e-Car Pricing Optimization

Maximizing Revenue with Data & ML

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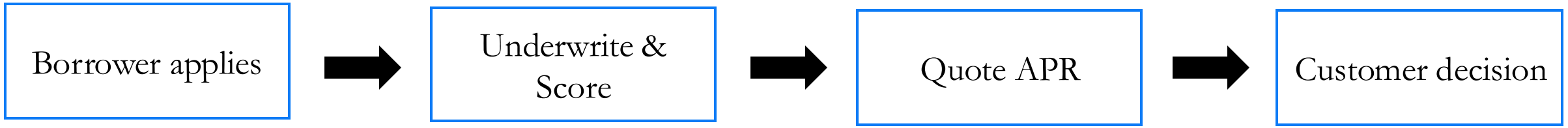
Mini Project 2: Nomis Solutions Case Study

April 30, 2025

Situation & Objectives

How e-Car Works:

e-Car operates as a pure-play online auto lender, sourcing applicants through its own website and third-party aggregators (e.g., AutoCompare.com, LendingTree) and then both underwriting each loan and setting its interest rate based on application data (including FICO score, income, vehicle details, loan type and term)



Our Project Goal:

1. **Quantify the APR trade-off** between take-rate and per-loan revenue
2. **Identify the optimal flat APR** for our target segment
3. **Build and compare ML models** (RF, SVM, KNN, ANN) to predict acceptance
4. **Optimize pricing at the segment and individual level** to maximize expected revenue

Five Key Uncertainties

- **Default risk mis-measurement:** FICO scores can lag real-world shocks—say, a sudden job loss or regional downturn—so actual loss rates may diverge from model estimates.

- **Hidden competitor promos:** e-Car doesn't see manufacturer-subsidized dealer rates or last-minute cuts by rivals, which can undercut its offers unexpectedly.

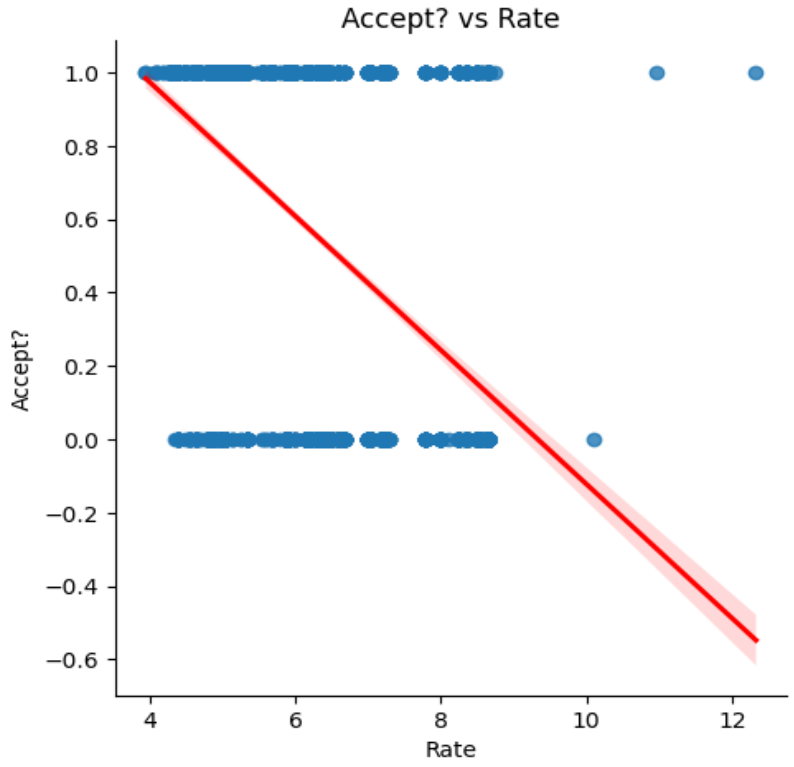
- **Borrower price sensitivity:** willingness to pay can drift over time or differ by acquisition channel; past experiment results may not perfectly predict future take-rates.

