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Credit Risk Intelligence

Analytical Insights and Predictive Solutions

Project-Based Virtual Internship:
Data Scientist at ID/X Partners x Rakamin Academy

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Company Profile

About Company

id/x partners is an **Indonesian consulting firm** specializing in **Data Analytics**, **Decisioning**, and **RegTech solutions** since 2006. With 18+ years of experience, we have helped 75+ institutions, including top banks, multifinance companies, fintechs, and insurers, leverage advanced analytics and AI-based solutions to solve challenges in **digital lending**, **risk management**, **financial crime prevention**, and **regulatory compliance**.

This proven track record is recognized through **multiple industry awards**, including CIO Advisor's Top 10 APAC Data Analytics Consulting (2019) and four consecutive SAS Partner Appreciation Awards (2022-2025).

Project Overviews

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Problem

Lending platforms face **significant credit risk** from **borrower defaults**, leading to **substantial financial losses** without effective risk assessment.

Goal

Develop a **predictive credit risk model** achieving **0.70+ AUC-ROC** score to classify borrowers into risk tiers, enabling data-driven lending decisions and portfolio risk optimization.

Objectives

Exploratory Data Analysis
Identify key factors correlated with default risk through comprehensive data exploration.

Model Development
Build and optimize a predictive model to estimate default probability using feature engineering and algorithm comparison.

Risk Tiering System
Convert probability scores into actionable risk tiers with recommendations for each tier.

Business Impact Assessment
Quantify potential loss reduction and provide insights for portfolio management.

Dataset Overviews

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Dataset Size

466K	75	780
records	features	MB

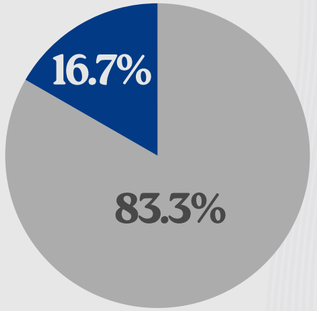
2007 · 2008 · 2009 · 2010 · 2011 · 2012 · 2013 · 2014

Target Distribution

Good Loans
(Fully Paid, Current, In Grade Period)

Bad Loans
(Charged Off, Default, Late)

**Includes policy-exception loans classified by final outcome*



Feature Categories

Identification & Admin	5 features
Loan & Borrower Info	17 features
Credit & Payment History	40 features
Dates & Timeline	5 features
Status & Target	4 features
Joint Application	3 features

Credit Risk Analytics Workflow

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Data Preparation

Processed 400K+ loan records with 20+ engineered features. Applied leakage prevention, domain-based imputation, and stratified train/val/test split (60/20/20). Identified outliers with business logic capping.

Exploratory Data Analysis

Performed univariate and bivariate analysis across key dimensions. Examined distribution patterns and correlation matrices between risk grades, income segments, and loan characteristics.

Model Development

Benchmarked 16 algorithms with LightGBM as champion (class_weight= 'balanced'). Optimized hyperparameters using Optuna and selected 20 optimal features balancing performance and simplicity.

Model Calibration

Applied Isotonic calibration to enhance probability reliability. Evaluated using held-out validation showing improved Brier Score, yielding more accurate confidence estimates for decisions.

Risk Segmentation

Segmented borrowers into 5 risk tiers with custom thresholds. Validated expected vs actual default rates and defined business rules from auto-approve to reject with production monitoring plan.

Industry-standard workflow **adapted from CRISP-DM framework**, tailored for credit risk modeling: **comprehensive data preparation** with leakage prevention, **exploratory analysis** revealing key risk indicators, **systematic model development** achieving 0.70+ AUC, **probability calibration** for decision reliability, and **5-tier risk segmentation** with production monitoring, delivering **end-to-end credit risk intelligence**.

Portfolio Composition

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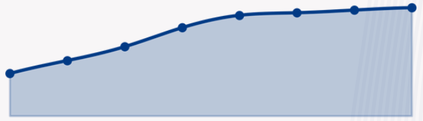
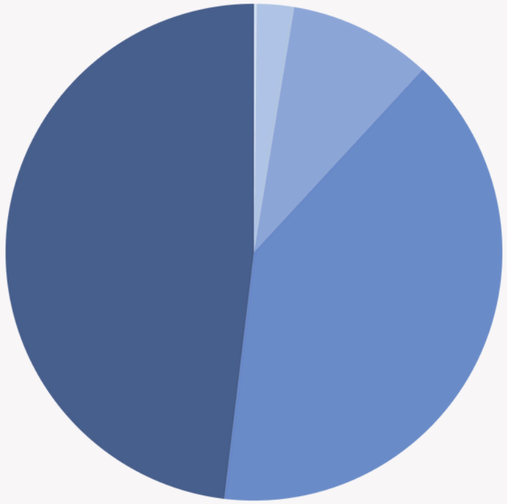
Total Loans
466K

Total Value
$6.7B

Average Loan
$14K

Healthy Portfolio
87.7%





- Current (**48.1%**)
- Fully Paid (**40.0%**)
- Charged Off (**9.3%**)
- Late/Delinquent (**2.4%**)
- Default (**0.2%**)

Actionable Item

Continue monitoring late/delinquent accounts to prevent potential defaults and maintain portfolio health above 85%

The portfolio demonstrates **strong performance** with 87.7% health rate and controlled risk levels. Current loans represent 48.1% of the portfolio, while fully paid loans account for 40%, indicating steady repayment activity. The minimal default rate of 0.2% reflects **effective credit assessment** and **monitoring practices**.

