SURVIVAL RATE ANALYSIS - UNSECURED PERSONAL LOAN PORTFOLIO

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SURVIVAL RATE MODELING

Analysis of Unsecured Personal Loan Portfolio Segemented by Credit Score, Rate and Original Loan Amount

This notebook demonstrates advanced survival analysis techniques using Kaplan-Meier and Cox regression models applied to unsecuredpersonal loan portfolio data. We progress from exploratory data analysis through univariate survival modeling to risk-adjusted survival estimates and competing risk analysis. Lastly, we'll compile findings for credit risk management and portfolio optimization applications. Key Analyses:

1) Portfolio EDA and survival model readiness assessment
2) Kaplan-Meier survival estimation with censoring adjustments for young loans
3) Credit risk management applications (PD modeling, portfolio segmentation, loss forecasting)

1.0 Loan Portfolio Summary and Exploratory Data Analysis

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Loan data imported successfully.


Total Loans: 4,591
Date Range: 2021-02-01 to 2025-01-31
Years Covered: 5
```

Overview

This analysis utilizes an Unsecured Personal Loan portfolio of 4,455 loans originated between February 1, 2021 and January 31, 2025.

Loan Volume & Timing

- Total Loans: 4,591
- Origination Period: February 1, 2021 – January 31, 2025
- Volume Distribution: Strategically weighted to reflect market conditions
- Higher origination volumes during low-rate environment (2021-2022)
- Reduced origination volumes post-rate increases (2022-2025)

Loan Terms & Structure

- Principal Amount Range: $2,500 – $50,000
- Average Original Amount: $13,679
- Maturity Terms: 6 Months to 6 years (variable by loan)
- Product Type: Unsecured personal loans with fixed rates and terms
- Amortization: Standard fixed-payment structure

Credit Risk Profile

- Credit Scores: Distributed across realistic range (350-900) | NOTE: 900 credit score is utilized in the FICO v8 Auto model
- Average Credit Score: 698
- Risk Segmentation: Four-tier credit quality spectrum (Subprime, Near-Prime, Prime, Super-Prime)
- Portfolio Average Rate: 12.44%

Portfolio Performance

- Total Defaults: 300 loans (6.5% of portfolio)
- Default Rate by Credit Tier:
  - Subprime (< 600): 14.4% (41 of 284 loans)
  - Near-Prime (600-649): 11.2% (135 of 1,204 loans)
  - Prime (650-729): 5.8% (90 of 1,560 loans)
  - Super-Prime (> 729): 1.7% (24 of 1,407 loans)

Rate Environment Stratification

Additional analysis will be performed on the interest rate structure given the shift in macroeconomic market conditions and mnteray policy during the period between 2021 and 2025. We will asses the impact of capturing the significant rate increases that began in March/April 2022 and their impact on lending volumes and borrower quality distribution.

1.1 Portfolio Summary and Review

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PORTFOLIO SUMMARY STATISTICS RESULTS:
  Total Number of Loans: 4,591
  Total Number of Defaults: 300
  Average Portfolio Rate: 12.44%
  Average Original Amount: $13,679
  Average Term: 49
  Average Credit Score: 698
```

Portfolio Performance Overview

The 4,591-loan portfolio demonstrates strong performance characteristics with a 6.5% overall default rate and 32.6% closure rate, reflecting a mature portfolio with predictable risk patterns. With an average portfolio rate of 12.44%, original amount of $13,679, term of 49 months, and credit score of 698, the portfolio represents the characteristics of small- to mid-market usnecured personal loan portfolio profile. Origination volumes peaked in 2022 (1,400 loans) during favorable market conditions before declining in 2023-2025 as credit markets tightened. One notable event is a spike in loans originated in 2024. Given there was inherent uncertainty and additional risk in the market, it is likely underwriting was tightened in 2023 until rates began to stabilize, as they did in mid-2024. At which point, hopefully, appropriate pricing models were developed in an elevated rate environment. The portfolio composition shows natural seasoning effects, with earlier vintages (2021-2022) exhibiting higher closure rates as loans mature while maintaining consistent default patterns across all origination years, suggesting stable underwriting standards despite evolving market conditions.

