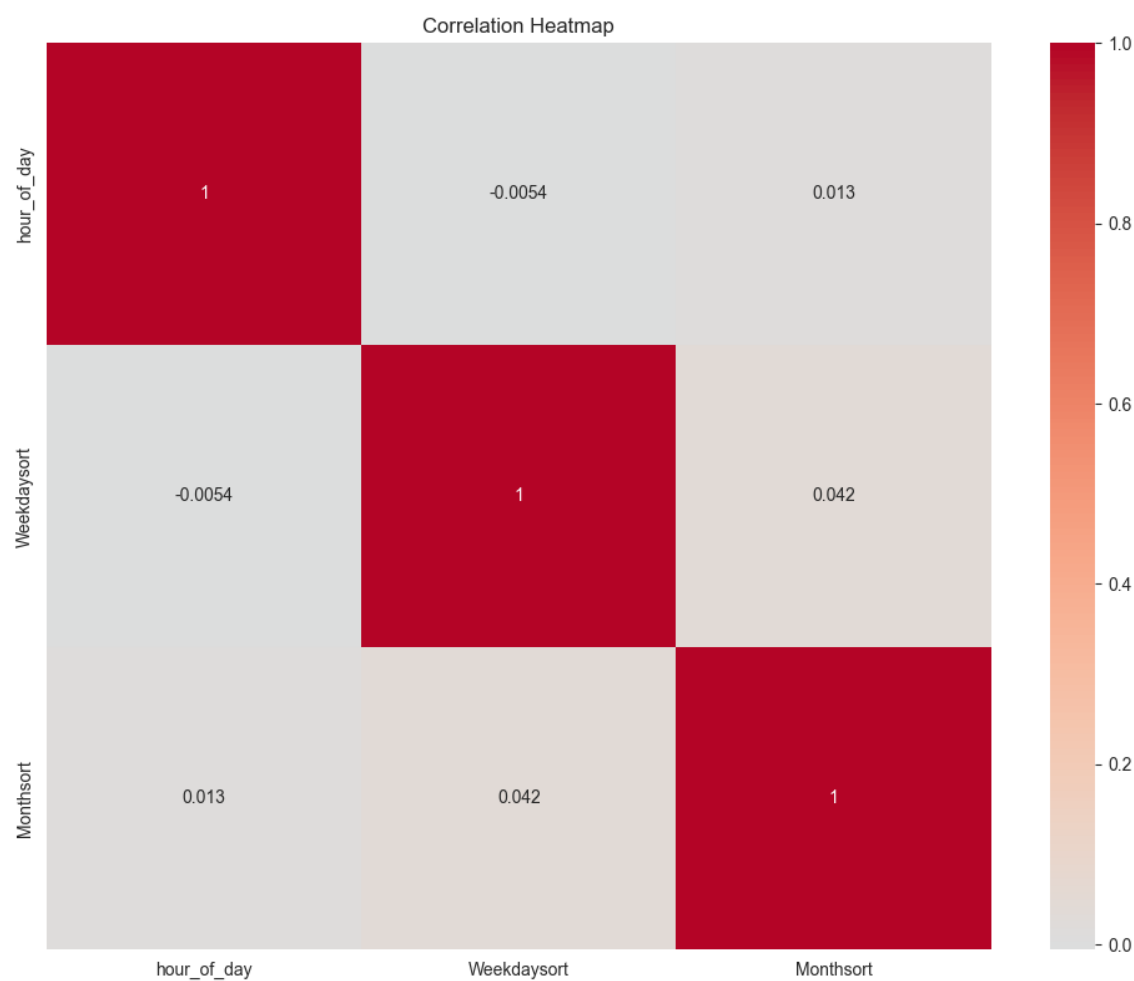


Figure: Correlation Heatmap

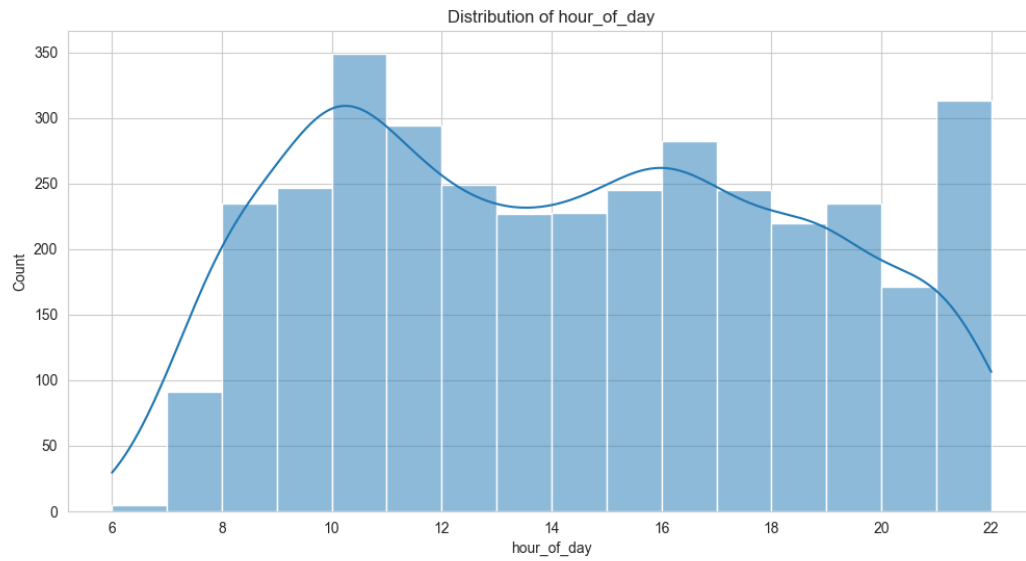


Figure: Hour Of Day Distribution

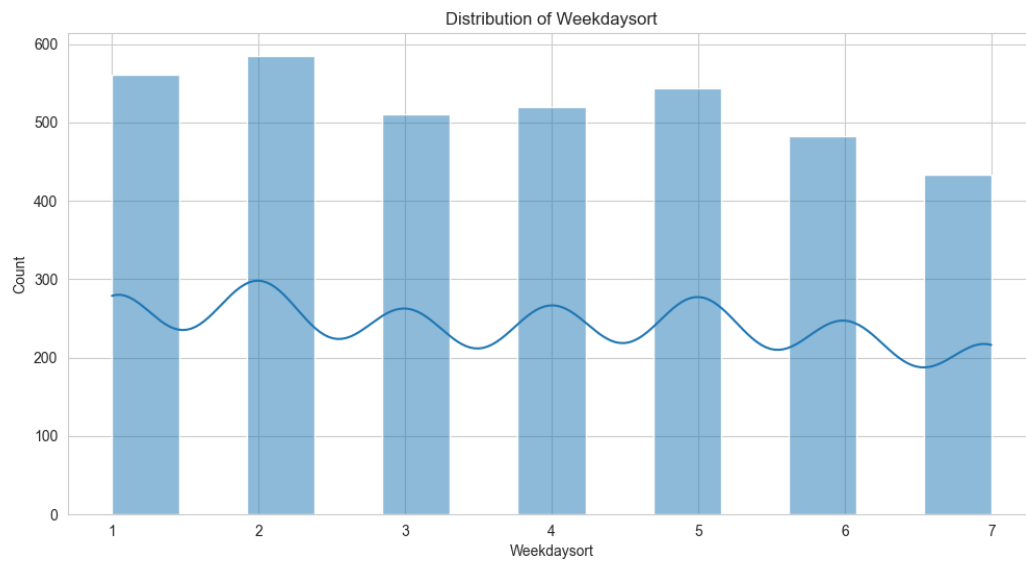
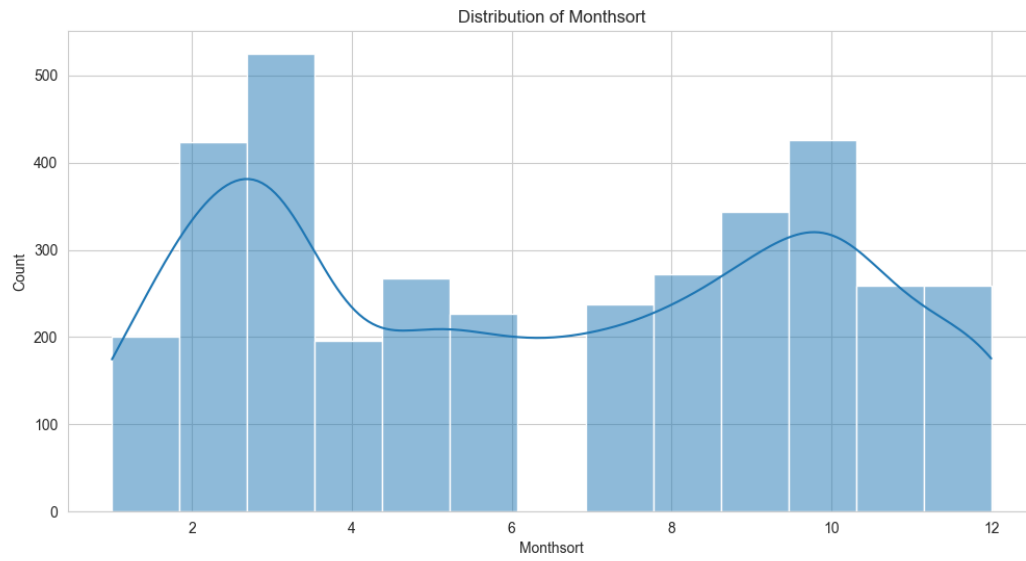


Figure: Weekdaysort Distribution



*Figure: Monthsort Distribution*

## Model Card

# 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
- R<sup>2</sup>: 0.9989

## Performance

### *Quantitative Analysis*

- Mean Squared Error (MSE): 0.0058
- Root Mean Squared Error (RMSE): 0.0760
- Mean Absolute Error (MAE): 0.0426
- R<sup>2</sup> 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