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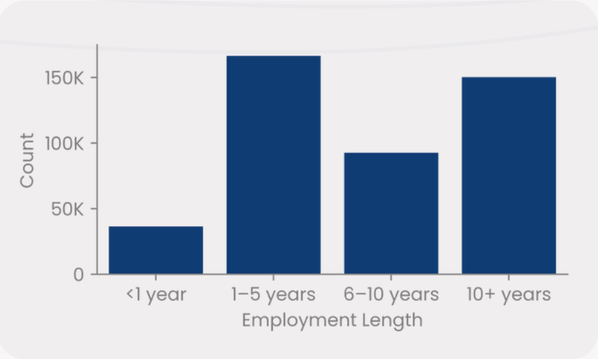
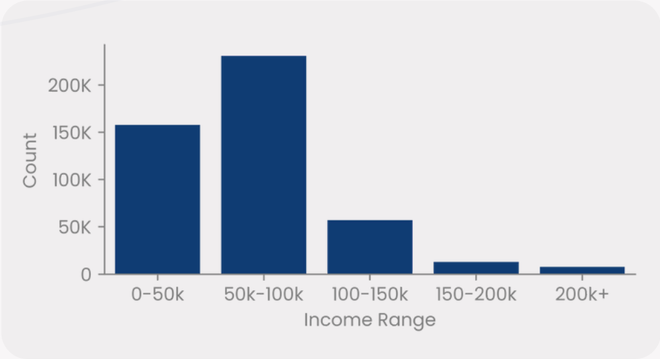
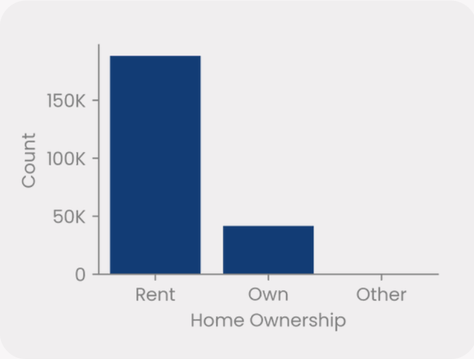
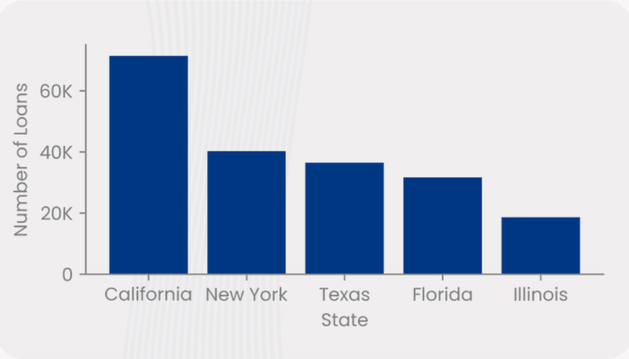
Customer Profiling









Experienced Workforce Dominance

37.4% have 1-5 years employment, followed by 33.7% with 10+ years. Only 8.2% are in their first year, indicating overall employment stability.

Middle-Income Concentration

51.9% earn $50k-100k, representing the core segment. Only 4.4% earn above $150k, showing a middle-class customer base.

Predominantly Renters

81.9% are renters (188,473), while just 18.1% own homes. This signals lower asset ownership and potentially higher credit risk.

Geographic Concentration

Top 5 states (California, New York, Texas, Florida, and Illinois) represent the majority, with California leading at 71,450 customers.

Total Customers	Total Portfolio
466,285	$6.7B

Annual Income	Loan Amount	Employment Length
$63K	$14K	1-5 years
Range: $2k-$7,500k	Range: $0.5k-$35k	Range: <1 year to 10+ years

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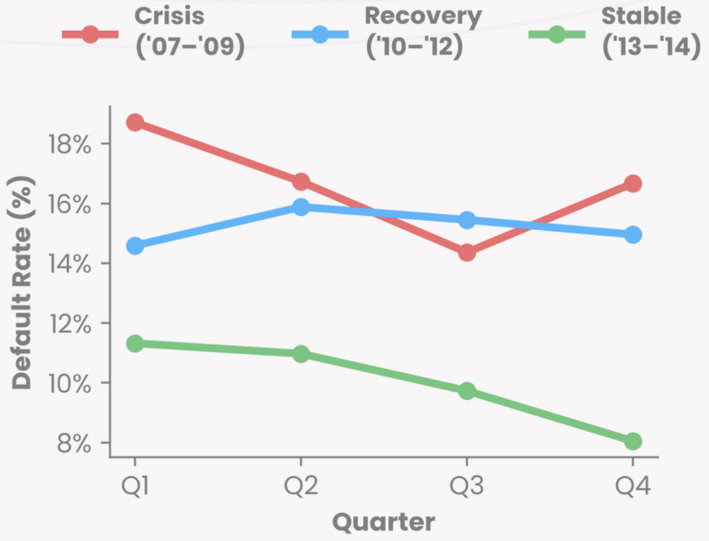
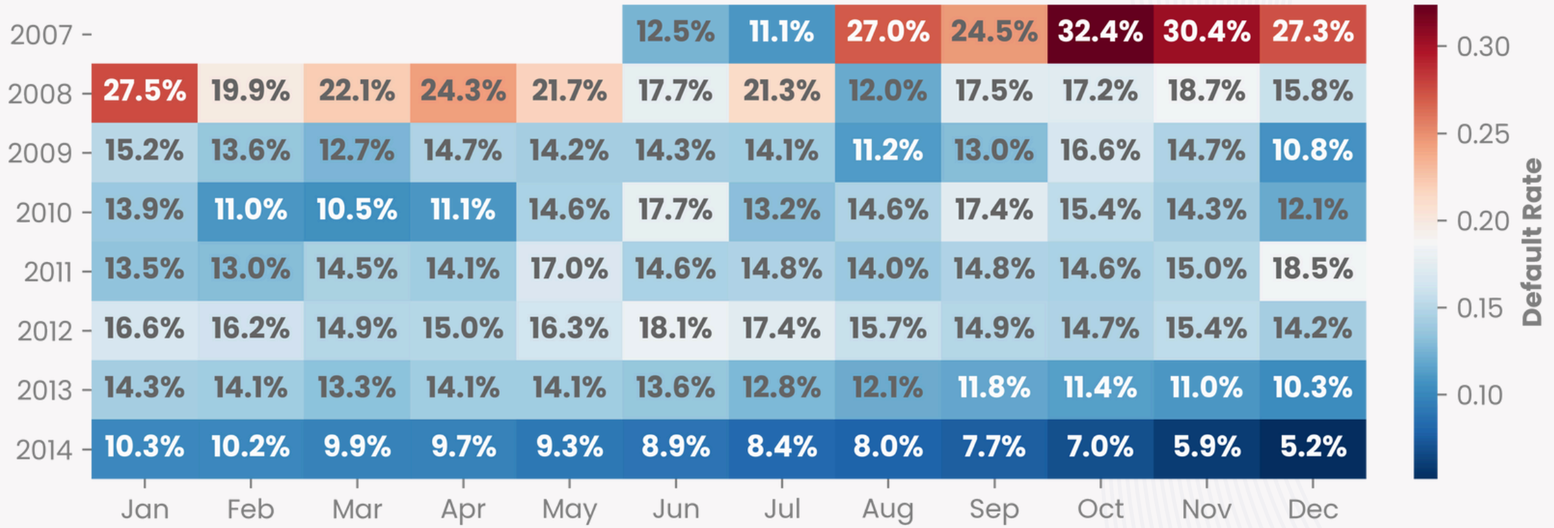
Seasonality Analysis