1.2 Key Metrics Summary by Credit Score, Rate, and Opening Amount

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DEFAULT RATES BY ORIGINATION VINTAGE:
 open_year  Total_Loans  Defaults  Default_Rate_Pct  Avg_Duration_Months
      2021          952       108              11.3                 43.3
      2022         1400       125               8.9                 31.3
      2023          955        47               4.9                 18.9
      2024         1208        20               1.7                  7.3
      2025           75         0               0.0                  0.5

DEFAULT RISK ANALYSIS BY KEY SEGMENTS:
1. Default Rates by Credit Score Segment:
              Total_Loans  Defaults  Default_Rate_%
score_bucket
Subprime              277        48            17.3
Near-Prime            346        54            15.6
Prime                2139       139             6.5
Super-Prime          1828        59             3.2

2. Default Rates by Interest Rate Segment:
             Total_Loans  Defaults  Default_Rate_%
rate_bucket
```

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Low                   983        42             4.3
Low-Med              2092       132             6.3
Medium               1079        73             6.8
Med-High              315        37            11.7
High                  115        14            12.2

3. Default Rates by Loan Amount Segment:
                    Total_Loans  Defaults  Default_Rate_%
orig_amount_bucket
Very Low                    877        68             7.7
Low                        1358        80             5.9
Medium                     1469       105             7.1
High                        699        31             4.4
Very High                   187        16             8.6

4. Risk Differentiation:
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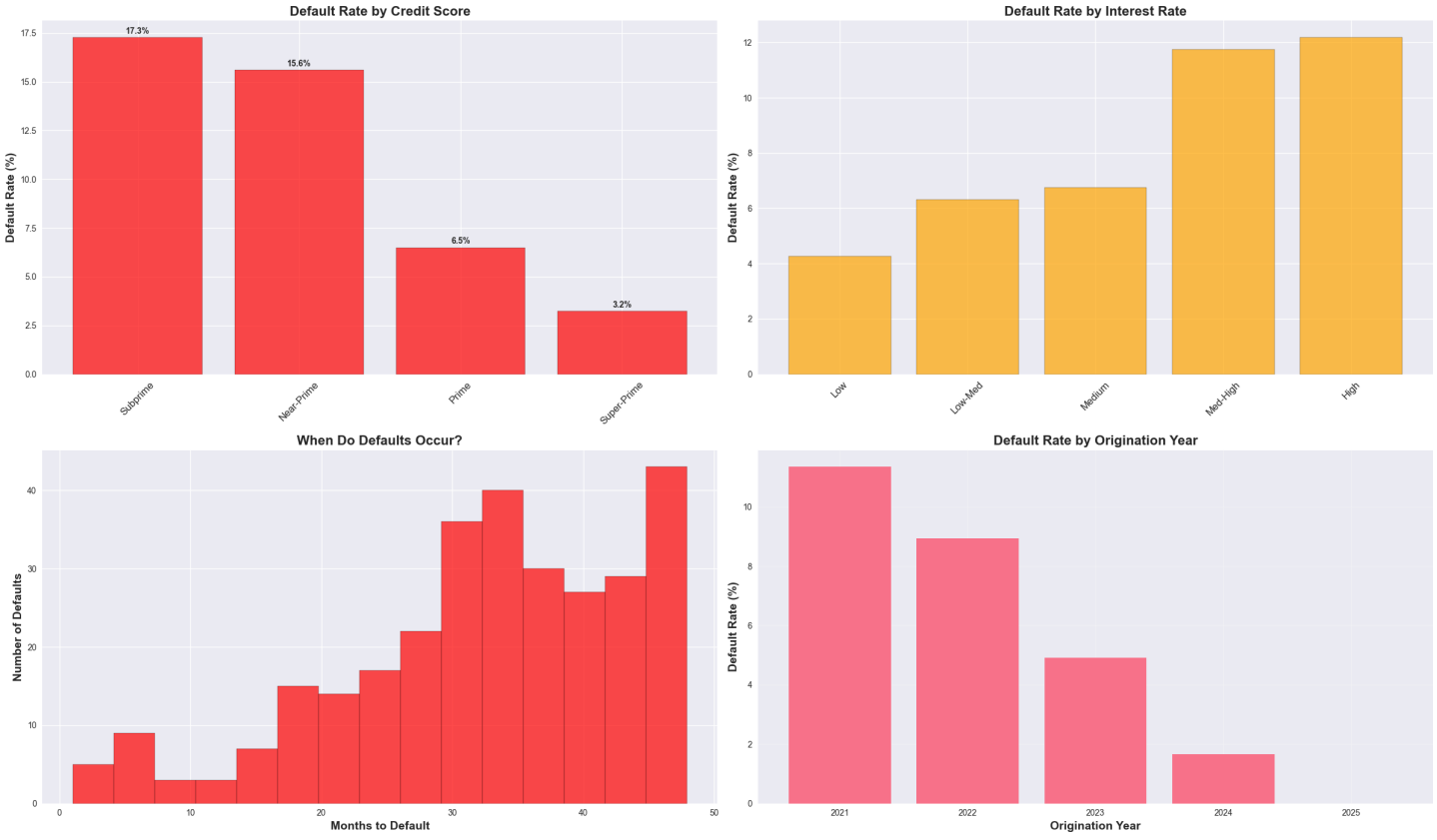
- Credit Score Risk Spread: 14.1 percentage points
- Highest Risk Segment: 17.3% default rate
- Lowest Risk Segment: 3.2% default rate



Risk Segmentation Validation

The portfolio demonstrates clear risk differentiation across credit score risk segments. The credit score segmentation shows the strongest risk discrimination with a 14.1 percentage point spread between highest-risk (Subprime: 17.3%) and lowest-risk (Super-Prime: 3.2%) borrowers. Interest rate segmentation similarly reflects appropriate risk pricing, with high-rate borrowers exhibiting 12.2% default rates compared to 4.3% for low-rate segments. The Loan Amount segmentation shows little differentation and does not appear to have an impact on predicting the borrowers risk profile.

Segmentation by vintage reveals the portfolio's natural maturation cycle, with older vintages (2021: 11.3% default rate) showing natural seasoning effects as loans reach their typical default periods, while newer originations demonstrate lower current default rates due to insufficient seasoning time. The 2022 vintage's 8.9% default rate at 31.3 months average duration may suggest peak default timing occurs in the 24-36 month range.

2.0 Survival Rate Analysis

This analysis employs two survival analysis techniques to model loan default behavior within an unsecured personal loan portfolio. The study utilizes binary event outcomes where 1 indicates loan default and 0 indicates open or closed loans. Two complementary survival modeling approaches are implemented to provide comprehensive risk assessment capabilities.

The first model is the Kaplan-Meier Fitter to determine the portfolio survival profitability at the life-of-loan evolution. The second model employed is the Nelson-Aalen estimator to calculate cumulative hazard functions.

This survival modeling framework directly supports key lending operations including loan pricing strategies, portfolio risk monitoring, and regulatory stress testing requirements. The Kaplan-Meier outputs enable risk-adjusted pricing decisions and portfolio segmentation strategies, while the Nelson-Aalen cumulative hazards inform loss provisioning and capital allocation planning. Together, these models provide actionable insights for optimizing portfolio performance while managing risk.