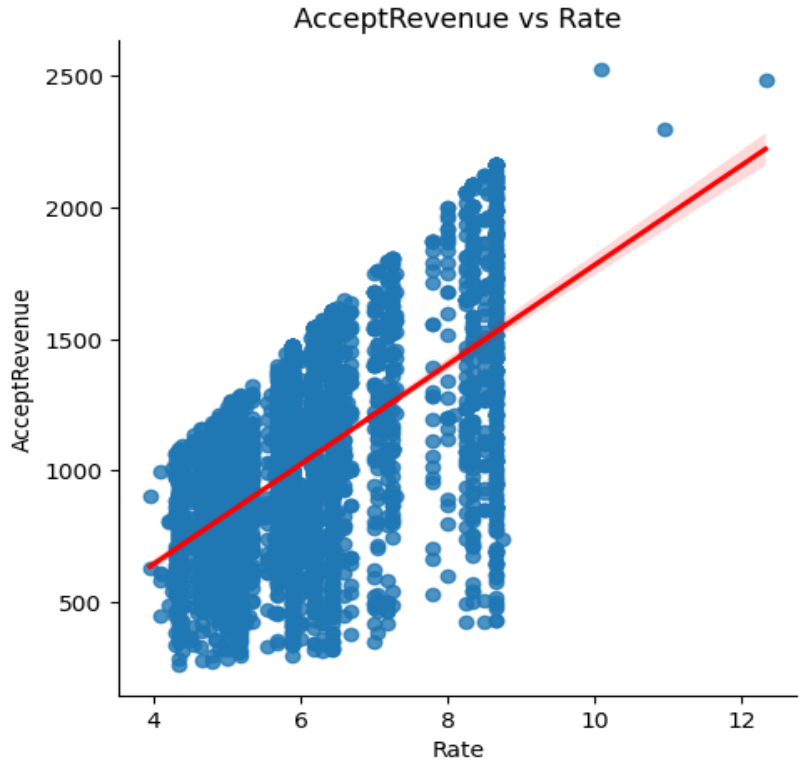
- **Funding-cost volatility:** when benchmark rates spike, e-Car's cost of capital rises before it can roll out new APRs—pinching margins in the short.

- **Collateral-value swings:** used-car prices ebb and flow with seasonality and supply changes, affecting both how much to lend against a vehicle and recovery values in repossessions.

Main Trade-off

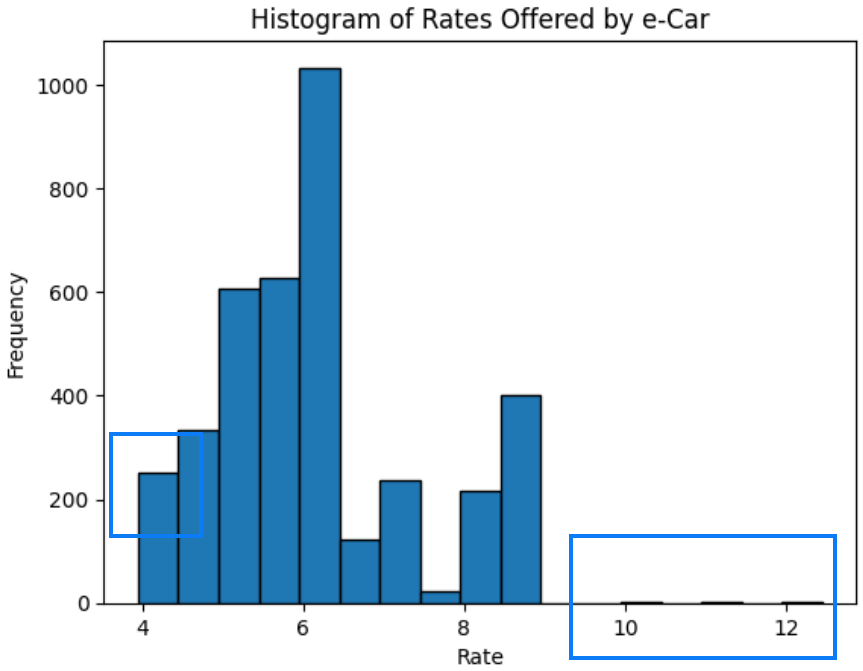
As e-Car raises its quoted APR, the share of customers who accepted the loan falls sharply, but each funded loan generates more revenue. In other words, e-Car must **trade off higher per-loan profit against a lower take-rate**.