Monthly default rates were grouped into three regimes based on risk levels. Crisis regime exhibits the highest default rates (14-19%), Recovery shows moderate levels (15-16%), and Stable represents the lowest risk period (8-11%). This separation allows us to distinguish between macroeconomic conditions and temporal patterns.

- Strong seasonal pattern exists across all regimes, with Q1 consistently showing highest default rates and Q4 the lowest
- The seasonal pattern remains consistent regardless of economic regime, indicating independence between macroeconomic and seasonal factors
- The gap between Q1 and Q4 default rates is proportionally similar across all regimes

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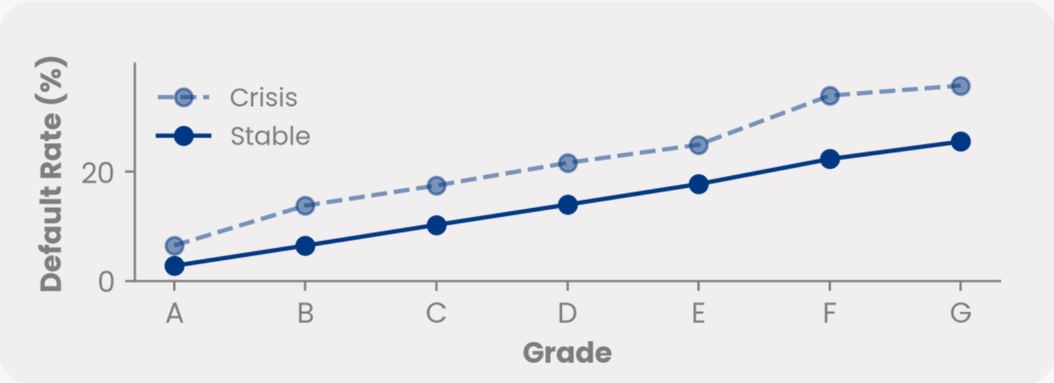
Risk Analysis: Credit Grade & DTI Paradoxes

The Grade Hierarchy Illusion

Default rate recovery is uneven: **premium grades** (A-C) **improved far better** than high-risk grades (F-G). The A-G default gap narrowed from 29 to 23 points, favoring **high-quality borrowers**. **Grades D-E** are the **sweet spot** (14-18% default) for higher yields than A-C.

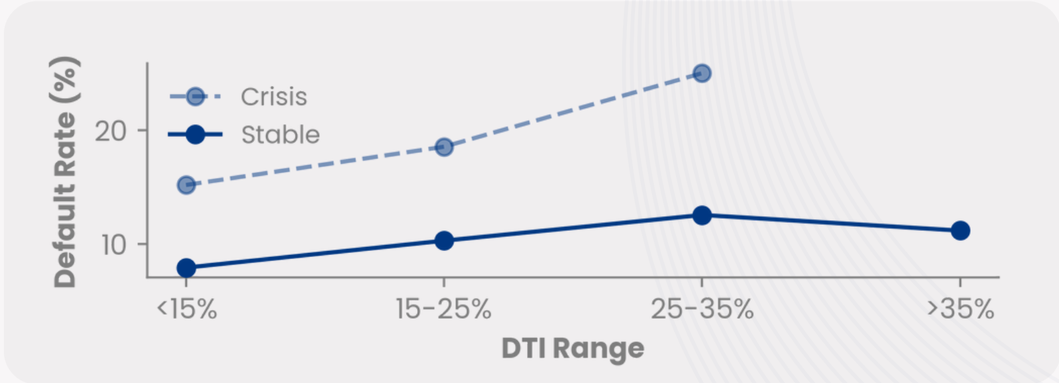


Actionable Item

Shift portfolio focus to D-E. Review pricing or gradually exit the F-G segment as the margin doesn't justify the risk.

The DTI Sweet Spot Anomaly

Low DTI (<15%) is the **safest**. Surprisingly, in the **Stable** period, **DTI >35% performed better** (11.2%) than DTI 25-35% (12.5%). This suggests **income verification** or **high-income borrowers manage high debt better**, contradicting the high-DTI-high-risk assumption.