2.1 Baseline Kaplan-Meier Survival Rate and Cumulative Hazard Analysis

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BASELINE SURVIVAL ANALYSIS - DATA PREPARATION:
  Observation Date: 2025-01-31
  Total Loans: 4,591
  Default Events: 300 (6.5%)
  Censored Observations: 4,291 (93.5%)
  Average Duration: 24.4 months
  Duration Range: 0.0 to 48.0 months
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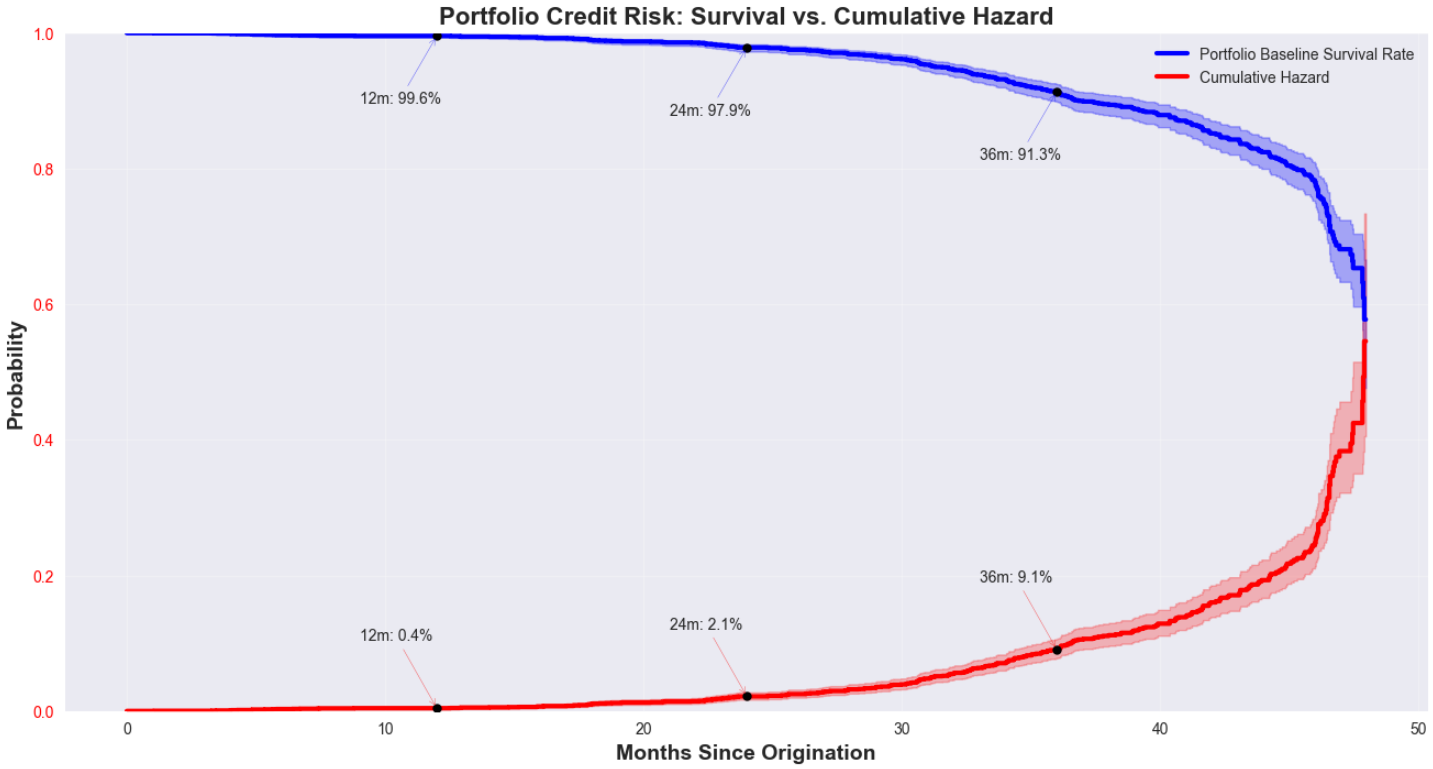
2.2 Fit and Visualize the Baseline Model

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PORTFOLIO RISK METRICS:
  Overall Default Rate: 6.5%
  Average Observation Period: 24.4 months
  Estimated Annualized Default Rate: 3.2%


BASELINE SURVIVAL STATISTICS:
   6 months: 99.7% survival | 0.3% default rate | Cumulative Hazard: 0.3%
  12 months: 99.6% survival | 0.4% default rate | Cumulative Hazard: 0.4%
  18 months: 99.0% survival | 1.0% default rate | Cumulative Hazard: 1.0%
  24 months: 97.9% survival | 2.1% default rate | Cumulative Hazard: 2.1%
  30 months: 96.2% survival | 3.8% default rate | Cumulative Hazard: 3.9%
  36 months: 91.3% survival | 8.7% default rate | Cumulative Hazard: 9.1%

  Median time to default (for loans that default): 33.6 months

  Average time to default (for loans that default): 32.4 months
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The survival analysis reveals distinct risk phases within the loan portfolio lifecycle, most notably at 24 and 36 months. During the initial 24-month period, the portfolio demonstrates strong performance with minimal default activity (cumulative hazard of only 2.1%), reflecting effective underwriting standards and borrower selection criteria in the short term.

The analysis identifies 24-30 months as a critical risk transition period, which also coincides with the portfolio's average loan duration of 24.4 months. This appears to be a critical inflection point and represents a shift in borrower behavior patterns, where loans transition from the stable early-life phase into a higher-risk maturity period. The survival probability decline from 97.9% at 24 months to 91.3% at 36 months represents a clear acceleration of credit stress as loans approach their natural conclusion.

