MODEL VALIDATION REPORT

FRB SR 11-7 / OCC 2011-12 Compliance

MODEL INFORMATION

- **Model Name:** Customer Churn Prediction Model v2.1
- **Model ID:** MDL-2024-CHN-001
- **Model Type:** Gradient Boosting Classifier
- **Risk Tier:** HIGH
- **Business Unit:** Retail Banking - Customer Analytics
- **Validation Date:** March 25, 2024
- **Validation Team:** Independent Model Validation Group

VALIDATION STATUS: ✅ APPROVED WITH CONDITIONS

EXECUTIVE SUMMARY

The Customer Churn Prediction Model v2.1 has been thoroughly validated according to FRB SR 11-7 requirements. The model demonstrates strong predictive performance with an AUC-ROC of 0.89 and meets most validation criteria. However, some fairness concerns were identified requiring ongoing monitoring and mitigation strategies.

Key Performance Metrics

Metric	Score	Status
Accuracy	0.870	✅ Pass
Precision	0.890	✅ Pass
Recall	0.820	✅ Pass
F1 Score	0.850	✅ Pass
AUC-ROC	0.890	✅ Pass

Risk Assessment Summary

- ✅ **Model Risk Rating:** HIGH - Due to direct customer impact and financial implications
- ⚠️ **Fairness Risk:** MEDIUM - Demographic parity difference of 8% detected across age groups
- ✅ **Operational Risk:** LOW - Model demonstrates stable performance under stress testing

- ✅ **Data Quality Risk:** LOW - Comprehensive data validation procedures in place

Key Recommendations

1. Implement fairness monitoring for age-based disparities

2. Establish monthly performance monitoring with drift detection

3. Develop contingency plans for model degradation scenarios

4. Schedule quarterly revalidation for high-risk classification

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PERFORMANCE VALIDATION RESULTS

Model Performance Analysis

The model underwent comprehensive performance testing including:

- **ROC Analysis:** AUC of 0.89 indicates excellent discrimination ability

- **Precision-Recall:** Well-balanced trade-off with F1 score of 0.85

- **Calibration:** Model predictions are well-calibrated (Brier score: 0.18)

- **Threshold Analysis:** Optimal threshold identified at 0.52

Confusion Matrix Results

	Predicted No Churn	Predicted Churn
Actual No Churn	8,543 (TN)	1,457 (FP)
Actual Churn	1,823 (FN)	7,177 (TP)

Key Metrics:

- True Positive Rate (Sensitivity): 79.7%

- True Negative Rate (Specificity): 85.4%

- Positive Predictive Value: 83.1%

- Negative Predictive Value: 82.4%

FAIRNESS AND BIAS ANALYSIS

Demographic Parity Analysis

Age Group	Positive Rate	Accuracy	Disparity
18-25	0.42	0.83	-6%
26-35	0.45	0.87	-3%
36-45	0.48	0.89	0% (ref)
46-55	0.47	0.88	-1%
56+	0.40	0.82	-8% ⚠️

Fairness Metrics Summary

Metric	Age Disparity	Gender Disparity	Status
Demographic Parity	0.08	0.03	⚠️ Age exceeds threshold
Equalized Odds	0.06	0.04	✅ Within limits
Equal Opportunity	0.05	0.03	✅ Within limits

Bias Mitigation Recommendations

1. **Age-based Disparity:** Implement age-aware calibration to reduce the 8% disparity
2. **Disparate Impact:** Continue monitoring selection rates across demographic groups
3. **Ongoing Monitoring:** Establish monthly fairness audits with automated alerts
4. **Model Retraining:** Consider fairness-constrained optimization in next iteration

ROBUSTNESS AND STABILITY TESTING

Stress Test Results

Scenario	Performance (AUC)	Status
Baseline	0.87	✅ Normal
Market Shock	0.82	✅ Acceptable
Data Drift	0.78	⚠️ Monitor
Feature Noise	0.75	⚠️ Monitor
Label Shift	0.73	⚠️ Monitor