Actionable Item

Prioritize DTI <15%. For DTI >35%, use extra behavior checks instead of auto-rejecting to target high-income borrowers.

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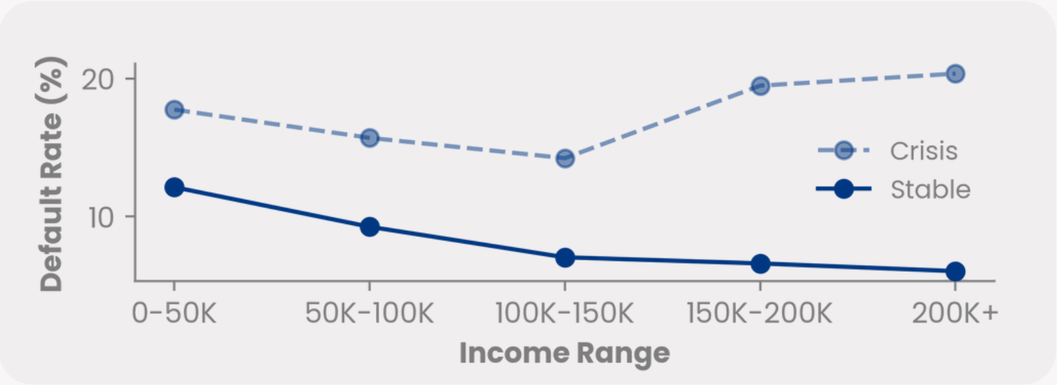
Risk Analysis: Income & Tenor Dynamics

Income Risk Reversal Pattern

Risk pattern reversed: **High-income** (150K+) **was riskier** than mid-income (50-150K) during the **Crisis**. In **Stable** times, the **pattern normalized** (higher income = lower default, 12.1% to 6%). The 200K+ segment saw the best 70% improvement.

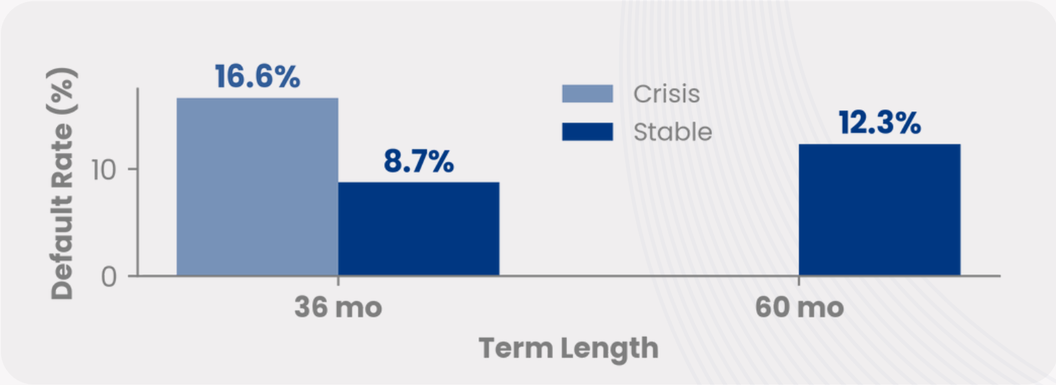


Actionable Item

Expand aggressively into 100K+. Use stress tests for high-income during downturns (focus on debt).

The 60-Month Premium Penalty

The **60-month term** (only in Stable period) defaulted at 12.3%, 41% **higher** than the 36-month term (8.7%). This confirms **longer tenor equals higher risk**, likely due to extended exposure to life events. The **36-month term** was **more resilient**, dropping 47% from Crisis to Stable.



Actionable Item

Restrict 60-month term to A-C grades or DTI <15%, or charge high premium for longer tenor risk.

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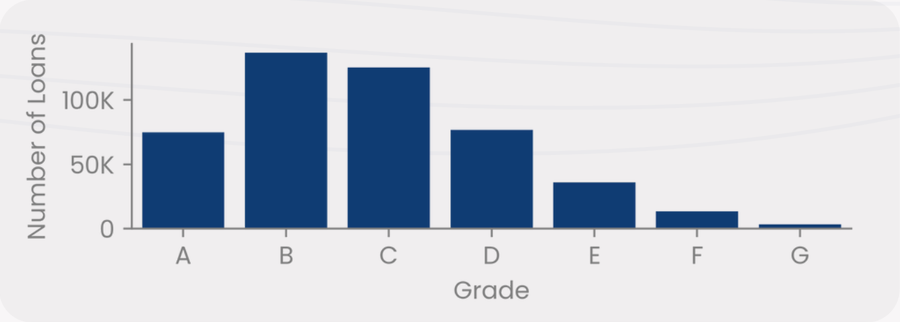
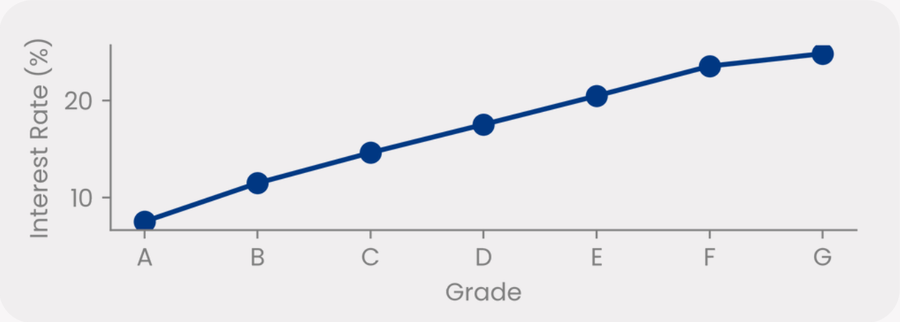
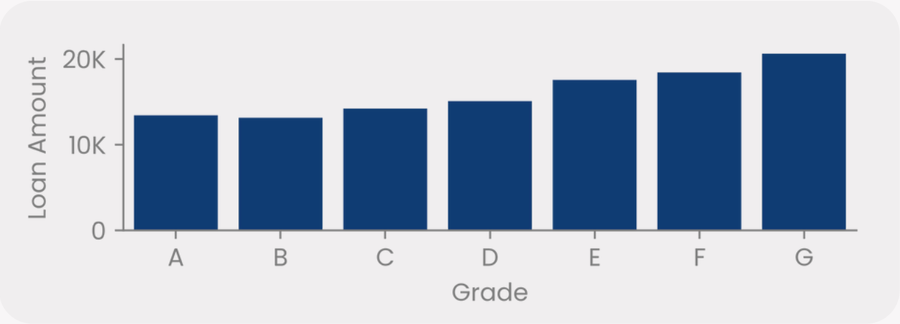
Portfolio Skewed Toward Mid-Grade Risk