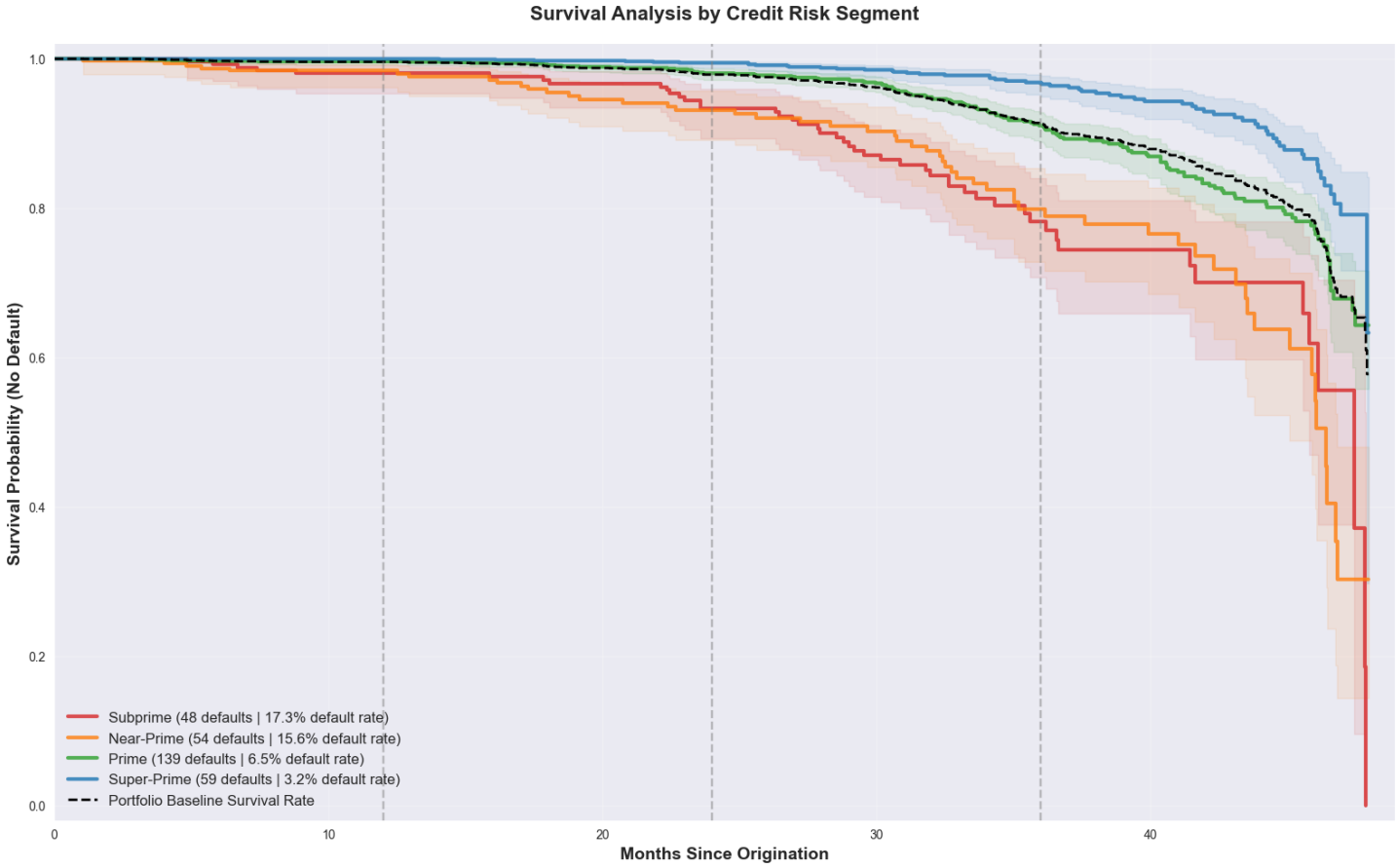
Most notably, the risk profile steepens dramatically beyond 36 months for both the survival probability and cumulative hazard curves. This pattern suggests that loans extending beyond three years face significantly elevated

default risk, indicating potential borrower financial distress or changing economic conditions affecting repayment capacity.

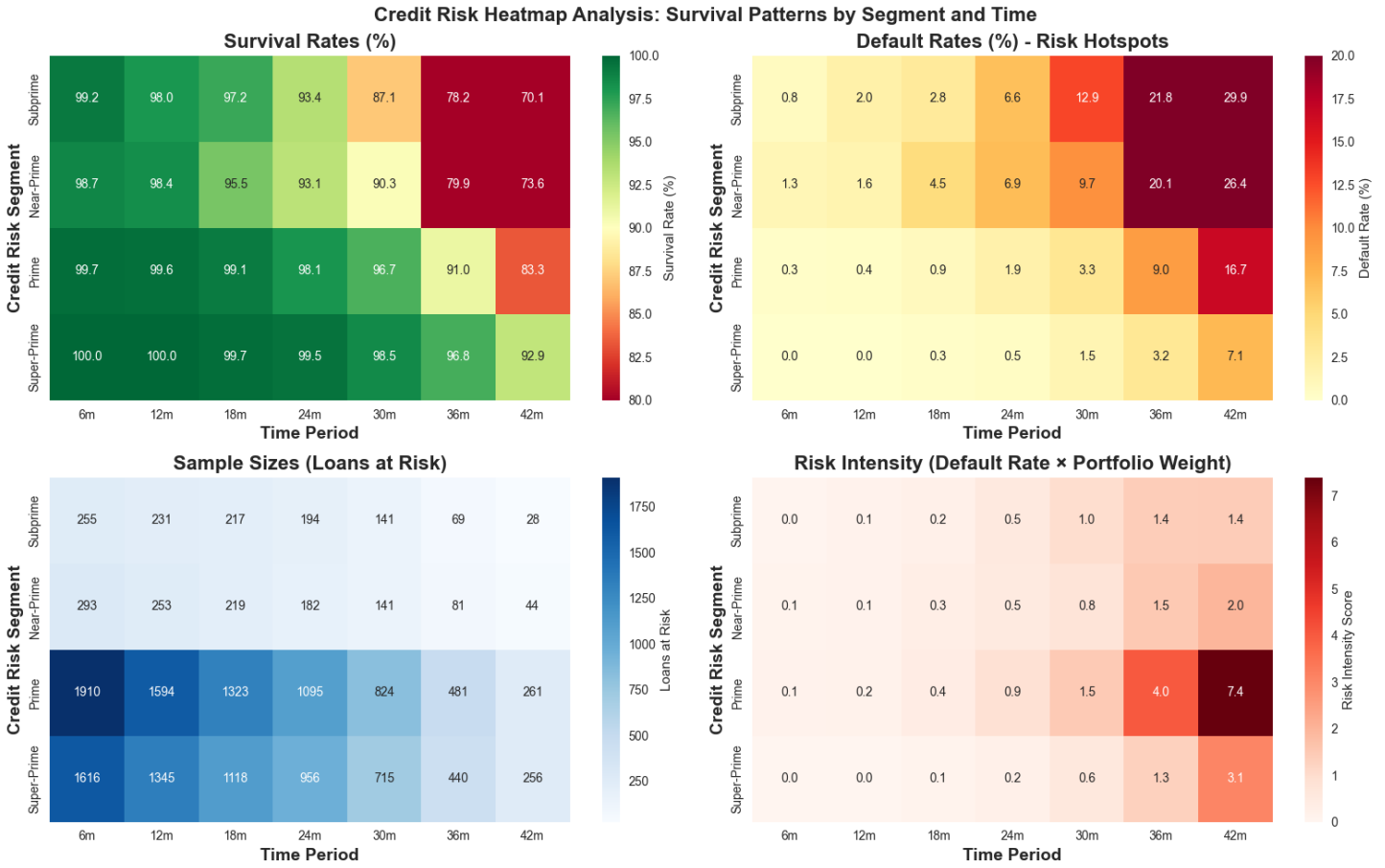
2.3 Fit and Visualize Models with Risk Segmentation

SEGMENTED CREDIT ANALYSIS:

	Risk Segment	Total Loans	Default Loans	Default Rate (%)	Average Duration