Feature Sensitivity Analysis

Top sensitive features requiring monitoring:

1. Credit Score (15% impact)

2. Account Age (12% impact)

3. Transaction Volume (10% impact)

4. Support Calls (8% impact)

Temporal Stability

Model shows gradual performance degradation over 12 months:

- Month 1-3: 0.87 average AUC

- Month 4-6: 0.85 average AUC

- Month 7-9: 0.83 average AUC

- Month 10-12: 0.81 average AUC

Recommendation: Implement quarterly retraining schedule

MONITORING AND GOVERNANCE PLAN

Production Monitoring Configuration

- **Monitoring Frequency:** DAILY (High-Risk Model)

- **Alert Channels:** Email, Slack, PagerDuty

- **Performance Metrics Thresholds:**
    - Accuracy: Warning @ 0.85, Critical @ 0.80

    - AUC-ROC: Warning @ 0.85, Critical @ 0.80

    - F1 Score: Warning @ 0.78, Critical @ 0.73

Data Quality Monitoring

- Missing Feature Rate: Alert if > 5%

- Feature Distribution Drift: KS Test with threshold 0.1

- Prediction Drift: PSI threshold 0.2

Business Metrics

- False Positive Cost: Alert if > $50,000/day

- Processing Time: Alert if p99 > 1000ms

- Daily Volume: Alert if outside 500-100,000 range

Governance Structure

- **Model Owner:** Customer Analytics Team Lead

- **Technical Validator:** Independent Model Validation Group

- **Business Approver:** VP of Retail Banking

- **Risk Oversight:** Model Risk Committee

Review Schedule

- **Monthly:** Performance metrics review

- **Quarterly:** Full revalidation

- **Annually:** Comprehensive model review

- **Ad-hoc:** Triggered by performance degradation

APPENDIX: TECHNICAL VALIDATION DETAILS

Model Specifications

- **Algorithm:** XGBoost Classifier v1.7.0

- **Features:** 127 engineered features from 43 raw inputs

- **Training Data:** 2.3M customer records (Jan 2022 - Dec 2023)

- **Validation Split:** 70/15/15 (train/validation/test)

- **Hyperparameter Optimization:** Bayesian optimization with 5-fold CV

Validation Methodology

- **Performance Testing:** Stratified holdout test set (n=345,000)

- **Temporal Validation:** Out-of-time validation on Q1 2024 data

- **Cross-validation:** 5-fold stratified CV with consistent results

- **Benchmark Comparison:** Outperforms previous logistic regression by 12%

Key Limitations

- Limited performance on customers with <6 months history

- Potential seasonality effects not fully captured

- Feature drift risk for third-party data sources

- Model complexity may impact interpretability

Compliance Checklist

- ✅ SR 11-7 Section IV: Model Development - Complete documentation

- ✅ SR 11-7 Section V: Model Validation – Independent validation performed
- ✅ SR 11-7 Section V.1: Conceptual Soundness – Methodology reviewed
- ✅ SR 11-7 Section V.2: Ongoing Monitoring – Monitoring plan established
- ✅ SR 11-7 Section V.3: Outcomes Analysis – Backtesting completed
- ✅ SR 11-7 Section VI: Governance – Approval workflow defined

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VALIDATION APPROVAL SIGNATURES

Model Developer: Dr. Sarah Chen, Lead Data Scientist Date: March 15, 2024

Independent Validator: Michael Rodriguez, Senior Model Validator Date: March 18, 2024

Business Sponsor: Jennifer Thompson, VP, Retail Banking Date: March 20, 2024

Risk Management: David Kumar, Chief Risk Officer Date: March 22, 2024

FINAL APPROVAL: MODEL RISK COMMITTEE

Status: APPROVED WITH CONDITIONS **Approval Date:** March 25, 2024 **Next Review:** June 25, 2024