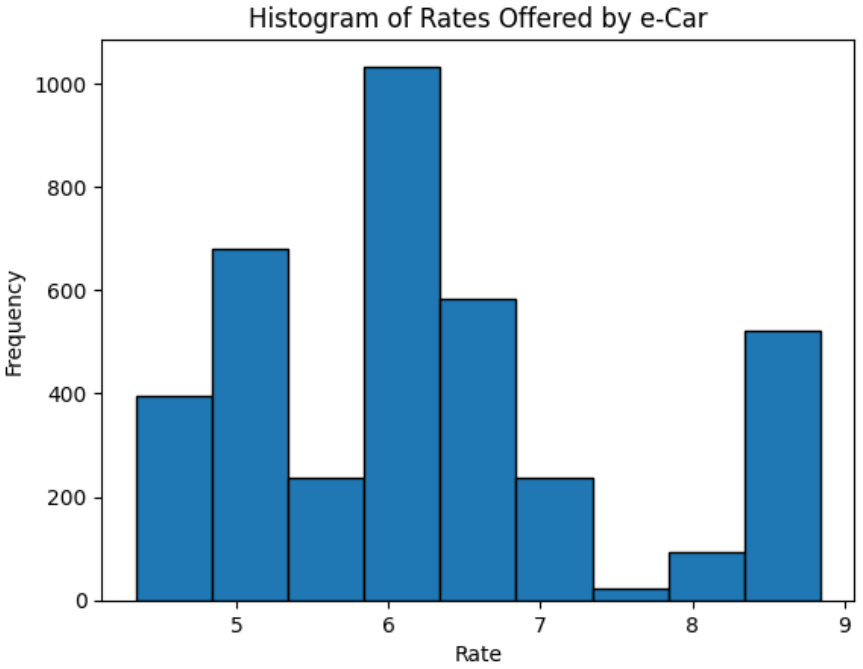


Expected Revenue

On average across all applications, e-Car can expect to earn about **$550.55 per loan offer**



Remove top and bottom 2%

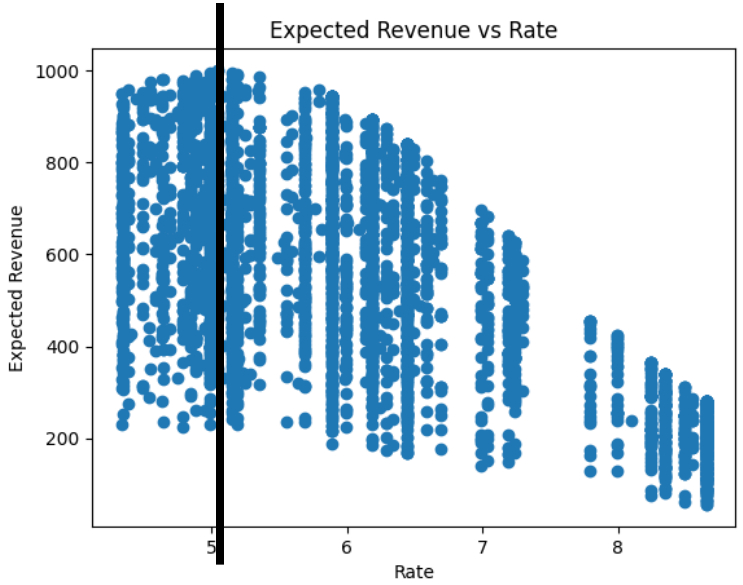


We see outliers in our dataset

Majority of offers ~6.15%

"Which flat APR maximizes e-Car's expected revenue?"