0	Subprime	278	48	17.3	27.63
1	Near-Prime	346	54	15.6	24.19
2	Prime	2139	139	6.5	24.14
3	Super-Prime	1828	59	3.2	24.27

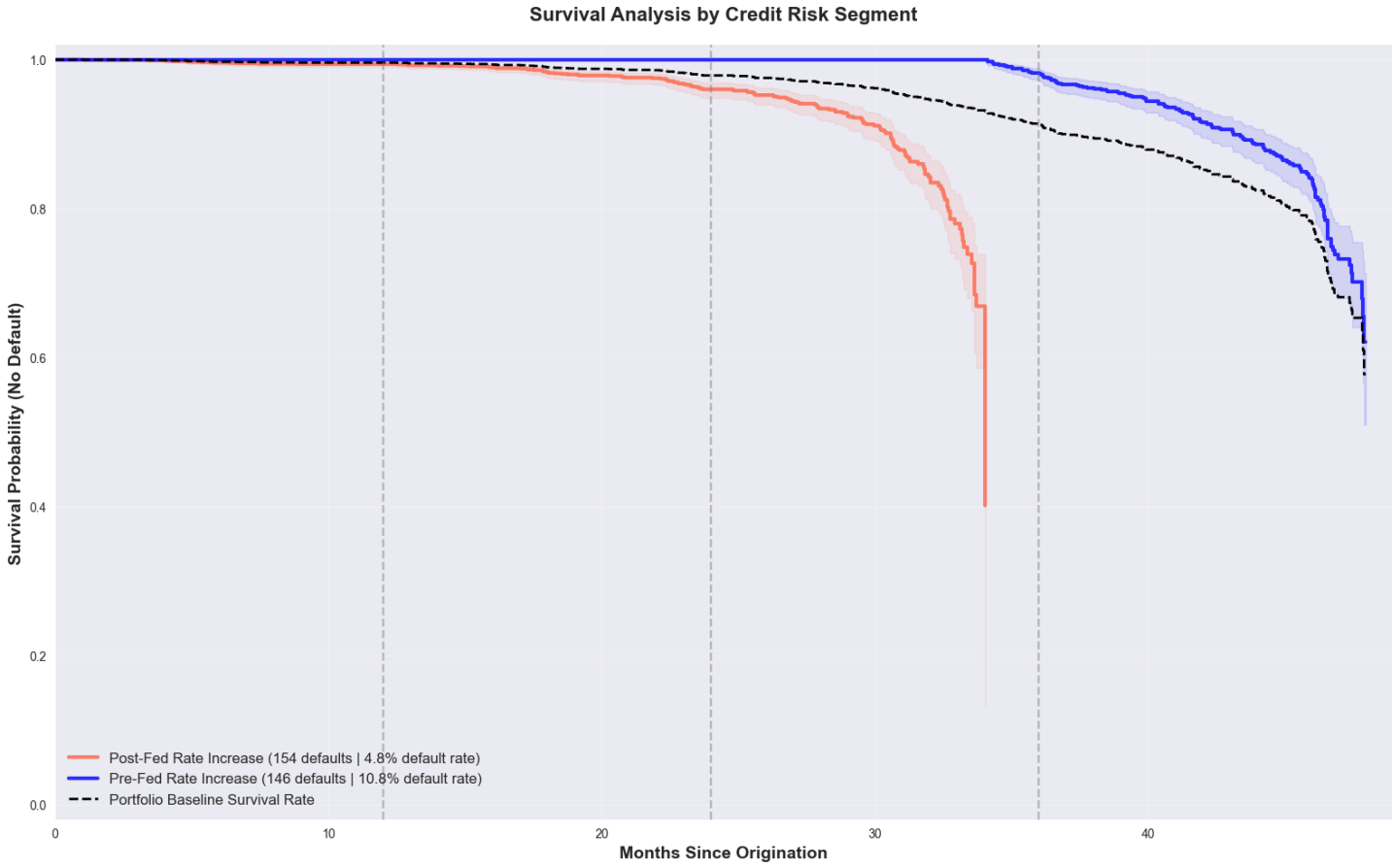


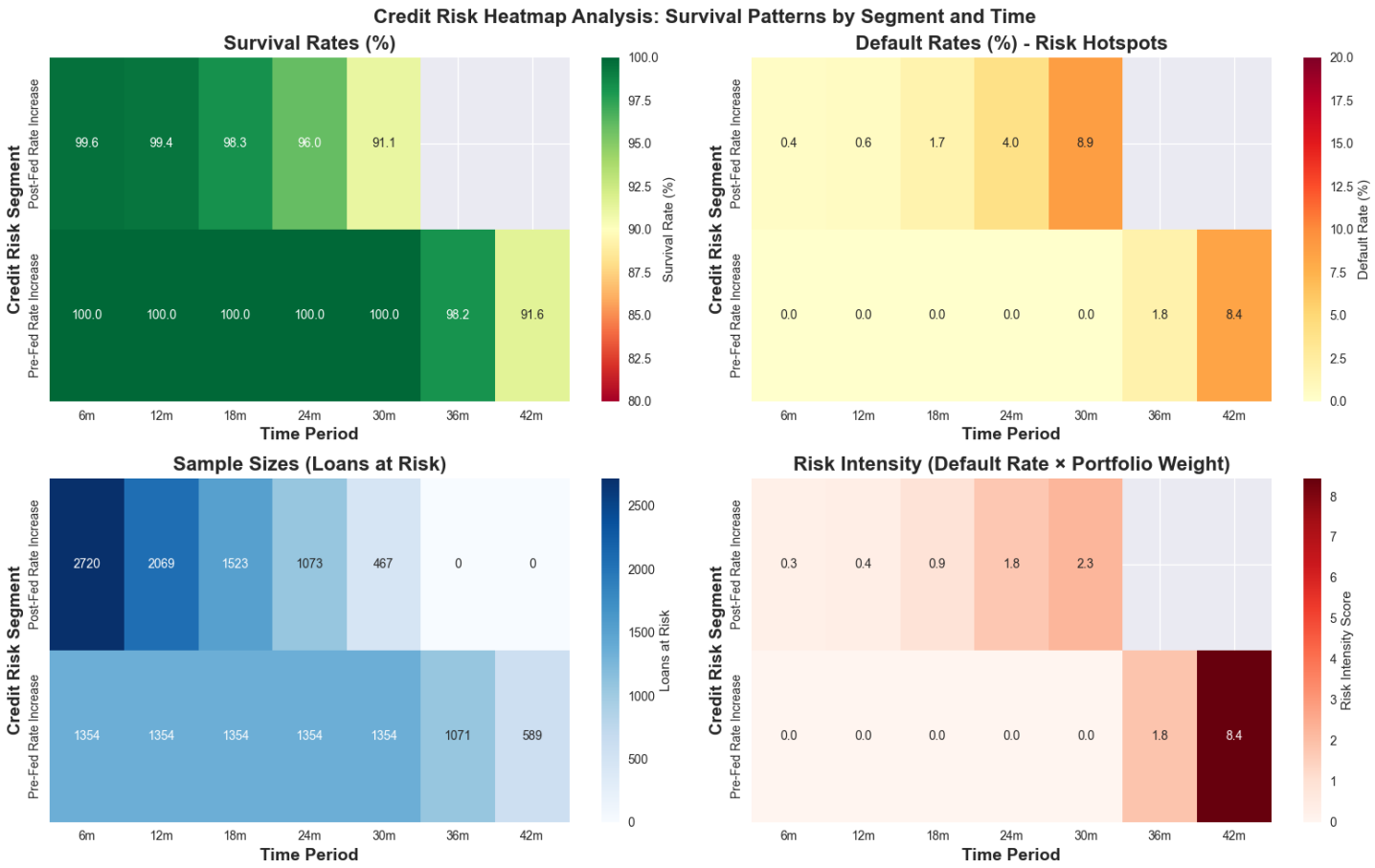
CREDIT RISK HEATMAP ANALYSIS:



This analysis reveals that traditional credit score segmentation may oversimplify risk patterns in the 24+ month timeframe. While Super-Prime borrowers maintain consistently superior performance, the convergence of Near-Prime and Subprime survival curves suggests that after the initial seasoning period, factors beyond credit scores (employment stability, life events) may become more predictive of default risk. The significant contribution of Prime borrowers to later-stage defaults (As indicated in the Risk Intensity measurement) highlights the importance of monitoring portfolio concentration risk, not just segment-level default rates. Prime has lower default rates (6.5%) but much larger exposure (2,139 loans). At 42 months, their sheer volume makes them a major contributor to absolute losses at level that outpaces Near-Prime and Subprime loans.