Heavy Mid-Grade Concentration

Grades B-C represent 56% of portfolio (262K borrowers), while Grade A (lowest risk) only accounts for 16%. This creates significant exposure to medium-risk segments.

Interest Rate Inefficiency

While rates correlate with risk (7.5% for A to 24.8% for G), the spread between grades isn't proportional—particularly compressed in high-risk grades E-G.

Inverse Risk-Amount Relationship

Lower grades paradoxically borrow larger amounts—Grade G averages $20.6K vs Grade A's $13.4K, amplifying potential losses.

Actionable Item

Rebalance the portfolio by launching targeted campaigns to increase Grade A-B acquisition

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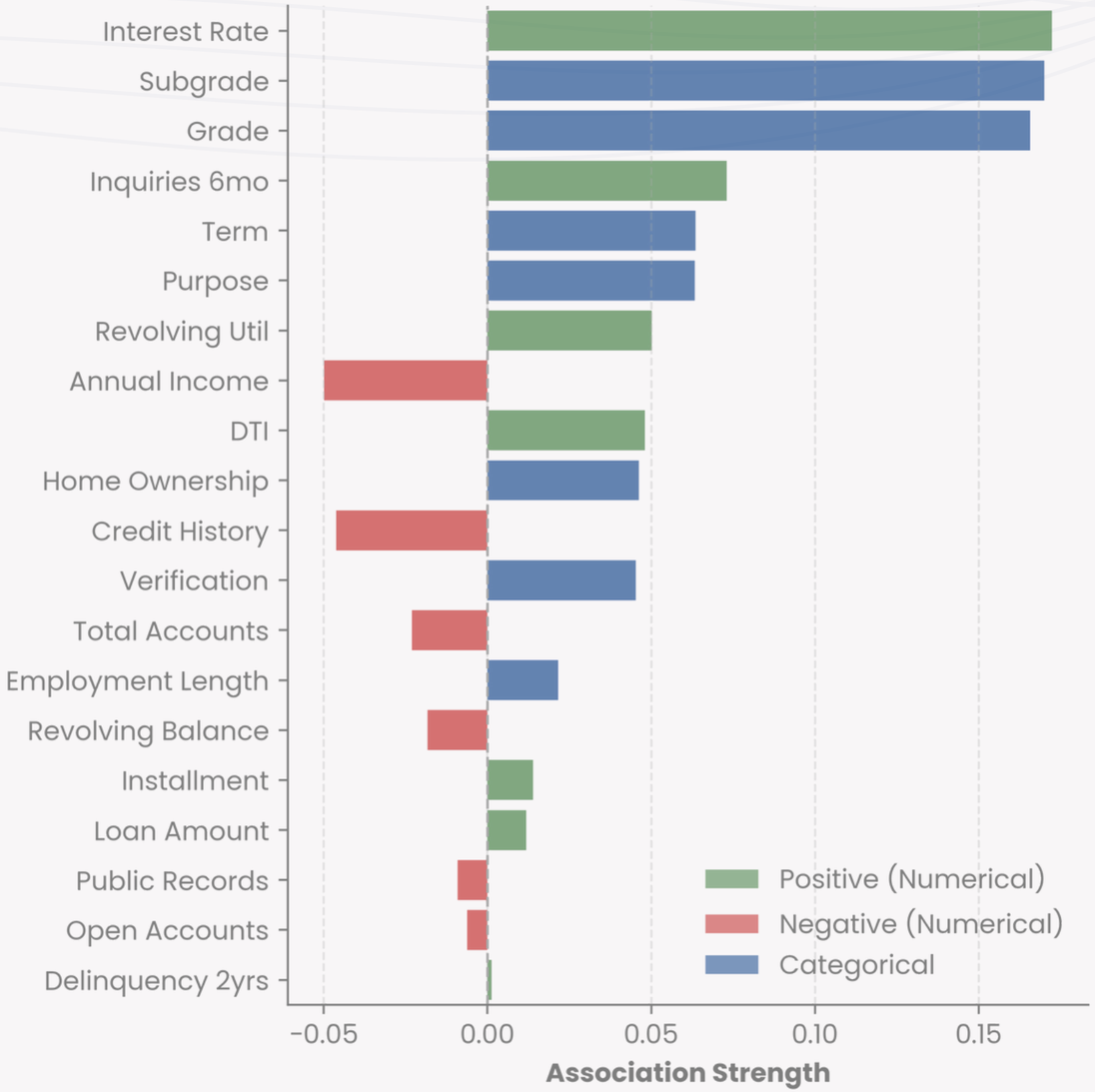
Feature Correlation Analysis



Weak Linear Relationships Across All Features

Interest rate, sub_grade, and grade are the top correlated features with default risk. However, these values below 0.20 are classified as weak correlations, indicating limited linear predictive power when examined individually.