Expected Revenue

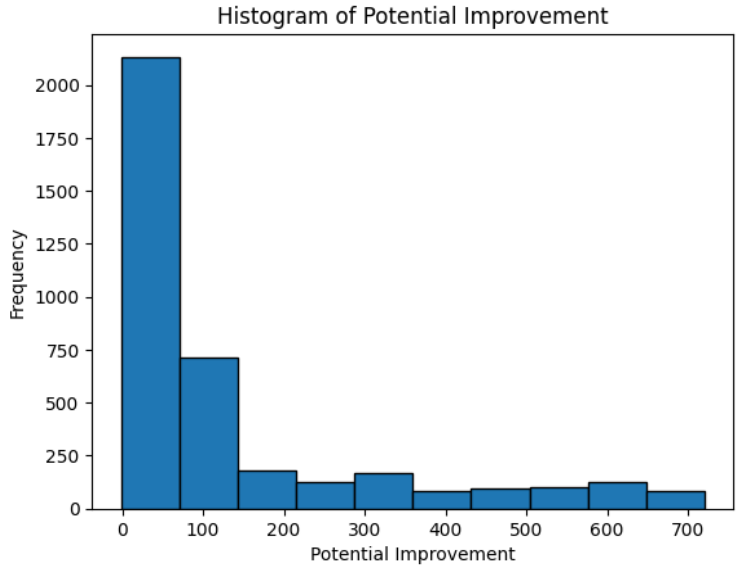


Quoting a flat **5.1% APR** maximizes the models' average expected revenue

Lifts revenue from **$550.55 to $682.96** per offer (**$132.41 gain** on average).

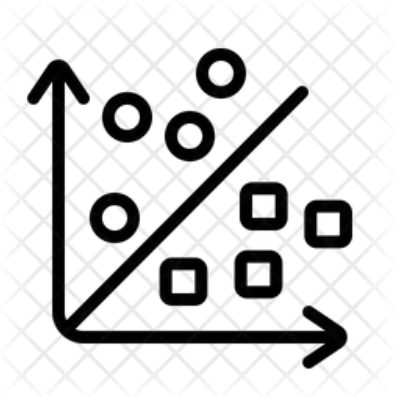
3,493 applications improve their revenue.

0 applications stay the same or degenerate their revenue.



Data & Methodology

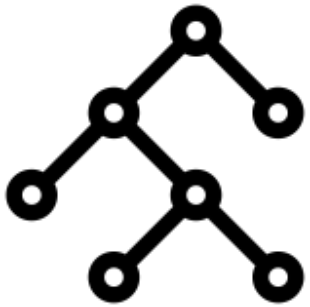
SVM



Training accuracy:
0.825

Validation accuracy:
0.800

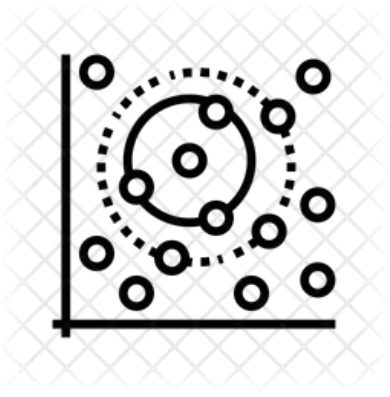
Random Forest



Training accuracy:
0.926

Validation accuracy:
0.893

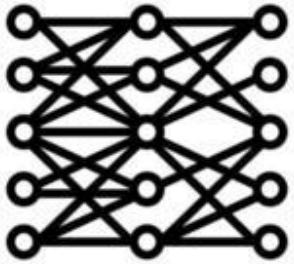
KNN



Training accuracy:
0.817

Validation accuracy:
0.779

ANN



Training accuracy:
0.822

Validation accuracy:
0.802

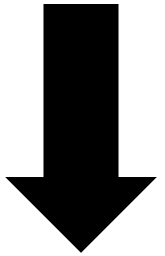
Individual-Customer Optimization

Example Case:

Sample Customer

FICO Score	700.0
Loan Amount	11,723.5
Competition Rate	4.79
Rate	6.44
Cost of Funds	1.94
Partner Bin	2.0

Original Rate: 6.44%
Original Expected Revenue: $361.52



Optimal Rate: 5.6%
Optimal Expected Revenue: $538.05

Our sweep shows 5.6% maximizes revenue at $538.05—a $176.53 lift

Portfolio-Wide Revenue Uplift from Personalized Pricing

Approach:

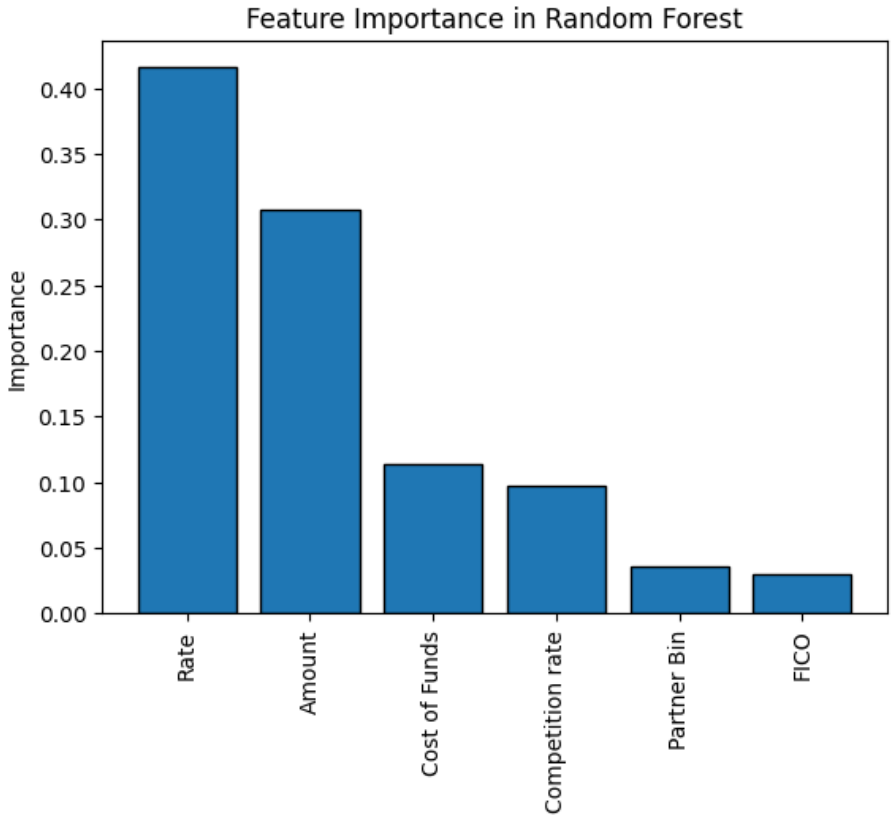
- For each customer in the test set, sweep APR from 4.0%→8.5% in 0.1% steps
- Use our Random Forest model to predict take-rate at each APR
- Compute expected revenue and select the APR that maximizes it

	Total Expected Revenue
Quoted APRs	$201,305
Optimal APRs	$285,254
Improvement	$83,949 (+42%)

Key Takeaway:

Personalizing APRs for each applicant increases total expected revenue by $83.9K (≈42%) on our test portfolio—demonstrating substantial upside from individualized pricing.

