Credit Risk Modeling: Fairness Evaluation (Equity Assessment)

1 Fairness Evaluation (Equity Assessment)

1.1 Objective

The fairness evaluation aims to determine whether the Calibrated Logistic Regression model systematically disadvantages any protected demographic groups in the credit approval process. Specifically, the analysis assesses fairness across **gender** and **age**, two attributes often linked to regulatory scrutiny in credit risk modeling.

1.2 Methodology

The evaluation focused on the **Equal Opportunity Difference (EOD)** metric, which measures the disparity in the True Positive Rate (TPR)—or Recall—between the unprivileged (protected) and privileged (reference) groups.

$$EOD = TPR_{unprivileged} - TPR_{privileged}$$

Interpretation:

- $EOD = 0$: perfect fairness (equal opportunity)
- $EOD < 0$: unprivileged group faces higher false negatives
- $EOD > 0$: privileged group faces higher false negatives

Visual and statistical analyses were conducted using the test dataset, with TPR computed for each subgroup defined by gender and age segment.

1.3 Results and Findings

Attribute	Metric Evaluated	Observed Result	Interpretation
Gender	Equal Opportunity Difference (EOD)	≈ 0.01 (Minimal)	Male and female applicants exhibit nearly identical TPR, indicating equitable detection of creditworthy clients.
Age	Equal Opportunity Difference (EOD)	≈ -0.02 (Minimal)	Minor deviation across age segments; the model maintains stable sensitivity to true positives regardless of age.

Table 1: Fairness Results by Demographic Attribute

1.4 Visual Fairness Analysis

Fairness plots (EOD by group) indicate no statistically significant disparities. Both groups maintain comparable recall and calibration levels, suggesting that model predictions are consistent and non-discriminatory.

Additionally, feature attribution (via SHAP values) showed that age and gender contributed minimally to prediction variance, confirming that the model's decisions are primarily driven by financial and behavioral variables (e.g., credit utilization, payment history).

1.5 Interpretation and Implications

The Calibrated Logistic Regression model demonstrates:

- High equity in predictive behavior across gender and age.
- Regulatory compliance readiness, as no material biases were observed.
- Alignment with ethical AI principles, ensuring fair treatment of applicants regardless of protected attributes.

This supports the operational deployment of the model within environments governed by fairness-sensitive regulations such as the Equal Credit Opportunity Act (ECOA) or equivalent local frameworks.