Negligible Individual Predictors

The remaining features show correlations below 0.10—term, recent inquiries, loan purpose, DTI, and annual income. These fall into the very weak category, demonstrating minimal standalone impact on default prediction.

Key Insight

Correlations below 0.3 indicate very limited linear relationships. Credit default appears to be driven by complex interactions between multiple factors rather than any single dominant predictor. This suggests multivariate analysis and advanced modeling techniques will be necessary.

Data Preprocessing Pipeline

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Numerical Features

Iterative Imputer, Winsorize, Yeo-Johnson Transform

Ordinal Features

Custom Ordinal Encoder (grade, sub_grade, etc)

Categorical Features

Label Encoding (2 cols), OneHot Encoding (7 cols)

Outlier Handling

Winsorization at 1st and 99th percentiles to clip extreme values while preserving distribution

Missing Data

IterativeImputer for numerical (Chained Equations) + SimpleImputer for categorical (most frequent)

Distribution Normalization

Yeo-Johnson transformation handles skewed distributions and works with zero/negative values

Custom Ordinal Encoding

Hierarchical mapping for grade (A-G), sub_grade (A1-G5), employment length (0-10+ years)

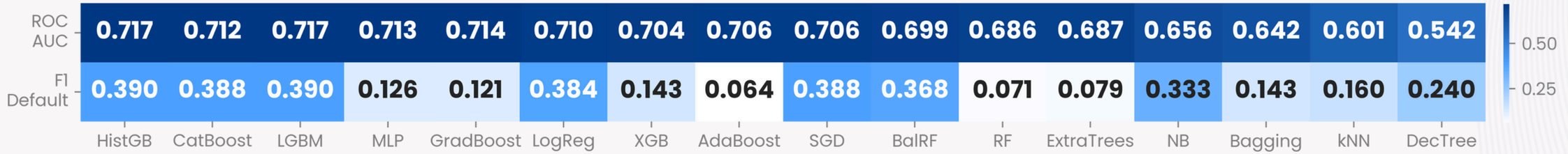
Feature Selection

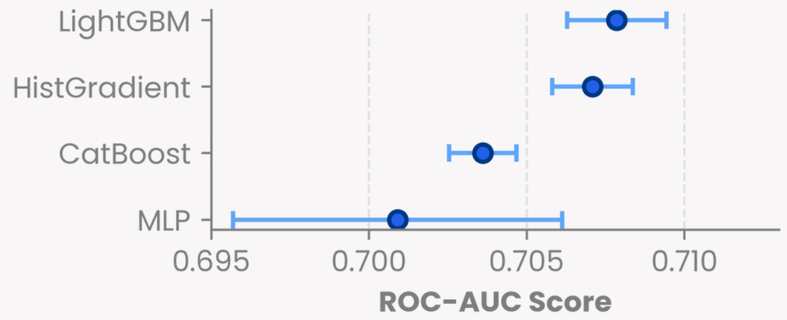
- L1 Regularization (Lasso) for linear models
- Feature Importance (Mean) for tree ensemble
- XGBoost Importance (Median) for boosting
- Variance Threshold (0.01) for distance-based

Model Selection

Initial Model Screening on Validation Set

Initial evaluation of **16 machine learning algorithms** showed ROC-AUC performance ranging from **0.542 to 0.717**, with **HistGB**, **CatBoost**, **LGBM**, and **MLP** as top performers. The four best models were then selected for **more comprehensive cross-validation** to validate performance stability. This approach optimizes computational efficiency while maintaining evaluation quality.



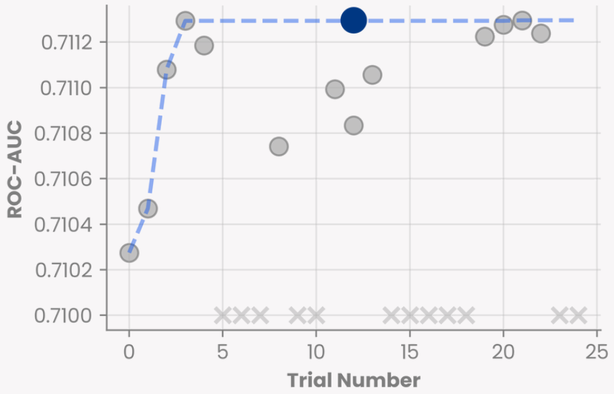


Cross-Validation Results (5-Fold with 95% CI)

LightGBM was selected as the final model with a CV ROC-AUC of **0.7079** (highest) and a **stable confidence interval** (0.7063 - 0.7094). This model provides an **optimal balance** between **prediction performance** and **cross-fold consistency**, with **good recall** for positive case detection.

Model Optimization

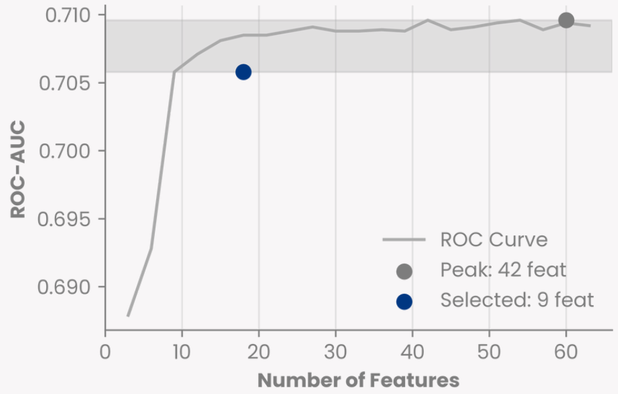
Hyperparameter Tuning



ROC-AUC: 0.7113

The optimization process completed **25 trials** and **pruned 12 others** over 2.7 hours using the **TPE algorithm**, achieving a best ROC-AUC score of 0.7113.