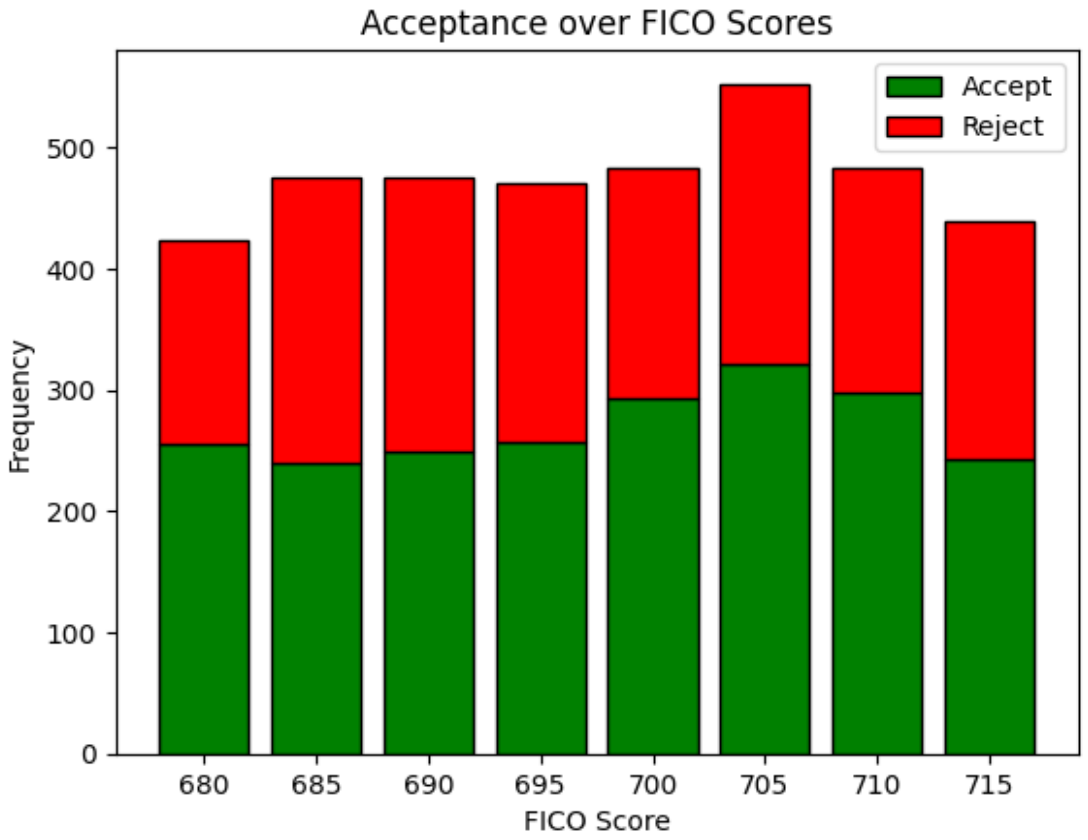
Key Insights: Feature Importance



- In our Random Forest model, **Rate and Loan Amounts dominate predictive power** (more than 70% combined), whereas **Partner Bin and FICO contribute minimally** to the prediction (6% combined).

- It shows that focusing on Rate and Loan Amounts during APR optimization will have the greatest impact.

Key Insights: FICO Score



- Within 680-720 band, **acceptance does not vary by finer FICO sub-ranges**, so further subdividing this segment would increase complexity without improving model accuracy.
- This goes along with the **lowest predictive power of FICO** in Random Forest. We can consider taking out this feature for generalization.

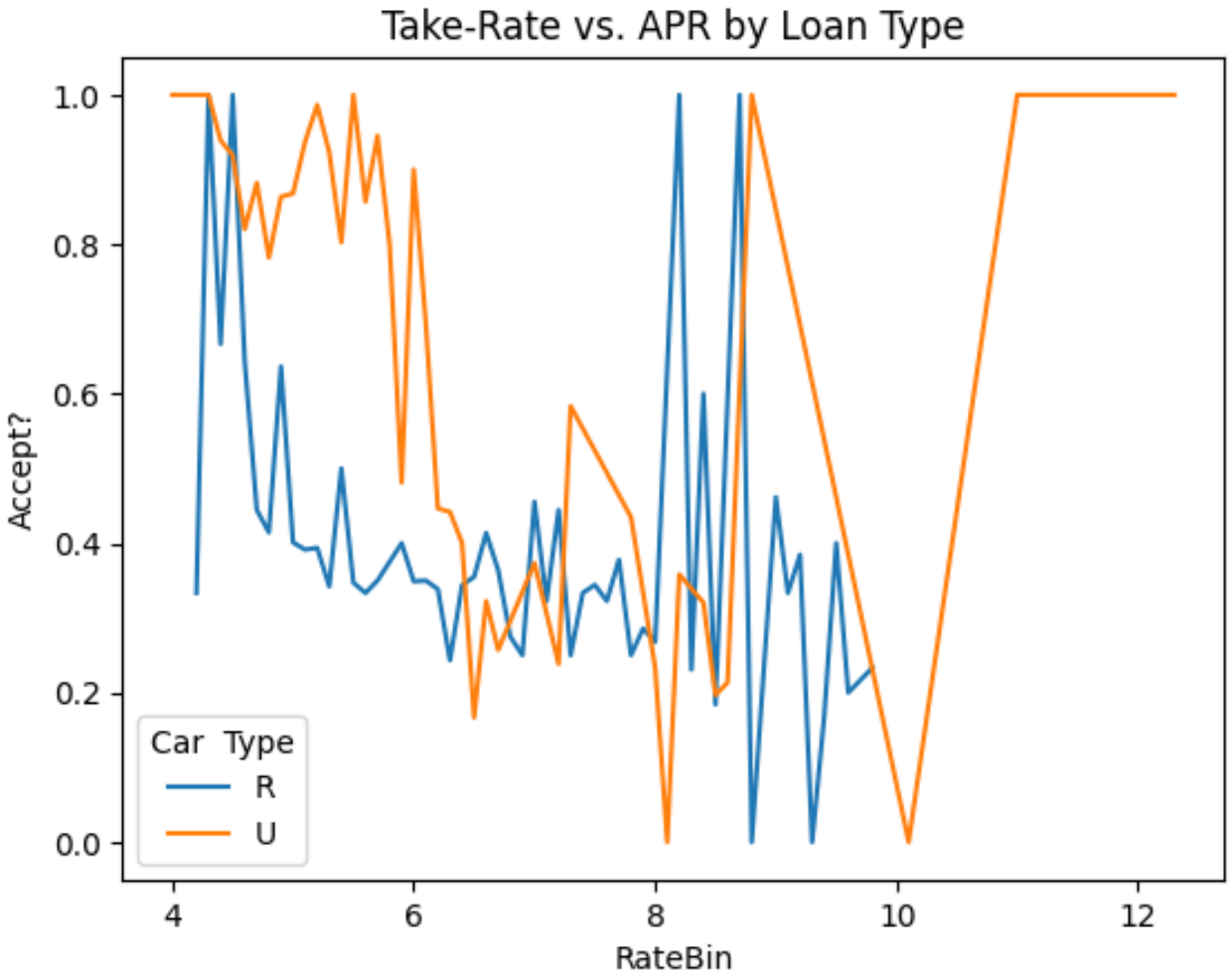
Key Insights: Refinance Borrowers Are Less APR-Sensitive