2.5 Fit and Visualize Model with Interest Rate Period Segmentation

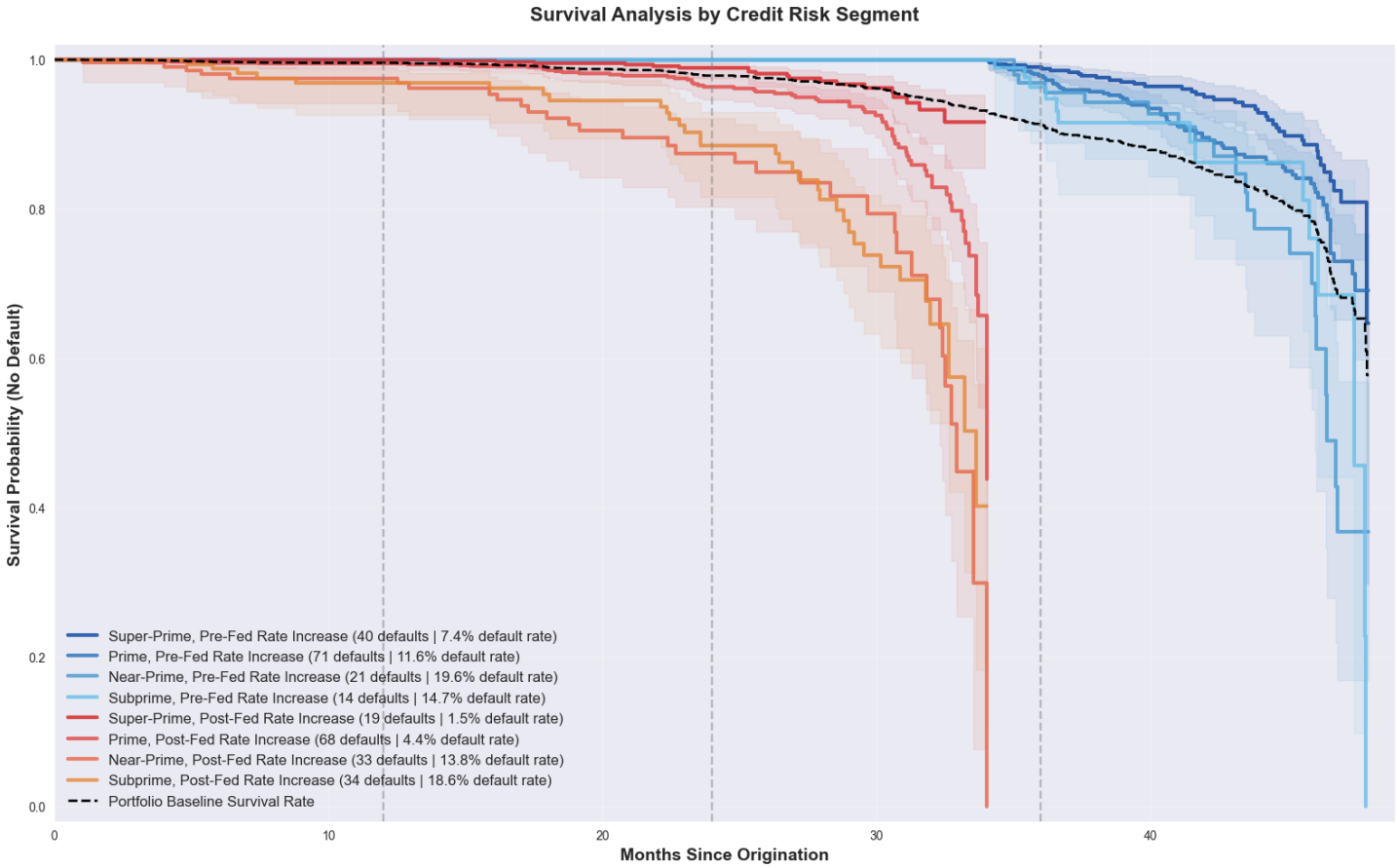


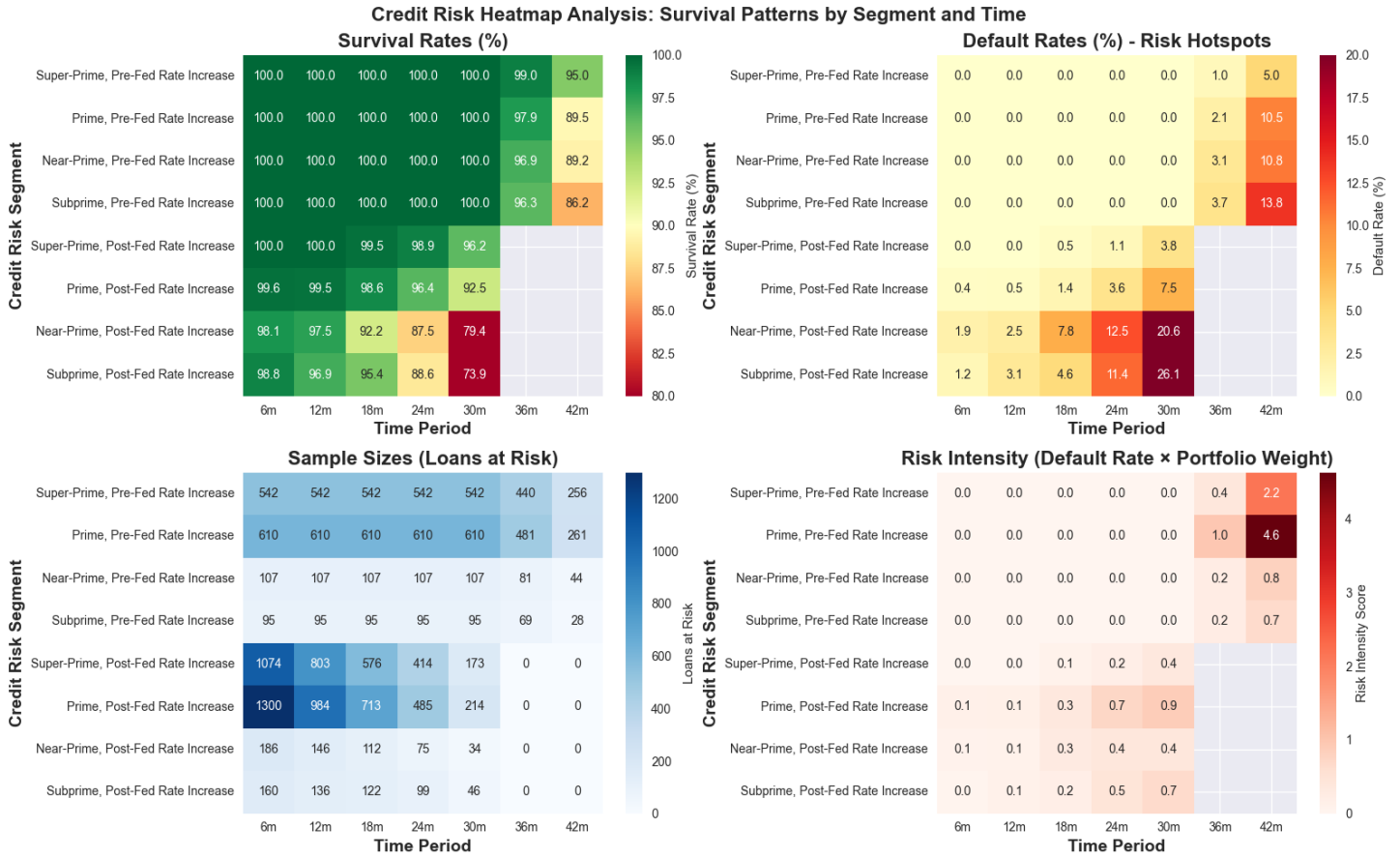


The steeper survival curve decline for post-Fed rate increase originations signals elevated immediate default risk, suggesting borrowers are experiencing financial stress earlier in the loan lifecycle. While total observed defaults

remain lower due to insufficient seasoning (4.8% vs 10.8%), the accelerated default timing pattern indicates these vintages may ultimately perform worse than pre-rate increase loans once fully matured. As a result, those segment of the loan pool may see an earlier inflection point somewhere between 18 to 24 months.

2.6 Fit and Visualize with Risk and Interest Rate Period Segmentation





The combined credit tier and rate environment analysis shows a clear and distinct shift in portfolio risk dynamics, with the elevated rate period (April 2022-2025) showing dramatically accelerated default timing. While pre-rate increase originations had survival rates above baseline through 42+ months regardless of credit tier, post-rate increase loans show steeper decline curves and earlier default materialization (18-24 months vs. 30+ months), which is likely an indicator that payment burden stress is overwhelming current borrowers. This likely suggests current underwriting standards are insufficient and require recalibration for elevated rate environments. For example, higher minimum credit score thresholds and a shift toward shorter-term products (24-36 months) that function as bridge financing rather than long-term consumer loans.

3.0 Risk Management Applications

Credit Risk Management Strategy: Rate Environment Adaptation

Survival analysis reveals that elevated interest rate environments fundamentally alter borrower stress patterns, requiring immediate portfolio strategy adjustments to maintain risk-adjusted returns while protecting against accelerated default timing. This strategy would take a three-pillar approach: 1) Portfolio Composition Management, 2) Risk-Adjusted Recalibration of Underwriting, and 3) Early Warning Detection System.

Three-Pillar Implementation Framework:

1. Portfolio Composition Management:

OBJECTIVE: Reduce and manage concentration risk during elevated rate cycles

In order to reduce and manage concentration risk, rate environment triggers should be established as standard policy. This would require adjusting exposure limits for different fed funds rates tiers. For example, in a normal rate environment the maximum Subprime/Near-Prime combined concentration should be limited to 30%. At Fed