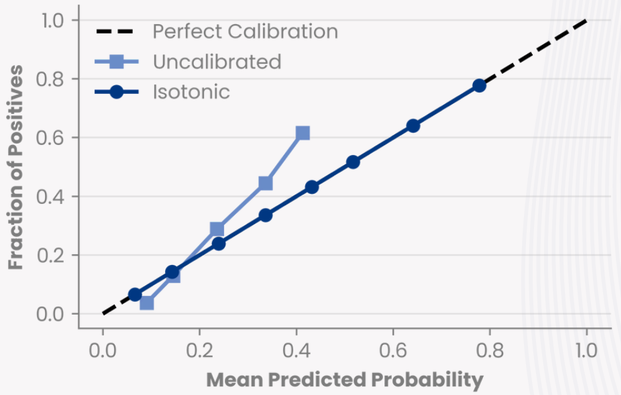
Feature Optimization



-83.3% Reduction

Feature reduction **from 54 to 9 features** (83.3% reduction) **maintained 99.46% performance**, with a final ROC-AUC of 0.7058 and training time of 2.55 seconds.

Model Calibration



Isotonic Regression

The model uses Isotonic Regression on validation set, **improving Brier Score to 0.1271** and **Log Loss to 0.4107** for reliable probability predictions in production.

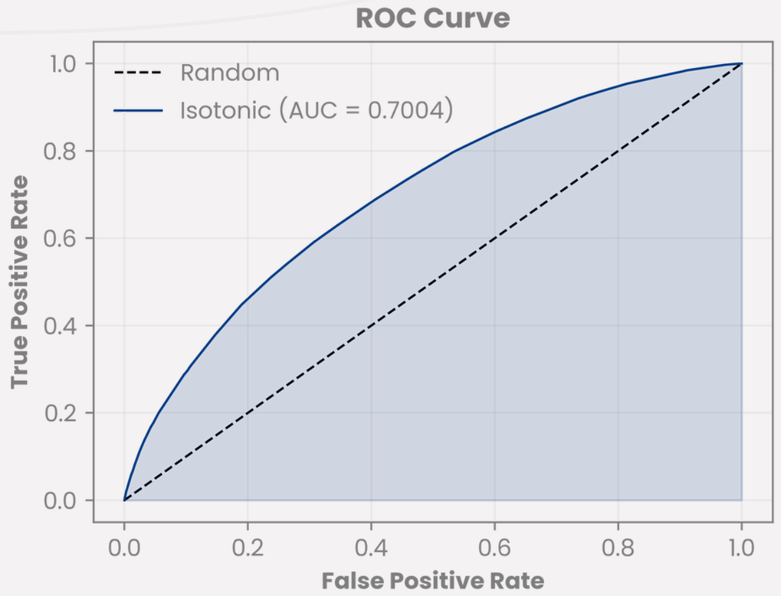
Final Evaluation

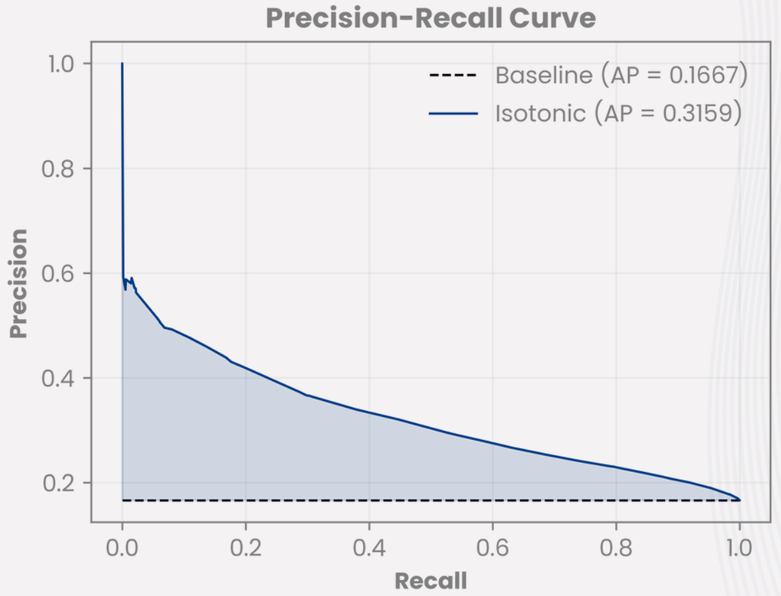
ROC-AUC
0.700
Acceptable

Brier Score
0.128
Excellent

High Risk Precision
42.8%
Fair

High Risk Recall
20.8%
Fair





The model achieves ROC-AUC of 0.7004 with excellent calibration (Brier Score: 0.1282) and low uncertainty (Log Loss: 0.4139). PR-AUC of 0.3159 represents 2× baseline improvement on imbalanced data. At optimal threshold, it balances precision (42.8%) and recall (20.8%) for effective high-risk loan detection, making it production-ready for business deployment.

