Power Company Shutoff Optimization: Analytics Framework Analysis

Course: ISYE 6501 - Introduction to Analytics Modeling

Assignment: Homework 8 - Case Study Analysis

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# Executive Summary

This document analyzes a multi-faceted approach to optimizing power company shutoff decisions, combining original analytical frameworks with peer insights to develop a comprehensive solution. The approach addresses both strategic customer segmentation and operational efficiency while maintaining ethical considerations.

# Problem Overview

The power company faces a complex optimization challenge:

* Limited worker capacity for performing shutoffs
* Travel time constraints between customer locations
* Need to identify customers who will pay versus those who won't
* Ethical considerations around customers unable versus unwilling to pay

# Analytical Framework Comparison

## Original Approach Strengths

* Comprehensive multi-model integration
* Strong focus on revenue impact analysis
* Detailed route optimization considerations
* Legal and regulatory compliance awareness

## Peer Approach Innovations

* Four-step sequential framework with logical progression
* Three-tier customer classification (Good Standing, Occasionally Late, Chronically Delinquent)
* Ethical distinction between 'Can't Pay' vs 'Won't Pay' customers
* Hybrid clustering + optimization for computational efficiency

# Enhanced Analytical Framework

## Step 1: Enhanced Customer Segmentation

Given: Payment history data, seasonal patterns, economic events, and customer lifecycle stage

Use: Random forest with time-series features and ensemble methods

To: Classify customers with confidence scores and assess segment stability over time

## Step 2: Enhanced Ability Assessment

Given: Partial payment history and autopay status, Failed payment attempts (insufficient funds errors), Household income and demographic data, Electricity usage patterns, External data (property values, employment verification where legal)

Use: Gradient boosting regression with uncertainty quantification

To: Estimate ability-to-pay scores with confidence intervals, distinguishing: Can Pay but Won't Pay → Priority for shutoff, Cannot Pay → Refer to assistance programs

## Step 3: Enhanced Dynamic Prioritization

Given: Ability scores, financial impact, aging of debt, seasonal factors, and historical collection success rates

Use: Multi-objective optimization with weighted scoring and time decay factors

To: Create dynamic priority scores accounting for: Total unpaid balance and average monthly bill, Time since last payment, Certainty of ability to pay, Diminishing returns over time

## Step 4: Enhanced Route Optimization

Given: Ranked priority customers and addresses, Worker capacity constraints and availability, Real-time traffic data and weather conditions, Customer availability windows

Use: Adaptive clustering (DBSCAN) + vehicle routing with time windows + machine learning for travel time prediction

To: Generate robust daily schedules with contingency plans

# Key Improvements and Innovations

## Sequential Logic Framework

The step-by-step approach provides clearer decision flow than parallel model execution, enabling better validation and debugging at each stage.

## Ethical AI Implementation

Explicit separation of 'can't pay' from 'won't pay' customers ensures fair treatment and compliance.

## Computational Efficiency

K-means clustering before route optimization reduces computational complexity while maintaining solution quality.

## Dynamic Adaptability

Time-based priority scoring and real-time route optimization account for changing conditions.

# Data Requirements and Governance

## Required Data Sources

* Internal: Customer billing, payment history, usage data, previous shutoff responses
* External: Property records, demographic data, economic indicators
* Operational: Worker schedules, vehicle tracking, geographic data

## Privacy and Compliance Considerations

* Ensure compliance with utility regulations and privacy laws
* Implement bias monitoring and fairness auditing
* Establish data quality validation processes
* Regular model performance reviews

# Implementation Strategy

## Phase 1: Foundation (Months 1-2)

* Implement customer classification model
* Establish data governance framework
* Pilot ability-to-pay assessment

## Phase 2: Optimization (Months 3-4)

* Deploy priority scoring system
* Implement route optimization
* Begin performance monitoring

## Phase 3: Refinement (Months 5-6)

* Integrate feedback loops
* A/B test model variations
* Scale across full customer base

## Phase 4: Continuous Improvement (Ongoing)

* Monitor model performance and bias
* Update based on regulatory changes
* Refine based on operational feedback

# Expected Outcomes

## Operational Benefits

* Increased efficiency
* Reduced travel time
* Better targeting

## Financial Benefits

* Improved collections
* Reduced costs
* Risk mitigation

## Ethical Benefits

* Fair treatment
* Regulatory compliance
* Community relations

# Conclusion

The enhanced analytical framework combines the best elements of multiple approaches while addressing practical implementation challenges. By focusing on ethical customer segmentation, operational efficiency, and continuous improvement, this solution provides a robust foundation for optimizing power company shutoff decisions while maintaining fairness and regulatory compliance.