Key Insights:

- **Higher Base Conversion:** At a competitive APR (≈5 %), refinance applicants fund at ~90%, while purchase borrowers fund at ~80%.
- **Gentler Decline:** As APR climbs to 7–8 %, refinance take-rates remain above 60%, whereas purchase take-rates fall below 40%.
- **Wider "Price Cushion":** Refinance loans tolerate ~1% higher APR before volume drops off sharply compared to purchase loans.

Recommendation:

- Increase refinance APRs by 0.5–1.0% relative to purchase deals.
- Capture extra margin from a segment that clearly values refinancing more highly without risking significant volume loss.



Strengthening e-Car's Insights with Additional Data

Market & Macroeconomic Signals

- Real-time competitor rates & dealer/manufacturer promos by region
- Local unemployment, income growth & consumer sentiment indices
- Used-car price indices for collateral valuation

Borrower Profile/Post-Funding Enrichment

- Employment history & income volatility metrics
- Finding alternative credit signals (rent, utilities, bank-relationship data)
- Time-to-delinquency and default survival curves
- Prepayment and refinance behavior

Channel & Vehicle Analytics

- Cost-per-acquisition and click-through/abandonment rates by partner
- Vehicle telematics (mileage, usage) and resale-value forecasts

Advanced Analytical Applications

- Survival/Lifetime-Value models for dynamic risk & revenue forecasting
- Stress-tests under adverse economic scenarios
- Pricing algorithms that adapt to economic shocks

Final Recommendation

1. **Pilot Flat 5.1% APR:** Launch a small-scale test quoting a 5.1% APR for our target segment to capture the $132.41 uplift (from $550.55 → $682.96 per offer) demonstrated in our ExpectedRevenue analysis.

2. **Deploy Random Forest Take-Rate Model:** Integrate the RF acceptance-probability model into the origination system so future rate decisions are driven by data, not guesswork.

3. **Roll Out Individualized Pricing:** Build a simple service that sweeps each applicant's APR to maximize their ExpectedRevenue. Pilot this per-app pricing on 10–20% of volume to validate the 42% uplift across the portfolio.

4. **Refine with Channel & Macro Signals:** Layer in partner-level performance, regional economic indicators, and used-car price indices to sharpen risk estimates and capture additional upside from partner-specific and seasonal pricing.

Questions?