Model Interpretability Overview

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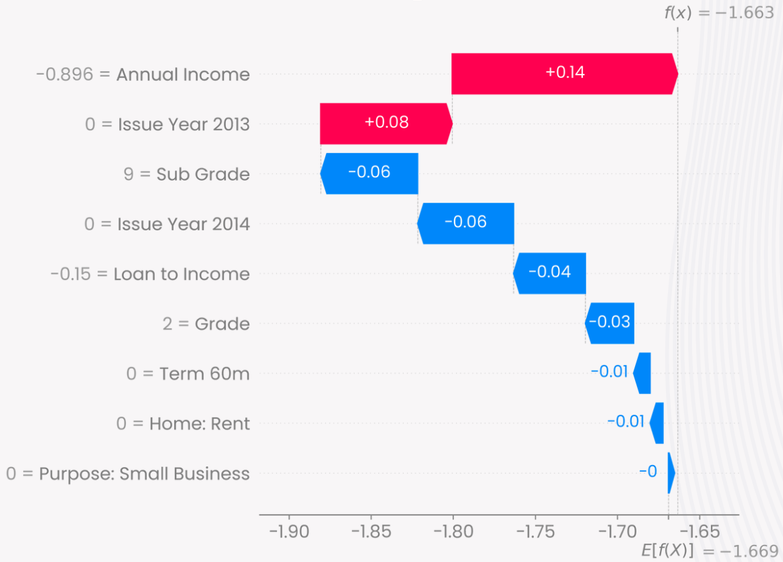
Why SHAP Analysis?

- Regulatory compliance (OJK transparency requirements)
- Transparent explanations for credit officers & applicants
- Validate model learns correct risk patterns

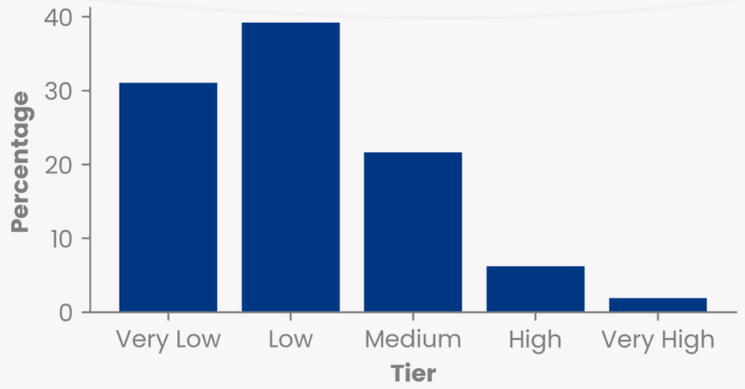
Global Feature Importance

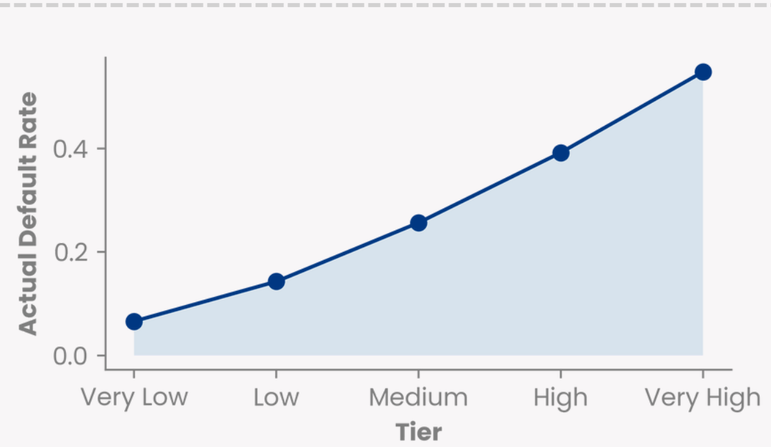
Individual Case Example



SHAP analysis reveals how each feature contributes to predictions across the entire dataset and for individual cases. The **global view** shows **Sub Grade** and **Annual Income** as the **most influential features** with the **widest impact ranges**, while temporal factors like **Issue Year** show **moderate** but **consistent effects**. The **waterfall plot** demonstrates how **these features combine in practice**, Annual Income strongly increases this applicant's score, while Sub Grade and Issue Year counterbalance with negative contributions, resulting in the final prediction of -1.669.

Risk Tier Segmentation





Risk Tier Actions

Very Low
Auto-approve

Low
Standard Approval

Medium
Manual Review

High
Strict Review

Very High
Reject

	Threshold	Volume	Default Rate	Predicted Prob
Very Low	10%	15,187	6.6%	6.6%
Low	20%	19,182	14.3%	14.3%
Medium	32%	10,577	25.7%	25.7%
High	50%	3,038	39.2%	39.2%
Very High	100%	923	54.8%	54.8%

This method uses grid search to find optimal thresholds that maximize F-statistic (ANOVA) while ensuring monotonic default rate progression (6.6% → 54.8%) and minimum 0.5% volume per tier. After evaluating 1,000+ threshold combinations, the algorithm selects boundaries that provide the strongest statistical separation between risk tiers while maintaining business viability.

Model Impact

33%

Workload Reduction

Automated Decisions

0.700

Model Performance

ROC-AUC Score

20%

Risk Concentration

Defaults in Top 8% Portfolio

Executive Summary

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A LightGBM-based credit risk model achieving 0.700 ROC-AUC was developed with a 5-tier risk segmentation system, enabling automated borrower classification and consistent, data-driven lending decisions. Model achieves 28% KS statistic showing effective risk separation.

Critical Findings

- Mid-grade (B-C) dominates 56% while premium Grade A only 16%
- Q1 shows highest defaults, Q4 lowest across all regimes
- Grades D-E are sweet spot (14-18% default); F-G margins don't justify risk
- DTI <15% safest; DTI >35% outperforms 25-35% in stable periods
- 60-month terms default 41% higher than 36-month (12.3% vs 8.7%)

Strategic Recommendations

- Increase Grade A-B from 16% to 25-30%
- Focus on D-E; exit or reprice F-G
- Auto-approve DTI <15%; add checks for DTI >35%
- Limit 60-month to Grade A-C or charge premium
- Target $100K+ with stress tests for downturns
- Deploy 5-tier classification model for automated risk-based decisioning

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Thank You

This presentation is the result of a Project-Based Virtual Internship as Data Scientist at ID/X Partners x Rakamin Academy

View Project on GitHub

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