Funds > 2%, reduce exposure to 25% exposure; at > 4%, reduce to 20% exposure. In addition, there would be value in vintage concentration limits, such as ensuring no single origination year >25% of total portfolio.

Portfolio Concentration of this sort should be managed, monitored and reported at a monthly committee meeting, such as a Credit Risk Committee (CRC). This could a standing presentation and report for committee packets. However, there would also be value in monthly dashboard monitoring to track actual concentration against target composition to identify variances.

2. Risk-Adjusted Underwriting Standards

OBJECTIVE: Align loan terms and amounts with borrower payment capacity

Implement tiered lending limits that reduce payment burden on borrower capacity. Subprime borrowers (<600 credit score) will be limited to 24-month terms with maximum loan amounts of $10,000, maintaining payment-to-income ratios below 10% to ensure sustainability. Near-Prime borrowers (600-649) receive 30-month maximum terms with $15,000 loan caps and 12% payment-to-income limits. Prime borrowers (650-729) qualify for 36-month ter**ms up to $25,000 with 15% payment ratios, while Super-Prime borrowers (730+) access the full product suite up to $35,000 and 48-month terms during normal rate environments. During elevated rate periods (Fed Funds >4%), minimum credit score requirements increase by 20-40 points per tier, and 48-month terms are suspended entirely. All applications must pass stress-testing at 200-300 basis points above the note rate to ensure payment viability under potential rate increases.

3. Early Warning Detection System

OBJECTIVE: Proactive intervention before inflection point of 30-month default window

Establish 18-24 month monitoring triggers such as: 1) Identify payment pattern deterioration (late payments, partial payments, negative deposit balances) and 2) Credit score declines of >30 points from origination. Proactively reach out to borrowers to identify root cause of financial stress.

Early intervention strategies could include refinancing of Auto or secured loans to consolidate payments, payment modification (Temporary rate reduction or term extension), or even early settlement to minimize loss.

GOAL: Risk Adjusted Value Creation

Rather than simply reducing lending activity during challenging market conditions, this strategy enables continued growth through appropriate risk pricing and proactive risk management. The tiered approach ensures that each borrower segment receives terms aligned with their demonstrated payment capacity while providing early intervention opportunities to protect portfolio performance before defaults materialize.